# STUDYING A SYNCHRONOUS ONLINE COURSE USING A COMMUNITY OF INQUIRY FRAMEWORK

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*We studied two iterations of an online course provided to rural mathematics teachers. The online courses, which involved primarily synchronous activity, emphasized high-leverage discourse practices. We applied a community of inquiry framework, which emphasizes deep intellectual work, and its three tenets: cognitive presence, social presence, and teaching presence. We adapted the framework by creating a category on content-related interactions and by using mediating processes from our conjecture maps (e.g., Sandoval, 2014) to characterize cognitive presence. The adapted framework allowed us to notice substantive differences between the course iterations, especially in relation to teaching presence and cognitive presence. The implications of the study are that the framework helps us gauge the efficacy of synchronous online interactions and to better gauge goals for future iterations of the course.*

Online platforms and learning environments are emerging as important contexts for teachers' professional development (Johnson et al., 2018; Keengwe & Kang, 2012; Means et al., 2009), and thus as sites of research. The online context provides access to professional development to teachers who may be geographically distant from conventional professional development providers, such as institutions of higher education, and from critical masses of colleagues. Because this trend is likely to grow, it is important to conceptualize ways to research online professional development, specifically within mathematics education. Many online learning projects have asynchronous environments. We argue that online *synchronous* learning environments also have the potential to provide impactful professional learning experiences for teachers, as they incorporate features of face-to-face environments. However, there has been inadequate research on the efficacy of features within synchronous online environments. In this study, we explore one component of a three-part online professional development model for middle grades mathematics teachers in rural contexts. We apply a *community of inquiry* framework (Garrison, Anderson, & Archer, 2000) because of its assumptions about engaging participants in demanding intellectual work, and connect the framework to the design literature, specifically *design conjectures* (Sandoval, 2014). The mediating process component of design conjectures provides a way to characterize and analyze the cognitive presence in a community of inquiry, which has been an outstanding methodological problem in studying online contexts (Akyol & Garrison, 2011).

The purpose of this study is to examine the quality of the learning environment we created in a synchronous online course. The community of inquiry framework allowed us to examine the characteristics of the teaching, cognitive, and social presences. Prior research has shown that confirmed that online environments can establish social presence (e.g. Whiteside, Dikkers, & Swan, 2017). However, it has been less clear how content-related features of online courses are evident, particularly interactivity related to subject matter, cognitive presence, and aspects of teaching

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presence. In this study, we use the community of inquiry framework to explore these features within and across two cohorts of teacher participants who took the same online course.

## Online Professional Development Course

We designed a three-part online professional development model with the goal of providing rural mathematics teachers access to high quality professional development. We originally designed and implemented the three components in face-to-face formats, which we then iteratively transformed into fully online versions for the purposes of this project. Our project utilized a series of synchronous online experiences, which departs from the typical asynchronous nature of much of the current online professional development, educational coursework, and virtual teacher communities. The three parts of the model included online course modules, demonstration lessons, and online coaching.

The online course modules emphasized discourse practices that orient teachers toward high-leverage discourse practices to facilitate mathematically productive classroom discussions (Smith & Stein, 2011). These discourse practices are catalyzed by five practices emphasized in the course, entitled *Orchestrating Mathematical Discussions* (OMD), anticipating, monitoring, selecting, sequencing, and connecting. The modules also emphasize key aspects of lesson planning, such as goal-setting, in addition to having teachers solve and discuss high-cognitive demand tasks. The specific goals of the modules were to: develop awareness of specific teacher and student discourse moves that facilitate productive mathematical discussions; to understand the role of high cognitive demand tasks in eliciting a variety of approaches worthy of group discussions; and to further develop participants' mathematical knowledge, particularly the rich connections around big mathematical ideas (Ball, 1991; Ma, 1999). The modules involved a combination of synchronous and asynchronous work to minimize the amount of time teachers met together virtually (Robinson, Kilgore, & Warren, 2017). This minimized logistical challenges and maintained a high degree of teacher effort and attention due to the shortened synchronous time. Hrastinski (2008) found that synchronous and asynchronous components complement each other.

We conducted the OMD course in Zoom, a video conferencing platform, which allowed for synchronous whole class and small group interactions. In addition, we simultaneously used Google Docs and Google Draw, which allowed participants to collectively develop and share artifacts, including approaches to mathematical problems. The instructor presented challenging tasks to the participants, who then worked in virtual breakout rooms to create a document that they shared with the other groups. They talked to each other, worked simultaneously on the shared document, and used the chat window to communicate in the virtual space. The course instructor listened to and participated in these group discussions to facilitate the group work.

## Framework

We draw primarily from the community of inquiry framework (Garrison et al., 2000), that identifies three components of online learning environments: cognitive presence, teaching presence, and social presence. Garrison and Cleveland-Innes (2005) define a community of inquiry in terms of deep learning that extends beyond simple interactions, stating that a community of inquiry is a place where "ideas can be explored and critiqued; and where the process of critical inquiry can be scaffolded and modeled" (p. 134). Below, we describe each of three components of online learning environments: teaching presence, cognitive presence, and social presence.

### Teaching Presence

*Teaching presence* entails three aspects of teaching: interactive instruction, design, and direct instruction. We highlight the interactive aspects of teaching, following Garrison and Cleveland-Innes (2005), who state that "if students are to reach a high level of critical thinking and knowledge construction, the interaction or discourse must be structured and cohesive" (p. 134). Structuring interaction in productive ways includes explicitly articulating the designed features of the learning environment and directing students via explanation, scaffolding, or evaluative feedback. Anderson, Rourke, Garrison, and Archer (2001) describe these three roles of the instructor as designer, facilitator, and subject matter expert. In our perspective, the most critical role of the instructor is to *facilitate* productive interactions with and between the participants, as this is most likely to elicit and advance thinking related to the goals of the course. This is different from the social interactions described below, which are not necessarily related to course goals but are productive for building community. Articulating the design of the learning environment creates expectations and opportunities for participants; however, as learners engage with design, the instructor must insert themselves into the online interactions (via feedback, explanation, and scaffolding) in order to support students understand expectations and develop their thinking.

## Cognitive Presence

Garrison, Anderson, and Archer (2001) describe *cognitive presence* as "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (p. 11). Cognitive presence is synonymous with critical engagement with content; consequently, developing analytic tools to characterize cognitive presence must include the intellectual practices deemed essential to the learning goals. In past research, cognitive presence has been the least analytically developed dimension of community of inquiry (Akyol & Garrison, 2011), in part because processes and content that determine cognitive presence are specific to a given discipline and domain.

In order to characterize cognitive presence, we turned to the design literature to identify the essential processes related to our learning goals. We utilized *conjecture maps* to operationalize cognitive presence analytically. According to Sandoval (2014), "*conjecture mapping* is a means of specifying theoretically salient features of a learning environment design and mapping out how they are predicted to work together to produce desired outcomes" (p. 19) and is intended to reify the conjectures regarding the learning environment and how they interact to promote learning. There are four main elements to a conjecture map. The first element involves *high-level conjectures* about how the learning context supports learning. Researchers then operationalize these conjectures in the *embodiment* of the learning design, the second element, by articulating tasks, participant structures, and so forth that provide opportunities for learners to engage with content. In the third element, researchers conjecture how the design of the learning environment (embodiment) generates *mediating processes* that produce desired *outcomes.* Mediating processes occur *within* the learning environment and potentially lead to the outcomes that may occur *outside of* the learning environment, such as enacting high-leverage discourse practices in mathematics classrooms. To analyze cognitive presence, we turn to the third element, the mediating processes, as they were the intended targets of the designed learning environment.

Designers of a learning environment articulate mediating processes to reflect the desired practices, and associated cognitive work, that should result from the design of the learning environment. Thus, observations of mediating processes focus on the interactions between learners and the learning environment. To articulate the mediating processes, the project team reflected on the goals of the project, the goals of the course, and specific aspects of the learning environment, to generate four mediating processes, described in the methods section.

## Social Presence

Garrison et al. (2000) describe *social presence* as the ability for participants to project themselves and to establish personal and purposeful relationships. Rourke, Anderson, Garrison, and Archer (2001) state that the three main components of social presence are affective responses, interactive responses, and cohesive responses. As described in our analysis below, we separated out content-related interaction from the other two categories and primarily used affective and cohesive responses to define social presence.

## Research Focus

We used the community of inquiry framework to focus on how the synchronous online environment affected the teaching presence and the opportunities for the teacher participants to engage with the content directly and with each other around the content. We studied two cohorts of teachers who participated in the same online course; this allowed us to compare the two course enactments to better characterize teaching and cognitive presence within and across cohorts. As noted above, the ability of designers to facilitate social presence is sufficiently documented, and we, too, found that the teacher participants engaged in friendly banter around their lives and jobs. We conjecture that this social presence facilitated interaction around content, but we do not explicitly explore that conjecture in this paper. Our research questions were:

1. What aspects of teaching presence were evident in the two online courses, especially in terms of interactive teaching and direct instruction?
2. How did this teaching presence differ across the two cohorts, and how were these differences related to teacher participation?
3. To what extent did the participants in the two cohorts engage in mediating processes (evidence of cognitive presence)?
4. To what extent did the participants in the two cohorts engage with each other around the content (level of content-related interactions)?

## Methods

### Data Collection

We video recorded the OMD sessions, six for each cohort, twelve in total, using screen capture technology. For each session, we video recorded the host computer as well as each of the breakout rooms, creating three to five video files for each session. We used Panopto so that we could record the Zoom window and simultaneously the Google Docs the groups were creating. We transcribed all of the breakout rooms and the subsequent whole class discussions, omitting the introductory whole class segments in which the instructor outlined the task goals and expectations. This reduced the frequency of the design aspect of teaching, which was not emphasized for this study. Overall, there were 24 episodes for Cohort 1 and 45 for Cohort 2. These differences reflect data collection issues we encountered in Cohort 1 and less participation from Cohort 1 in the OMD course relative to Cohort 2.

### Data Analysis

We coded the transcripts turn-by-turn, assigning as many codes as were relevant to a given turn across the three presences. After a few rounds of consensus coding, we independently coded transcripts, with pairwise kappas between 0.45 and 0.54, considered moderate agreement (Landis & Koch, 1977). Below, we provide more details related to the codes we applied for each of the presences.

**Cognitive presence**. The coding team for cognitive presence included members of the project team who were most familiar with the course design, including two instructors and one designer, in addition to the two lead researchers. To analyze cognitive presence, we coded all turns for the presence of the following four mediating processes we had previously developed in the conjecture mapping process (Sandoval, 2014):

- Explaining how features of a lesson/task design influence opportunity to engage in mathematical thinking;

- Explaining mathematics in the task in ways that make connections;
- Explaining anticipated or observed strategies or misconceptions for a given task; and
- Explaining how teaching moves impact access to mathematical thinking, participant frameworks, student authority, or formative assessment.

**Teaching presence**. We coded for the three forms of teaching presence, though we minimized the emphasis on the design aspect of teaching. For interactive teaching, we adapted the facilitating discourse category from Anderson et al. (2001). Our codes included: *identifies areas of agreement/ disagreement*; s*eeks to reach consensus*; *encourages (acknowledges, reinforces)*; e*licits contributions; presses or probes*; and r*edirects discussion*. For direct teaching, we adapted the direct instruction category and our codes included: *explains content*; *focuses or funnels*; *summarizes or provides feedback*; and *responds to technical concerns*. The coding team consisted of one of the two lead researchers and four doctoral students.

**Social presence**. Adapting the work of Rourke et al. (2001), we used the three main categories of affective responses, content-related interaction, and cohesive responses, each of which had sub-categories that we modified to take into account that we were working in a synchronous video-based environment. For example, in the content-related interaction category, we revised *continuing a thread* to *building from or extending another participant's response* and we revised *quoting from other messages* to *repeating or paraphrasing another participant's response*. The coding team was the same as for teaching presence.

**Second phase of analysis.** In the second phase of our analysis, we reorganized and reduced the codes. We pulled out the two codes for content-related interaction - *building from or extending another participant's response* and *refers to or paraphrases another participant's response* – because we felt these codes involved interaction around content and were not purely social in nature. That left the affective and cohesive categories to represent social presence. We collapsed all codes in the cognitive presence category into one count, and did the same for social presence and for each of the three aspects of teaching presence – design, interactive teaching, and direct teaching. We also added a category for *technical*, which involved all turns related to resolving technical issues in the Zoom and Google environments. We then collected all the totals of the reorganized and collapsed categories across each cohort.

## Results

We present the results initially by looking at cross-cohort comparisons, which allowed us to look at patterns within cohorts and then patterns within cohorts. The comparisons look at different distributions and rates within and across categories for both instructors and teacher participants. The purpose of presenting the cross-cohort comparisons is not to evaluate the instructors or teacher participants, but to highlight the ways the community of inquiry framework provides insights into the dynamics and efficacy of the online courses. We noticed three distinct trends. First, we noticed a much more prominent teacher presence in the Cohort 1 course. Second, we noticed that participants in Cohort 2 had much higher rates of cognitive and social presence, as well higher rates of turns involving technical issues. Third, we noticed that the teacher participant turns were more evenly distributed in Cohort 2 than Cohort 1. We discuss each of this in detail below.

### Teaching Presence

The Cohort 1 instructors had six times as many turns coded as interaction (building from or referring to other participants' contributions) and roughly three times as many turns coded as interactive and direct teaching, with similar rates of design codes (see Table 1). There are some possible reasons why these differences occurred. One reason is that the instructor with the most prominent presence in the Cohort 1 implementation had a different teaching style than the instructor with the most prominent presence in Cohort 2. This is borne out in the analysis of the coaching cycles that were another component of the professional development project, in which the primary instructor in Cohort 1 had considerably higher rates of direct assistance (explanations, suggestions) than the other coaches. A second reason is that the number of participants in Cohort 2 was 50% higher per session (roughly three more participants per session in Cohort 2), perhaps allowing the instructor to offload some of the work onto the participants. For example, the *interactive presence* and *interactive teaching* categories for Cohort 1 indicate that the instructor was much more active in engaging participants with their contributions, and referring to and paraphrasing those contributions to make them objects of discussion. Perhaps this was because the participants did not engage each other with their ideas to the satisfaction of the instructor and she felt compelled to intervene. At any rate, these substantive differences likely had an impact on the learning opportunities for the participants.

**Table 1: Teaching Presence across Cohorts**

| Instructors | Interactive Response | Interactive Teaching | Design | Direct Teaching |
|---|---|---|---|---|
| Cohort 1 | 41 | 82 | 38 | 99 |
| Cohort 2 | 7 | 28 | 28 | 30 |

## Participant Rates across Categories

The teacher-participants in Cohort 2 contributed nearly twice as many turns in three categories: cognitive presence; social presence; and technical concerns, with roughly equal numbers of turns coded as content-related interaction. This may have been in part because there were on average 50% more participants in each session relative to Cohort 1, but this does not account for all of the difference nor does it account for the fact that the content-related interaction was roughly equal. In the two sessions in which there were the most participants in Cohort 1 (8 of the 11), roughly 80% of the overall turns coded as interactive response and social presence occurred, and over 50% of the cognitive presence. This suggests that for this group, having more participants was associated with higher levels of interaction, both content-related and socially-related. Importantly, Cohort 2 participants engaged in the mediating processes at much higher rates, which we hope eventually to tie to the project outcomes and other data sources in the project.

**Table 2: Participant Rates across Cohorts**

| Teacher Participants | Cognitive Presence | Content-related interaction | Social Presence | Technical Concerns |
|---|---|---|---|---|
| Cohort 1 | 101 | 104 | 185 | 77 |
| Cohort 2 | 189 | 108 | 406 | 194 |

## Distribution of Turns across Participants

We noted that contributions from teacher participants were more equitably distributed in Cohort 2 than Cohort 1 with respect to cognitive presence. The top four contributors in Cohort 1 accounted for 61% of the cognitive presence codes, while the top four contributors in Cohort 2 accounted for 48% of the cognitive presence codes. Although this may be related to the fact that there were more 50% participants per session on average for Cohort 2, one of the participants in Cohort 1 who attended all of the sessions had very few turns coded as cognitive presence. This participant similarly had low levels of interaction with her coach in the coaching cycles, which suggests that she was having difficulties engaging with key processes emphasized in the project. Nevertheless, the distribution indicates that learning opportunities, and evidence of potential learning, were not ideally distributed in Cohort 1.

### Two Cases of Participants

We turn to two cases of teachers, one from Cohort 1 and one from Cohort 2 to provide nuance to our findings. The participant from Cohort 1, Dixon, had the second highest number of codes applied from his cohort (70), with the highest number of cognitive presence and social presence codes. Much of the turns coded as social presence were related to expressing vulnerabilities related to his teaching, while much of the turns coded as cognitive demand explained the impact of teachers' actions, often including detailed examples from his class. The participant from Cohort 2, Fleming, had a below average number of contributions for that cohort (67), with above average for turns coded as cognitive presence (24) and content-related interactions (16), and below average for turns coded as social presence (20). Fleming's contributions were mostly related to content, though she occasionally joined in the social banter. Most of her cognitive presence turns involved describing mathematical strategies. These two cases demonstrate differences in the content and nature of participation. Dixon was introspective with respect to his teaching, describing situations he faced, often in a self-deprecating manner; however, he did not often describe or analyze mathematical strategies. Fleming, by contrast, talked more frequently about mathematical strategies, her own and those she anticipated seeing in students, and relatively less frequently engaged in social banter or talked about her teaching.

## Discussion

A goal for this study was to explore how a synchronous online environment could engage mathematics teachers in demanding intellectual processes that could help them grow professionally. We employed a community of inquiry framework to research the social and intellectual vibrancy of the environment and the ability of instructors to productively structure interactions around the goals of the course. The framework allowed us to see substantive differences between instructors and between participation rates of two cohorts enrolled in the same online course. It also allowed us to conjecture about the relationship between the instructors' actions and the ways the teacher participants interacted with each other and with the content.

The results provide insights into how the online courses achieved content-related purposes related to interaction (recognizing and building from the contributions of others) and cognitive presence (engaging in the mediating processes). Participants in both cohorts engaged in forms of social and cognitive presence, albeit in ways that differed substantively. Notably, the instructors in Cohort 1 were far more active in structuring and modeling content-related interaction, in explaining content, and in providing feedback to participants. Conversely, the participants in Cohort 2 contributed in considerably higher rates with respect to cognitive and social presence. We conjecture that these differences occurred because Cohort 2 had on average 50% higher attendance rates and because the most active instructor in Cohort 1 had a style oriented toward direct instruction, which was consistent with results related to her coaching style (Authors, date). We will attend to these patterns closely as we finalize our analysis for the same two cohorts in the second online course. We also note that the two cases of teacher-participants discussed above demonstrate how participants in the same learning environment engage differently with the content and with the social features of the environment. These results highlight the ability to research dynamics between instructors and participants in a synchronous online environment and to consider how differences in individuals contribute to those dynamics.

## Implications

We focus on three implications. First, we feel this study is a step toward formulating a version of the community of inquiry framework suited for synchronous online professional development in mathematics education. Three key adaptations we made to the framework reflect issues highlighted in the mathematics education literature: productive content-related interactions, characteristics of cognitive presence that reflect learning processes for mathematic teachers, and a stronger focus on non-design aspects of teaching. The category of content-related interactions is comprised of high-leverage practices with respect to developing collective knowledge within a community. Related to the second adaptation, using mediating processes to characterize cognitive presence provided us meaningful ways to connect our conjectures about our learning environment and the practices we hoped they would facilitate. A third adaptation involved focusing on interactive teaching and direct instruction as the two teaching components of greatest interest to research a synchronous online environment. These two aspects of teaching account for the ways instructors intervene to structure interactions and to focus those interactions on content in synchronous moments. The online learning environment afforded us a comprehensive picture of these actions, as all teacher-participant interactions took place in an environment that was video-recoded. From this study, we can reach a tentative conclusion that online synchronous platforms can be sites of teacher learning and research.

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