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## Perceptions of Online Learning Spaces and Their Incorporation in Mathematics Teacher Education

Deborah Moore-Russo

*State University of New York at Buffalo*

Jillian Wilsey

*Niagara County Community College*

Jeremiah Grabowski and Tina M. Bampton

*State University of New York at Buffalo*

### Abstract

While digital environments can offer convenient, viable options for preservice and inservice teachers to engage in or continue their studies, little is known about teachers' experiences with and perceptions of various existing online learning spaces. This paper describes an initial investigation using data from a group of preservice and in-service mathematics teachers who interacted by posting their reflections regarding online learning spaces to an asynchronous, electronic discussion board. Inductive qualitative techniques were incorporated to determine which online learning spaces study participants had experienced as well as their perceptions of each. Results are reported in light of possible implications for teacher education, including specific suggestions for additional study of online learning spaces.

The growth of online learning and the use of online learning spaces have rapidly increased over the last decade. The Pew Research Center stated that roughly one in four college graduates (23%) reported enrolling in a class online (Parker, Lenhart, & Moore, 2011). When narrowing the focus to those who graduated within the last 10 years, the share doubled to 46%.

Due to the increased use of online learning spaces, not only in online courses but also in hybrid and face-to-face courses, examining student perceptions of such online learning spaces is necessary. This paper describes a review of future and current mathematics teachers' educational experiences with and perceptions of various online learning spaces through the lens of the Transactional Distance Theory (TDT; Moore, 1993). More specifically, this study, conducted with a sample of mathematics education preservice and in-service teachers, addressed the following research questions:

1. What digital resources had participants experienced in online learning spaces?
2. When talking about online learning spaces, which types of class formats were mentioned: online, hybrid, or face-to-face classes?
3. What was the nature of the digital experience that participants discussed?
4. What were the participants' perceptions of the online learning spaces they had experienced?

### **Literature Review**

This study investigated online learning spaces using Moore's (1993) TDT as a lens. This review of the literature is framed around the three elements that comprise TDT: dialog, course structure, and learner autonomy.

In online learning spaces dialog, or interaction between students and instructors, is important. One study showed that students preferred regular feedback from the instructor (Hodges & Cowan, 2012). Another study found that instructor immediacy and presence impacted both students' motivation and learning (Baker, 2010). Yet, the various forms of instructor-student interactions become more complex in digital environments than in face-to-face settings (Restauri, 2006), and external environmental factors (e.g., digital media used for interactions) play key roles in instructor-student interactions (Moore & Kearsley, 2005).

Even though Moore's (1991, 1993) definition of dialog focused on instructor-student interactions, Moore (1989) also considered student-student and student-content interactions. In fact, Hillman, Willis, and Gunawardena (1994) added student-interface interaction to the three forms of interaction identified by Moore. Zhang (2003) found that the most important interactions impacting students' engagement were those with their peers, followed by those with the instructor.

When examining issues related to both student-student and instructor-student interactions in online learning spaces, findings are often filtered through specific digital platforms used to facilitate communication, each with its own particular affordances and constraints. In one study, students found asynchronous discussion forums to be appealing because they could post at their own convenience, usually after they had taken time to reflect on their experiences (Nicholson & Bond, 2003). Similarly, Hawkey (2003) found that students enjoyed having time to comment on questions. However, studies disagree over student preferences between synchronous and asynchronous discussions.

He, Levin, and Robbins (2006) found that students' initially thought they would prefer asynchronous discussions based on their previous familiarity with the format, but surveys administered after the class indicated that students preferred synchronous communication. A study by Im and Lee (2003) found students' preferences for digital platforms for communication and sharing was based on the purposes of the tasks at hand. Students preferred synchronous chats for social bond formation and asynchronous

discussion boards for information sharing and discussing content at a more advanced level.

Since interaction is an essential element for students in all learning spaces (Kassop, 2004; Weimer, 2002), it is important to consider factors that influence interaction. Students have been found to be more cautious in online discussions when they are less familiar with a topic, often not wanting to appear unintelligent (Du, Zhang, Olinzock, & Adams, 2008). Time spent in an online learning space also appears to impact interaction, perhaps because deep conversations often are predicated on relationships, which take time to develop. As a course progresses, forum posts become more synergistic, continuous, and engaging (Hara, Bonk, & Angeli, 2000).

The second element of the TDT framework is course structure. The instructional design and organization of a course has been found to play a central role in students' perceptions related both to learning and general satisfaction of online learning spaces (Gerbic, 2010; Shea, Pickett, & Pelz, 2003; Stein, Wanstreet, Calvin, Overtom, & Wheaton, 2005) and their participation in course activities (Vonderwell, Liang, & Alderman, 2007).

Prior to instruction, instructors should carefully consider and plan the delivery processes, organization, communication outlets, and evaluation mechanisms (Anderson, Rourke, Garrison, & Archer, 2001). In online learning spaces, instructors should "be more explicit, deliberate, and transparent in the design process in order to convey a sense of instructor presence from the onset of the course" (Baker, 2010, p. 24). Others have proposed that online learning spaces need to align course objectives with instructional tasks and assessment activities (Groves, & O'Donoghue, 2009; Zhu, 2006). Students in one study demonstrated a marked preference for well-designed courses with clear expectations and regular feedback from the instructor (Hodges & Cowan, 2012).

Based on findings from their study, Norton and Hathaway (2008) suggested that the role of the instructor appears to be essential in an online learning space. They posited that online instructors need to understand the nuances of that learning space so they are able to take into account students' experiences while facilitating a problem solving environment that promotes learning and reflection.

An appropriate course structure often depends on the students' familiarity with the use of the digital tools and technologies in the online learning space. Students who have less experience in online learning spaces or who demonstrate lower levels of autonomy might require more instructional scaffolding and structure for online tasks (Benson & Samarawickrema, 2009). This scaffolding might be related to the use of digital tools; however, Bonk and Zhang (2008) also emphasized the importance of providing students with rules and guidance on how to participate in tasks that occur in computer-mediated environments, such as online discussions.

Learner autonomy, or students' perceptions of independence and interdependence as they engage in an online learning space (Falloon, 2011), is the third element of the TDT framework. Learner autonomy refers to the capacity of individuals to guide their own education; it is how much control students have over the instructional activities and learning processes (Kang & Gyorke, 2008). Moore (1993) described it as the "extent to which in the teaching/learning relationship, it is the learner rather than the teacher who determine the goals, the learning experiences, and the evaluation decisions of the learning programme" (p. 31).

In their 2007 study, Chen and Willits identified two dimensions of learner autonomy, independence and interdependence, and found that self-reporting as independent learners was positively associated with both students' access to digital resources and their prior subject matter knowledge. In the same study, interdependence was found to be inversely related to students' prior subject matter knowledge in the study. Garrison (2000) challenged this kind of polarization of learner autonomy, claiming that it makes the element seem a function of structure and learning materials rather than a function of the individual.

Moore (1993) described the interwoven relationship between learner autonomy and the other elements of TDT as "the greater the structure and the lower the dialogue in a program, the more autonomy the learner has to exercise" (p. 27). This intertwined nature has even prompted some (e.g., Gorsky & Caspi, 2005) to disregard the element of learner autonomy in their research, treating the other two elements, dialog and course structure, as inversely related. However, ignoring learner autonomy seems shortsighted, since whether students deem either a high or low transactional distance to be acceptable might depend on their personal characteristics and autonomies (Kanuka, Collett, & Caswell, 2002). In fact, Benson and Samarawickrema (2009) reported that the inverse relationship between dialog and course structure is most likely affected by the level of learner autonomy in situations where there is neither low nor high but midrange transactional distance.

### Theoretical Framework

The study of communication as a recognized pedagogical methodology picked up steam late in the 20th century (Black, 2007). The modes by which instructors and students interact with each other have rapidly evolved. This evolution is closely associated with digital innovations and merits research on both how communication, in general, and learning, in particular, now take place in a variety of spaces that are not limited to physical locations but rather are mediated by digital tools and platforms.

Although the earliest studies focused on which methods and modes of instruction in distance learning were most effective for students (Moore & Kearsley, 2005), an emerging body of research has turned to the nature of student learning and engagement in a variety of online learning spaces. This line of investigation applies not only to traditional face-to-face classroom settings but also to online and hybrid (or blended) classes.

The incorporation of digital tools in online learning spaces (with the platforms and media that allow for engagement in instructional activities, interaction with others, and submission of assignments) introduces an element of distance that is not found in face-to-face settings (Benson & Samarawickrema, 2009). Moore (1989) used the term "transactional distance" to consider this separation. A *transaction* involves an interaction between individuals that denotes some two-way exchange; it often involves the trading of ideas, opinions, and thoughts. Even in common vernacular, the expression "intellectual transaction" is often used to refer to what occurs in the classroom.

Moore (1993) derived the idea of a transaction across space and time from Dewey and Bentley (1960), who contended that any learning transaction involves interplay in an environment where certain patterns of behavior become the established norms for all students. These patterns of behavior are extended and recontextualized in online learning spaces where the broadened concept of space allows for interactions that differ, to a certain degree, than those that occur in face-to-face settings. Distance is the amount of space that separates, or spans between, two people.

Transactional distance is the division or separation between the instructor and students in online learning spaces that can lead to gaps in communication, a space for potential misunderstandings between the instructor and students (Moore & Kearsley, 2005). Giosso, Koutsouba, Lionarakis, and Skavantzios (2009) remarked that “the particularities of space and time pertaining to teacher and learner which characterize distance learning, create particular behavioural models for the teacher and the learner, psychological and communication distance between them, and insufficient understanding of each other” (p. 2). This instructor-student gap in understanding and communication “must be bridged through distinctive procedures in instructional design and the facilitation of interaction” (Moore & Kearsley, 2005, p. 223).

Moore and Kearsley (2005) maintained that effective online learning spaces balance dialog, course structure, and learning autonomy. Such a triangulation requires that (a) the instructor and students participate in two-way interaction using at least one, but preferably more than one, mode of communication (dialog), (b) the course content and expectations be clear and organized to build on students’ needs while facilitating engagement and reflection (course structure), and (c) the students understand their roles as both independent learners and as active and integral members of the larger learning community (learner autonomy).

In TDT, individual differences in learning preferences, including preferred modes of communication and instructional methods, can be in a state of flux given the nature of the online relationships between the instructor and students. Moreover, the way a student approaches and understands both other students and the shared goals of the online learning environment becomes relative rather than a fixed or separate constant. The student, as an individual, has the potential to alter, and even author, the ways meaning is made.

All of these actions occur while the student is transacting with other students in the class who are working and invested in similar relationships across time and space to achieve common learning goals. From these transactions students simultaneously learn to be members of a learning community and gain individual autonomy.

Transactions take place in online learning communities without all of the customs (and barriers) imposed by traditional classroom environments and without the norms that have dominated face-to-face learning spaces for years. There is often a variance in students’ individual perceptions and engagement as they interact with their peers and instructor to form a learning community and as they engage with the content using digital tools. The students bring varying levels of expertise (related to the content and the digital interface) to learning in digital environments, since they hold various experiential, geographical, ideological, and psychological positions. In online learning spaces, this distance in the individuals’ positions has the potential to create a more marked separation, creating greater potential for misinterpretation, misunderstanding, and disengagement than face-to-face settings.

TDT was deemed most suitable to frame this study, as it considers the factors that contribute to successful online learning spaces while leaving room for differentiation in instructional approaches, including the manner in which the content is shared and the students are engaged. Such a focus on teacher-student agency, teacher-student perception, and student engagement is especially relevant in this study, as we analyzed data to understand how participants in the study transacted with each other, their instructors, and the content, even as they understood their roles as participants in online learning communities (Moore, 1993).

Just as no two face-to-face classrooms are the same, no two online learning spaces are either. The dynamics of one online learning space can never be completely replicated in another online space. The instructor must be aware that all distanced communication has the possibility of being misinterpreted or misunderstood, creating the possibility of adverse interactions and miscommunications between individuals.

TDT allows for an in-depth analysis of what it means to understand or effectively make meaning in online spaces, yet its focus is on complex, diverse, and individualized approaches to communication across immeasurable physical, social, and psychological space. However, scholars such as Gorsky and Caspi (2005) referenced TDT as a simple tautology, stating, “As the amount of dialogue increases, the transactional distance decreases” (p. 7). Saba (2003) also noted this inverse relationship, while others contended that the proper balance between dialog and structure depends on the content and the sophistication of the students (Moore & Anderson, 2004; Stein et al., 2005).

## **Methodology**

### **Participants and Setting**

Data were collected from a convenience sample of future and practicing teachers from three university courses offered to students to fulfill coursework for a master’s degree or Ph.D. in mathematics education. The first course was offered as a traditional face-to-face course in spring 2013 and focused on geometric concepts (“geometry class”). In this class, students were assigned to small groups in which they spent extensive time engaging in collaborative activities during class. Then, for homework, students were assigned to share what their different groups had discovered in an asynchronous online discussion forum.

The second course was offered completely online in fall 2013 and focused on technology in mathematics education (“technology class”). The third course was offered as a traditional face-to-face course in spring 2014 and focused on spatial reasoning (“spatial reasoning class”). This class was conducted in a format similar to the geometry class, with extensive small group work supplemented by an online discussion forum.

There were eight participants in the geometry class (four males and four females), 10 participants in the technology class (four males and six females), and 11 participants in the spatial reasoning class (five males and six females). One of the participants in the technology class was also in the geometry class (but not in the spatial reasoning class), five participants in the technology class were also in the spatial reasoning class (but not in the geometry class), and one participant in the geometry class was also in the spatial reasoning class (but not in the technology class).

Although there was some overlap of the participants in the classes, none of the participants contradicted themselves from one course to the next. However, the focus of the comments in the posts varied depending on the flow of the conversation and the particular course in which the discussion occurred (e.g., discussions in the technology class tended to focus more on the digital resources employed in online spaces), more so than by the participant doing the posting.

In total, the study included 22 unique participants. They had attended 21 different universities, including the university at which the study was conducted. All had previously experienced online courses, as well as courses that occasionally made use of online learning spaces.

## Data Collection

The same instructor taught all three courses and used the discussion board feature of Blackboard Learn™ system as the platform for the data collection. An electronic forum was set up for the participants to discuss their previous experiences in online learning spaces. The data collection was purposely timed about two thirds of the way through each class (a) so that the participants would be familiar with each other so as to engage more freely in a discussion and (b) to occur before the participants might feel the pressure of completing end-of-semester assignments. The prompt given to the participants to collect the data was as follows:

Given the wide variety of digital options for creating learning spaces and using them to support mathematics teacher education as well as the trend to move courses online, I am very interested in your opinions as preservice and inservice teachers about the use of online spaces in mathematics teacher education courses. You have been students in online courses and you have worked in synchronous or asynchronous online environments for education classes that were either face-to-face or hybrid (which is a mix of online and face-to-face coursework). I am not as interested in the content of these courses (unless that is pertinent) as much as I am in learning what you think about these learning spaces. So, for this discussion board, I'd like to see descriptions of the different online learning spaces you've encountered in your teacher education courses and to get your feelings as to how these online learning spaces have impacted your education. Don't hold back if you want to make either positive or negative comments. This is meant to be a forum where we honestly explore a trend in mathematics teacher education.

The word *hybrid* in the prompt was purposely vague to encourage discussion about all types of online learning spaces and course configurations rather than to restrict participants' thinking to only a few. In addition, while there were specific course expectations with regards to the amount and type of posts required in response to previous prompts (e.g., participants must generate one unique post and respond to three of their peer's posts), there were no course expectations for this prompt. Even without specific guidelines for the discussion forum, the participants still engaged in it as they had throughout the semester with other forums that had specific guidelines. In all three classes the participants more than simply answered the prompt; they responded to each other's posts, creating threads and engaging in a back-and-forth dialog.

The unit of analysis for the study was a post to the discussion board; 169 units were analyzed. The distribution of the posts and basic statistical information regarding the word counts of the posts are shown in Table 1.

**Table 1**  
Discussion Board Post Distribution and Word Count

Course	Participants	Posts Made	Range of Posts Per Person	Post Word Count			
				Mean	Median	Minimum	Maximum
Geometry	8	40	4 to 6	170	144	38	554
Technology	10	61	3 to 8	155	124	4	571
Spatial Reasoning	11	68	2 to 9	175	153	9	529

## Data Analysis

The goal of the research study was to explore teachers' experiences with and perceptions of the various online learning spaces that exist. To meet the research goal, the study analyzed asynchronous online discussions that ensued after all three groups of participants in the three classes were asked to respond to the prompt.

The data analysis was conducted in four phases corresponding to the four research questions; the same two members of the research team, the two lead researchers who are also the first two authors, conducted all phases of the analysis while the third and fourth authors were involved in the fourth phase only. The first three phases provided insight into the experiences the participants had with various online learning spaces.

In the first phase, the two lead researchers identified and recorded the digital resources (including software and platforms) that the teachers experienced. In the second phase, the lead researchers identified and recorded the class format where they experienced the digital resources. In the third phase, they categorized the nature of the digital experience that the participants referred to when discussing their experiences in light of particular digital resources, as well as with respect to online learning spaces, in general. Last, in the fourth phase, they used inductive techniques to develop overarching themes with specific coding categories to provide insight into the teachers' perceptions of online learning and online learning spaces.

The first three phases of data analysis were used to establish interrater agreement. For each of these phases, the two lead researchers separately coded the posts for each of the three classes and the percent agreement between the researchers was calculated for the entire data set. Agreement on the coding for the first three phases was 97%, 99%, and 96%, respectively. Once intercoder agreement was determined for each, the lead researchers discussed coding until consensus was reached for all posts.

For the first three phases, the two lead researchers repeatedly reviewed the data independently making theoretical memos. They then met to discuss their general impressions as to specific categories that should be included. After this conversation, both independently revisited the data set to determine if any categories needed to be added. For the first two phases, this process was extremely straightforward. For the third phase, they met one additional time to discuss the coding categories prior to coding; however, the categories selected were again, rather straightforward. For the fourth phase, an extensive, collaborative process was used for the development and categorization of the coding. The two lead researchers met in four sessions that spanned 14 hours to determine and refine the list of categories to be used for participants' perceptions of online learning.

Once the two lead researchers completed the data analysis, the data set and their findings were shared with the other members of the research team, who had been tasked with the literature review and the theoretical framework to ensure that we all agreed with the analysis of the data.

**First phase.** The posts for all three classes were examined to determine which digital resources were mentioned. The two researchers individually reviewed the posts of the three classes and compiled initial lists of the digital resources mentioned. Using both

researchers' lists, they reviewed the lists and the data from the three classes to categorize the specific and general resources or platforms mentioned.

As the researchers engaged in this process, they determined if any new specific or general resources were identified that were unique or could be subsumed under, or merged with, categories identified. This analysis continued until both researchers agreed that the categories represented the findings from the entire data set.

The two researchers independently used this document to code all posts. Since the unit of analysis was a single post, each post could be assigned multiple codes. For those posts where multiple categories were assigned, the posts were included in calculations for each category present. The categories used to code all posts are provided in Table 2. Categories were ranked according to their frequency. The researchers then reviewed the results to consider patterns across digital resource categories and across classes.

**Table 2**  
Coding for the Digital Resources Mentioned by Participants

Code	Category	Digital Tool or Platform Mentioned	
		Specific	General
AP	Audio Presentation		voice recording
BL	Blog	Blogspot	blog
BM	Bookmarking site	Diigo	
CM	Course Management System	Angel, BlackBoard, UBLearns, Schoology	
CO	Collaborative Office Software	Google Doc, Google Spreadsheet	
CP	Real-Time Communication Platforms (Video Chat and Instant Messaging)	Google Hangouts, Skype	chat room, video chat
CS	Collaborative Commenting Space	VoiceThread	
DF	Discussion Forums		online discussion boards, discussion boards
EJ	Electronic Journals		online journals
EM	Electronic Mail		email
HL	Hyperlinks		links to URLs
OA	Online Assessments		online quizzes (with and without feedback)
OB	Online Bulletin Board	Pinterest	
OC	Other Communication Forms		telephone, text messages
PS	Presentation Software	PowerPoint, Prezi, Voiceover PowerPoint	slide show makers, digital presentations
RF	Readable File	PDF, Word	
SC	Screencasts & Screen Capturing	Jing	
SM	Social Media Platform	Facebook, Twitter	
V	Video	EduTube, YouTube	video
WB	Website		website
WI	Wiki		wiki

For example, the following posts from two students, Crystal and James, in the technology class were coded as follows. (Note that in this post and all posts, none of the grammatical, spelling, or punctuation errors have been corrected. Due to a large number of errors in some posts, the authors have chosen not to specify “sic” after each error. Also, note that all names used are pseudonyms.)

The first post falls under the category Collaborative Office Software. The second post was coded under the category Presentation Software for the first two sentences, as well as under the categories Hyperlinks and Video for their mention in the third sentence.

I love google docs. I agree that they are the best thing to happen to group projects!! Not only can everyone work off the same document, you can also see who edited the document last. My only problem with google docs is that once the document is altered, you can only hit undo....I almost ruined my excel google doc this semester and panicked when I realized how much I screwed up, about a thousand moves later. I ended up having to hit undo for a while. (Crystal, technology class)

Powerpoint is a technique that was relied upon heavily in one of my online classes. Each week the professor would create a powerpoint with the necessary information for the week on it. The problem with these was how boring they were, I know that there were not a lot of options for this particular class because it was online but these powerpoints could have included some links to either other websites or even videos explaining the concepts. (James, technology class)

**Second phase.** To determine which class formats participants mentioned when talking about online learning spaces, we used three codes: Face-to-Face, Hybrid, and Online. Hybrid classes were considered to be those classes with a mix of online and face-to-face coursework (as was defined in the prompt given to the students). As many codes were assigned to each post as were evidenced. In cases where no class format was mentioned, the post was assigned the code None. For those posts where multiple class formats were mentioned, the posts were included in calculations for each class format present. Categories were ranked according to their frequency. We then reviewed the results to consider patterns across class format categories and across class.

For example, the following post from Teagan, a student in the geometry class, was coded as follows. The post was coded under the Face-to-Face category for the first sentence, as well as sentences that follow. The post was coded under the Online category because of the third full sentence (as well as the last two sentences) and then in the Hybrid category because of the fourth full sentence.

I think the focus for an in-class course is quality class time when everyone meets. I like then this time to be filled with activities, discussion, and peer presentations....I think the workload outside of class decreases and the assignments are secondary compared to class-time. For a class that's completely online, I think the focus is completely on assignments and tasks outside of class. I think in-class and hybrid courses come with the concrete learning environment of weekly or sometimes weekly meetings. This grounds the course for me. Each week we talk about whats currently going on and what will be coming up in the future. I can ask questions and get immediate feedback while also collaborating with classmates. I don't feel this way about the online courses that I am currently taking. Everything seems assignment based and I feel like I am on my own to learn and get things done. (Teagan, geometry class)

**Third phase.** In the third phase, the two researchers individually reviewed the posts of the three classes and identified categories representing the nature of the digital experiences discussed by the participants. Both researchers then jointly reviewed the categories identified. As they engaged in this process, they determined if any new categories were identified that were unique or could be subsumed under, or merged with, categories identified. This analysis continued until both agreed that the categories represented the findings from the entire data set. The categories used to code all posts are outlined in Table 3.

**Table 3**  
Coding for the Nature of the Digital Experience Discussed by Participants

Code	Category
AI	Actual instruction (direct instruction, mention of videotaped lecture)
CA	Completion/submission of assignments (engagement in instructional tasks not including course readings and discussion which are separate categories)
CO	Communication/interaction (emphasis on communication and interactions between individuals, including instructor-student interactions and student-student interactions)
DI	Discussions (group conversations, often whole class discussions or discussions within a group)
GW	Group/collaborative work
IE	Transparency and organization of instructor expectations
IN	Introductions (mechanisms to introduce individuals in the class, usually the instructor)
IW	Individual/independent work
RD	Assigned course readings
RE	Reflection (reflections on course readings, instructional tasks, previous individual experiences)
RI	Information relayed to students (providing information related to schedules or assignments)

The two researchers independently used Table 3 to code all posts. In this third phase, the posts were coded twice; once considering the nature of the digital experience in light of the particular digital resource mentioned and again considering the nature of the digital experience in general; i.e., the nature of the digital experience was discussed in the post without referring specifically to a particular digital tool or resource.

Since the unit of analysis was a single post, each post could be assigned multiple codes. For those posts where multiple categories were assigned, the posts were included in calculations for each category present. Categories were ranked according to their frequency. Once this was done, we reviewed the results to consider patterns across categories and across classes.

For example, the following posts from two students, James and Barbara, in the technology class were coded as follows. The first was coded under the categories Individual/Independent Work and Reflection. Note that in this particular post, the student discussed the nature of the digital experience without referencing a particular digital resource. The second post was coded under the categories Communication/Interactions and Completion/Submission of Assignments. In this

particular post, the student discussed the nature of the digital experience in light of particular digital resources (from Table 2 identified in the second phase of data analysis), electronic journals and discussion forums.

Online classes must be approached differently than those that are face-to-face. It is important that online classes are driven by independent learning activities and reflection. Instructors must embrace the advantages of online classes instead of hold onto traditional techniques from face-to-face classes. (James, technology class)

I agree I like journals as a way to communicate private thoughts to the professor without others seeing it. I like it more for assignments in which we have to answer questions that can get personal. In addition I find that professors will respond less generic in private communication rather than discussion boards. (Barbara, technology class)

**Fourth phase.** The posts for all three classes were then examined to determine the participants' perceptions of the online learning spaces they had experienced. Since both researchers had extensive experience with the data at this point, they started this phase as a team, jointly developing a preliminary list of categories (many of which had already been discussed in early phases) that was then used to evaluate every post. When a post was encountered that suggested the preliminary list of categories was incomplete or needed refinement, the list was modified to explain the new data. Then, every post was revisited repeatedly in light of the modified list of coding categories.

This process was repeated until all posts could be categorized by the current list of codes. The process of determining the categories for the fourth phase was consistent with the "flip-flop technique" of grounded theory described by Strauss and Corbin (1998). When no new codes emerged during the analysis process, theoretical saturation had been reached. Once all coding categories were identified, they were grouped under three overarching themes.

The first identified theme addressed Instructional Responsibilities in Online Learning Spaces. Even though participants recognized that students play significant roles in how online learning spaces are used, they still tended to identify responsibilities for instructors. Some of these were related to both online and face-to-face learning spaces, but they were coded only when in reference to instructors using online learning spaces. The coding categories under this theme are outlined in Table 4.

Participants tended to agree that both benefits and drawbacks were inherent in online learning spaces. While some of the posts contrasted the "convenience at a cost" tension between the two, others focused solely on either benefits or drawbacks. For that reason, the second theme addressed Convenience and Benefits of Online Learning Spaces, and the third theme addressed the Constraints and Drawbacks of Online Learning Spaces. The coding categories for both of these themes are outlined in Table 5 for benefits and Table 6 for drawbacks.

**Table 4**  
Coding by Category Under the Instructional Responsibilities in Online Learning Spaces Theme

Category	Code	"Instructors should..."
Alignment of Coursework	AC	Align coursework to the format of the course; feelings of injustice at having to work in a synchronous learning space (for an online course) or an online learning space (for face-to-face course)
Clear Purpose	CP	Assign tasks with clear purposes and assessments that are in line with the course objectives and that complement other coursework
Excessive Workload	EW	Assign a reasonable workload; they should not overcompensate for the online nature of the course
Fit Learning Format	FF	Assign tasks are that in line with the format of the learning spaces and the resources that are available
Instructor Involvement	II	Be involved, available, and provide timely responses/feedback to students
Monotony	M	Assign tasks that vary; they should not follow a single repetitive routine
Meaningful Assessments	MA	Assess student work in meaningful ways; instructors should provide feedback (either as informal or formal assessments) on student work
Meaningful Tasks	MT	Provide meaningful, engaging tasks; tasks should have value that justifies the time involved and should not be busy work
Need Interaction	NI	Provide activities and platforms that allow for students to interact and learn from each other
Private Communication	PC	Provide spaces that allows for private communications with students (not everything should be available for public consumption)
Quality of Instructional Materials	QM	Provide materials that are convenient, of high production quality (e.g., readability), useful, and well-organized
Transparent Expectations	TE	Make their expectations related to coursework, tasks, and due dates transparent

*Note.* Often these comments were related to both online and face-to-face learning spaces, but they were coded only when in reference to instructors using online learning spaces.

**Table 5**  
Coding by Category Under the Convenience and Benefits of Online Learning Spaces Theme

Category	Code	"Online learning spaces are convenient/beneficial because..."
Digital Resource Exposure	DR	Using digital resources fosters fluency in different educational technologies and digital platforms
Flexibility	F	They allow individuals to do work any time that is convenient, if nonsynchronous
Single Immediate Product	IP	Individuals can work on one document (even simultaneously) with some interaction, yet with an immediate product (e.g., Google doc)
No Conflicts	NC	Other obligations and conflicts do not impede anyone from taking an online course [a]
Personal Appearance	PA	Individuals do not need to worry about their personal appearances (e.g., attire), unless video is involved
Student Diversity	SD	Online courses allow interactions with diverse students (e.g., both in terms of experiences and geographic locations)a
No Transportation Issues	TI	Geographic distance, lack of convenient transportation, and parking issues do not impede anyone from taking an online coursea

[a]These comments were specific to online courses only, not general online learning spaces that could be part of either face-to-face or hybrid courses.

Since the unit of analysis was a single post, each post could be assigned multiple codes. For those posts where multiple coding categories from the three themes applied, the posts were included in calculations for each category present. Categories within each theme were ranked according to their frequency. We then all reviewed the results to consider patterns across theme, across category, and across class.

For example, in the following posts, the first was coded under the category Instructor Involvement under the theme Instructional Responsibilities and the categories Meaningful Discussions and Task Orientation under the theme Constraints and Drawbacks. The second post was coded under the category No Classroom Community under the theme Constraints and Drawbacks. The third post was coded under the categories Digital Resource Exposure and Student Diversity under the theme Convenience and Benefits.

**Table 6**  
Coding by Category Under the Constraints and Drawbacks of Online Learning Spaces Theme

Category	Code	"Online learning spaces are constrained/have drawbacks because..."
Dependent on Technology	DT	Communication/participation in online learning spaces is hampered by technology disruptions or the lack of availability of technology
Group Work	GW	Collaborative or group tasks are difficult to coordinate
Loss of Flow	LF	Interaction in asynchronous online learning spaces is often delayed or ignored resulting in a loss of flow in communication due to no back-and-forth
Meaningful Discussions	MD	Discussions forums are often stilted, not meaningful, lack any real depth or original thoughts, and are overly redundant (e.g., students just agreeing with what was already posted)
Interaction is Not Authentic	NA	Interaction in online courses is not authentic; individuals do not have access to the interpersonal clues (e.g., tone of voice, facial expression), are not able to immediately ask a person what was meant when meaning is unclear, and do not have easy access to multiple representations of mathematical ideas (as in a face-to-face conversation) <sup>a</sup>
No Classroom Community	SC	There is no sense of a classroom community in online courses <sup>[a]</sup>
Separation from Social	SS	Separation is needed between social and professional uses of social media platforms
Task Orientation	TO	There is a focus on completing a task (or series of tasks) rather than on learning

[a]These comments were specific to online courses only, not general online learning spaces that could be part of either face-to-face or hybrid courses.

...I completely confess that in previous semesters my discussion board comments became routine and something to "get done and check off my list". I shorted myself of an opportunity to take away something from that lesson, and I also think I took away from my peers by not offering another's input. Sometimes, you don't even realize when you are doing it, so it's nice having instructors who actually are as involved on the other side of the online course and will give you a kick in the butt when you need it :) (Crystal, spatial reasoning class)

...With online classes we lose the opportunity to network and become friends with people who can relate to us and help us out in the future. (Raymond, spatial reasoning class)

I like how you mention the shift in fluency towards technology. I never really thought about the technological abilities a person can take away from an online class. The experience in itself can be valuable for some who may not be the most computer literate. I also think it's interesting to think of students from across the country or world. As you said, they may have a completely different perspective on topics and can really shine a light on it for everyone else. Students could potentially experience different cultures through classmates which I think can really increase our cultural awareness as teachers. (Teagan, geometry class)

## Findings

We started by looking at the titles of the discussion forum threads and noted a qualitative difference in the topics addressed by the participants, even though given the same prompt. The participants in the technology class were more likely to focus on the particular digital platform or type of software (i.e., PowerPoint, Skype, and Facebook) than were the other two classes. For example, some of the threads for the technology class's discussion forum were titled "Powerpoints," "Prezi," and "Word Documents."

The geometry class was more likely to emphasize the type of course (online, hybrid, or face-to-face) in the discussion forum. For example, some of the threads for the forum were titled "Hybrid Courses," "My Experience With Online Courses," and "In-Class vs. Online." The spatial reasoning class was more likely to focus on the affordances and constraints, as well as personal preferences related to online learning spaces. For example, the titles of some of the threads for this class's forum included "Discussion Board: Some Dislikes and Likes" and "I Prefer In-Person Learning." We then looked at the length of the posts, since a single post was to be the unit of analysis. The length of posts in all three classes seemed relatively similar, as can be noted in Table 1.

## Digital Resources

To determine which digital resources participants had experienced in online learning spaces, 13 codes (found in Table 2) were used. As many codes were assigned to each post as were evidenced. The counts for each code are displayed in Table 7. For this sample of participants across the three classes, Discussion Forums were by far the most mentioned resource, occurring in 66 of the 169 posts. Next most mentioned across all posts was Collaborative Office Software (in 27 posts) followed closely by Course Management Systems (in 24 posts), Video (in 23 posts), Real-Time Communication Platforms (in 21 posts), and Social Media (in 20 posts).

**Table 7**  
Frequency Table Digital Resources by Codes

Course	Codes												Posts Made
	DF	CO	CM	V	CP	SM	EM	PS	HL	RF	WB	OC	
Geometry	14	3	6	6	5	1	5	2	1	0	4	2	40
Technology	12	13	10	9	9	7	6	13	11	11	5	6	61
Spatial Reasoning	40	11	8	8	7	12	4	0	2	2	1	1	68
All	66	27	24	23	21	20	15	15	14	13	10	9	169

*Note.* A single post may have received more than one code. Coding abbreviations are in Table 2. Only codes with totals of 5 or more shown.

All three classes acknowledged that discussion boards were typically utilized in online courses, as well as in other course formats. They tend to be seen, as one participant mentioned, as a "necessary evil." In general, the students stated that if discussion boards are employed correctly they can promote useful discussion among the class participants. However, the participants also acknowledged that the majority of the time

discussion forums are not correctly employed, tend to be cumbersome to use, and do not necessarily promote true discussions.

The technology class noted that holding synchronous discussions online utilizing a collaborative office software platform may be preferable to a discussion board. This strategy would not only allow a real-time back-and-forth discussion to proceed but also allow for collaboration on assignments and projects. The spatial reasoning class suggested it might be better to use social media platforms to facilitate useful discussions among the class participants. The technology class also saw the importance of using a good course management system to enable organization of assignments, grades, due dates, and so forth.

Although discussion forums were by far the top category for both the geometry and spatial reasoning classes, the digital resources mentioned by the technology class were much more evenly distributed among the codes. The technology class discussed the importance of utilizing presentation software, hyperlinks, and readable files. This result could be due to the nature of the class itself (focused on technology) or due to the fact that this class was offered entirely online, rather than as a face-to-face class with an online component (as was the case for the geometry and spatial reasoning classes). Some representative examples of posts that addressed discussion forums follow.

With an online course that is discussion boards I do not think you can communicate well. People don't get their discussion boards up on time (Like me in this case) then people can't respond. It takes forever to load in between each one which is obnoxious. It is just a slow way. By the time someone responds to what I wrote I have to go back read what I wrote, then read what they wrote then write something in response. It isn't like a chat room where everyone is on at the same time which makes it more difficult. Plus feedback is not there a lot of the time. (Caterina, geometry class)

I'm also very forgetful so the "make at least one post 2 days later, and one post 3 days later etc." is hard, and as has been discussed the flow of thinking about the topic is hard to recover. Not to say that I think the time lapse requirement is a bad thing, it forces students to reflect on what others have said and refine an argument before posting again, and continuous thought about a subject really deepens understanding, but at the same time students can forget the specifics of what was said and actually lose ideas they had before. (Sasha, spatial reasoning class)

Discussion boards almost seem like a necessary evil for online classes. First, the negative - I feel like "discussions" rarely happen. I agree with Johan's statements that discussion boards tend to become a requirement students must fulfill. Sometimes I am able to go back to a discussion board where I have already posted to read the comments. But that does not always happen. A discussion is supposed to be a frequent back and forth between parties and not just statements being posted. However, discussion boards tend to be one-sided and not a back and forth. (Jade, technology class)

The next posts exemplify how participants from the technology class commented on positive aspects of collaborative office software and course management systems, respectively.

In regards to google docs, I am partial to it. I really like it for group projects because you can use dialog back and forth in your work and add your own work as you go. (Sasha, technology class)

I really like blackboard compared to other internet environments. There are other sources such as ANGEL that just are not as user friendly as blackboard is. I think that in order to have a successful online learning space you need to be able to navigate the website easily and effiecently. Blackboard does a nice job of laying everything out in a coherent manner. This makes online learning more beneficial. (Karen, technology class)

### Class Formats

We next analyzed the data in light of the second research question with regard to the class format where the participants experienced the particular digital resource identified in the post. We wanted to determine if the participants understood that online learning spaces do not occur only in online classes. The counts for each code are shown in Table 8. The participants most often mentioned online class formats and least often mentioned hybrid classes when talking about online learning spaces. This distribution roughly held across all three classes. However, 54 of the 169 posts did not mention any class format.

**Table 8**

Frequency Table of Class Formats Mentioned in Posts

Course	Class Format Mentioned			No Format Mentioned	Posts Made
	Online	Face-to-Face	Hybrid		
Geometry	32	15	8	4	40
Technology	36	13	3	23	61
Spatial Reasoning	35	24	6	27	68
All	103	52	17	54	169

*Note.* A single post may have mentioned more than one class format.

While online class formats were mentioned most frequently, the participants commented on the use of online learning spaces within traditional face-to-face classes as well. Hybrid class formats were not mentioned often when the participants discussed the online learning spaces. It seemed that they had less experience in this type of class format than in online and face-to-face formats.

### Nature of the Digital Experience

To consider the third research question, we analyzed the data in two passes. To determine the nature of the participants' digital experiences, we first considered the data in light of particular digital resources and then with respect to online learning spaces, in general. In the first pass, we only coded the nature of the digital experience if the experience was couched in light of a specific digital resource. Those counts for each code are displayed in Table 9. As many of the 11 codes (listed in Table 3) were assigned to each post as were evidenced in that post; so each post could have received multiple codes.

**Table 9**

Frequency Table for the Nature of Digital Experiences in Light of Particular Digital Resources

Course	Codes										Posts Made
	CO	DI	CA	GW	AI	RI	RD	IN	RE	IE	
Geometry	9	9	10	2	3	1	2	3	0	3	40
Technology	22	12	17	15	15	16	4	2	2	2	61
Spatial Reasoning	18	28	15	7	4	4	0	1	3	0	68
Total	49	49	42	24	22	21	6	6	5	5	169

*Note.* A single post may have received more than one code. Coding abbreviations are in Table 3. Only codes with totals of 5 or more shown.

In the second pass, we coded the nature of the digital experience with respect to online learning spaces, in general. The coding category was, thus, assigned to a post whether or not the experience was couched in light of a specific digital resource. Those counts for each code are displayed in Table 10. Again, as many of the 11 codes (listed in Table 3) were assigned to each post post as were evidenced in that post; so each post could have received multiple codes. As can be noted in a comparison of Tables 9 and 10, whether a specific digital resource was mentioned or not, the top four categories remained the same, and little variation occurred. For that reason, we considered only the nature of the digital experience with respect to online learning spaces, in general, the counts shown in Table 10.

**Table 10**

Frequency Table for the Nature of the Digital Experiences in General

Course	Codes											Posts Made
	CO	DI	CA	GW	RI	AI	RD	IE	IW	RE	IN	
Geometry	15	18	20	3	6	5	9	8	3	2	3	40
Technology	29	17	19	19	18	15	6	3	5	4	2	61
Spatial Reasoning	28	37	17	7	5	7	8	0	3	4	1	68
Total	72	72	56	29	29	27	23	11	11	10	6	169

*Note.* A single post may have received more than one code. Coding abbreviations are in Table 4.

The top categories mentioned by the participants were Communication/Interactions and Discussions. Communication/Interactions related to interactions between two individuals and included both student-student and instructor-student interactions. Discussions referred to open discussions platforms where the entire class or a group was to participate.

Often, both Communication/Interaction and Discussions were mentioned in the same post. In the technology class both were mentioned together in 10 of the posts, in the spatial reasoning class both were mentioned together in 12 of the posts, and in the

geometry class both were mentioned together in eight of the posts. Thus, they were discussed together in almost half of the posts.

Both the technology class and spatial reasoning class participants most often mentioned Communication/Interaction or Discussions or both when considering the nature of their digital experiences. In contrast, even though Communication/Interaction and Discussions were frequently noted in their posts, the geometry class participants were slightly more likely to mention Completion/Submission of Assignments. However, these participants often stated that their experiences were negative, that there was a focus on assignments and a lack of either interaction with others or any kind of opportunity for group discussion. The posts reflected that participants felt they were using the online learning spaces and digital resources as a means simply to submit assignments as they would in an individual correspondence course, while opportunities for interacting with others, exchanging ideas, and learning about others' viewpoints were lacking.

As was found when considering the digital resources mentioned by the participants in the second phase, in this phase of analysis the codes for the nature of the digital experience mentioned by the technology class participants were more distributed across a larger number of codes. Again, this result could have been influenced by the nature of the class itself (focused on technology) or by the fact that this class was offered completely online rather than as a face-to-face class with an online component (as the geometry and spatial reasoning classes were).

The following three posts below exemplify how different participants touched upon discussion.

...Although I like knowing the people I am talking to on the discussion board, I don't think it makes me more likely to speak my mind. In my first online class, I was quick to disagree with people and argue my point.... I can be a very argumentative person so that could be why, and am also open minded when it comes to the technology so I can easily come up with a response. I feel that those discussion boards were easier then the ones that have to do with the math. If I don't have questions on the assignments, and everyone else's are answered, I don't know what to respond to on the discussion boards. (Sasha, spatial reasoning class)

I like the idea of having google docs and all posting at the same time as like a chat room. This can help discussion happen and a teacher could guide the discussion if there is a misconception about something. The discussion board is very important but again it is a place to post things and it does become useless if everyone posts the same things over and over again. (Caterina, geometry class)

One challenge I am facing right now is that, as many people know, I work a lot of jobs. This makes the times I am able to come on [discussion] boards limited. If there are no new posts when I sign on then I can't post anything in response. Also it works the opposite way, a lot of people post so then when I go back on there are 20+ "meaty" (and long) posts I need to catch up on. I find that a lot of people have similar thoughts to me and I feel like a lot of my posts may seem repetitious and redundant. (Raymond, spatial reasoning class)

The following posts show how participants talked about both Communication/Interaction and Discussion. In addition to those two codes, the second post was also coded under the category Completion/Submission of Assignment and Group/Collaborative Work.

Discussion boards are not designed to have any social depth within them or even to support any kind of social interactions between participants. (Tad, spatial reasoning class)

This quarter I had a professor that assigned group homework and we had to meet once a week on any forum of our choice. We all agreed on Skype. At first I did not appreciate having to be online for 2 hours once a week on a particular day and time. We decided we where only going to use the audio and we each would also have the google doc homework page opened and write down our answers as we discussed them. Very quickly I learned to appreciate my classmates. If it would have not been for the discussion we had every week some of the homework would have been very difficult to complete. We each had different strengths and managed to balance each other out. Although I enjoyed meeting and interacting with my classmates I did find it difficult to commit to 2 hours in front of the computer....Do not get me wrong I like the interaction with other students but I prefer it in a format where I am not committed to a particular time and day. (Barbara, technology class)

### Participants' Perceptions of Online Learning Spaces of the Digital Experience

To determine the participants' perceptions of online learning spaces, we used inductive techniques that resulted in three overarching themes. The first theme, Instructional Responsibilities in Online Learning, included 12 categories and focused on how the instructor and instructional decisions impacted the online learning space and, in turn, students' online learning experiences. Each of the 12 categories used were described in Table 4.

Table 11 displays the counts for the categories coded for the Instructional Responsibilities in Online Learning Theme. The most frequent category noted was Fit Learning Format, followed closely by the category Need Interaction. However, these results were not consistent across the classes, as can be noted in Table 11. For example, the categories Clear Purpose and Transparent Expectations that tied with the category Need Interaction for the most coded in the geometry class were not found as often in the posts of the participants in the other two classes.

**Table 11**

Frequency Table for the Instructional Responsibilities in Online Learning Theme

Course	Codes												Posts Made
	FF	NI	QM	CP	II	TE	MA	MT	AC	EW	M	PC	
Geometry	8	10	5	10	9	10	6	4	1	6	2	0	40
Technology	17	13	19	3	5	4	1	3	2	2	2	3	61
Spatial Reasoning	9	8	0	8	6	4	4	3	6	0	3	0	68
Total	34	31	24	21	20	18	11	10	9	8	7	3	169

*Note.* A single post may have received more than one code. Coding abbreviations are found in Table 4.

Common types of responses for the category Fit Learning Format are each outlined in the three following posts. Participants stated that the format of an online class should take

advantage of the digital tools and resources that environment offers; however, participants did not always mention specific examples but talked in vague, general terms. In other related responses, participants often suggested that an instructional activity could have been improved through the use of a different digital tool or if a particular digital tool was used in a more appropriate manner (as noted in the second post). As the third post shows, some participants felt that face-to-face courses that involve only lecturing might as well be moved online.

Online classes must be approached differently than those that are face-to-face. It is important that online classes are driven by independent learning activities and reflection. Instructor must embrace the advantages of online classes instead of holding onto traditional techniques from face-to-face classes. (Johan, technology class)

I think that there is a higher potential for online courses than is frequently achieved. Discussion boards are often used to post long rambling papers (I've had to post 3-5 page papers)...When everyone is required to post long winded posts, ... no one is really going to read through the entire paper, more likely [they will] pull out several quotes or points made and respond to those... If you consider the modes of each of the technological sources being used, educators can select appropriate tasks that will mirror their use outside of the classroom. (Molly, geometry class)

If a class were just lecture, where virtually no one asks questions, I think all parties would benefit from it going online. For instance, lectures could be taped and posted with all notes viewable, like a split screen. This would allow multiple viewings. Furthermore, the professor could have a question posting discussion board where students post questions and some students might even be able to answer them. (Johan, spatial reasoning class)

Participants also mentioned how online learning spaces need interaction.

...As I sat and went through these powerpoint presentations I found myself struggling to get through the material because I was not engaged. That is one of my biggest complaints with online learning environments, a student may never feel the excitement for a given topic of subject without that human interaction element. (James, technology class)

The category Quality of Instructional Materials related to the use of materials that were convenient, of high production quality (e.g., readability), useful, and well organized. This category was much more commonly noted in the posts by the participants the technology class, while it was not mentioned at all by the participants in the spatial reasoning class.

One online class that I took revolved around PDF documents...I will start by expressing a big thank you to this professor by not forcing us to buy any books for the class...[but] I have a complaint with how pages come out when they are scanned, I have had some show up backwards, upside down, cut off, or very hard to read. (James, technology class)

Organization is an important part of any class but it is made more difficult when organizing digital materials. Success in online classes is extremely dependent on organizing the assignments... (Johan, technology class)

The following quotes are representative of posts under the categories Clear Purpose, Instructor Involvement, and Transparent Expectations, respectively.

I want to reemphasize...the reasons why discussion boards are used. I think that they work well for reflection or for addressing difficulties encountered with a homework problem. I believe that there is difficulty in the way that they are managed or assessed. For example, in some cases a grade is made by the number of posts made, not the quality of the posts. This can lead to a high number of low interest threads and replies. (Rowan, spatial reasoning class)

The professor should in no way should appear entirely absent from your learning. (Edmond, geometry class)

A positive aspect of [a certain course] is the transparency. I like having clear tasks and deadlines. It makes it easier to manage the rest of my workload. (Teagan, geometry class)

Table 12 shows the counts for the categories grouped under the second theme, Convenience and Benefits of Online Learning Spaces. The top category for the entire data set was Flexibility.

**Table 12**

Frequency Table for the Convenience and Benefits of Online Learning Spaces Theme

Course	Codes							Posts Made
	F	IP	TI	NC	DR	SD	PA	
Geometry	5	0	7	3	5	2	0	40
Technology	7	9	2	3	0	2	2	61
Spatial Reasoning	9	3	2	4	3	0	1	68
Total	21	12	11	10	8	4	3	169

*Note.* A single post may have received more than one code. Coding abbreviations are found in Table 5.

The only reason that I like online courses is because I can do them basically on my time... (Kassidy, spatial reasoning class)

I feel the movement to take courses online certainly has its pros; for example, courses can be offered in an asynchronous manner making them more accessible to those whose schedules would not otherwise allow them to take a particular course. (Angie, spatial reasoning class)

Notable differences occurred between categories in the three classes. The geometry class participants discussed the convenience of online learning spaces related to Transportation Issues most often using comments similar to the one shown in the following post. "...save me the trouble of commuting to [campus] and dealing with the awful parking" (Johan, spatial reasoning class).

The technology class participants were more apt to discuss the benefits of being able to work collaboratively on one document (Single Immediate Product).

For group projects, google docs is a much better alternative than exchanging emails or texts. Users go to one location and can update and see each others work instantly. Adding to this, group members can be on google hangout or skype and talk about what changes need to happen, agree on them and make them instantly. It's fantastic that everyone can be on the document together. (Jade, technology class)

Table 13 shows the counts for the categories grouped under the third theme, Constraints and Drawbacks of Online Learning Spaces. First, there was one more category for this theme than the second theme, and there were more instances of these coding categories being addressed from this negative list than from the previous positive list for the second theme.

**Table 13**

Frequency Table for the Constraints and Drawbacks of Online Learning Spaces Theme

Course	Codes								Posts Made
	NA	MD	LF	DT	TO	SC	SS	GW	
Geometry	0	5	5	0	8	3	0	0	40
Technology	6	6	6	13	2	3	3	6	61
Spatial Reasoning	18	12	10	5	2	4	7	1	68
Total	24	23	21	18	12	10	10	7	169

*Note.* A single post may have received more than one code. Coding abbreviations are found in Table 6.

Second, considerable variance occurred in the data from the three classes, as can be noted by the category Interaction Is Not Authentic, which although it had the largest combined frequency count for the three classes was not noted in any of the posts for the geometry class participants. The spatial reasoning class participants mentioned Interaction Is Not Authentic most often and were also more likely to mention Meaningful Discussions and Loss of Flow. The first post below exemplifies the category Interaction Is Not Authentic, while the second exemplifies the category Loss of Flow.

Language loses so much meaning when given without visual or tonal components. Words can express the passion of a statement but they are nothing compared to seeing and hearing the comments. I think the actual act of writing does provide some development in terms of finding where ideas lead but they can get watered down with constant edits and the worry that there is a grammatical or spelling error. (Johan, spatial reasoning class)

Personally I am not a fan of online classes. The main points I have seen in others posts (that I agree) with are: 1. Responding to classmates posts is hard when your classmates don't respond. (I'm guilty, I know!) 2. It sucks having to go back and remember your thoughts from before in order to respond. Loss of flow I'll call it... (Sasha, spatial reasoning course)

The geometry class participants were relatively balanced in how they discussed the constraints and drawbacks, as well as the convenience and benefits, while the participants in the other two classes clearly saw more negative than positive aspects to online learning spaces. The technology class, which was a completely online class, felt that the most important constraint or drawback to online learning spaces was the category Dependent

on Technology and gave equal mention to the categories Interaction Is Not Authentic, Meaningful Discussions, Loss of Flow, and Group Work. The following post primarily addresses the category Group Work but also briefly mentions technical difficulties, which fall under the category Dependent on Technology.

Several problems arise when trying to complete group work with an online environment...when group members are able to agree on a common meeting time, some people forget, come late to the virtual meeting, have problems with technology, don't have the work prepared....Without using a common meeting time, emails seem to fly back and forth and that becomes increasingly difficult to keep track of. I have been in a group where I literally sat on google hangout and forced the other person to figure out their answers while I waited, even though the assignment should have been completed by this point. The person just agreed with what we already said....I had to resort to not divulging our answers until this person did the work...In a face to face classroom situation, the person would have had to immediately admit they didn't do the work. (Jade, technology class)

The following post not only addresses more than one category from the theme Constraints and Drawbacks of Online Learning Spaces, it cuts across two themes. In it, the participant explains how the lack of meaningful assessments (from the theme Instructional Responsibilities in Online Learning) sets up a situation where students focus on completing the task (category Task Orientation), which in turn, leads to discussions that lack any meaning or depth (category Meaningful Discussions).

As much as I think the use of discussion boards are great IN THEORY, but when it comes down to it, I think we all just try to get it done. As much as I reflect, most times I think students just measure how much they have written. Proof that this is true: almost all professors tell you that a post should be "x" amount of paragraphs long....For the most part, discussion boards seem like evidence of work, but are not beneficial. (Crystal, technology class)

To summarize, participants in the three classes spent the most effort discussing the instructional responsibilities associated with online learning spaces rather than the benefits or constraints. In general, participants from all three classes were more likely to mention constraints and drawbacks in online learning spaces than benefits.

I believe that some instructors really try to provide places for students to discuss different topics within an online class but I believe that one of the problems might be [if] the students "want" to participate in these online discussion posts. This might be bad to say, but I believe that the online classes I took, I only took to meet a requirement. I didn't necessarily take the class because I was interested in the material being presented, but instead I took the class because it will lead to my degree, and I wouldn't have to drive to campus. Now I am not saying that I did not get anything valuable out of taking these online classes, but I believe that my attitude towards [the classes] drove my likelihood to not put in any extra effort into any type of extra forum or discussion board. To be honest in my online classes I just did what I was told to do. I didn't go above and beyond to get to know the students that I was taking the class with. I just did the work... (Ros, geometry class)

## **Discussion**

In this study, we explored the educational experiences with and perceptions of various online learning spaces of future and current mathematics teachers using the lens of the TDT proposed by Moore (1993). Each of the four phases of analysis, corresponding to the four research questions, attempted to shed light on the experiences and perceptions the participants had with various digital resources, class formats, and online learning spaces they had encountered. Just as no two face-to-face classrooms are the same, no two online learning spaces are either. The dynamics of one online learning space can never be completely replicated in another online space.

The uniqueness of each online learning space was clearly evident, as all three classes were given the same prompt yet their discussions differed. Some similarities existed, however, one being that most of the participants seemed to prefer face-to-face courses over online courses. However, many participants saw the value in online coursework in providing flexibility to take courses without having the time and distance factors involved, with the caveat that for the online learning spaces to be effective, they must be properly and effectively structured and implemented. In short, their responses suggest the importance of an effective balance between dialog, structure, and learner autonomy.

With regard to the first research question, our findings suggested that the preservice and in-service teachers participating in the study had experienced a number of digital tools in online learning spaces. The five most common were online discussion forums, collaborative office software (with Google Docs most mentioned), course management systems (with the Blackboard Learning System most mentioned), video (often embedded in a course management system and instructor-created), real-time communication platforms (with Google Hangouts and Skype most mentioned), and social media (with Facebook and Twitter most mentioned). It is interesting to note that while the Blackboard Learning System has been around for approximately 17 years, most of the other digital tools and resources identified by name have been in existence only for a decade or less.

In considering the second research question, the preservice and in-service teachers mostly mentioned the online course format in their comments. However, they recognized that online learning spaces are not only associated with online courses but can be associated with both face-to-face and hybrid course formats.

In light of the third research question, which related to the nature of the digital experiences discussed, the study results showed that the participants primarily focused on communication and interactions at both the individual and group levels. This result was followed by a focus on the nuts and bolts of courses related to their daily functioning, including how assignments are completed and assessed, how groups collaborate on coursework, how instruction is carried out, and how information is relayed to students.

The fourth research question considered participants' perceptions of the online learning spaces they had experienced. The preservice and in-service teachers' key areas of focus were on the instructor, instructional responsibilities, and instructional efforts in online learning spaces and how these do (or in some cases do not) facilitate meaningful learning experiences for students. The participants also seemed to weigh the pros and cons of online learning, recognizing the tension between the convenience and benefits of online learning spaces and the drawbacks and constraints inherent in these digital environments.

## **Dialog**

Online learning environments tend to have high transactional distances (Benson & Samarawickrema, 2009; Moore, 1993). Thus, the goal is to structure a course such that the transactional distance perceived by students in online learning spaces is minimized, typically by creating opportunities for meaningful interactions and, thus, promoting a high level of communication between student and instructor. Our findings suggest that participants desired a high level of interaction with the course instructor, a sense of instructor presence in the course, and mechanisms for communication and feedback from the instructor. These findings align with what others have reported (Baker, 2010; Hodges & Cowan, 2012).

Participants posted a high frequency of comments regarding the instructor's responsibility to provide a means for interactions and the need for the instructor to be involved in the online learning space. The participants not only felt that student-instructor interactions were important, but many of their comments focused on the fact that the instructor's role was to provide the platforms for this communication.

Although this study did not note much emphasis on student-content interactions (Moore, 1989), data indicated considerable attention to interactions with peers, which aligned with Zhang's (2003) findings. Participants also mentioned issues with the technology that supported the need to consider student-interface interactions (Hillman et al., 1994).

Participants' reports of past experiences suggested that instructor-student and student-student interactions are not always facilitated in online learning spaces. The one digital resource that seemed to be most used to try to facilitate interactions was online discussion forums. While the participants noted they had the most experience with discussion forums that were used to try to promote peer discussions and communication, many expressed concern that the student discussions in online platforms were often neither meaningful nor authentic. Thus, commonly used digital tools were not seen as promoting desired positive interactions.

The noted exceptions, those instances when online discussion forums seemed to facilitate meaningful discussions, were when (a) students in face-to-face classes used online discussion forums for peer tutoring outside of class and (b) students engaged in online discussion already knew each other (either from other courses or due to the hybrid nature of the course that allowed some face-to-face time).

Besides stressing the need for student-student interactions to take place to aid in reflection and sharing of ideas, participants also felt that the lack of such interactions contributed to a lack of a sense of community. Studies by Falloon (2011, 2012) indicated that when students experienced synchronous virtual classrooms, they felt a greater sense of community and less isolation. This study's participants noted that the use of collaborative office software and real-time communication software, such as using Google Docs in coordination with Google Hangouts or using Skype for video conferencing, did seem to promote more positive interactions between peers for both collaborative assignment work but also in terms of community building. However, this benefit came at a cost.

The key tension was that the real-time digital platforms that allow for more authentic interactions remove the desired latitude in scheduling inherent in asynchronous online learning spaces. The participants felt they were obligated to devote a specific block of time in order to have a productive dialog. Thus, while they felt the need to achieve a

sense of community and desired meaningful interactions with peers, only synchronous digital resources that impacted schedules (and negated the flexibility many sought from online learning spaces) seemed to promote meaningful interactions.

## **Structure**

Moore's (1993) *structure* referred to the educational objectives, instructional design, teaching and assessment methods, and overall organization of a course. Our study found that the preservice and in-service teachers in this study felt the need for instructional designs and processes that created an effective, efficient online learning space. Our findings align with others' in that many of the participants' comments showed they believe that instructors in online learning spaces shoulder the responsibility for the course structure and that this structure should be designed so that it provides an organized environment that facilitates learning and reflection (Gerbic, 2010; Norton & Hathaway, 2008; Shea et al., 2003; Stein et al., 2005). Moreover, the participants wanted the instructional design to be explicit and transparent with clear expectations and organized, regular feedback, as suggested by Baker (2010) and Hodges and Cowan (2012).

The participants desired online learning spaces to be obviously and coherently structured so that course activities (a) provided two-way channels for communication and interaction with others, particularly the instructor; (b) aligned with assessments while addressing course objectives and (c) corresponded with the capabilities of the digital resources they incorporate or the digital platforms on which they are located. We have already addressed the first point, so now we turn to the next two.

Our findings suggest that instructors are expected to provide activities that explicitly align with the course objectives and deliberately complement other coursework. In contrast, participants described online learning spaces that were either disconnected from face-to-face segments of courses or overly repetitious in terms of repeating exactly what had been done online in face-to-face segments of courses. They also described unidimensional courses that involved a minimal number of learning activities that were constantly repeated (e.g., read a paper, write a reflection, read another paper, write another reflection, etc.) and that failed to engage or motivate students.

Participants made both indirect allusions and explicit statements that instructors of online learning spaces were not living up to the potential of the space or the digital resources the space incorporated. They said that instructors often adopt instructional practices from face-to-face classrooms without considering how to adapt them to the digital nature of the online learning space. For example, students much preferred a single document with hyperlinks to all the week's activities rather than a video where the weekly instructions are given verbally or a PowerPoint presentation where they were embedded in a series of slides.

Participants also pointed out that the instructor is responsible to provide students with quality digital copies of instructional materials. This may seem obvious, but more than one student commented on the careless nature of the organization and digital quality (e.g., pdfs that are cut off or upside down) of instructional materials in online learning spaces.

In the previous section on dialog, we discussed interactions that involve individuals (e.g., instructor-student, student-student, student-content, and student-interface). Another interaction that was of particular concern to the participants in this study is that of

activity-interface interaction. Participants' perceptions as to the quality of course activities were based on instructional decisions related to the activities assigned and the ways those activities were designed to take advantage of digital resources.

The digital resources chosen for a task as well as the instructions on how to accomplish the task assigned using these resources had a great impact on how much the participants felt they learned. This finding addresses the Task-Technology Fit theory outlined by Goodhue (1995) and revised by Goodhue and Thompson (1995). This general idea of activity-interface interaction is not limited to online learning spaces nor is it new. It follows Clark's (1983) argument that it is not the medium itself but rather how the medium is used that impacts the effectiveness of a course and Owston's (1997) assertion that "the key to promoting improved learning...appears to lie in how effectively the medium is exploited in the teaching and learning situation" (p. 29).

### **Learner Autonomy**

Learner autonomy describes a students' self-direction and ability to take responsibility for their own learning. This autonomy is considered to be a student's wherewithal to learn independently. Moore (1993) suggested that learners who prefer online courses tend to take more responsibility for their learning and work well independently with less dialog and less structure. Others who prefer face-to-face courses tend to require more instructor guidance and tend to benefit from group work.

The participants in this study expressed a desire for a higher level of structure. (This desire was evidenced in the frequency of comments regarding the instructional responsibilities of the instructor; namely, quality course materials, clear purpose to the tasks and assessments, instructor involvement, and transparent expectations.) While some did see the benefits to more interactions among students, including collaborative activities, others expressed frustration in having to do group work. They felt that it was a constraint in having to find common meeting times and having to rely on others to complete tasks.

Keller and Karau (2013) found that students who were more hardworking and conscientious would benefit the most from an online learning space. Conversely, students who are not as conscientious, those with a lower level of learner autonomy, tended to benefit more from a face-to-face classroom format. In this study, a number of participants expressed that they appreciated online learning spaces for their convenience and flexibility but felt they enrolled in courses with online formats just as easy ways to fulfill a curriculum requirement rather than significantly further learning. These students exhibited lower learner autonomy and were the ones who were more likely to discuss or describe experiences where they completed required assignments with minimal effort.

However, some participants did seem to have a higher level of autonomy. They, as students, might be deemed as more conscientious than others. Often it was those participants who had made the most posts and whose posts were longest when responding to the prompt. They were also the participants who were more likely to prefer online learning spaces and were more likely to get the most out of them.

Although lengthy, the following quote does a good job of summarizing the study's findings.

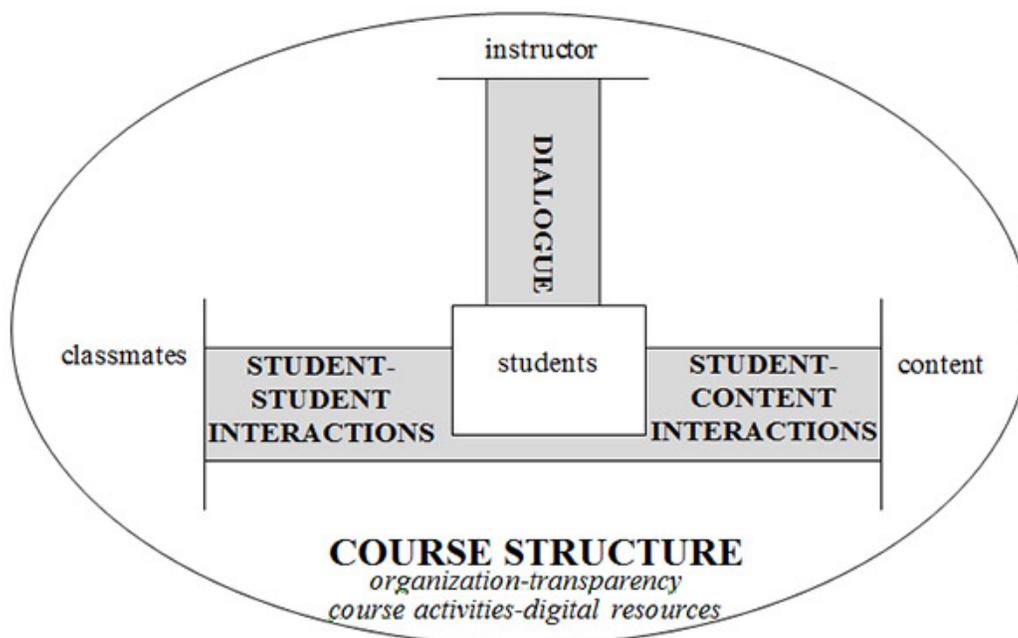
I've had the opportunity to take several courses online. When reflecting back on those courses, I can clearly pick out the ones that were good from those that

needed improvement. So, what makes the class good?...the instructor, the student, the technology used...I answer that all three...are necessary for an online course to turn out well. Students play an important role when deciding how well an online course went. An instructor may have pulled out all the stops with videos, intriguing questions for discussion boards, flexible homework schedules, and alternative assessments, but if students aren't engaged, it affects everyone in the class....If fellow students are holding up the process by not responding to discussion boards, then that activity turns out to be a flop. Technology is also another measure of how well a course went. Without a good Internet connection, videos and live streams run very slowly. Without the proper platform then the motivation for students to fully participate dwindles. If the technology is too difficult to use, students lose interest....But of all the measures of how well an online class went, I believe a larger proportion of it lies with the instructor. The instructor usually chooses the technology that will be used and which tools/platforms the course will be housed. The instructor decides which content is uploaded for the course and how the material will motivate/engage students. The instructor decides how frequently to communicate with students, to check on them when they fall behind, or to encourage students when they show frustration. The instructor decides how flexible or stern to be with due dates, assessments, and participation. There is a lot of effort that goes into a successful online class. Everyone should get credit for making it a great class, but I believe most of that responsibility rests with the instructor. (Rowan, technology class)

### **Conclusions and Implications for Future Study**

Figure 1 shows how the course structure with its selected activities and digital resources mediates the key interactions in a course. The channel of interactions between the instructor and the student, Moore's (1993) dialog, is displayed in the vertical connection between the individual student and the instructor in the figure. This student-student interaction and student-content interaction channels are located on the left and right, respectively. These three channels of interactions all fall under the course structure and are mediated by (a) the digital tools and platforms the instructor selects, (b) how the instructor decides to use the digital resources, and (c) the activities and related assessments that are selected by the instructor and incorporated in the course. So, the instructor impacts all three channels. In addition, the individual student's autonomy, attitude, and effort also impact the three channels. Finally, the three channels are impacted by the digital resources and platforms that are available to the instructor and students in the course and their capabilities.

While the results from the current study are for a particular population and may not be generalizable to all preservice or in-service teachers, this study makes an important contribution to the research on teachers' experiences with and perceptions of the various online spaces they may encounter. As digital environments become more common, the teacher education community must be cognizant of the complexities that exist in utilizing these environments. Teacher educators must take into consideration how interactions, course structure, digital resources, individual's learning autonomy, and the instructor's role interrelate when considering the design of an online course.



**Figure 1.** Course structure as a mediator of interactions in online learning spaces.

This study adds to the understanding of the framework of Moore's (1993) TDT. However, future study is needed to flesh out the activity-interface interaction and how best both to understand and identify which digital resources are best suited for a specific activity with a specific population. Further study could also attempt to determine best practices that could be employed in utilizing online learning spaces. While this study did not specifically seek to analyze learner autonomy, future study could illuminate the issues surrounding an individual's learning autonomy and how best to accommodate the differing levels that students bring to a course.

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### Author Information

Deborah Moore-Russo  
State University of New York at Buffalo  
Email: [dam29@buffalo.edu](mailto:dam29@buffalo.edu)

Jillian Wilsey  
Niagara County Community College  
Email: [jdeverin@buffalo.edu](mailto:jdeverin@buffalo.edu)

Jeremiah Grabowski  
State University of New York at Buffalo  
Email: [jsg6@buffalo.edu](mailto:jsg6@buffalo.edu)

Tina M. Bampton  
State University of New York at Buffalo  
Email: [tinabamp@buffalo.edu](mailto:tinabamp@buffalo.edu)

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