ABSTRACT

NESMITH, COURTNEY TAYLOR. Instructors' Decisions About Resources Utilized for Teaching Mathematics Online: A Mixed Methods Study. (Under the direction of Dr. Erin Krupa).

With the rise of online courses taught at the post-secondary level, instructors must make decisions on what resources and tools they implement since this can directly impact student learning (Ascough, 2011; Means et al, 2010; Simonson, 2011). Moreover, instructors have access to thousands of free resources and tool though a click of a mouse as well as the resources and tools provided by their institution. (Webel et al, 2015). However very little is known about the decision making process on choosing resources and tools, specifically for online mathematics instructors at the post-secondary level (Oncu et al, 2011; Simonson et al, 2011; Zawacki, 2009). The goal of this study was to, first, identify what resources and tools mathematics instructors are implementing in their online courses at either four-year institutions or community colleges in North Carolina. Second, this study focused on if and what instructor characteristics influences the decision making process. Finally, factors or priorities that influence the decision making process were discerned.

A convergent mixed methods study was implemented to dissect the decision making process for online mathematics instructors at the post-secondary level in North Carolina. A survey was sent out to mathematics instructors at both four-year and community colleges in North Carolina to collect what resources and tools they currently implement in the online courses. Chi-square test for independence was utilized to analyze if and what instructor characteristics influence the decision making process for certain resources and tools. In parallel, semi-structured interviews with six online mathematics instructors were conducted to provide a

more-in depth picture of the decision making process, specifically uncovering what priorities or factors did the instructors have.

The findings from this study indicate that mathematic instructors in North Carolina use a wide variety of resources and tools in their online courses. Overall, Desmos was the most frequently mentioned resource by the instructors. For tools, instructors used learning management system to for course organization and online learning platforms for student homework. Certain instructor characteristics were also found to be significant to the decision making process. Instructors from four-year institutions and held a doctoral degree were found more likely to deliver courses synchronously. Instructors from a community college and taught lower-level mathematics course were more likely to implement an online learning platform. Finally, instructors holding a doctoral degree were more likely to utilize an app in their online course. From the interview, four priorities were found to be an influence on the decision making process: instructional, design, organizational, and individual. The instructional priority held the largest influence on the instructors as they discern through the plethora resources and tools. More specifically, the effectiveness of the resource or tool was a high priority for all six of the instructors.

Overall, the study illustrated how dynamic and interconnected the decision making process is for online mathematics instructors. Findings suggest that online courses do require different resources and tools than a face-to-face course and instructors do take this into consideration. Findings also suggest the need for professional development on the different resources and tools institutions provide in order for instructors to discern what aligns with their priorities.

Instructors' Decisions About Resources Utilized for Teaching Mathematics Online: A Mixed Methods Study.

by
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DEDICATION

To my forever best friend and love of my life, Joshua Strachan.

BIOGRAPHY

Courtney Taylor NeSmith was born on October 19, 1992 in Jesup, Georgia. She grew up in Jesup and graduated from Wayne County High School in 2011 as valedictorian. She attended Kennesaw State University, where she also was accepted into the Urban Education program. After graduating summa cum laude with a Bachelor of Science in Mathematics with teacher certification in 2015, Courtney worked at Wayne County High School from 2015-2016.

At Wayne County High School, Courtney taught Geometry and math support classes. During this time, she worked as the Color Guard and Winter Guard instructor for the Wayne County High School Band. In 2016, Courtney decided to pursue a master of science in mathematics at Georgia Southern University in Statesboro, Georgia. She worked as a graduate assistant in the mathematics department, which included working at the mathematics lab for the first year. In the second year, Courtney was appointed Instructor-on-Record for the fall and spring semester for a college algebra course. She earned her degree in 2018 and moved to Raleigh, North Carolina to pursue a doctorate in mathematics education at North Carolina State University.

During her four years at North Caroline State, Courtney served as a teaching assistant. She co-taught Introduction to Teaching Mathematics for two semesters as well as helped with the NCCTM student organization. In the second and third year, Courtney was the Instructor-on-Record for Calculus for Elementary Education I & II. She also helped organize Math Field Day for the college as part of a research team. Currently, Courtney is an Adjunct Professor at the United States Naval Academy in Annapolis, Maryland.

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CHAPTER 1

Background

While the first iteration of distance education in the 1840's used the postal service for correspondence learning, the technology boom allowed for learning to take place through a variety of mediums, such as through the use of the internet with online courses. Distance education can be defined as "institution-based, formal education where the learning group is separated, and where interactive telecommunications systems are used to connect learners, resources, and instructors" (Simonson et al, 2011, p.126). Under the umbrella of distance education are online courses at the post-secondary level, which have increased drastically. "…since 2010 online enrollments have increased by 29%...with more than 60% of community college students enrolling in online classes" (Wladis et al, 2015, p. 143). Online courses have even expanded for STEM courses at the post-secondary level. "Of the 35% of 4-year degree-grading mathematics departments offering distance-learning courses, 72% were "completely online""" (Trenholm, Peschke, & Chinnappan, 2019). Moreover, the increase of online courses called for research in this new area. Research of online learning has concentrated heavily on student achievement with comparisons to face-to-face courses in non-mathematics online courses. However, little is known about the instructors who designed these online courses, specifically online mathematics courses at the post-secondary level.

With this delivery method of courses, mathematics instructors must adapt to this newer environment. First, the instructor needs to decide how to design their online course, including what resources and tools they want to use. There is a clear trend that more and more instructors are retrieving resources and tools from online. "Thousands of resources for teaching and learning mathematics are accessible with a few keystrokes" (Webel et al, 2015, p.4). However, there is

little research on what types of resources tools instructors use in their online courses. For the purpose of this study, resources will be defined to be an instrument to guide student learning. Resources can be interactive or informational (Ellis et al, 2006). An interactive resource allows the student to "develop their own perspectives" as active learners, such as the use of an online learning platform or a dynamic graphing applet (Ellis et al, 2006, p.317). An informational resource is a one-dimension mode of learning and can be used to provide extra help, such as a recorded lecture or written notes. Tools will be defined as an instrument to facilitate an online course, such as a learning management system or a tablet used for instruction. These choices of resources and tools by the instructors can influence student achievement and overall satisfaction with the online course.

Significance

Distance education research, as a whole, has grown since the days of correspondence learning through the postal service, but it is still a young research field. Saturated with comparative studies that have shown there are no significant difference between face-to-face and online courses, the call to research other domains of online learning has increased (Simonson et al, 2011; Zhao, 2005). The focus of research, instead, needs to turn to determining what attributes of online learning influence the effectiveness of student achievement, student attitude, as well as student identity, especially for different subpopulations and content areas (Simonson et al, 2011). Moreover, there have been very few studies that have focused primarily on the instructors' choice of technology in online course environments and institutional supports for instructors (Lou, 2006). With this, future research needs to expand to cover other areas, such as faculty support and professional development (Oncu et al, 2011; Simonson et al, 2011; Zawacki, 2009)

Research of STEM distance education, at the post-secondary level, is even more limiting, despite the major expansion of STEM online course offerings (Trenholm et al, 2019). Wladis and colleagues (2015) additionally emphasize the lack of research of STEM online course outcomes at the community college level, which provides learning opportunities for an even more diverse population. In two meta-analysis of distance education, the inclusion of STEM based courses is lacking, especially for mathematics. This is because many "...systematic reviews and meta-studies [of distance education] …are considered within the context of health care or language learning" (Nosegaard et al, 2015). For example, Zhao and colleagues (2005) reported fifteen studies that focused on STEM online courses out of the fifty-one total studies. Only one of those fifteen studies looked specifically at an online mathematics course. Similarly, Lou and colleagues (2006) reported fourteen mathematics and fifty science studies out of 218 total studies. Trenholm and colleagues (2019) claim to be the first meta-analysis that targets fully online mathematics courses at the post-secondary level, which only had 2.2% of the studies included that were focused on fully online mathematics courses. The meta-analysis provides insight into how students are faring in online courses.

Mathematics courses at the post-secondary are seen as gateway courses. "Mathematics is a building block for success or failure across different majors; mathematical knowledge and skills are critical for all 21st century college students" (Kim et al, 2012, p. 173). With the increasing need of skilled STEM workers and student needs of flexibility in learning, researchers must dedicate resources to studying STEM distance education to ensure rigorous courses at the post-secondary level.

Statement of Problem

With the rise of online courses at the post-secondary level, especially during the COVID-19 pandemic, what is known about the mathematics instructors who are behind the student learning? More specifically, how do these instructors choose among the plethora of resources and tools to implement in their online course? Studies of online courses at the post-secondary level often focus on the student and their attributes or achievement levels. There is a need to know more about the 'wizard behind the curtain" that is creating the environment for learning to take place. Specifically, there is a need to know what factors contribute to the decision-making process in choosing these resources and tools to use in their online mathematics course.

Purpose Statement

This mixed methods study addresses the type of resources and tools instructors choose to use and the decision-making process behind these choices for an online mathematics course at the post-secondary level. A convergent mixed methods design was used to explore this issue. Quantitative and qualitative data was collected and analyzed separately and independently of each other. The data was then be merged and interpreted for convergent and divergent findings. In this study, survey data was used to measure the relationship of instructor characteristics and choice of resources and technology tools. In parallel, semi-structured interviews of post-secondary instructors with experience teaching online mathematics courses and their online mathematics syllabi documents was used to inquire into the decision-making process on resources and tools. The justification for collecting both quantitative and qualitative data was to corroborate the two forms to bring greater insight into this research gap.

CHAPTER 2: Review of Literature

Overview

This section will first begin with an overview of online courses with descriptions of various resources and technologies. Secondly, a review of purposeful research studies of relevant research areas of online learning: student achievement, student identity, student attitude, and the instructor's role. Much of the research in online learning has been focused on the student perspective to see if this environment provides the same learning opportunities as a traditional course. One of the first foci was to see if students can achieve equally in an online course versus a traditional face-to-face course. From here, researchers have looked into how student attitudes and identities are affected by this newer medium of learning. With limited research, the perspective of the instructor in an online course is discussed followed by the critiques and limitations of the studies that were presented. Finally, a pilot study is reviewed to provide insight into one instructor's choices of resources and technology tools in an online mathematics course at a post-secondary institution.

Description of Online Courses

Online courses can have a variety of options to meet different student needs as well as instructor needs. "The use of technology in education holds great promise in extending opportunities for students to learn…" (Garcia-Cabereo et al, 2018, p. 814). Moreover, online courses allow for the student and teacher to be separated by time and space. Asynchronous online courses allow the student to learn separately and within their own pace from the instructor. Asynchronous online courses offer the most flexibility because of the freedom from time and distance. Synchronous online courses make use of video/audio-conferencing software that allow the instructor and students to meet in real-time, but in different locations. Some

variations of online courses may offer both asynchronous and synchronous components. A compromise of online and face-to-face course is blended or hybrid courses. In this type of course, a student will have in-person lectures as well as online components.

In order to establish the online components, many post-secondary institutions use a learning management system (LMS), such as Blackboard, Moodle, or D2L (Chen et al, 2010). Instructors use this platform to organize their online course, upload resources, and provide feedback for students. A variety of interactions can be added as well, such as discussion boards or polls. Some online courses may also use an online learning platform (OLP), where students can asynchronously complete online homework, tutorials and assessments.

Selection of Studies for Review

In this literature review, research studies were chosen purposefully to synthesize and analyze to provide an overall status of online mathematics courses at the post-secondary level. Specifically, the studies had to focus on student achievement, student attitude, student identity, and the instructor's role in an online mathematics course. The studies are bounded by type of online instruction, content area, as well as level of education. The focus of a distance education course is on synchronous or asynchronous online instruction. The content area of interest is STEM, particularly mathematics. The instruction needs to be taking place at the post-secondary level (i.e. community colleges as well as four-year institutions). The analysis of the selected papers included population, content area, type of online course and methodologies. The research questions and data sources were analyzed for the overall focus of each study. The foci were classified into three types: *comparison, tech effect, and use of tech.* If the study compared face-to-face (F2F) courses to the equivalent online courses, then the studies was grouped into the *comparison* classification. If the study was focused on how an online course or a certain piece of

technology had an effect on the student in some way (i.e. cognitive domain or affective domain), then the study was classified into *tech effect.* Finally, if the study was interested in how students or instructors interacted in an online course as a whole or with a certain piece of technology, then the study was classified into *use of tech.* Studies were also analyzed by the type of variables used or data sources, such as identity, attitude, and outcomes. Overall, twenty-three studies were chosen to analyze.

Demographics

While the research focus of this paper is geared towards undergraduate studies, few of the papers were focused on other levels of education. Of the twenty-three studies, the majority were focused on populations at the undergraduate level (n=17). The other levels of education studied were graduate (n=1), undergraduate/graduate (n=1), dual enrollment (n=1), and high school (n=2). Finally, a study solely focused on undergraduate mathematics instructors at a community college (n=1). Only two other studies, included in the undergraduate and high school population, included data sources collected from instructors.

The type of courses that the studies researched were varied as well. Majority of the online courses were strictly asynchronous (n=10), while some online courses offered both asynchronous and synchronous components (n=4). The remaining courses were blended (n=3) and F2F (n=1). The study on the F2F course was included based on the focus on the instructor's perspective of integrating technology. Finally, some of the descriptions of online courses were inadequate to determine (n=3) and two studies chose to focus on all types of course offerings at the post-secondary level.

The content areas of the studies can be broken down by general education mathematics (n=13), upper undergraduate level mathematics (n=3), remedial mathematics (n=1), and graduate

level mathematics (n=1). Some studies focused on multiple content areas (n=4), while other studies did not explicitly state the content area (n=1). Of the studies that explicitly stated the multiple content areas, only one did not include a STEM content area (Dennen et al, 2011). This study included because of the exploration of identity in online undergraduate courses.

The majority of the studies employed quantitative methods (n=12). The remaining studies used qualitative methods (n=7), mixed methods (n=3), and action research (n=1). From the research questions, the studies' foci were grouped into three classifications: *tech effect* (n=12), *use of tech* (n=6), *comparison* (n=5). Finally, after reviewing the data sources, the majority had variables that measured student achievement (n=9), student attitude (n=8), and student identity (n=6). Of the studies that had data sources measuring student attitude, most also had data sources that measured student achievement (n=5). From this information, the typical study was interested in the student population of a general education mathematics asynchronous online course with the focus on determining the effect on student achievement.

After categorizing the studies based on the main focus from the research questions and data sources from the methodology, Table 1 showcases the comparison of foci and data sources (see Table 1). It is no surprise that all of the comparative studies had data sources that measured student outcomes. Whether explicitly or implicitly stated, these studies employed the Equivalency Theory. In essence, the Equivalency Theory helps frame how online courses should be designed in regard to creating a learning environment where student outcomes are similar to traditional face-to-face courses. "The more equivalent the learning experiences of distant learners are to those of local learners, the more equivalent will be the outcomes of the educational experiences for all learners" (Simonson et al, 1999). It is also not surprising that student achievement data sources were collected in the majority of studies. Outcome data sources, such

as exam scores or course grades, are one of the main ways for the researcher to know if a student is making progress from the treatment or not.

The highest cross-section occurs when studies focus on the effect of student attitudes in an online course. Since this is still a relatively new research area, these studies offer insight into how student attitudes are affected through a newer medium of instruction. Since interactions can be just through written technical from, such as a discussion forum or email, "…the online format of the course…made it difficult for students' negative attitudes to be addressed" (Hodges et al, 2013, p. 60).

Table 1

Comparison of foci and data sources

	Achievement	**Attitude**	**Identity**
Comparative	5	0	0
Effect of Tech	3	6	3
Use of Tech	1	2	3

Student Achievement

The research has shown that online learning yields the same outcomes, if not better in some cases, than a traditional lecture course at the post-secondary level (Simonson et al, 2011). However, Trenholm and colleagues (2019) find troubling mixed findings for online mathematics courses at the post-secondary level. This literature review adds to the mixed findings. Of the nine studies looking at student achievement, three studies concluded no significant difference (Corey, 2005, Fonolahi et al, 2014; Weems, 2002). Three studies concluded statistically significant difference in favor of the online course or treatment (Chen, 2010; Harris et al, 2013; Moradi et al, 2018). Finally, two studies reported statistically significant difference in favor of face-to-face

courses (Jones et al, 2013; Vilardi, 2013). One study, not included above in the break down, looked at the gender differences in an online mathematics course and reported that overall men out performed women (Morante et al, 2017). To further digest the studies above, we need to separate the *comparative* studies and the *tech effect* studies. *Comparative* studies used the enrollment in an online course as the treatment and face-to-face courses as the control. For the *tech effect* studies, they used the presence or absence of a treatment to see how student achievement was affected in an online environment.

For the *comparative* studies, the results were not consistent, but all of the studies used either exam scores or course grades as a data source to track student achievement over a certain time period. In accordance with the Equivalency Theory, three studies found no statistical difference between the face-to-face and online courses (Corey, 2005; Fonolahi et al, 2014; Weems, 2002). Each of these three studies had different sample sizes as well. With that in mind, this can potentially make the case, that no matter the medium of instruction, that students can be successful in an mathematics online course. For instance, Fonolahi and colleagues (2014) found that students in the online mathematics course had better course work grades when compared to their face-to-face counterparts. However, the face-to-face course had higher exams scores. Weems (2002) also pointed out that the online course exam grades were lower and decreased with each exam over the course of a semester.

The other two studies positive benefits of the face-to-face courses (Jones et al, 2013; Vilardi, 2013). To break these findings down, both of these studies collected data across multiple semesters at a university and combined all of the data to report initial findings. Interestingly enough, when both of the studies dissected the data from semester to semester, different results came to light. Jones and colleagues (2013) had student outcome data from seven semesters. In

the first three semesters, face-to-face courses had higher course grades and then switched to the online courses having higher course grades in the following semesters. The researchers do point out that the online courses were first implemented at the beginning of the data collection and technology has improved over the years, which could account for the growth of course grades in online courses. Vilardi and colleagues (2013) analyzed data that was collected from 2007 to 2012. While the researchers still found that face-to-face courses outperformed online courses each semester, the grade distribution of online courses change significantly after Fall 2010 with higher amount of A's.

For the *tech effect* studies, all three reported positive findings. Chen and colleagues (2010) analyzed data from a national survey on engaging online learners. The researchers concluded there was a positive relationship with students engaging with technology and self-reporting outcomes. While this study did not include a rigorous experiment to back up the relationship, the importance and power of technology and learning outcomes is of value from the student perspective, whether that is a face-to-face or online course. Moradi and colleagues (2018) implemented online interactive instruction modules for mathematics and physics courses. For students in the treatment group, significant improvement on the post-quiz scores were found and no significant improvement in the control group. It is important to note that this study makes a case for the effectiveness of a blended or hybrid courses. Chen and colleagues (2010) also point out that students do have a preference for the blended model. Finally, Harris and colleagues (2013) make a case for an online dual enrollment mathematics course for high schoolers. The authors conclude that the course is successful based on the majority of the students passing with an A, B, or C. The data is collected over three iterations of the course. This was not compared to any other courses being offered.

Student Attitudes

Students do favor, and have positive attitudes towards, online courses in general (Chen et al, 2010). However very few studies have targeted student attitude in online mathematics courses at the post-secondary level (Trenholm et al, 2019). Of the twenty-three studies, only three studies specifically address student attitudes with one study providing a definition (Corey, 2005; Hodges et al, 2013; Weems, 2002). To clarify Corey (2005) and Weems (2002) were included in the section of student achievement. However, seven other studies had focuses within the affective domain and will be discussed in this section (Hodges, 2008; Kim et al 2016; Kim et al, 2012; Kim et al, 2014; Ku et al, 2011; Pan et al 2012; Pape et al; 2008). Student attitudes can be classified under the affective domain, which also includes student beliefs and emotions towards mathematics. The affective domain can be defined as the "wide range of beliefs, feelings, and moods…regarded as going beyond the domain of cognition" and student attitudes can be defined as "affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (McLeod, 1992, p. 576, 581). For the purpose of this paper, we will extend this section to cover what has been studied in the affective domain in online learning.

First, the studies that specifically looked at student attitudes will be discussed. Corey (2005) is one of the few case studies that brings attention to the experience of a high school African American male who was placed in a blended Algebra I class. The narrative provided valuable insight in how the culture of a face-to-face classroom can impact a student's attitude and learning experience. Overall, the student felt less culturally threatened in the online environment than in the face-to-face classroom and was able to make gains in his learning and therefore had a more positive attitude towards learning mathematics in an online environment. "Fred [student] credited this change in attitude to the extensive access of information and

explanation in the Web-supported learning environment" (Corey, 2005, p.330). Both Hodges et al (2013) and Weems (2002) collected student attitude data using different tools. Weems's (2002) collected data through the Scale of Attitude toward Mathematics, which measured attitude with four constructs: engagement, motivation, importance, and freedom from fear. Hodges and colleagues (2013) first defined the term: "…attitude toward mathematics as a construct that determines the way of reacting to mathematics in certain context and we argue that motivational factors constitute attitudes" (Hodges et al, 2013, p. 60). The researchers used the usefulness and math anxiety portions of the Fennema-Sherman Mathematics Attitude scale. Clearly, these two studies have constructed different meanings on student attitudes. "Clarification of terminology for the affective domain remains a major task for researchers in mathematics education" (McLeod, 1992, p. 576). The two studies also had different findings. Weems (2002) found there was no statistical significant difference between student attitudes in an online versus face-to-face course. Hodges and colleagues (2013) implemented a video treatment to improve student attitudes and resulted in statistically significant difference for the treatment group. The control group even had a decrease in student attitudes toward mathematics, but the study did not offer any insight into why this could have occurred.

As defined earlier, student emotion is under the affective domain. One study solely focused on academic emotions and their effect on student outcomes (Kim et al, 2012). The researcher defines academic emotions as "emotions related to either achievement outcomes or achievement-related activities" (Kim et al, 2012, p. 174). Kim and colleagues (2012) implemented an emotion control treatment in a form of a video. The researchers found that the treatment group experienced more positive emotions after watching the video, but there was no difference in achievement between the two groups. They also found a positive correlation

between emotions and student motivation. This finding was extended in a later study, where the researchers concluded that the academic emotions of boredom, enjoyment, and anger were predictors of student achievement (Kim et al, 2014).

Two studies focused on student motivation, which can be considered to be under the affective domain (McLeod, 1992). Hodges (2008) implemented a motivational email treatment, while Kim and colleagues (2014) had students fill out the Achievement and Emotion Questionnaire in Mathematics to measure motivation. Similarly, Kim and colleagues (2016) studied the effect of student volition using a virtual change agent as the treatment, which included discussions of student motivation. Both the studies found there was no difference in student motivation between the groups (Hodges, 2008; Kim et al, 2016). In all three studies, self-efficacy was used to measure student motivation. Two studies also measured intrinsic value along with self-efficacy for student motivation (Kim et al, 2016; Kim et al, 2014).

All of these studies showcase the complex, interrelated relationships between academic emotions, motivations, and student outcomes. Interestingly, Kim and colleagues (2014) showed that motivation can predict student achievement, however when emotions were added as a variable this was no longer the case. Additionally, anger was found to be the strongest negative predictor of achievement. Hodges (2008) also was able to find a positive relationship with student motivation and achievement. The research also supports the correlation of emotions and student motivation (Kim et al, 2012; Kim et al, 2014).

Student Identity

Student identity has been defined in many ways in mathematics education literature, but it is clear in the literature that a person can express multiple identities. (Darragh, 2016). For example, broadly in the academic field, Gee (2001) discussed four faces of identity that are

woven together in complex ways: nature, institution, discourse, and affinity. These faces provide the lens in which the studies can frame student identity. In mathematics education research, the term *community of practice* has been used to explore student identity in the classroom (Wenger, 1998). Out of the twenty-three studies, six studies, whether explicitly or inexplicitly, explored student identity in an online course (Dennon, 2011; Ke et al, 2011; Rosa et al, 2011; Solomon, 2007; Van de Sande, 2011; Wladis, 2015).

Solomon (2007), through interviews with undergraduate students, established a narrative of not belonging to the mathematics community and this narrative was especially strong for the females. Solomon makes the argument of pedagogy affecting student identity. For example, a student discusses the correlation of being 'smart' and of being 'fast' to answer correctly. This practice in the community can be alienating. "Much research indicates that mathematics teaching is frequently excluding, and that is treats many students as powerless and unimportant 'outsiders'" (Solomon, 2007, p.92). Many of the students reflected having a fixed mindset, which in turn created a negative mathematics identity within. This study was unclear if the students were in a face-to-face or online course. However, we can assume through the narrative of the students that it was a face-to-face mathematics course. Moreover, the negative alignment towards mathematics can be seen through any medium of instruction. With an online course, the social aspect can be challenging to create. The instructor can choose to use technology tools that allow students to interact with each other as well as the instructor to create a more welcoming and open environment to combat these negative mathematical identities students face.

Many online courses utilize discussion forums for discourse and interactions. For asynchronous courses, this could be the only form of interactions they could have with peers and the instructor. Four studies specifically collected data from discussion boards (Dennen, 2011; Ke

et al, 2011; Van de Sande; 2011; Wladis, 2015). Ke and colleagues (2011) discuss how student identity is developed in an online environment through the "artifacts that they leave in the environment," such as files or discussion forums (p. 351). A major finding from this study is that learners are not active in building their identities online. Identity presence was linked with tasks or discussions that explicitly asked students to share personal experiences.

Dennen (2011) concluded that, in a discussion board, students are less likely to challenge the position of the instructor and did not see the instructor as a discourse partner. This study explains that the identity of student and teacher, specifically the power dynamics, are more clearly stated in an online environment. For example, students would use the discussion forum for clarity or knowledge seeking on a mathematics task. The student expected a tradition role of the instructor in an online environment; mainly on feedback on tasks and knowledge giver. Van De Sande (2011) noticed that students had four types of behaviors in a discussion board: coasting, slacking, sustaining, or ramping. Coasting and slacking align with the traditional student and teacher identity of asking for help and expecting an answer. There is no personal identity presence seen in these types of post.

Rosa and colleagues (2011) viewed how multiple identities can be helpful when learning mathematics through an online role-playing game. Students created their own 'online character' that was based in a game. Through this created identity and their 'offline identity', students were able to relate to the mathematics. "Each online identity is immersed in cyberspace and experiences a new life and each individual experiences the flow of knowledge between his online identity and offline identity…" (Rosa et al, 2011, p. 88).

Instructor's Role

Instructors play a large role, in any type of course, when it comes to the delivery of content. The materials and technologies are selected by the instructor based on what they believe to be best practices for learning the content effectivity. For an online course, the instructor must make pedagogical choices based on the resources and technologies that the institution provides. Instructors "…must confront pedagogical, technological, organizational, and motivational challenges" (Weems, 2002, p.10). The choices are often based on their teacher identity. "The facilitator seemed to be naturally translating his or her regular teaching identity to the online space, whether that be teacher-centered or learner-centered, or interactive or not" (Dennen, 2011, p. 537). Research has shown that learner-instructor interaction is important for student success in an online course. "…frequent interaction between student and teacher led to high levels of engagement and lower attrition" (Morante, 2017, p. 272). Zhao et al (2005) discussed the importance of having both synchronous and asynchronous components for the student to likely have better outcomes when compared to face-to-face courses. "The lack of interactions between students and instructors as well as among students in both quantity and quality can impact a student's motivation, emotions, and cognitive processes…" (Kim, 2014, p. 174).

These challenges also are motivated by the instructor buy-in. Pan and colleagues (2012) noted that the instructors were overall satisfied with the implementation of their created videos to help with just-in-time learning and all said they would continue making these videos for future classes. However, in other cases, instructors struggle to implement new technology and lack the buy-in for their courses. Pape and colleagues (2018) discussed many challenges instructors had despite having extensive professional development with using technology in the classroom. "Even though the faculty had administrative support and PD that paired pedagogy with a

technology tool, there was some question about whether the faculty had buy-in to the innovation" (Pape et al, 2018, p.632).

Instructors are also motivated by their own needs and guided by the content. "Different disciplines had different issues to address and varying approaches for accomplishing those goals" or needs (Pan et al, 2012, p. 306). Both studies that focused on the instructor perspective addressed how technology influenced their personal pedagogy in the course (Pan et al, 2012 & Pape et al, 2018). If implementing technology conflicts with pedagogy, instructors felt the content was in danger of being pushed aside. Furthermore, the technology threatened how the content was being taught to these instructors, mainly due to loss of time. "Use the education to put emphasis on math, not take away math…" (Pape, 2018, p.629). However, if the technology provided positive feedback from students during implementation, instructors had more of a buy-in to continue its us (Pan et al, 2012). It is important to note that not all technology is created equal and should be used an online course. "At a foundational level, putting pedagogy before technology will allow for the effective delivery for online distance education courses" (Ascough, 2011, p.17). Simonson (2011) reinstates the importance of 'not one size fits all' mentality when it comes to online learning. "There is not super technology. Each has its strengths and weaknesses; therefore, they need to be combined" (Simonson, 2011, p.132). With so many options for designing an online mathematics course, professional development and faculty support needs to be accessible and research-based.

Instructors are often not prepared to teach or use "educational technologies" when hired (Caplan et al, 2004, p. 250). Furthermore, faculty have reported that "lack of adequate support to be one of the major reasons for dissatisfaction in online teaching" (Oncu et al, 2011, p. 1101). Along with the lack of support, many faculty members find that online courses require more time

and effort to develop (Caplan et al, 2004 & Hicks, 2014 & Pape el al, 2018). “The technology was seen as using up valuable instructional time” (Pape et al, 2018, p.631). The faculty are also reliant on the materials, software, and technology that the institution provides. “… the tools an institution uses and the support if offers very much influence the choices the instructors will need to make” (Simonson, 2011, p.136). The instructor’s manipulation of the online course has found to be a factor that “affects the achievement, engagement, and retention of learners” (Oncu et al, 2011, p. 1101).

With online learning research still developing, there is also a lack of theoretical perspectives and pedagogies to inform current faculty and other stakeholders. Means et al (2010) cautions that many studies have often been “ad hoc rather than theory based” and therefore the field “lacks a coherent body of studies that systematically test theory-based approaches” (p.49). The lack of relevant theories and pedagogies available for institutions and faculty can lead to frustrations when choosing the right materials and technology for an online course. The faculty are also reliant on the materials, software, and technology that the institution provides. “… the tools an institution uses and the support if offers very much influence the choices the instructors will need to make” (Simonson, 2011, p.136). The instructor’s manipulation of the online course has found to be a factor that “affects the achievement, engagement, and retention of learners” (Oncu et al, 2011, p. 1101). With all of the new advances in technology, software, and materials, institutions need to take the time to help their faculty “teach and learn with and through technology” (Burns, 2011, p. 270).

Limitations and Critiques

Research in distance education has been controversial. Meta-analyses have pointed out the substandard research in distance education, which has included varying effect sizes and the

overly reliance of achievement measures (Simonson et al, 2011; Trenholm et al, 2019, Zawacki et al, 2009). "…these studies have yielded very little useful guidance for distance education practice" (Zhao et al, 2005, p. 1837). With this in mind, critiques of the twenty-three studies are given. Majority of the studies had small sample sizes of 100 or less (n=11). Many of the studies on student achievement did not include the demographics of the sample size (Fonolahi et al, 2014, Harris et al, 2013; Jones et al, 2013; Weems, 2002; Vilardi, 2013). Based on the recommendations from the NRC, demographics must be reported in order to make sense of the findings (NRC, 2004). "…depending on the design of a study, its results may be limited in generalizability to other population and circumstances" (NRC, 2004, p. 132). It is also very important that the demographics and ability levels are equivalent if doing a comparison study between the two groups. In one comparison study between F2F and online courses, the researchers had a sample size of (n=1426) for the face-to-face courses and then only (n=300) for the online version of the same course (Fonolahi et al, 2014). The researchers of this paper also did not show the demographics of these populations. Similarly, Jones et al (2013) and Vilardi (2019) only used student outcomes as a data source. We do not know the demographics or prior achievement outcomes of the students in the study. More than likely, when comparing groups, these groups were unequal, which could affect the interpretation of the findings. With the growing population of online learners, the ability to have a larger and diverse sample size should be easier to attain. Finally, four studies used extra credit or prizes as incentive for participation (Kim et al, 2012; Hodges, 2008; Hodges et al, 2013; Moradi et al 2018). This could have impacted the students' engagement in some way, which in turn could affect the results of the studies.

As researchers, we must also be critical of the tools used to measure student attitudes and student motivation. If the tools are not correctly aligned and tested, then this may affect the overall findings. Many of the tools were crafted around face-to-face courses, but there are tools created for online courses. Hodges (2008) used the Self-Efficacy for Learning Mathematics Asynchronously (SELMA) to measure student motivation. This tool was specifically created and aligned for online courses. Two studies reworded the Achievement Emotion Questionnaire in Mathematics (AEQ-M) tool that measured student emotions to align better for the online environment (Kim et al, 2012; Kim et al, 2014). However, three studies did not address whether the tool was appropriate for measuring student attitudes or student motivation in an online mathematics course (Hodges et al, 2013; Kim et al, 2012; Kim et al, 2014). The Motivated Strategies for Learning Questionnaire (MSLQ) was used to measure student motivation in two studies, but it is unsure how aligned this tool is for online courses (Kim et al, 2016, Kim et al, 2014). Finally, Hodges and colleagues (2013) used FSMA to measure student attitudes and it was not addressed if the tool was appropriate for online courses. Again, other researchers and readers need to be critical of the tools being implemented for online courses.

Decisions in Online Courses

An instructor at the post-secondary level has some level of autotomy when it comes to how they design and implement their online mathematics course. Different delivery methods, from blended to asynchronous, can also influence how instructors design and teach their course (Ellies, 2006). This can include making decisions on what resources and tools they use. The underlying goal of the resources and tools is to provide a vehicle to promote quality learning in an online environment. Instructors have to navigate through a plethora of resources or tools in order to find what fits best for them and for their online mathematics courses.

For resources, it is important for the instructor to understand how it can fit into their instruction and then affect student learning. It is also important for instructors to be comfortable with the resource in order to model or demonstrate for students (Caniglia & Meadows, 2018). For tools, instructors must be able to understand how it works and again how it fits into supporting the instruction. Moreover, research also shows that there can also be many other factors or reasons why they use certain resources or tools that contribute to this decision-making process (Caniglia & Meadows, 2018).

In order to promote quality learning, many instructors consider how the resource or tool will affect instruction. One study specifically looked at why instructors chose to adopt open education resources (ORE) in their post-secondary courses. OREs are free resources or tools that can be reused or reworked, including interactive activities to whole courses (Jung & Hong, 2016). The researchers classified their codes into four instructional priorities: effectiveness, efficiency, appeal, and extension. Jung and Hong (2016) found that the effectiveness of the OER was the most important factor for the instructors, meaning how well the OER achieved a certain learning outcome. They also concluded that many instructors used the OERs as they are, which reflects the efficiency of a resource or tool.

Very similarly, a study followed how pre-services teachers chose website resources. Caniglia and Meadows (2018) found that the top three reasons were: usefulness, accessibility to navigation, and variety in resources. Unlike OERs, some website resources or tools have a cost. They also concluded that may of the pre-service teachers chose the website for multiple reasons.

Instructors are also bound by their institution and in turn can be influenced by their college, department, and peers. These factors can be classified under organizational priorities. Underneath organizational priorities, Hora (2012) concluded that instructors were influenced by

structural factors, such as institution type or course policies, and socio-cultural factors, such as power dynamics and social hierarchy. Further, Hora (2012) reported that instructors were also speaking to individual factors in the interviews, such as individual initiative and course pedagogy. With this study, organizational and individual factors "represented the core building blocks of decision-making" (Hora, 2012, p. 216).

Pilot Study

A pilot study was conducted in April 2020 for a graduate mathematics education course. The purpose of the study was to understand how the resources and technology tools provided by an institution affects the design and implementation of an online mathematics course through the perspective of one instructor. Instrumental case study was chosen as the approach to this study. The participant was chosen through purposeful sampling for a semi-structured interview. A fake name was used to conceal their identity. The participant was an instructor who has teaching experience with online mathematics courses at the post-secondary level as well as face-to-face courses.

The Case

Dr. Smith[1] has extension experience at the post-secondary level. From being an associate professor to associate dean to a full professor, Dr. Smith brings a wealth of knowledge of teaching undergraduate to graduate level mathematics courses. While most of their courses have been face-to-face, Dr. Smith faced the unique challenge of moving face-to-face courses to online courses due to the COVID-19 pandemic. This is the first experience of teaching fully online for

[1] Pseudonym name for participant.

Dr. Smith. Furthermore, Dr. Smith's perspective provides valuable insight of having to design and teach an online course at the post-secondary level in such a quick manner.

Needs

The design process for the online course relied heavily on student-needs. Dr. Smith discussed the importance of being able to meet the needs of all students in the course as they transitioned to online learning for the remainder of the semester. Furthermore, another student-need of being in an online course is the flexibility and sometimes personalized learning experience (Serirami et al, 2014).

> Dr. Smith: *Yeah, so I have different students. I'm trying to be flexible to figure out what their needs are. But I was really trying to think about how I am doing to meet any anticipated needs. I didn't know what the needs were going to be, but I wanted to be able to get my students all sorts of resources so that whatever works best for them to enhance their learning.*

To meet the needs of the students, Dr. Smith chose to have a variety of materials through different mediums. Dr. Smith holds Zoom meetings to answer questions, records lectures via Zoom, and post notes on Moodle, which is the online learning platform being used to host the courses. "The use of technology in education holds great promise in extending opportunities for students to learn…" (Garcia-Cabereo et al, 2018, p. 814).

Dr. Smith*: I have students who absolutely can't be at the Zoom meetings. So I'm doing different things, such as posting my handwritten notes to pre-recorded videos.*

When it comes to online learning, equity needs to be addressed and researched (Oncu et al, 2011). Equity means providing "opportunities and eliminating barriers" (NRC, 2004, p. 156). With the ever-changing demographics of classrooms at every level, this is an important issue that

needs to be addressed in an online environment. For a student to take an online course, they will need to have access to a computer, internet, and usually have to purchase some sort of software. If a student does not have consistent access to these components, then this could play a big role in how they perform in the course. Dr. Smith was fully aware of the equity issues the students in her class faced and knew that multiple access points to learning would need to be available.

Dr. Smith*: I have a student, who is now living with their siblings, and they don't have enough computers.*

Simonson (2011) states that "Using many technologies makes the design more complex and expensive" and we should try to limit what is being used (pg. 132). Overall addressing student-needs in the online course guided the design process of the online course.

Comfortability

The design and implementation of the online course also relied upon the professor's comfortability and familiarity with the technology. While the university and college provided numerous resources during this transition, Dr. Smith decided to use resources that they had familiarity of in the past, such as Zoom and Moodle.

> *Dr. Smith: So there's tons of resources that the campus offers…the department has made short videos to help people think about how you are going to upload things…but frankly, I was so used to zoom that I decided that I was going to use Zoom and record my videos through Zoom.*

It is important to note that not all technology is created equal and should be used an online course. "At a foundational level, putting pedagogy before technology will allow for the effective delivery for online distance education courses" (Ascough, 2011, p.17). Simonson (2011) reinstates the importance of 'not one size fits all' mentality when it comes to online learning. "There is not super

technology. Each has its strengths and weaknesses; therefore, they need to be combined" (Simonson, 2011, p.132). For example, Dr. Smith showcased a variety of access points for learning in the online course for their students.

Implications

The decision making process of how to design and implement an online mathematics course at the post-secondary level can be influenced by a variety of factors. Through this single case study of a professor, the factors with the most impact on the decision-making process were student-needs and comfortability. This pilot study showcased how just one professor chose to use certain technology to provide an online experience that tried to mirror a face-to-face course as close as possible. "Teachers will play a critical role in the creation of learning objects that then become automatous agents able to support..." student learning (Anderson, 2003, p. 137). However, many other potential factors were not exposed or explored in this study due to certain limitations.

One limitation is the mid-semester switch of course delivery mediums from face-to-face to online due to the COVID -19 pandemic. Dr. Smith had very little preparation for this change, which was about two weeks. Another limitation of the study is the professor's lack of experience with online courses as both an instructor and a student. Moreover, faculty members with no experience with online learning can gain so much from being a student in an online course. "The experience will give a sense of what it is like to learn online and might even inspire some practices that can be adopted in their own courses" (Ascough, 2011, p. 27). These limitations are addressed moving forward with including instructors with a wide variety of online teaching experience. The additional research interest to see if personal online experience as a student influences the creation of the instructor's own online course.

Moving Forward

From the literature review and pilot study, there are many more components that need to be researched and understood when it comes to mathematics distance education at the post-secondary level. Particularly, the research needs to be from the instructor perspective since "…the nature of the new learning paradigm of the 21st century that focuses more on the learner rather than the instructor of administrator" (Bozkurt, 2015, p. 343). Simonson (2011) reiterates that the focus should be on "what attributes of the medium can contribute to a positive, equivalent learning experience" (p. 127). To create this environment, the instructor must first make decisions on resources and technology tools to use. Some decisions will be made by the institution, while others will be up to the instructor's individual preferences. "Each institution, discipline, region, and user group will develop unique cultural practices and expectation related to their need for and use of interactions" (Anderson, 2003, p. 141). Further research of interest would look at how the resources and technology tools impact student achievement, student identity, and student attitude.

Overall, the influences or factors behind the preferences for certain resources and technology tools have not been explored in totality. Researchers have focused on just one or two overall priority factor groups, such as organizational or instructional priorities. The more that is known about the factors in the decision-making process can help future research to improve student achievement, student identity, and student attitude. The findings also give insight into instructor buy-in into certain resources and technology tools. This study was motivated and guided by the lack of knowledge of the 'wizard behind the wall.' The study aims to provide an overview of these instructors and the choice of resources and technology tools in online mathematics courses.

CHAPTER 3: Methodology

In this chapter, the methodology is discussed in detail. The theoretical framework provides the lens through which to view the research questions and the methods. The sample, data sources, and data analysis give the structure to which the study will be implemented and bounded.

Theoretical Framework

Engestrom's Activity Theory provided the theoretical framework for this study (Figure 1). At the heart, Activity Theory looks at how people, in this case mathematics instructors, learn by interacting in an "activity system", such as designing an online mathematics course (Greeno & Engestrom, 2014, pg. 128). More specifically, research of an activity system focuses on "the ways the individual components act and interact with each other" (Greeno & Engestrom, 2014, 128). In this study, the components, which are discussed below, were researched in how they interact or influence each other when designing an online mathematics course at the post-secondary level.

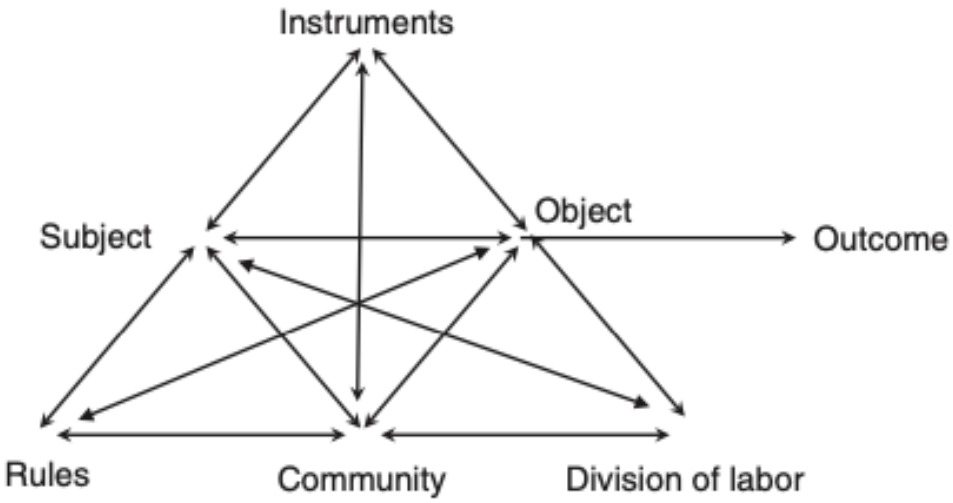
Activity theory is built upon three major components: subject, object, and outcome. In this study, the subject is the online mathematics instructor. The subject works on the object, which is the online course. The overall outcome for the instructor is to create this online mathematics course. In this study, the interaction of the instrument and subject component is of primary interest. The instruments in this case are the resources and technology tools used to build the online mathematics course. More specifically, the decision making process on how the subject chooses the instruments to build the object in order to reach the ultimate outcome.

The other components within the Activity Theory, such as rules, community, and division of labor, could also influence the decisions the instructor makes on the choice of instruments

within their online mathematics course. For example, the college or mathematics department may have certain *rules* that the instructor must abide by when designing their own online mathematics course, which may in turn influence which types of resources or tools that they can implement.

Figure 1

General model of an activity system (from Greeno & Engeström, 2014)



Research Questions

The purpose of this study was to provide understanding and insight into the resources and technologies instructors at the post-secondary level decide to use for their online mathematics courses. The main research question, followed by three sub questions to address the main question, for this dissertation study are:

How do mathematics instructors decide which resources to use when teaching online mathematics courses?

1. What resources do mathematics instructors use when teaching online mathematics courses?

2. Are there significant differences in the types of resource used by online mathematics instructors based on instructors' characteristics?
3. Why do mathematics instructors choose to use particular recourses in their online mathematics instruction?

Methods

For this study, a mixed methods design was purposefully chosen based on the research questions. "Mixed methods research provides more evidence for studying a research problem…" (Creswell & Clark, 2018, p. 51). This type of design allowed for both qualitative and quantitative data to be collected. In particular, a convergent mixed methods design guided this study (Figure 2). A convergent design's intent is to "obtain different, but complementary data on the same topic" (Creswell & Clark, 2018, p. 65). The rationale for using a convergent mixed methods design was to have a more complete picture of the topic. "…researchers gain new knowledge that is more than just the sum of the two parts [quantitative and qualitative data]" (Creswell & Clark, 2018, p. 68). With the quantitative strand, the types of resources, technologies, and instructor characteristics was collected. Instructors were also asked to elaborate on why they chose certain types of resources or tools in their online mathematics courses. This data provided just one piece of the puzzle. To complement, the qualitative strand provided insight into the decision-making process on choosing these resources and technology tools for an online mathematics course through the words of instructors.

Figure 2

Flowchart of procedures

Step 1 Data Collection	**Quantitative Data** Survey		**Qualitative Data** Semi-structure interviews (n=6) Course syllabi
Step 2 Data Analysis	**Quantitative Data** Chi-Square Test		**Qualitative Data** Descriptive and In vivo coding
Step 3 Merge Results	**Quantitative and Qualitative Data** Creating a joint table display of the separate results based on common themes and concepts		
Step 4 Interpret Results	**Quantitative and Qualitative Data** Assess data for discrepant and congruent results		

Sample

The population of interest for this study were mathematics instructors at the post-secondary level in North Carolina. This included instructors at technical colleges, community colleges, and four-year public universities. To further bound the study, the instructors must have had experience with teaching an online undergraduate mathematics course. Mathematics content is very diverse and in turn can incorporate a variety of resources and technological tools when designing an online course. By focusing on undergraduate mathematics, this eliminated outliers that could exists and allowed for a common language to be used across the analyzation.

This study had two different sample sizes for each strand of data. For the quantitative strand, convivence or nonprobabilistic sampling was used since the nature of the study does not allow for random sampling. The ideal sample size for the survey would be over 100, but the sample size of 61 was adequate to analyze. This allowed for the sample size to "meet the requirements of the planned statistical tests and provide a good estimate for the parameters of the population" (Creswell & Clark, 2018). The criteria to be included in this sample was for the instructor to have experience teaching an online undergraduate mathematics course at either at the community college or four-year institution.

To collect mathematics instructors' emails, public records requests were submitted via an online portal or email to human resources department, asking for mathematics instructor's name, school email, and rank for the Fall 2020 and Spring 2021 semesters. The University of North Carolina System (UNC System) houses all 16 four-year public universities in North Carolina. The North Carolina Community College System houses 58 community colleges that are in North Carolina. Twelve four-year public universities and twenty-one community colleges submitted their mathematics instructor's records, which resulted in 704 instructor emails to use for the survey. Once all emails were collected, a mass invite, via Qualtrics, to participate in the survey was sent out to the prospective population. After one week, a second invite was sent out to encourage participation in the survey. The survey was open for a period of two months. In total, seventy-two instructors had participated in the survey. After reviewing the survey data, eleven participants were not included in the data analysis because of incomplete data. The final sample size for the quantitative strand was 61 participants.

For the qualitative strand, participants were chosen from a subsample of the participants in the survey. Sixteen participants from the survey indicated interest for the interviews. Those

sixteen participants were ranked based on demographics through purposeful sampling. Initially, twelve participants were sent invitations, via email, to participate in the interviews. Six of those participants responded and were selected for the semi-structured interviews via Zoom. This allowed for "…cases that show different perspectives on the problem…", which is most desirable (Creswell & Poth, 2018, p. 100). The participants were equally chosen based on the type of institution they were employed by; three from community colleges and three from four-year institutions. The participants were also chosen to represent a wide range of instructional experience with traditional and online courses. Gender was also taken into consideration when choosing participants with females (n=4) and males (n=2) being represented. This variety of demographics will help with continuity of the data as well as give time for a more rigorous and in-depth data collection (Creswell & Clark, 2018). All sixteen participants to respond were white, so ethnicity was bounded. The type of mathematics course also played a factor in choosing the participants. Pre-calculus or a calculus course was chosen because a majority of participants chose this course to discuss in the survey. These courses reflected similar content that allowed for continuity for data analysis. Table 2 showcases the participants' demographics. They are listed in the order of when they interviewed.

Table 2

Demographics of interviewees

Participants	Teaching Exp.	Online Exp.	Institution	Age	Gender
Instructor A	4	3	Community	20-29	Female
Instructor B	12	5	Four-Year	30-39	Female
Instructor C	20	10	Four-Year	50-59	Male
Instructor D	15	13	Community	70+	Male
Instructor E	14	5	Community	40-49	Female
Instructor F	20	0.5	Four-Year	40-49	Female

Data Sources

Multiple data sources were collected for this study to obtain a more complete understanding of the choices and decisions instructors make for their online mathematics courses.

Quantitative Strand

For the quantitative strand, an online survey was administered, via Qualtrics, to collect a variety of data on online mathematics instructors at the post-secondary level in North Carolina in January 2021. First, the survey collected demographic data, such as age, gender, ethnicity, education level, overall instruction experience and online instruction experience. This data gave an overview description of who teaches online mathematic courses at the post-secondary level. Second, the survey asked for type of institution, four-year public or community/technical, and delivery method of their online course; hybrid, asynchronous, or synchronous. Third, the survey

gathered the types and names of resources and technology tools that the instructor chose to use in their online mathematics course. The survey specifically asked if the instructor used resources and tools in a learning management system, such as discussion forums, polls, and so on. The instructor could have also provided additional resources and tools they chose to use in their online mathematics course. The instructor was then asked to elaborate on why they chose to use a certain resource or tool. The data collected from these questions provided information on the resources and tools used in an online mathematic course. The questions which asked instructors to elaborate on the decision-making process for the resources or tools provided information on other components from the Activity Theory that influenced the design of an online mathematics course at the post-secondary level. The instructor was asked to reference just one online undergraduate mathematics course that they taught in Fall 2020 or Spring 2021 semesters. At the end of the survey, the participants had an optional choice to provide contact information for follow-up interviews.

Qualitative Strand

Two sources of data were collected from participants in this strand: interviews and their online course syllabi. A semi-structured interview protocol was designed to align with the research questions (See Appendix A). The questions were framed around their online teaching experience and choices of resources and tools used in their online mathematics courses. To further address research question 3 (RQ.3), questions based on the instructors decision-making process surrounding those choices were designed. Furthermore, questions were guided around the data from the survey about the specific resources or tools the instructors decided to use. The wording of the interview questions reflected the different components of the Activity Theory to allow for a more informed understanding of how an instructor designed an online mathematics

course at the post-secondary level. The interviews were recorded, via Zoom, with written and verbal consent from each participant. Finally, the interviews were transcribed, via Zoom and the researcher as needed. Information that could expose the participants was not transcribed due to ethical issues. The instructors were also asked to provide their course syllabi for a document analysis.

Data Analysis

Quantitative Strand

To address research question 1 (RQ.1), the data collected from the survey was first analyzed by the frequency of types of resources and tools used by the instructors. This information showcased if a certain type of resource or tool was used frequently by instructors across North Carolina. To further address research question 2 (RQ. 2), the chi-square test for independence was implemented to determine if there are any relationships between instructor characteristics, resources, and tools chosen. The chi-square test was chosen based the inclusion of frequency data from the survey data. STATA was the statistical software tool used in this study.

The courses were categorized into either a lower or higher-level course to create a new variable. Lower-level courses are open to all majors at an institution, such as pre-calculus or college algebra. Higher level courses are typically open to specific majors, such as Calculus I or Modern Algebra. The age of the instructors was also categorized into two groups to create a new variable: 20-49 and 50-70+. Finally, the rank of the instructors was also categorized: adjunct/lecturer and professors. Most instructors with a rank of professor usually have a research component with a teaching requirement, while adjunct instructors or lecturers only have a teaching component.

Eight Chi-squared tests were used to determine if there are statistically significant differences between the following variables:

1. Type of institution and online learning platform
2. Type of institution and online management system
3. Type of institution and audio/video software
4. Type of institution and type of online course
5. Type of institution and discussion forums/apps
6. Online course and type of online course
7. Education level and type of online course
8. Education level and discussion forums/apps

The first four Chi-square tests were chosen to see if there is a relationship between the type of institution and the resources and technologies that are usually provided by the institution. The last four Chi-square tests were chosen to see if there is a relationship between online experience or education level and the type of online course or use of discussion forums or apps. This measurement is created to assess the significance of a relationship between two binary variables that have two values, which is why it was chosen.

Qualitative Strand

The six transcripts were read over several times to ensure an understanding of what each participant explained and described. This helped provide a whole picture perspective before the coding process occurs. A total of 648 turns across the six transcripts were determined to be coded. For each of these turns, it is important to code for the resource or tool being specified as well as the reason for the resource or tool. This means most of the turns had two codes unless the turn is a description of an instructor's past experiences or their online course in general. The

description codes were categorized into current course, educational experience, teaching experience, and professional development or training experience. These description codes were mainly used for context and in turns were not used towards the frequencies of when analyzing.

A pre-made code list for resources and tools were created before coding occurs, such as learning management system, discussion forums, app, and so on. These codes were for identifying the types of resources and technologies an instructor described in the interview. After reading through the transcripts, the specific names of resources and tools were also added to the codebook as a sub-code. Ten categories of resources and tools were determined, which included learning management system and communication tools. There were 43 sub-codes that referenced a specific tool or resource by the instructor.

To code for the decision-making process on tools and resources, Hora (2018), which focused on organizational factors as well as individual factors, and from Jung and Hong (2016), which focused on instructional factors, were used for coding. The interview transcripts and syllabi were also coded by using descriptive coding and in-vivo coding that did not correspond to the organizational and instructional priority codes (Miles et al, 1994). These types of coding are chosen due to the nature of this study. Descriptive coding allows for the summarization of the data, while in vivo coding allows for the voice of the documents and participants to remain true (Miles et al, 1994). The descriptive coding summarizes the overall mindset through the instructor's decision-making process, such as emotions, needs, or pedagogical views, through a word or a short phrase. In-vivo coding, repeated or similar phases will be of importance to understand the instructor's decision-making process. There were 22 codes and 58 sub-codes that denoted reasonings for tools and resources. In total, there were 1209 turns across the six transcripts after coding for resource or tool and their reason.

For an example of coding, this was a turn from Instructor A's interview that was coded: *I created an* [Desmos] *activity in Module One that is really nice because it is very graphical, so I can have students playing around with the graph.* The turn above was first coded based on the resource or tool the instructor was discussed, which in this case was Desmos. Then the turn was coded for the reason or influence. In this case, Instructor A was using specific language, such as *playing around with the graph*, to indicate the priority of students being able to interact with the content. This turn was then coded to the instructional priority. Within the instructional priority, the language of the instructor aligned with the effectiveness of the resource or tool because of the priority of interactions between student and content.

Overall the coding for the decision-making process were synthesized into four themes. From Jung and Hong (2016) some codes were grouped into instructional priorities. From Hora (2018), some of the codes were grouped into organizational priorities and then some into individual priorities. While synthesizing, codes were reflecting another priority instructors were taking into consideration: design priority. These codes were mainly in the design priority were mainly around the structure of their learning management platform and how the platform worked with the other resources and tools.

The course syllabi were analyzed using a document analysis protocol that was created in line with the research questions (see Appendix B). The same pre-made code list for resources and technologies will also be used for partial coding the syllabi. Secondary coding was utilized if the resource or tool has a specific use in the course, such as a student having to buy an access code. In total there were 185 turns across the six course syllabi. The syllabi were also read for points of convergence and divergence.

Validation

For validation of the qualitative strand, there are recommendations that studies employ at least two types of validation strategies (Creswell & Poth, 2018). First, in this study, there were multiple data sources, which are the interviews and syllabi, that corroborated "…evidence through triangulation…" (Creswell & Poth, 2018, p. 211). Secondly, a peer review of the data with at least one outside person was conducted. The peer coded sections of the transcripts using the codebook that represented 32% of the total codes. This process helped build interrater reliability as well as an "external check on the highly interpretive coding process" (Creswell & Poth, 2018, p.264). The agreement rate needed to reach .80 to provide a 'strong' confidence in the interpretation of the data (Cohen, 1960). The final agreement rate with the peer coder was 0.89.

Merging of Data

The two stands of data were analyzed separately and independently. From here, the data were merged by creating a joint display around the common themes and concepts that emerged from each strand. Additionally, to address RQ.1, frequencies of resources and tools from both strands was compared in the joint display.

The merged data were then gleaned for discrepant and congruent results. In this sense, the interpretation foundation is "how the quantitative and qualitative databases tell different stories and to assess whether the statistical results and the qualitative databases are more congruent than incongruent" (Creswell & Poth, 2018, p.224). The findings were analyzed and merged to include all instructors.

CHAPTER 4: Results

In this chapter, the study findings are discussed from the quantitative and qualitative strands separately. Followed by a discussion of the findings from the merged data.

Quantitative Results

In this section, the results of the survey are interpreted. First the demographics of the 61 participants are described followed by the results of the chi-square analysis.

Demographics

The survey provides a small snapshot of an online mathematics instructor at the post-secondary level in North Carolina. Table 3 breaks down the ranks, degrees, and type of institutions of the 61 instructors that participated in the survey. The average teaching experience was 14.6 years with a range of 2.5 to 50 years with the average online teaching experience was 3.8 years with a range of 0.5 to 15 years. With online courses still being relevantly new, it is expected for instructors to have less experience teaching courses online.

Table 3

Demographics of instructors

Rank		Degree		Institution	
Full Professor	11	Doctoral	34	Four-Year	43
Associate Professor	5	Master	26	Community	18
Assistant Professor	10	Bachelors	1		
Professor of Teaching	1				
Assistant Teaching	3				
Professor Adjunct	10				
Instructor Lecturer	21				

Most instructors held a lecturer position (n=21), which teach most of the lower-level mathematics courses. Moreover, there were 31 instructors that were adjuncts or lecturers, while 30 instructors held some sort of professor rank. Many instructors had a doctoral degree (n=34). Four-year institutions were overrepresented (n=43). Not surprisingly, 91% of the instructors with doctoral degrees worked at a four-year institution with 9 of those instructors holding a rank of full professor. While if an instructor held a master's degree, the probability of working at either type of institution was about even.

Table 4 showcases the 61 instructors demographics. Over half of the instructors were between 30-49 years old (n=38). Also, over half of the instructors were also female (n=38). Then majority of the instructors were also white (n=54).

Table 4

Demographics of instructors

Age		Ethnicity		Gender	
20-29	3	White	54	Female	38
30-39	20	African-American	4	Male	23
40-49	18	Asian	1		
50-59	10	Native American/Alaskan	1		
60-69	6	N/A	1		
70+	4				

A variety of mathematics courses were represented by the survey, including low-level courses (n=36), such as developmental mathematics, to higher level degree bearing courses such as modern algebra (n = 25). Table 5 displays the overview of the types of courses, delivery method, tools, and resources from the survey. The courses represented with the highest frequencies were statistics for non-mathematics majors (n=11) and precalculus (n=11). These courses are typically offered for all students in general education requirements. Overall, there were 14 mathematics courses represented in the survey data. Synchronous courses had the highest frequencies across the survey (n=30). It is important to remember that the data was collected during the COVID-19 pandemic and many of the courses could have had to shift online. From the instructors' responses, 60% of four-year institutions offered synchronous mathematics courses (n=26), while 61% community colleges offered asynchronous courses (n=11). Hybrid courses were the least represented in this study (n=12). This could be because of

the face-to-face component of having a hybrid course. Many colleges did not offer face-to-face courses in the Fall 2020 or Spring 2021.

The resources and tools listed in Table 5 are embedded into the learning management system that instructors use for their online mathematics course. With tools, 85% of instructors chose to implement *announcements* component in their learning management system. With resources, 90% of instructors chose to upload *files* to the online management system. Out of the 29 instructors who use *discussion forums,* 25 instructors followed up with reasons why or how they use these forums in their online mathematics course.

Table 5

Overview of online mathematics courses

Course		Delivery		Tools		Resources	
Applied Math	5	Synchronous	30	Forums	29	Apps	15
Calculus I	8	Asynchronous	19	Polls	12	Files	55
Calculus II	4	Hybrid	12	Quiz	36	Videos	53
Calculus III	1			Test	34	OLP	46
Calculus non-math	1			Announcements	52		
College Algebra	6			Website	6		
Developmental	2						
Linear Algebra	3						
Modern Algebra	2						
Precalculus	11						
Statistics	2						
Statistics non-math	11						
Trigonometry	1						
Other	4						

In the survey, instructors were asked to provide specific online learning platforms, resources, and tools that they implement in their online mathematics courses. Table 6 reveals the top four online learning platforms, resources, and tools used by the instructors. There were many

more resources and tools that had a frequency of 1 or 2. In total, there were 22 different tools and resources listed by the instructors. The resources and tools in the table were chosen because they shared characteristics of the others not listed. With learning management systems, MyMathLab was discussed the most by instructors in the survey. However only 14 instructors specifically discussed an app they used in the survey and then 13 instructors discussed how they use their learning management system. Many of the specific resources and tools in Table 6 were collected from Question 9 of the survey, where 90% of the instructors explained how they chose a particular resource or tool in their online mathematics course.

Table 6

Frequencies of online learning platforms, resources, and tools

OLP		Resource		Tool	
MyMathLab	16	Desmos	10	Zoom	4
WebAssign	10	Excel	2	Gradescope	3
WebWork	4	Rossman-Chance	2	Kahoot	2
MyStatLab	3	CODAP	1	Goodnotes	2

Chi-square test results

For all chi-square tests, the null hypothesis assumed there were no relationships between the two variables with $\alpha = .05$. The teacher characteristics variables were *female, rank, doctoral, age1, four-year,* and *higher.* The resource variables were *olp* and *app.* The tool variables were *syn, polls, forums, quiz* and *tst.* Variables representing announcements, course websites, files, and videos were not used in the chi-square tests because the majority of instructors were using or not using the resource or tool.

For the first chi-square test, the data showed there was a relationship between type of institution and a synchronous course delivery method, $\chi^2(1, n = 61) = 7.42, \rho < .05$. Four-

year intuitions were more likely to hold courses synchronously compared to community colleges. More specifically, 60% of instructors at four-year institutions held course synchronously, while 78% instructors at community colleges delivered their courses non-synchronously (i.e. asynchronous or hybrid).

For the second chi-square test, the data showed there was a relationship between type of degree and a synchronous course delivery method, $\chi^2(1, n = 61) = 7.41,\ \rho < .05$. Instructors with a doctoral degree were more likely to delivery their course synchronously. More specifically, 65% of instructors with doctoral degrees held courses synchronously compared to 29% of instructors without a doctoral degree.

For the third chi-square test, the data showed there was a relationship between type of institution and the implementation of an online learning platform in an online mathematics course, $\chi^2(1, n = 61) = 8.33, \rho < .05$. Instructors at a community college were significantly more likely to use an online learning platform. All instructors at a community college used an online learning platform compared to 65% of instructors at a four-year institution.

For the fourth chi-square test the data showed there was a relationship between type of degree and the implementation of an app in an online mathematics course, $\chi^2(1, n = 61) = 4.75, \rho < .05$. At 35%, instructors with a doctoral degree with more likely to use an app in their online course, while only 11% of community college instructors used apps.

For the fifth chi-square test, the data showed there was a relationship between type of degree and employment at an institution, $\chi^2(1, n = 61) = 15.80, \rho < .05$. At 91%, instructors with a doctoral degree with more likely to be employed at a four-year institution, while 55% of instructors with a master's degree are employed at a community college.

For the sixth chi-square test, the data showed there was a relationship between type of degree and implementation of a test in a learning management system, $\chi^2(1, n = 61) = 6.60, \rho < .05$. Instructors with a non-doctoral degree were more likely to have students take a test in their learning management system at 74%.

For the seventh chi-square test, the data showed there was a relationship between type of course and a synchronous delivery method of a course, $\chi^2(1, n = 61) = 8.83, \rho < .05$. If the course was a higher-level mathematics course, then 72% were through a synchronous delivery method compared to 33% of lower-level courses.

Finally for the eighth chi-square test, the data showed there was a relationship between type of course and implementation of an online learning platform, $\chi^2(1, n = 61) = 17.16,\ \rho < .05$. Lower-level mathematics courses were more likely to implement a learning management system at 94%.

There were many other chi-square tests completed in order to fully answer RQ.2. The non-significant relationships help provide an overall picture of how characteristics may not influence the choice of a resource or tool in an online mathematics course at the post-secondary level (see Table 7). Most interesting, the data found no significant relationship between the instructors' gender and the choice of forums, polls, apps, quizzes, tests, and synchronous courses. This was also found to be true about the instructor's age.

Table 7

Non-significant relationships from the chi-square tests

Ind. Variable	Dep. Variable
female	*forums*
female	*polls*
female	*app*
female	*quiz*
female	*test*
female	*syn*
age1	*forums*
age1	*polls*
age1	*app*
age1	*quiz*
age1	*test*
age1	*syn*
higher	*forums*
higher	*polls*
higher	*app*
higher	*quiz*
higher	*test*
four-year	*forums*
four-year	*polls*
four-year	*app*
four-year	*quiz*
four-year	*test*
doctoral	*forums*
doctoral	*polls*
doctoral	*quiz*

Qualitative Results

Demographics

The average teaching experience was 14 years with an average of 6 years teaching online. The average age of the instructor was in the 40-49 age range. The courses represented were pre-

calculus (n=3), calculus I (n=2) and calculus II (n=1). The delivery method of the courses was asynchronous (n=3) and synchronous (n=3). All courses being discussed are bounded within the COVID-19 pandemic. All these instructors have moved completely online and for the most part in a remote location.

The Instructors

In this section, a brief overview of each instructor is given to provide context for the data. The instructors are listed in the order in which they were interviewed.

Instructor A is the youngest instructor to be included in the interviews, but her experience in graduate school lead to an innovative creation in her online, asynchronous pre-calculus course. Technically, her highest earned degree is a Bachelor's. However, she started on her PhD in math education but decided to take full time instructor position at a community college after 2.5 years into the program. The same community college she worked at part-time during graduate school. The community college utilizes Blackboard as their learning management system and WebAssign as the online learning platform for their pre-calculus sections.

Instructor B first started out in teaching civil engineering during undergraduate but switch to teaching mathematics courses as a graduate student. She helped develop and implemented, with a faculty member, an online course for the mathematics department during this time. After graduation, she developed and implemented another online mathematic course. The four-year institution uses Moodle as their learning management system and WebAssign as the online learning platform for their synchronous calculus I sections.

Instructor C has the most diverse teaching experience in terms of type of post-secondary institutions out of the other five instructors. He worked at both a community college and a private college in North Carolina before going back to pursue a higher degree. Now, he works at

a four-year public institution where he received his PhD. He pioneered an online course for nursing majors, which lead to a translation of skills to his own mathematics courses. His course was originally planned to be face-to-face, however the course was shifted online. The four-year institution uses Canvas as their learning management system and WebWorks as the online learning platform for their synchronous calculus I sections. WebWorks is an open-source platform, which means it is free for students and instructors to use.

Instructor D is the oldest instructor and in fact retired from the profession in 2015 but came back to teach part time at the same community college. Armed with a master's degree and experience of being in an online mathematics course, he spearheaded the mathematics department's first online course. The community college utilizes Moodle as their learning management system and MyMathLab as the online learning platform for their asynchronous pre-calculus sections. However the department chair is transitioning over to a new online learning platform that would be cheaper for students to purchase: Hawkes.

Instructor E recently changed jobs from one community college to another. She has teaching experience at both private and public-four year before finishing her PhD. Pioneering the first online pre-calculus/trigonometry course and experience as a department head lead to her seeking out information on bettering the online mathematics course experience. Instructor E has attended a multitude of trainings and professional developments on resources and tools for the online environment. The community college utilizes Blackboard as their learning management system and WebAssign as the online learning platform for their asynchronous pre-calculus sections.

Instructor F is the only instructor that has experience with teaching in the public school system before doing back to pursue her PhD, where she was also a teaching assistant. However,

at the post-secondary level, she has taught exclusively at the same four-year institution. During this tenure, she only taught face-to-face courses up until the COVID-19 pandemic forced a move to the online modality. Faced with this challenge, Instructor F foraged headfirst into a newer experience as an online instructor. The four-year institution utilizes AsULearn as their learning management system and Sapling as the online learning platform for their synchronous calculus II sections.

Interview Findings

The six instructors used a wide variety of resources and tools in their online mathematics courses. The main categories of resources and tools were learning management system, online learning system, audio/video conferencing software, apps/applets, physical tools, recording software, content resources, assessments, human resources, and communication tools. The coding for reasons why an instructor decided to use a certain resource or tool were synthesized into four themes: instructional priorities, design priorities, organizational priorities, and individual factors. The resources and tools as well as the domains will be discussed in detail below.

Resources and Tools

Compared to instructors in the past, it is fair to say technology has improved leap and bounds even over the last ten years. This has changed the way instructors have taught their courses. For example, Instructor C recalled recording lectures on VHS tapes and sending them out to students for asynchronous mathematics courses. The internet has drastically changed how distance education courses look and are implemented. Correspondingly, teaching practices at the post-secondary level have also started shift. Post-secondary instructors have relied on the "sage on the stage" model to relay content to the class, where students are primarily passive. However,

research, specifically with the rise of learning theories, has shown that active learning will yield more effective results in the classroom. Because of this, "policies and educational initiatives advocating such research-based teaching methods are based on the assumption that more effective instruction will yield multiple benefits" (Hora, 2012, p. 208). With the increase of technology and the internet, instructors at the post-secondary level have many resources and tools to choose from for their online mathematics courses.

Some of these resources or tools are required by the institution or department for the instructor to use for a particular mathematics course. For example, institutions license a certain online management system for all instructors to use for both face-to-face and online courses. Other resources and tools are optional for the instructor to use and are provided through the institution or college. This can be a wide range of resources and tools, such as video recording software to pre-made interactive activities. Outside of the institution, instructors have a plethora of resources and tools at their fingertips through the internet. Table 8 shows the top five resources or tools categories the six instructors discussed during their interviews.

Table 8

Top resources and tools implemented in quantitative study

Top Resource/Tool	Frequency	Percentage
Applets	91	22.6
Communication Tools	82	22.3
Content Resources	54	13.4
Online Learning Platforms	53	13.2
Assessments	30	7.4

The top resources and tools were applets or apps, with Desmos being the most referenced across the six instructors. Instructor A referenced Desmos the most because they created their

lessons through the applet, while Instructor C was the only instructor to not mention Desmos. The other applets mentioned were GeoGebra and virtual whiteboard apps. Desmos and GeoGebra are interactive graphing and visual applets. Virtual whiteboards allowed the instructors to “write” on a board during their live class sessions or when recording a lecture.

Communication tools were the next highest category discussed in the interviews. These included tools used to communicate during a class session, such as polls or collaboration software, as well as tools used to relay information outside of class times, such as emails. Discussion forums and polls were referenced the most throughout the interviews. Combined, applets and communication tools made up almost 50% of the references made by the instructors. Overall, the top five specified resources and tools discussed by the six instructors, in order of frequency weights, were Desmos, videos, discussion forums, polls, and WebAssign.

To further digest the results, it is also important to remember that community colleges and four-year public institutions may differ in what they offer to their instructors. For example, different colleges license different learning management systems as well as online learning platforms. Also, synchronous and asynchronous online courses can require different design components as well as the use of different resources and tools. For example, synchronous courses require the use of a video/audio conferencing software, such as Zoom or Teams. In this study, it is also noteworthy to point out that all of the community college instructors taught an asynchronous pre-calculus course and the four-year instructors taught synchronous calculus I or calculus II courses. Table 9 shows the top resources or tools used by the instructors based on where they worked.

Table 9

Top resources and tools for community colleges and four-year institutions instructors

Rank	Community College	Four-Year
1	Applets	Communication Tools
2	Assessments	Applets
3	Communication Tools	Content Resources

The community college instructors' top resource or tool was applets in their asynchronous courses, while four-year institutions instructors discussed communication tools more frequently with applets being the second most discussed. It is clear that all six instructors valued applets in their online courses, specifically the use of Desmos, which again was the most referenced tool across all six instructors. Desmos was heavily mentioned by Instructor A and Instructor E because of their course design and implementation. Communications tools were also valued by both, with instructors at a four-year institution discussing them most frequently. The top communication tool for the three instructors at a four-year institution was polls, specially within their synchronous class sessions, followed by the use of discussion forums outside of class time. For community college instructors, two specific tools were discussed at a high rate: Teams and WebAssign. It is important to note the use of Teams in this discussion was for the messaging component not the video/audio conference component of Teams. WebAssign had a high frequency due to four instructors using this as an online learning platform for homework and other assessments in their online courses. Individual instructors' top resources and tools are discussed below.

Instructor A's top mentioned resource or tool was Desmos. This is mainly due to her own creative innovation by creating interactive lessons for each topic. Instructor A also relied heavily on the use of Teams' Channels, which allows for the instructor to interact with students outside of class time for questions or help in the course. Instructor B's top resource or tool was also Desmos. She discovered how interactive Desmos can be through a collaboration with other peers when cultivating resources and tools for mathematics instructors across the UNC system to use during the COVID-19 pandemic. Instructor B also chose to unitize polls heavily during synchronous class sessions for ease of communication. Instructor C discussed recording their lectures via Zoom as well as utilizing past recorded lecture videos in his current synchronous course. Outside of class time, discussion forums allowed students to ask questions about the homework and the course in general.

Instructor D spoke frequently about the usage of "labs" in his course, which are quizzes for the students to work through outside of their homework each week. The labs allow for the content to be connected to real-world context in some topics throughout the course. Instructor D also first started using a pilot recording software, ECHO 360, to record lectures for students to watch on their own time. Instructor E discussed how VidGrid was implemented in her class to allow her to "see" students and to get to know them better since the course was asynchronous. Instructor E, first, learned about VidGrid through a training by the college. Finally, Instructor F also mostly discussed the use of Desmos in their synchronous course. Sapling, an online learning platform, also plays a big role in her course with homework, textbook, and assessments.

Themes

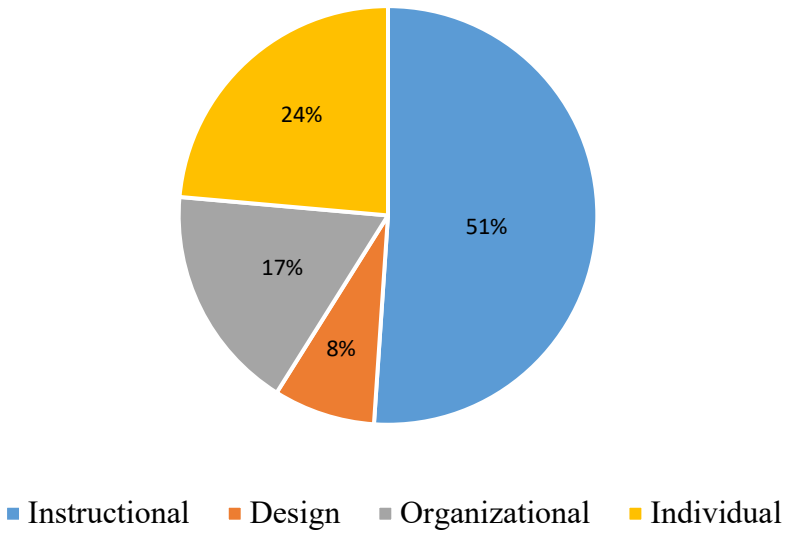
Through this study, four themes emerged as priorities the mathematics instructors used to help make decisions on the resources and tools they used in their online courses: instructional,

design, organizational, and individual. These four themes provide a way to answer RQ.3. Within each theme, sub-domains were identified that the six instructors discussed in their decision-making process on resources and tools. There are 17 sub-domains in total. Figure 3 illustrates the magnitude of the priorities for the six instructors from the coding percentages, which reflected how often each reasoning for a tool or resource was mentioned by the six instructors throughout the interviews. Overall, there were 58 sub-codes identified across the four priorities.

Instructional priorities had the most influence on the decision-making process for the instructors representing about 51% of why tools or resources were chosen. Individual priorities influenced about 24% followed by organizational priorities at 17%. Lastly design priorities had the least influence in the decision-making process across the six instructors at 8%. Within each priority, there were sub-domains that emerged. The most important sub-domains was effectiveness in the instructional priorities with an overall magnitude of 19%. After this, three sub-domains all had a magnitude of about 11%: efficiency in instructional priorities, governance in organizational priorities, and conflicts in individual priorities. An in-depth overview of each priority will be discussed below.

Figure 3

Resource and tool priorities



Instructional priorities

Instructional priorities were composed of the following sub-themes based on Jung & Hong (2016): effectiveness, efficiency, appeal, and extension. Instructional priorities had the largest magnitude of 51%, which means this priority was the most important influence or factor to the six instructors when it came to their decision-making process on resources and tools in online mathematics courses. A total of 29 sub-codes were identified in this study as an instructional priority, which accounted for 50% of the total turns identified. Table 10 shows the magnitudes for the sub-domains within the instructional priority. For all six instructors, instructional priorities had the highest magnitude of influence when choosing a resource or tool.

Table 10

Magnitude of sub-domains in the instructional priority

Instructional Priority	**Effectiveness**	38%
	Efficiency	25%
	Appeal	21%
	Extension	16%

Effectiveness

Jung & Hong (2016) defined effectiveness as "the extent to which the application of an instructional method helps achieve a learning outcome" (p. 30). Overall, for the instructors, effectiveness was discussed the most in their decision-making process for resources and tools at an overall magnitude at 19%. It is not surprising then that the magnitude within the instructional priority for effectiveness was also the largest at 38%. Instructor B and Instructor C most frequently discussed effectiveness as a factor. Within the effectiveness sub-domain, resources and tools that helped promote various interactions, active learning methods, and the ability to monitor students were accentuated by the six instructors.

All six of the instructors described how interaction was an important component for their online mathematics courses. For the three synchronous instructors, interactions were mentioned as the top reason for choosing to run a synchronous course over an asynchronous course. For Instructor C, it was important to be able to interact with her students during the week instead of simply having her students watch videos throughout the week. "I could have recorded myself doing problems, but they already had videos to watch. I mean, I was lonely too, so you want to see people." Moreover, since students and instructor cannot physically be in a classroom for interaction, instructors found tools to allow for instructor-student and student-student interaction.

For Instructor C, discussion forums allowed the students to interact with each other and the graduate assistants with the Calculus I content. Instructor C noted that the discussion forums were "a way of getting the students connected to each other, more so than me. The purpose is to try to get the students to interact and work with each other." Since the course was synchronous, it was important to Instructor C to have the students working together and interacting even outside of class times.

Within effectiveness, active learning methods were also discussed by all six instructors. Tools and resources that allowed students to explore, manipulate, and visually see various mathematics concepts in a new way were critical for the instructors. Instructor B explained, "It's just a visualization tool, but they have a little more control…. and it's so personal how people learn math and maybe they just need to see the ladder fall in order for it to click." For Instructor B, the use of Desmos allowed her students to manipulate foundational Calculus I content, such as the delta-epsilon definition of a derivative and related rates problems.

In a face-to-face classroom, an instructor can provide immediate feedback to students when they are working on problems in groups or when a student asks a question during a lecture. In an online class, immediate feedback can look very different for both synchronous and asynchronous courses. For synchronous courses, the use of tools embedded within the audio-visual conferencing software were helpful with culling feedback from students. Instructor B and Instructor C both used the chat feature in Zoom, where they could ask students questions and the students responded in the chat with their answers. The instructors also used the poll feature to get feedback from students. Instructor B enthused her love for polls by stating, "So I really love chat blast and polls for anonymous-ish feedback from everyone…You see like 45 answers flash up and then it's not so pinpointed. And then you get lots of feedback."

In an asynchronous course, students work at their own pace through the course. Because of students working through the lessons at different times means immediate feedback needs to happen at different times for students in a course. For the three instructors teaching asynchronous courses, tools and resources that could provide feedback when a student finished an activity was crucial. For Instructor A, Desmos Activity allowed her to program for immediate feedback when a student completed a question within an activity. For Instructor D, he utilized the "quiz" feature on the learning management system, where he coded for immediate feedback after a student completed a quiz. The immediate feedback or "check-ins" were imperative to all six instructors to ensure they knew how the students were progressing and to allow the students to know where they stand in their understanding of the content.

Efficiency

Efficiency is defined by the "measure of time and/or cost involved" (p. 30). In Jung & Hong (2016), cost was considered only from the perspective of the instructor. From the six instructors, cost for the student was also considered an influence in the decision-making process and in turn became a sub-code. In this study efficiency was the second most important factor at a magnitude of 25%. Instructor A discussed efficiency most frequently as a factor. Within the efficiency priority, time-saving, costs, and tool/resource capability were emphasized by the six instructors.

Resources or tools that save time can be valuable for instructors by allowing them to focus their attention on other priorities in their courses. For example, online learning platforms, such as MyMathLab, can self-grade homework and other assessments for instructors. Self-grading tools can make an impact on online courses with large class sizes, which save instructors time and energy. For example, Instructor F discussed using the online learning platform, Sapling,

provided by the department for homework and part of assessments to help with the burden of grading. She added that "the reason why I've decided to use the homework system is that…it's much faster than I can grade it."

Another time-saving factor is the ability for the resource or tool to be set-up and ready to go, meaning the instructor can make minimum edits or no edits at all to implement in their online course. Interestingly, the resources or tools that have minimum edits that the instructors discussed where required by the department, such as an online learning platform. Instructor A used WebAssign in her pre-calculus course for homework. Instructor A further explained that, "We do have the ability to make edits [in WebAssign] but I typically don't because I spend a lot of my time doing other things in the course." The pre-calculus coordination team sets up the homework for the course each semester and instructors are allowed to make edits if they so desire. However, Instructor A decided to not edit the ready to go homework in order to focus on other components.

For instructors, certain features of a resource or tool, were valuable. One feature was the ability to make simple edits to the resource or tool. For example, online learning platforms allow for instructors to create homework from a bank of questions. The creation of homework requires very little edits. Another feature was the ability to customize the resource or tool to fit the instructor's needs, such as Desmos Activity, which will be discussed later. Lastly, instructors valued if the tool or resource had technology support, such as How-To guides or customer service. While these features may not be time-saving upfront, the instructors felt it was an important feature to be able to meet the needs of their students.

For example, Desmos Activity has a computation layer, where instructors can create customized coding for the mathematics activities to fit their needs, such as adding feedback after

a student answers a question. Instructor A described, “I can code specific feedback for when a student makes a common mistake… We can also connect multiple representations with the computation layer.” While the time spent to create the customized Desmos Activity was tedious, Instructor A now has 52 Desmos activities she can use for future sections with minimal effort to implement.

Some resources or tools are required by the department for the instructor to implement in a specific course, such as an online learning management system. Because of the tool or resource being required, the department or institution could also consider cost as a factor from the student perspective. This aspect of cost was discussed specifically by Instructor C and Instructor D. Both instructors acknowledge lowering cost for students at the post-secondary level. For Instructor C, their department used an online learning platform that was free for students to use. “The price is right, because it was a NSF grant…It’s [WebWork] free for all students.” Similarly, Instructor D explained how their department was in the process of switching online learning platforms to lower overall cost for their students. While this was not explicitly stated by the six instructors, Desmos is free for instructors and students to use. Therefore, the cost, for both instructor and student, could have been a factor when deciding to implement Desmos in their courses.

For two of the instructors, cost for a tool was overridden by other priorities. This means for the instructor that cost was not a factor, and they were willing to purchase a tool or resource to implement in their courses. For example, Instructor E was accustomed to certain tablet provided by her previous community college and wanted to continue using the same tablet at her new place of employment. While her new institution offered similar tools, Instructor E stated, “But I spent about 50 bucks to get one of those tablets, where I could write on what I was doing….” Correspondingly, Instructor B purchased a tool that acted as a virtual whiteboard to

write on while using her tablet during synchronous class sessions as well as recorded video lectures. While Zoom does have a whiteboard feature that instructors or students can use, Instructor B added that the feature is difficult to write on and doesn't allow her to highlight or add visuals within the lecture, which she considered important. Even though the web and their institution have a plethora of free resources and tools to choose from, if the free tool or resource does not meet the instructor's needs then cost no longer becomes a factor. Three of the instructors specifically talked about purchasing a tool to meet their needs.

Appeal

Appeal of a resource or tool in this study was defined as the "measure of enjoyment and participation in learning" and instructing (Jung & Hong, 2016, p.30). The findings from the interviews were clear that the instructor's enjoyment of using a resource or tool was a factor in their decision-making process. However, Jung & Hong (2016) defined appeal only though the perspective of a students' enjoyment and usage. Appeal was the third most important factor in the decision-making process for the six instructors with a magnitude of 21%. Instructor B and Instructor E discussed appeal as a factor most frequently for a resource or tool.

As stated above, both student factors and instructor factors had an influence in the decision-making process on a resource or tool. For the student factors, the instructors wanted to add relevancy or make connections to the real world using a resource or tool. For Instructor C, many of his Calculus I students were pursuing a degree in engineering and would soon be in degree specific courses. In order to show the importance and relevancy of the Calculus content to their degree, Instructor C used discussion forums to showcase physics problems for students to engage with each other. He further explained, "There are specific topics, especially when you get

into the physics application for students to discuss and the discussion forum is very helpful for that."

The six instructors also valued if a resource or tool was easy to use or navigate from the student perspective. For example, Instructor A used a messaging feature in the Teams' software to communicate with students if they had questions, but to also keep them up to date on course changes. The messaging feature is very similar to texting and the students can download an app to their smartphone to use this communication feature. Instructor A noticed that many of her students were using this method to communicate with her more than emails. Instructor A further explained, "And I feel like because a lot of these students are young, they feel more comfortable doing that…it's a lot quicker to ask a question through like texting."

For the last student factor, the instructors tended to chose a tool or resource that was able to add variety to how the student could learn the material throughout the course. For the instructors, the online learning platform was where they added variety of methods for learning. Many of these platforms offer more than just homework problem sets for students to practice. Instructor D and Instructor F utilized the pre-made study plans for students, which allowed for students to go back and review topics they struggled with in the homework. All the online learning platforms the instructors implemented gave students access to the online textbook and tutorial videos.

For the teacher factors, the instructors discussed how the importance of creating an environment similar to face-to-face courses through the help of certain resources or tools. The instructors wanted to be able to see students faces in both synchronous and asynchronous courses. For example, Instructor E used Vidgrid for video introductions at the beginning of the semester. She stated, "I feel like I have a better idea of who my students are as a result." Since

there is physical distance between the students and the instructor, tools or resources that helped increased instructor presence were valued. Finally, all the instructors described the significance of being able to write mathematic notation with ease. Overall, student factors were only slightly more important than teacher factors in the decision-making process.

For asynchronous courses, students may or may not visually see their instructor through the online components. However for synchronous courses, students can see their peers and instructor through the audio-video conferencing software used for the live class sessions. For Instructor E, she wanted her students to be able to put a face to the person that was their instructor in the asynchronous course. Instructor E further explained, "Mostly I just tried to increase my presence, especially since it's somebody else's video. Like I want them to know that I'm their instructor and I want them to have a connection with me." She increased her instructor presence by making weekly videos, where she would appear in the video for students to see.

All six instructors spoke about the importance of writing class notes or visuals out as they would do in a face-to-face classroom, typically on a whiteboard or through a document camera and projector. Mathematics can require unique, content specific notation, such the Sigma or Integral notations. When a mathematics course is online, instructors must find another medium for note-taking or visuals. This can be done through a variety of tools, such as PowerPoints or recorded lecture videos. However, mathematical notation is sometimes not supported by certain software if the instructor wants to type their notes for the course or is time-consuming to create.

The six mathematics instructors used a plethora of tools to deliver content to their online mathematics courses. One tool five of the instructors used specifically was a tablet. The main reason for choosing this tool was the ability to mimic writing notes on a whiteboard either through recorded videos or screen-sharing in a synchronous course. Instructor B discussed the

ease of using a tablet in her current Calculus I online course, “Math is so much easier to teach on a tablet, like it’s the best thing in the universe. Now you can type in ODE, but you can’t type calculus I.” She recorded her synchronous courses on her tablet and used software that is similar to a whiteboard for note delivery.

For Instructor F, she had the least experience with teaching an online course, since COVID -19 forced her typical face-to-face courses to online courses. With her synchronous courses, she wanted to keep the integrity of the mathematical notations. Instructor F stated, “Math is so much easier to teach on a tablet, like it’s the best thing in the universe. Now you can type in ODE, but you can’t type calculus I.” Calculus II introduces and extends the use of complex notations and symbols. A tablet allowed her the ability to screen-share pre-made PowerPoints, where she could convert to a PDF and notate with a stylist. Overall, the synchronous courses allowed Instructor F to create an environment like a face-to-face course, where she felt comfortable and in control.

Extension

Extension, using a resource or tool, is defined as the ability to “broaden or support learning opportunities for students” (Jung & Hong, 2016, p. 33). Extension was the least important factor, within the instructional priority, in the decision-making process for the six instructors with a magnitude of 16%. Instructor A discussed extension as a factor in her decision-making process most frequently. Within the extension priority, the six instructors discussed how the resources and tools they chose supported extended learning opportunities outside of class time, such as office hours, and promoting networking within the course, such as student led discussion forums.

In the traditional college experience, students usually can attend an instructor's office hours for to ask questions and to get extra help outside of the class time. With an online course, instructors and students may be physically distanced for students to attend for face-to-face office hours. With the help of technology, there are a variety of ways students can contact their instructor to help for both face-to-face and online courses. All six instructors utilized email as their main point-of-contact for students. However, one tool changed the game for office hours: audio-visual conferencing software.

The instructors either used Microsoft's Teams or Zoom for their virtual office hours. Students are able to log on to office hours and ask questions. Five of the instructors talked about virtual office hours positively with even considering using virtual office hours for eventual face-to-face courses. Instructor F further discussed, "But actually, that's one of the things I'm going to keep doing when we're back to face-to-face. I get more people coming in virtually than walk into my office… it was way more convenient." The ease and convenience of being able to log into a virtual office hour from anywhere was a benefit to both student and instructor.

For asynchronous courses, Teams and Zoom allowed for instructors and students to interact with each other outside of destinated virtual office hours. Instructor A explained her usage of Teams, "I've decided to hold synchronous meetings, but they are optional. And I just kind of go over some of the more challenging topics of the week and give them time to ask questions." Also, through Teams, both Instructor A and Instructor E utilized the messaging or chat feature, if students wanted to contact them through that method for help during office hours. All six instructors discussed the importance of students being able to collaborate, while still being physically distant. While in a classroom, students can gather and work on projects. For online courses, groupwork must utilize tools for collaboration to occur. Instructor F implemented

Google Jamboard in her synchronous course. She explained, “I like it for the collaborative workspace…they can add typing, post it notes…” Instructor F would also be able to see what the students were doing and provide immediate feedback on their process through the problems. She actively chose Google Jamboard over Zoom’s breakout rooms. Instructor F wanted to collective see the group work and comment instead of having to go in and out of breakout rooms. This feature permitted her to give quicker feedback if students had questions or were struggling.

Overall, instructional priorities were the biggest factor in choosing a resource or tool for an online mathematics course. The effectiveness of a tool or resource was the largest factor in the instructor’s decision-making process out of all the sub-domains. Specifically, instructors were implementing tools and resources that increased human interactions and provided interactive visuals for mathematical content.

Design Priorities

Design priorities were mainly centered around how the instructors chose to set up their course, using resources or tools, through the learning management system (LMS). Most post-secondary institutions license a specific online learning management system for instructors to use for their courses, but face-to-face and online. Each section or course typically has its own website that the instructor can customize to meet their needs. Design priorities were composed of the following sub-domains: structure and course delivery. Table 11 shows the break down the magnitude of the sub-domains within the design priority.

The structure sub-domains had three components: navigation, organization, and accessibility. The course delivery sub-domain relied upon whether the instructor had a synchronous or asynchronous online mathematics course. Instructor A discussed design priority most frequently, while Instructor C only explicitly spoke about design one time during the

interview. Overall, design priorities seemed to be the least influential for the six instructors when deciding on a resource or tool for their online course.

Table 11

Magnitude of sub-domains in the design priority

Design Priority	**Structure**	64%
	Delivery	36%

Structure

Within the structure sub-theme, half of the instructors discussed designing their course website to allow for ease of navigation for students. Instructor A and Instructor E were required, by their institution, to take part in a training for how to teach online. In this training, accessibility was an important topic for the instructors to take into consideration when designing their online courses, which can include choosing their resources and tools. For Instructor A, the training influenced how she designed her Blackboard course page by making course content and information. She stated, "…because if students are just click, click, click, click, trying to find something, it could literally be overwhelming…." Instructor A designed her course in a way where students only have at the most three clicks in order to access material. This allows for students to be able to find components, such as resources and tools, easier within the course website page.

Instructor A used certain design tools within the BlackBoard LMS so that students have an easier time of navigating through the course page. The design tools Instructor A specifically implementing were using a certain number of tabs to link to important files and modules. She also used folders to represent the different modules or topics students would cover from week to

week. While this is a minute tool that many would not think of using, the impact of using the design tools can help with the effectiveness of the overall course.

Under the structure sub-domain, organization of the course website through the learning management system was the most discussed. Learning management systems play a big role in the world of online learning. Students can access course information, learning activities, assessments, gradebook, resources, and tools through this platform. More specifically, instructors can embed or link resources and tools within the learning management system. In essence, learning management systems are the ultimate tool for instructors. All six of the instructors utilized their institution's learning management system for their online mathematics courses in some manner.

Both Instructor A and Instructor D used tools to promote interaction with different components of their online mathematics courses. For Instructor A, she wanted to encourage her students to watch a weekly video which introduce the weekly topics. Because of the data tracking in the learning management system, she noticed that not many students were watching the videos. Because of this data tool, she decided to reorganize where her weekly video is in the module to encourage students to watch each week. This small data tool was important to Instructor A because she was able to reorganize her course page in order to improve her course overall. Very similar, Instructor D used a data tool to promote interaction with various components within his online asynchronous course. He explained, "…I give them a choice, they can look at my lecture or notes, and I tell them that they use whichever works best for them." Through the learning management system, Instructor D required students to click on components, such as files or videos, before they can move on to the next components. While

students have the option to open the files or videos, this required click shows the student these resources are available to them.

Accessibility also emerged from the structure sub-theme. Accessibility ensures every and all students can interact with any component in the course. “To design distance education courses and curriculums of study without acknowledging the variety of access issues that the intended audience may face can lead to the exclusion of many…” (Moore, 2013, p. 279). For the instructors, accessibility was something new for them to considered when setting up their course, but also factor when choosing certain resources or tools. Instructor A did not explicitly say what tools or resources have contributed to the course being more accessibility because of her training but expressed how important accessibility was in general. Instructor A stated, “ … the things you’re posting are accessible for student who have visual impairments or anything like that…” Instructor C also inexplicitly mentioned accessibility by discussing working with Quality Matters to get certain online mathematics certified. One part of this certification is to ensure your online course is accessible through a variety of components, which can include having transcripts for videos or audio for files.

Accessibility is not only taken into consideration for the online course page but can be a factor when choosing other tools. For example, Instructor E discussed her use of VidGrid in her course. VidGrid is a video platform that allows instructors to make videos for their courses, but also can be used as a video discussion board for students to interact. While VidGrid allowed her to “see” her students during the asynchronous course, the platform also supports audio captioning for videos. This aspect of VidGrid was important to Instructor E because this permitted her videos to be more accessible to students.

Delivery

Delivery of the course was not frequently mentioned explicitly by the instructors as a driving force behind why they chose certain tools or resources in their online course. When it was explicitly stated by the instructors, this was to confirm what type of delivery method their course was during the interview process. Overall, the delivery method was mentioned only about 2% during the interviews, which was the lowest frequency out of all of the sub-domains.

Synchronous and asynchronous courses can require different hardware and software tools instructors will need to utilize for the course to run. Instructor E discussed the differences in prep in the following quote:

> You can be teaching the same class, but if one of them is asynchronous, one of them synchronous, and one of them is a hybrid, that's really three preps even though it's the same class. Because it's a different modality and the way that you do it is going to be different…

For synchronous classes, instructors and students need access to a webcam, microphone, and an audio/visual conferencing software to attend and participant. For asynchronous courses, those three tools may not be necessary but helpful for both the instructor and students. For example, the three asynchronous instructors held virtual office hours and virtual study groups, which require an audio/visual conferencing software.

Overall, design priority held very little influence compared to the other priorities for the six instructors. The main motivation behind the design priority was building and shaping the overall structure of the online mathematics course, mainly through the learning management system. The course delivery influence was mainly seen through the usage of audio-video conferencing software for a synchronous course.

Organizational Priority

Organizational priorities were composed of the following sub-domains influenced by Hora (2012): institutional or departmental governance and department influence. Table 12 showcases the magnitude of the sub-themes within the organizational priority. A total of ten codes were identified in the organizational priorities, which accounted for 17% of the turns. Even though instructors do have a certain level of autonomy within their courses, their department and institution can influence or dictate certain things within a course, such as the use of a certain tool or the curriculum. All six of the instructors had certain elements that were required for their online mathematics courses, which shows with the higher magnitude of 65% in the organizational priorities. While a small influence in choosing resources and tools, all of the instructors reported they felt supported and inspired by their department, especially teaching during the COVID-19 pandemic. Out of all the codes, governance had 11.6% magnitude of choosing resources or tools, while department influence was only 6.5%.

Table 12

Magnitude of sub-domains in the organizational priority

Organizational Priority	**Governance**	65%
	Department Influence	35%

Governance

The six instructors taught mathematics courses that are typically taken by many students at the undergraduate level. Institutions offer multiple sections of introductory mathematics courses, in different delivery methods as well, by a variety of instructors to meet the needs of the student population. To be consistent across all of sections of the same course, institutions may

require certain components for uniformity (Hora, 2012). Instructor E stated, "…pre-calculus algebra is a pretty high stakes course….there are a ton of sections of it… and there are a lot of instructors teaching it, so for consistency there is a curriculum committee." Instructor A and Instructor C also described how their institution had a committee, formal or informal, that would meet at the end of the semester to discuss improvements or modifications to the pre-calculus or calculus I sections for the following semester. Specifically, Instructor C described, "after the semester we do a review of the system and we check for things that worked and didn't work, such as problems on WebWorks."

For the instructors, departments or the course curriculum committee required specific tools or resources instructors to implement in their online mathematics courses. The type of resources and tools that were required were mostly uniform across the six instructors. Five of the instructors had to use a certain online learning platform, such as MyMathLab or WebAssign for homework or other assessments. Instructor F had an optional online learning platform for homework that she implemented, but overall, the platform was required because this was the only way students could access their online textbook. For Instructor B and Instructor D, students could also access their required textbook through their online learning platform. Instructor C had a unique situation where the textbook was required as well as a Calculus I guided notes notebook students had to purchase for the calculus I sections.

Curriculum for introductory undergraduate courses, of any delivery method, is often dictated by the department (Hora, 2012). All instructors had to cover certain topics in their courses Again, required curriculum helps establish consistency across many sections of a course that are being taught by several different instructors. For example, Instructor E had to teach her pre-calculus course through a certain approach. She described, "But the [community college]

uses a spiral approach…. so its like looking at the broader topics and then drilling down to specific…I think they're calling it a spiral because they keep revisiting things and I think it helps reinforce."

Also, part of the required curriculum can be common assessments across all sections of a course. For example, Instructor D had to implement "labs" in his asynchronous pre-calculus course, which were essentially quizzes taken within the learning management system. Another example would be the implementation of common tests as well as common finals. Five of the instructors, sans Instructor F, had common tests and finals they had to implement in their online courses.

Assessments in an online environment can be difficult to navigate for instructors. The biggest concern for all the instructors was how can the integrity of the test be maintained in an online environment. More specifically, how does is a test administrating in an online environment? For example, Instructor A, Instructor C, and Instructor E were required to use a lockdown browser to prevent student cheating by not allowing open website tabs as well as recording student actions during test time.

Also in the governance sub-domain, professional development, whether required or volunteered, can lead to an introduction to other resources or tools that instructors can choose to implement in their course. Two of the instructors had required professional development to teach online course at their institution: Instructor A and Instructor E. The trainings were valuable for the instructors in terms of how to design and set-up their asynchronous online course using current research in distance education. Instructor E reiterated the influence of the EPIC training by stating, "It was just incredibly helpful. It was incredibly thorough class. I am really glad that I took it."

Delivery of the course may or may not be a decision the instructor can make. At times, departments or institutions can dictate the delivery to meet various needs. For example, many institutions moved to online courses during the COVID- 19 pandemic. This was the case for three of the instructors in this study. The three instructors from community colleges teaching pre-calculus courses were already scheduled to teach their courses asynchronously. However, the four-year institution instructors were allowed to choose the online delivery method, which they all chose to teach synchronously. As mentioned in the instructional and design priorities, course delivery can be a factor when choosing a resource or tool.

Department Influence

While a small influence, five of the instructors discussed how their department, specifically co-workers, were a factor when choosing a certain resource or tool. For Instructor F, this discovery for a tool occurred during an informal conversation with a colleague. She stated, "I had gotten a few and didn't like them. And a colleague of mine said she uses Notability and she described the way she sues it… and it is exactly the way I want to use it." Instructor F was struggling to find a tool that fit her needs for being a virtual whiteboard that was able to write over her PowerPoint slides during her live synchronous classes. Also, she wanted her lecture notes to be saved as a PDF to upload after class. The new tool was able to fit her requirements.

For Instructor C, the peer collaboration with the other Calculus I instructors had an impact on choosing to use a specific quiz in the class. He was looking for a way to make sure students were taking notes using the guided notebook that follows the lecture videos. A colleague suggested using a Notes-Check quiz for students to complete after each topic. This Notes-Check quiz is now used across the Calculus I sections at his institution.

Also, all six instructors responded positively when asked if they felt supported by their department. This support was crucial for Instructor A when learning a new feature on Desmos Activity in her asynchronous pre-calculus course. Desmos Activity recently updated the software to have a coding layer in the activities, so that instructors can personalize to fit their needs. Instructor A described how another faculty member, also using Desmos, was helpful when she first started coding. **"**He started coding first and so every time I couldn't figure anything out, I would run over to his office to get help." For Instructor A, this peer collaboration help extend her usage of a resource and transform the way she implemented this resource in her online course.

Overall, the organizational priority had a magnitude of 17% for instructors when choosing a resource or tool, which means close to one fifth of the discussions surrounding a resource or tool were linked to the department or institution. Most of the influence came directly from the department or institution when they required an instructor to implement a certain tool or resource in their online courses. Moreover, peer collaboration and peer influence were also a small, mostly informal, factor for the instructors in their decision-making process on resources and tools.

Individual Priority

Individual priorities were composed of the following subthemes: initiative, personal experiences, and conflicts. These sub-domains are factors that Hora (2012) also noted in their study to affect the decision-making process defined as "characteristics of the respondents themselves, but also to the individual with whom they regularly interact", which are students (p. 216). A total of thirteen codes were identified in the individual priorities, which accounted for 22% of the turns. Overall, individual priorities had a magnitude of 24%, which means about one fourth of the discussions about the decisions for resources or tools were uniquely personal to the

instructors. Instructor A and Instructor E relied upon individual priority more frequently than the other instructors to help make decisions on resources and tools.

Table 13

Magnitude of sub-domains in the individual priority

Individual Priority	**Initiative**	37%
	Personal Experience	19%
	Conflicts	44%

Initiative

The initiative sub-theme deals with the instructor taking a personal initiative to implementing a resource or tool in their online course. This sub-theme had a magnitude of 37%. Within the initiative sub-theme, the instructors discussed that lack of content resources and the drive to improve their own course experience were influences in their decision-making process. Instructor A and Instructor C, out of the six instructors, discussed how their own personal initiative was an influence when choosing a tool or resource more frequently. For example, Instructor A discussed how displeased she was with the structure of the curriculum being procedural based. She stated, “Desmos kind of forced me to do that because before students were just watching videos and it was not really interactive at all.” Because of the want to improve the course, she took initiative and started using Desmos to make the course more interactive.

While some instructors can use a resource or tool as is, other instructors want to modify or create something from scratch to meet their instructional goals. For example, Instructor F noticed that many resources were not tailored towards Calculus II content. She stated, “I find that I don’t see a whole lot for Calculus II in Desmos…it’s important to be able to see which region

in the plane of the functions are actually bounding, so I created one for that one." She knew she could modify Desmos to allow students to interact with the content in a new way in her online course.

For Instructor C, the COVID-19 pandemic allowed for him to take initiative and build a video library of his recorded lectures. He described, "The students said that they enjoy that [recorded lectures] because they can hear the interactions….they like that interaction…that its not so scripted. So, I want to make them better. I can be better." The strong positive feedback by students for the recorded lectures and the underlying desire to be a better educator has led Instructor C to wanting to improve upon his previous videos by creating a new set of recorded lectures. Even though Instructor C has used this resource of recording lectures in the past, his continued use and initiative to progress his videos is a commitment to continued use of a resource in this course.

Personal Experience

The personal experience sub-theme deals with how the instructors' past educational and past teaching experience can influence choosing a certain tool or resource in their online mathematics courses. Within the personal experience sub-theme, teaching experience and education experience were prominent in the decision-making process for the six instructors. Personal experience had a magnitude of 19%. Instructor B and Instructor E most frequently discussed that their personal experience had an influence on their decision-making process out of the six instructors.

For Instructor B and Instructor C, both had experience with building an online course from scratch. They both used their experiences to shape their current online mathematics courses. For Instructor B, she was in graduate school and co-teaching with a faculty member on

an online advanced mathematics course using videos and guided notes as tools. She liked this method of teaching online and decided to use the same tools, videos and guided notes, in her Calculus I course. For Instructor C, he started to record his lectures for his face-to-face courses as a resource for students to use a review or if they missed a class day. Because of good feedback from students, he continued recording his lectures as he transitioned to online courses via Zoom.

Conflicts

The conflict sub-theme is a unique factor that all six instructors expressed throughout the interviews. The conflicts the instructors encountered led to seeking resolutions through a resource or tool. There were five common conflicts that the instructors specified: set curriculum, online group work, online assessments, tool/resource frustration, and student stress. The conflict sub-theme had a magnitude of 44%, which was the highest influence for the instructors in the individual priority. Instructor A and Instructor F most frequently expressed conflicts being an influence in their decisions-making more frequently than the other six instructors.

Assessments in an online environment can be stressful for the student and instructor. What happens if technology fails during a timed test or quiz, such as the testing software or internet? What happens if students decide to cheat since they are not physically in a classroom taking the assessment being monitored? The six instructors had to navigate how they approached assessments, specifically tests and finals. For example, Instructor B chose to have students take their assessment over Zoom to monitor to prevent cheating. In a previous semester, she allowed students three days to take and turn in tests virtually, but quickly realized her tests were being uploaded to Chegg, which is a website where students can get help. She stated, “And that is how I will always do tests. I will watch them on Zoom. I mean if you are copying and pasting a screenshot on Chegg, I am seeing you and I will call you out.”

For three of the instructors, a lockdown browser was implemented during assessments to combat and prevent cheating by preventing students from accessing websites. The decision of using the lockdown browser came from their department. The tool can also record the student while they are taking the assessments to mimic being in a physically classroom being monitored.

The lockdown browser was a tool surrounded with controversy for some instructors. For the three instructors that did not use the lockdown browser, they discussed the conflict and how in their own terms came to their version of testing in an online course. For Instructor F, the reason why she chose to not use the lockdown browser boils down to the impression of not trusting students to have academic integrity when taking assessments in an online course. She stated, “I think that it treats the students in a way that I don’t….I don’t know ..I mean it says we don’t trust you.” While she did acknowledge that students can and could cheat on her assessments, she still chose to not use the lockdown browser. Instructor F decided to use Sapling, the online learning platform, since students are familiar with the tool for one part of the test. The second part of the test required students to handwrite solutions and upload them to the learning management system. Because of not using the lockdown browser, she created her test in a way where students could not easily find solutions via websites or problem-solving software.

For Instructor E, she had to use the lockdown browser due to a department policy for assessments, but she also expressed a conflict with using this tool. Since this course occurred early during the COVID-19 pandemic, students were mostly likely not staying on campus. With the video recording portion of the lockdown browser, students must do a scan of their environment before taking the assessment. Instructor E expressed how students were embarrassed about showing their living situation. **“**I really don’t like the [lockdown browser]. I

don't like it. Nobody does…. because it is somewhat invasive and it does create equity issues… the lockdown isn't the problem, it is the video recording part."

Another conflict some instructors faced was the set curriculum for core mathematics classes. While set curriculum allows for consistency across numerous sections of the same course, the curriculum may not align with the instructor's pedological goals. "…respondents stated that undergraduate introductory courses are constrained by the need to cover a certain amount of content…these courses tend to have distinctive pedagogical constraints…" (Hora, 2012, p. 219). The mathematics courses the six instructors were teaching are considered core mathematics courses, which are often standardized. Instructor A expressed this conflict most frequently, which led to one of the many reasons she chose to use Desmos.

Instructor A's conflict was the procedural nature of the pre-calculus curriculum. Many of the topics are centered around memorizing formulas and repetition of similar problems. The mathematics department also structured how the asynchronous pre-calculus course were to be taught, mainly through students watching videos and working on practice problems. However, instructors could make different choices in their own course. Because of autonomy and the push from curriculum conflict, Instructor chose to revamp her sections with using Desmos Activity to allow for discovery and interactions.

The biggest conflict the instructors struggled with in an online mathematics course was balancing student stress. Many of the instructors voiced how they did not want to overwhelm students with too many components in an online course. For example, Instructor E structured the number of homework problems to a length where she felt would not overwhelm students. For Instructor B and Instructor C, they both created shorter videos for students to watch as lectures because they both felt students would be overwhelmed if they knew the video was longer. For

Instructor F, it was finding a balance of tools and resources for students to be responsible for. She described this conflict below:

> As instructors to do these innovative things and that's great. Don't get me wrong, but I just don't know that we really have the notion of the cognitive toil of having you know…like I just listed five different things for my one class.

Priorities between Institutions

For the priorities, there was very little difference between instructors from a four-year institution versus community colleges in North Carolina. For both types, the priorities still held the same level of importance: instructional, individual, organizational, and then design.

Overall, four-year institution had a total of 259 turns and community college had 301 turns for reasons why they chose a certain tool or resource in their online mathematics course.

The noteworthy difference occurs with the instructional priority. Four-year institution instructors discussed the importance of a tool or resource 14 percentage points more than community college instructors. With this difference, community college instructors shifted more influence into the organization and individual priorities with both being 6 percentage points higher than four-year institutions instructors. Both types of college instructors discussed design priority the least with only 2 percentage points difference.

Within the instructional priority, the three instructors from four-year institutions discussed the effectiveness of a resource or tool more frequently with a magnitude of 46% compared to community college instructors of 28%. Overall, community college instructors discussed the effectiveness, efficiently, appeal, and extension of a resources or tools evenly with efficiency at the highest of 30%.

Within the design priority, the instructors were focused on different aspects. For the community college instructors, they discussed the structure of their online course significantly more than four-year instructors with a magnitude of 93%. The difference could be because all of the community college instructors taught asynchronously, while the four-year instructors taught synchronously. Different modes of delivery can require different design aspects.

Within the organizational priority, the sub-domains of governance and departmental influence were conferred differently. The four-year instructors discussed the sub-domains evenly with their choices of resources and tools. While community college instructors discussed how governance affected their usage of resources and tools in their online courses with a much higher frequency.

Within the individual priority, community college instructors did discuss how the individual priorities influenced their choice of resources and tools about 7% percentage points more than four-year college instructors. However, across all six instructors, inner conflicts had the most influence on choice of resources or tools in this priority.

Figure 4

Magnitude of priorities for community college instructors

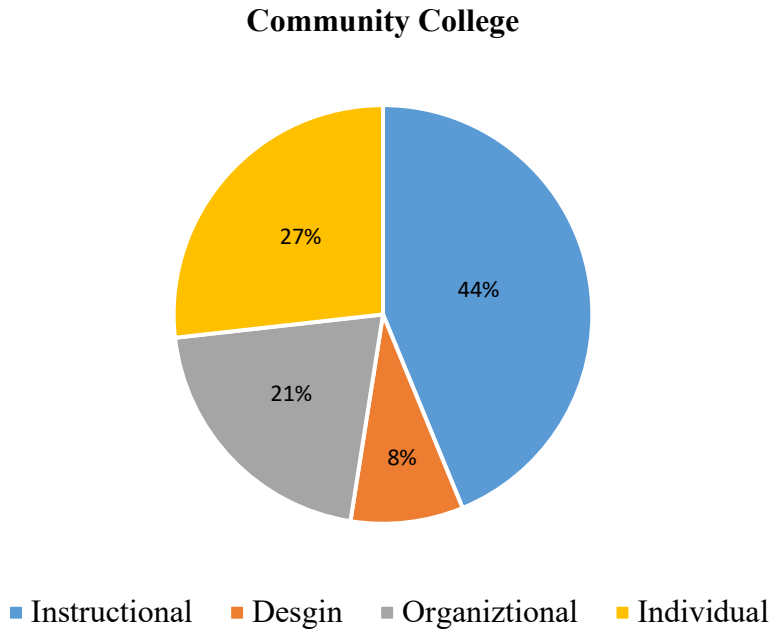
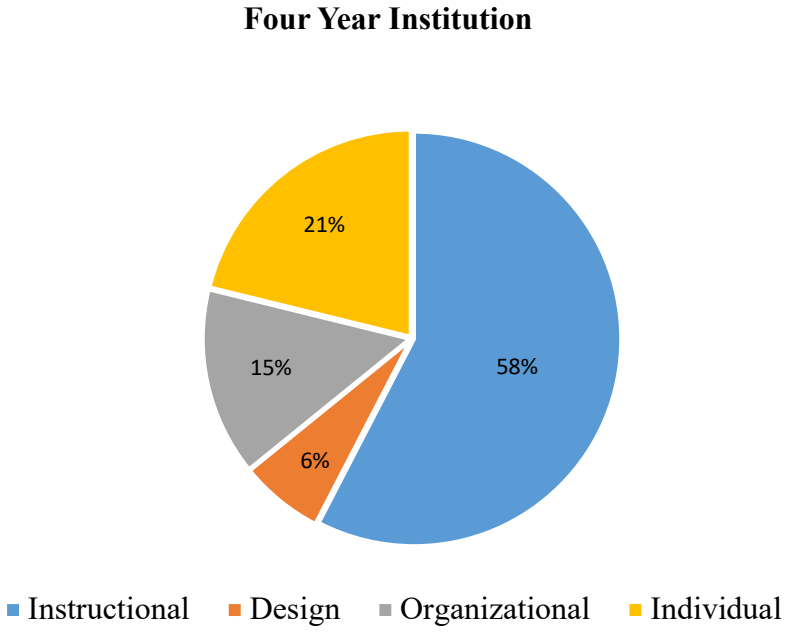


Figure 5

Magnitude of priorities for four year institution instructors



Syllabi Findings

The syllabi provided a lens to view the course from the student perspective. Syllabi can be regarded as contract between the student and the instructor. Through the syllabi, expectations of both the instructor and student are explicitly or inexplicitly stated. The student will know what content they will be learning and how they will be assessed on the content. More importantly, the student will know what resources and tools they will need to acquire to be successful in the course. The expectations for the instructor can be as simple as how communication will be handled as well as setting up dedicated time for office hours. The syllabi from the six instructors showcased how unique syllabi can be formatted but share a common language of information about their mathematics course.

One theme that emerged from the document analysis is student attendance. All but one syllabus included a section about the important of attendance for success in the course. Synchronous courses stated that attendance would be taken through the live online sessions with the video-conferencing software. This is similar to how face-to-face courses take attendance. However asynchronous course instructors do not "see" their students for class time. One asynchronous syllabus specifically stated that students must complete two items each week to count for attendance. The other courses did not state how attendance will be counted for students.

With online courses, whether synchronous or asynchronous, students need access to certain hardware and software to be successful. Again, all but one syllabus had a detailed list of required hardware and software that students needed for the course. This included access to reliable internet and a computer. Synchronous courses specifically listed that students needed access to a webcam and microphone to attend class virtually. Software requirements included

gaining access to online learning platforms or downloading lockdown browsers. The syllabi were also very clear in the type of computer or laptop that would be compatible with the required software.

Finally, each syllabus explained how students could communicate with the instructor, mainly through school email. However, half of the syllabi also gave students the option to communicate through the learning management system as well. This communication also was paired with the importance of reaching out to the instructor if the student felt they need help.

To answer RQ.1, all of syllabus named the learning management system as well as the online learning platform that students would access throughout the course. If the course was synchronous, the video/audio conference software was listed as well as the link for students. Instructor B and Instructor E's syllabi listed that students will be using Desmos throughout the course. Instructor C's syllabus was the only one to specify website links for students if they needed extra resources or help. Instructor B's syllabus was the only synchronous course to articulate that students would be recorded and being in the course gives their consent to be recorded.

Converging Results

Demographics

The sample of the overall study provides a small snapshot of an online mathematics instructor at the post-secondary level in North Carolina. In total, the sample size for the study was 61 participants. The quantitative sample size included all 61 participants. From the 61 participants, six were purposeful selected for the qualitative sample.

For the quantitative study, the average teaching experience was 14.6 years with the average online teaching experience was 3.8 years. The instructors taught at four-year public

institutions (n=43) and community colleges (n=18) in North Carolina during Fall 2020 or Spring 2021. The delivery methods of the online mathematics courses were grouped into synchronous (n=30), asynchronous (n=19), and hybrid (n=12). There were 14 different mathematics courses represented by the 61 instructors. Over half of the instructors were between 30-49 years old (n=38). Also, over half of the instructors were female (n=38). Then most of the instructors were white (n=54).

For the qualitative study, the average teaching experience was 14 years with an average of 6 years teaching online. Three of the instructors taught at community college, while the other three taught at a four-year institution in North Carolina during Fall 2020 or Spring 2021. The courses represented were pre-calculus (n=3), calculus I (n=2) and calculus II (n=1). The delivery methods of the courses were grouped into asynchronous (n=3) and synchronous (n=3). The average age of the instructors was in the 40-49 age range. The instructors identified as male (n=2) and female (n=4) and with all six being white.

Resources and Tools

In this section, the merged findings are discussed of the resources and tools the instructors utilized across this study to answer RQ.1. Second, a discussion of if and what instructor characteristics play a role in how certain resources or tools are chosen to answer RQ.2 follow.

In the quantitative study, there were seven online learning platforms identified as well as twenty-two different resources and tools being utilized by the instructors. The six instructors from the qualitative study utilized five online learning platforms and twenty-five different tools and resources for their current online mathematics courses. Table 14 exhibits the results of the resources and tools engaged by the instructors in their learning management system (LMS). The

frequencies are comparing the quantitative sample (n=61) to the qualitative sample (n=6) results. Note, that the six instructors in the qualitative study were also included in the frequencies for the quantitative.

Table 14

Merged results of resources and tools implemented

Resource/Tool	Quantitative	Qualitative	Frequencies
Announcements	52	5	85%, n=61, 83%, n=6
Apps	15	2	25%, n=61, 33%, n=6
Files	55	5	90%, n=61, 83%, n=6
Forums	29	6	48%, n=61, 100%, n=6
OLP	46	6	75%, n=61, 100%, n=6
Polls	12	2	20%, n=61, 33%, n=6
Quiz	36	4	59%, n=61, 67%, n=6
Test	34	3	56%, n=61, 50%, n=6
Videos	53	5	86%, n=61, 83%, n=6
Website	6	1	10%, n=61, 17%, n=6

The use of announcements, files, and videos were the most utilized tools or resources for the instructors to implement in their online mathematics courses. Online learning platforms were also widely used for the instructors. The proctoring of quizzes and tests through the learning management system were used by roughly 55% of all instructors. The least utilized tools or resources were apps, polls, and finally websites with usage below 25% of all instructors. The biggest difference of usage between the quantitative and qualitative results were the use of discussion forms. The most mentioned app, overall, was Desmos by the instructors (n=10).

To answer RQ.2, Chi-Square tests were implemented using the data from the quantitative study. There were eight significant results from those tests. Two of the significant results highlighted distinct characteristics of the instructors that were more likely to deliver courses

synchronously. Two of the significant results distinguished two instructor characteristics to implement OLP's in their online mathematics courses. Two of the results showcase how an instructor's degree can factor into choosing a certain resource or tool to utilize in their online mathematics course. The Chi-Square results will be compared with the qualitative data. Below are the significant Chi-Square test results.

1. Instructors from four-year institutions were more likely to delivery courses synchronously.
2. Instructors with doctoral degrees were more likely to deliver courses synchronously.
3. Instructors employed by community college were more likely to implement OLP in their online mathematics courses.
4. Instructors teaching a lower-level mathematics course were more likely to implement OLP in their online mathematics courses.
5. Instructors with doctoral degrees were more likely to utilize an app in their online mathematics course.
6. Instructors with non-doctoral degree were more likely to test in a learning management system.
7. Instructors with doctoral degrees were more likely to be employed by a four-year institution.

Out of the eight tests, there is one that cannot be compared. With the quantitative data, the findings showcased that higher level online mathematics courses were more likely to deliver classes synchronously than compared to lower-level classes. The courses represented in the qualitative study were considered lower-level mathematics courses since a variety of degrees would require students to take pre-calculus, Calculus I, and/or Calculus II. Therefore, this

significant relationship cannot be merged with the qualitative findings. The last significant result also doesn't imply that a certain instructor characteristic leads to a choice on a certain resource or tool, so this significant will not be discussed either.

The results point to two instructor characteristics that lead an instructor to deliver an online mathematics synchronously: employed by a four-institution and holding a doctoral degree. Three instructors from the qualitative study that delivered their course synchronously were employed by four-year institutions and held a doctoral degree. However, Instructor E does hold a doctoral degree but delivers their course asynchronously at a community college.

Two of the significant results distinguished two instructor characteristics to implement OLP's in their online mathematics courses: employed by a community or technical college and taught a lower-level mathematics course. Three instructors from the qualitative study that delivered implemented an OLP in their mathematics course were employed by community college and taught a lower-level mathematics course. The three other instructors also implemented an OLP in their mathematics course, but only matched to one of the characteristics: teaching a lower-level mathematics course.

Two of the results showcase how an instructor's degree can factor into choosing a certain resource or tool to utilize in their online mathematics course. Instructors with doctoral degrees were more likely to utilize an app in their course. Five out of the six instructors specifically discussed using apps/applets in their course. Out of those five, only one did not hold a doctoral degree, but Instructor A did take doctoral level courses before deciding not to complete their degree.

Instructors with non-doctoral degree were more likely to test in a learning management system. Both instructors that held a master's degree, Instructor A and Instructor D, both

implemented assessments in their LMS. Instructor D utilized Blackboard for quizzes and not testes specifically. However, all six instructors utilized their LMS in some sort of form for assessment, whether it was for testing or quizzes.

Priorities

In this section, the decision-making process of the resources and tools to answer RQ.3 will be discussed. From the qualitative results, the decision of choosing resources or tools were categorized into four priorities: design, individual factors, instructional, organizational. The codebook, from the qualitative study, was used to analyze the written responses from quantitative survey. First, the specific questions from the survey where the sixty-one instructors were able to elaborate on why they chose to implement OLP, discussion forums, and apps is discussed. Then the findings are compared with the results of the qualitative findings about OLP and discussion forums.

Results from Question 7

Question 7, from the survey, asked instructors to describe why they chose online learning platforms (OLP) in their online mathematics courses, which 75% of the instructors (n=45) answered. Every instructor that answered discussed in some form that the OLP provided the students opportunities to complete homework problems or take assessments (i.e quizzes and/or tests). A very small percentage of 6% or less of the instructors discussed how the OLP provides automatic grading of homework or assessments and/or access to an online textbook. Another small percentage of 5% or less discussed how the OLP was required by the department for the course.

Comparing the quantitative results to the qualitative results, the study showed that all six of the instructors used an OLP in their online mathematics course. Five of these were required to

use an OLP in their course by their respected departments for their mathematics course. All six of the instructors utilized their OLP for students to complete their homework, which in turn provided automatic grading. Instructor C and Instructor D both commented on the automatic grading.

For implementing discussion forums in an online mathematics course, this tool had the largest margin of difference between the studies, where about half of the instructors in the quantitative study utilized discussion forums in their online mathematics course as opposed to all six of the instructors in the qualitative study. Twenty-five instructors from the quantitative study provided reasons for implementing discussion forums. All explanations were aligned to the instructional priority, where the extension sub-domain had the highest priority for the instructors followed closely by the effectiveness sub-domain.

Specifically in the extension sub-domain, instructors utilized dissuasion boards for the purpose of providing a space to ask questions or get help from their peers. From the effectiveness sub-domain, discussion boards served the purpose of providing interaction between students as well with the content. An instructor from the survey explained, “The forums are usually to encourage student-to-student interaction and for reflections.” Both purposes of the discussion forums were discussed by the six instructors in the qualitative study.

In the survey, the instructors were able to elaborate on why they implemented a certain resource or tool in their online mathematics courses of their choosing. These results were compared with the qualitative results using the same priorities: instructional, organizational, design, and individual. Table 15 exhibits the converged results for the priorities of choosing a resource or tool. Because of the small number of comments, some of the priorities will not be

discussed thoroughly since there is a lack of data to compare the quantitative study to the qualitative study.

Results from Question 8

In Question 8, instructors were able to provide reasoning to why they choose a specific app or applet. Twelve of the instructors responded to this prompt. There was a total of 11 codes for these responses. The main apps or applets discussed by the instructors were Desmos and various statistics software. The reasoning behind choosing these types of resources were wholly in the instructional priority.

Instructors spoke to the apps ability for students to be active in learning by seeing different representations of mathematical content. The visual and interactive components of the apps and applets were a driving force in implementing in their online mathematics course. This was echoed in the qualitative study, specifically with Instructor A with Desmos. Overall, Desmos was the most discussed across the six instructors through the lens of the instructional priority. However, in the quantitative study, many of the instructors discussed the use of statistical software in their online courses. An instructor from the survey described, “I used quite a few of the Rossman-Chance applets. The applets allow me to provide a visual representation of complicated statistics ideas.” These apps/applets still fulfilled the priority of allowing students to explore the content in an interactive way and to also calculate complex statistical tests in order for students to be able to interpret what the data is saying.

The two outliers were the mandatory usage of a lockdown browser for testing by the department and the mandatory usage of Microsoft TEAMS for synchronous courses, which both reasonings are under the organizational priority.

In the survey, the instructors were able to elaborate on why they implemented a certain resource or tool in their online mathematics courses of their choosing. These results were compared with the qualitative results using the same priorities: instructional, organizational, design, and individual. Table 15 exhibits the converged results for the priorities of choosing a resource or tool. Because of the small number of comments, some of the priorities will not be discussed thoroughly since there is a lack of data to compare the quantitative study to the qualitative study.

Table 15

Merged results for priorities

Priorities	Quantitative	Qualitative
Instructional Priority	85%	51%
Organizational Priority	1.50%	17%
Design Priority	12%	8%
Individual Priority	1.50%	24%

Overall, the instructional priority was the most discussed when choosing a resource or tools by the instructors. However, the order of importance diverges for the qualitative and quantitative studies. The divergence could be from the number of survey questions, or lack of, where the instructors could explain in detail why they chose a certain resource or tool for their online mathematics course. The instructors from the quantitative study only had one chance to discuss one app/applet they used. Moreover, only one question on the survey allowed for elaboration on a resource or tool of their choice. This means the instructors only had two

questions to express their decision-making process a resource or tool of their choice, outside of discussion forums and online learning platforms.

Instructional Priority Merged Results

Instructional priority was the largest factor when choosing a resource or tool for the mathematic instructors. Table 16 compares the instructional sub-domain results. Specifically, the effectiveness of a resource or tool was the most important factor when choosing a resource or tool for the instructors in this study. Jung & Hong (2016), likewise, found effectiveness to be the most important influence or factor in the decision-making process. Then the second most important factor was the efficiency of a resource or tool. The last two factors for both groups were appeal and extension of a resource or tool. Again, this difference could be from the lack of questions requiring instructors to express motivation behind more than one resource or tool in the quantitative study.

Table 16

Merged results for sub-domains in the instructional priority

Sub-Domains	Quantitative	Qualitative
Effectiveness	51%	38%
Efficiency	20%	25%
Appeal	11%	21%
Extension	16%	16%

Effectiveness Merged Results

For the effectiveness sub-domain, instructors discussed how visualization, feedback, and the ability to monitor students were important factors when choosing a resource or tool to implement in their online mathematics course. Effectiveness held the greatest influence for the instructors.

The ability of a tool or resource to present mathematics in multiple representations was very important for instructors. Desmos, Mathematica, and various statistical software were implemented in their online mathematics courses because they allowed for students to connect content to a visual representation, such as an interactive graph or surface. An instructor from the survey described, "I use Mathematica, which is great for visualizing surfaces…." Five of the instructors from the qualitative study commented on how Desmos allowed for students to interact with the math content in a visual interactive way.

Providing feedback to students in a timely manner was another important factor when choosing resources or tools in an online mathematics course in the effectiveness sub-domain. Instructors discussed how they could program feedback for common mistakes and provide scaffolding for students when completing assignments virtually. A quantitative instructor explained, "My students use Desmos to explore topics…there are also programming options to offer feedback." This feature also occurs in some online learning platforms. Instructor D discussed how MyMathLab provided extra examples and hints for students as they complete their homework.

The ability of a tool or resource to provide monitoring was an important factor for instructors in the instructional priority, specifically to track students' progress and provide instant formative assessments virtually. One instructor from the quantitative study used Google

JamBoard to be able to monitor group work in their online course. The instructor explained, “In a seated class, I walked around and could see when most [students] finished, but now polls allow me to do that.” Instructor B talked about her use of polls in her online mathematics course to help keep students engaged as well as see if they are understanding the content in real time.

Efficiency Merged Results

For the efficiency sub-domain, the instructors discussed how a resource or tool could save time, especially when it comes to grading. In the qualitative study, Instructor C talked about how some online courses could have up to 90 students, so it would be important to have tools that could be time-saving when it comes to grading. An instructor from the survey stated, “Moodle quizzes allowed us to auto grade some questions…” As stated early, many of the instructors implements an online learning platform for students to use to complete their homework and other various assessments. Online learning platforms can auto grade for instructors.

Appeal Merged Results

For the appeal sub-domain, instructors expressed how certain tools allowed for a virtual whiteboard, where instructors can write in real-time during a synchronous course or use during a video recording for an asynchronous course. One instructor, from the survey, described, “GoodNotes is a great app for allowing you to annotate pdfs during sessions and I am able to post them on Moodle afterwards.” All six instructors in the qualitative study echoed the usefulness of a tool to mimic a whiteboard. Instructor B and F both described how important this was specifically in a mathematics course.

Also in the appeal sub-domain, instructors explained how they wanted students to feel like they were in a face-to-face course. Instructors in this study used tools that helped with

increasing instructor presence, like through personalized videos. Instructor B discussed how just keeping the camera on during her recorded videos allowed for her students to put a face to the voice. An instructor from the survey also echoed the same sediment by stating, "…. making my own videos makes class more personalized and makes students feel more like they are in a seated course."

Extension Merged Results

For the extension sub-domain, instructors expressed how tools and resources were able to provide supplemental material and a space for students to get extra help. Overall, discussion boards were the most discussed tool that were able to provide a space for students to reach out for extra help either from the instructor or peers. For many instructors, their learning management system allows for the ease of uploading old class notes sets and videos for students to use as supplemental materials. An instructor from the survey explained, "My students love to use [old class notes and old tests] in addition to my lectures to help with practice problems and studying." Similarly, Instructor C expressed how he uploaded his own lecture recordings for students to use as supplement material because of good student feedback. In fact, Instructor A, Instructor B, and Instructor E also uploaded videos and notes for students to use as extra resources for studying.

In the extension sub-domain, instructors expressed the need for tools to provide a space for students to ask questions and get extra help. Since the mathematics courses were delivered online and during the height of the COVID-19 pandemic, office hours were more likely to occur virtually. An instructor from the survey explained, "Blackboard Collaborate is used for weekly virtual tutorials with students." All six instructors in the qualitative study used various audio-video conferencing software to meet with students, such as Microsoft Teams or Zoom.

Differences of Priorities between Studies

For the qualitative study, the individual priority was the second most important factor when choosing a resource or tool. Inner conflicts were expressed by the six instructors throughout the interviews. The instructors were frustrated with set curriculum, testing in an online environment, and how to navigate the course with trying to not overwhelm students. However, for the quantitative study, this priority was discussed explicitly one time by one instructor. The instructor stated, "Pearson MyMathLab… I use it because I have to, not because I want to. It is awful. This instructor expressed their frustration with a tool that was required by the department to implement in their online course.

This difference of priorities could be to the wording of the questions in the survey. In the survey, the instructors were able to choose one or two tools or resources to discuss. It is more likely they choose based on how satisfied they were with the tool or resource. The comments made in the survey were overwhelming positive in nature about implementing this tool or resource in their online mathematics course.

For the design priority, this was the last priority for the qualitative study and the second priority for the quantitative study. The design priority consisted of two domains: organization and delivery. For the organization priority, instructors discussed how the learning management system is helpful for when uploading notes, videos, and links. An instructor from the survey described, "I use our LMS, Canvas, as tools to organize material and disseminate information to the class." The six instructors, from the qualitative study, all elaborated on how their online course was organized so that students can easily navigate through the various materials and links. Instructor A was very careful on how students should be able to reach any piece of material within three clicks of a mouse. An instructor from the survey echoed Instructor A's tone by

stating, “With hybrid instruction, students need a single location to access all class resources and see exactly what is being covered that week in class.”

Lastly in the design priority, the delivery method of the course factored into how resources or tools an instructor would need to implement. For example, synchronous courses require the need of a audio-video conferencing software, such as Zoom. Six instructors from the quantitative survey specially listed an audio-video conferencing software as a tool used in their online mathematics course. All instructors that taught synchronously used this type of software as well. Zoom and Microsoft Teams were the two software listed in this study.

The organizational priority was the third most important factor for the qualitative study and one the last factors for the quantitative study. The organizational priority is how the department or college can influence an instructor to implement a tool or resource in their courses. This was mostly seen through requirement components. In order to be consistent across all of sections of the same course, institutions will require certain components for uniformity (Hora, 2012). For consistency, the department may require a certain curriculum, online learning platform, and testing software. An instructor from the survey explained, “I don’t create my course; it is created for me so there is continuity across all the sections.” The six instructors, from the qualitative study, discussed how departmental committees would set the course curriculum from year to year with input from faculty.

Conclusion

To conclude the results, the data highlighted that post-secondary instructors in North Carolina teaching an online mathematics course implement a multitude of resources and tools. The tools and resources were grouped into ten categories, ranging from learning management systems to content resources. The resources and tools were chosen based on how they fit into

four priorities: instructional, organizational, design, and individual. The instructors discussed the most how a resource or tool fulfilled their instructional priority. For example, Desmos allowed for instructors to implement a resource that could provide visualization and discovery of mathematics content in an online environment. Certain instructor characteristics were found to be significant for implementation of certain tools and resources, such as type of college, type of degree, and type of mathematics course. In conclusion, each of the tools and resources chosen and then implemented in an online mathematics course by the instructor had a purpose which satisfied at least one of the four priorities.

CHAPTER 5: Summary, Implications, and Discussion

Introduction

In this chapter, findings are summarized through the research main question and the three sub research questions. Second, the findings will be discussed through the theoretical framework. Thirdly, limitations of the study will be presented. Finally, implications for instructors, administration, curriculum developers, professional development will be given.

The purpose of this study was to delve into the decision-making process of post-secondary instructors in choosing certain resources and tools to implement in an online mathematics course in North Carolina. In this study, survey data was used to measure the relationship of instructor characteristics and choice of resources and technology tools. Concurrently, semi-structured interviews of post-secondary instructors teaching online mathematics courses and their online mathematics syllabi documents were used to inquire into the decision-making process on resources and technology tools.

Significantly, studies of online courses at the post-secondary level often focus on the student and their attributes or achievement levels. There is a lack of research into why instructors choose certain resources and tools in an online mathematic course at the post-secondary level. Specifically, there is value in knowing what factors contribute to the decision-making process of instructors when choosing these resources and tools to use in their online mathematics course.

Summary of Findings

This study was designed to be able to answer the main research question along with three sub research questions. As a reminder, the research questions are listed below.

How do mathematics instructors decide which resources to use when teaching online mathematics courses?

1. What resources do mathematics instructors use when teaching online mathematics courses? (RQ1)
2. Are there significant differences in the types of resource used by online mathematics instructors based on instructors' characteristics? (RQ2)
3. Why do mathematics instructors choose to use particular recourses in their online mathematics instruction? (RQ3)

Research Question 1

Overall, the sixty-one instructors used and implemented a variety of resources and tools in their online mathematics course at the post-secondary level. The tools and resources were organized into the following categories: learning management systems, online learning platforms, audio-video conferencing software, apps, physical tools, recording software, content resources, assessments, human resources, and communication tools. More specifically, the use of announcements, files, and videos were the most utilized tool or resource to embed in their learning management system by 85% of participants. Online learning platforms were also widely used by the instructors with usage above 75% of the instructors. MyMathLab was the most frequently mentioned online learning platform (n=16). The proctoring of quizzes and tests through the learning management system were used by roughly 55% of all instructors. The most mentioned resource, overall, was Desmos by the instructors (n=10). The most mentioned tool overall by the instructors was Zoom (n=4). The least utilized tools or resources were apps, polls, and finally websites with usage below 25% of all instructors.

Research Question 2

To address research question 2 (RQ. 2), the chi-square test for independence was implemented to determine if there are any relationships between instructor characteristics,

resources, and tools chosen. There were eight significant test results from the quantitative study. The significant results were also compared with the instructor characteristics of the six instructors in the qualitative study to see if there was alignment. For example, the three instructors in our qualitative study that work at a four-year institution did deliver their courses synchronously, which aligned with the first significant test result below. Seven of the significant test results aligned with the instructor characteristics of the six instructors. One test result from the quantitative study could not be compared since it required instructors to teach higher level mathematics course. The six instructors in the qualitative study taught low-level mathematics courses. Below are the significant chi-square test results.

1. Instructors from four-year institutions were more likely to delivery courses synchronously.
2. Instructors with doctoral degrees were more likely to deliver courses synchronously.
3. Instructors employed by community college were more likely to implement OLP in their online mathematics courses.
4. Instructors teaching a lower-level mathematics course were more likely to implement OLP in their online mathematics courses.
5. Instructors with doctoral degrees were more likely to utilize an app in their online mathematics course.
6. Instructors with non-doctoral degree were more likely to test in a learning management system.
7. Instructors teaching a higher-level mathematics course were more likely to deliver classes synchronously.

8. Instructors with doctoral degrees were more likely to be employed at a four-year institution.

Three of the significant results highlighted distinct characteristics of the instructors that were more likely to deliver courses synchronously: instructors from four-year institutions, instructors with doctoral degrees, or instructors teaching a higher-level mathematics course. Two of the significant results distinguished two instructor characteristics to implement OLP's in their online mathematics courses: instructors teaching a lower-level mathematics course or employed by a community college. Two of the results showcased how an instructor's degree can factor into choosing a certain resource or tool to implement in their online mathematics course. From the non-significant results, the instructor characteristics of age and gender may not play as large of factor into choosing a resource or tool since none of the test results were significant.

Research Question 3

To answer RQ3, four themes emerged as priorities for the instructors when choosing resources and tools to use in their online mathematics course: instructional, design, organizational and individual. Instructional priority had the most influence on the decision-making process for all instructors in this study. Instructional priority had four sub-domains: effectiveness, efficiency, appeal, and extension. The effectiveness and then the efficiency of a resource or tool were the most important factors in the decision-making process for the instructors.

To remind the reader, Jung & Hong (2016) defined effectiveness as "the extent to which the application of an instructional method helps achieve a learning outcome" (p. 30). More specifically within the effectiveness of the resource or tool, the instructors wanted to increase overall interactions, such as student to student and student to instructor. Interactions were the

most important factor when choosing a resource or tool for the instructors since the courses were delivered online. The instructors wanted the resource to engage students with the content in an interactive or discovery manner. Finally, instructors wanted the ability to monitor students' progress and give meaningful, instant feedback.

Efficiency was defined by the "measure of time and/or cost involved" (Jung & Hong, 2016, p. 30). The most important factor for instructors within the efficiency sub-domain was the ability to customize the tool to fit their instructional needs. Secondly, the ability to save time by implementing a resource or tool that required little to no edits was also important to the instructors. Finally, the instructors leaned towards choosing resources and tools that would be free for students.

Main Research Question

To answer the main research question, the findings were synthesized from the three sub research questions. From this study, post-secondary instructors in North Carolina teaching online mathematics courses implement a plethora of resources and tools. The choice behind each of the resources and tools varied based on the instructor's needs or priorities: instructional, design, organizational, or individual. A singular resource or tool could satisfy multiple priorities the instructor may have for their online mathematics course. Moreover, the most important priority for the instructors was the instructional priority. Specifically, instructors considered the effectiveness of the resource or tool to be valuable in the decision-making process. The characteristics of the instructor also influenced a choice on a resource or tool, such as degree, type of institution, or type of mathematics course. In conclusion, the decision-making process is also not linear in nature but instead constructed like a spider's web, weaving and connecting through needs and wants of the instructor.

Discussion

In this section, the findings from this study are compared to the current research in the field. The findings are also connected to the theoretical framework: Activity Theory.

Priorities

In this study, instructors were concluded to have four main priorities that guide their decision-making process on choosing resources and tools for their online mathematics course. Instructional priority's codes were based on the study by Jung and Hong (2016). Organizational and individual priorities' codes were based on the study by Hora (2018). The design priority codes were strictly from the use of descriptive and in-vivo coding.

By a large margin, the instructors chose resources and tools based on their needs within the instructional priority. "No matter the technology, the implicit goal of their use is to facilitate quality learning" (Ellis, R. A., Steed, A. F., & Applebee, A. C., 2009, p. 313). More specifically, instructors were choosing resources and tools that they believed increased the effectiveness of their instruction in the online course. Jung & Hong (2016), likewise, found effectiveness to be the most important influence or factor in the decision-making process for instructors.

Within the effectiveness sub-domain, instructors wanted students to be an active participate be interacting with other peers and be more interactive with the content. Similarly, Trenholm & Peschke (2020) discussed there is more of an emphasis on student-led learning and discussion in online mathematics courses than face-to-face courses. Because of the delivery method, instructors are having to be more creative in how to engage students effectively. The instructors, in this study, engaged students was through the timely feedback that the resources and tools provided.

Efficiency sub-domain was the second most important factor at a magnitude of 25% within the instructional priority. In Jung & Hong (2016), efficiency was found to be the least important factor. "..they felt that the [resource or tool] did not save time or cost because finding high quality resources or tools was a very time-consuming process" (Jung & Hong, 2016, p.35). However, in this study, the instructors did not discuss how long they looked for a resource or tool. The difference is the instructors in the study were discussing tools and resources they have already chosen and implemented into their online courses.

Efficiency, for the sixty-one instructors, centered around the ability to customize a resource or tool to fit the needs of their students and course. Similarly, Zhen, Garthwait, & Pratt (2008) found that instructors' *philosophy* was an important factor when choosing to use resource or tool in an online course. They defined philosophy as the instructors' foundational belief on teaching. This is comparable because instructors in this study customized the tools and resources to meet their philosophy on teaching. For example, Instructor A customized 52 Desmos activities in order for students to interact with the content in a more dynamic way. While this took both time and effort, the outcome of the activities was more important. Similarly, Zhen, Garthwait, & Pratt (2008) found that time or time-related challenges did not affect their instructors' choice of using a resource or tool.

The other factor of efficiency that was important was cost for both student and teacher. Firstly, instructors chose resources and tools that would be free for students to use. Second instructors, themselves, were more inclined to spend money on a resource or tool they would implement, such as a tablet or app. Similarly, Caniglia & Meadows (2018) found that 40% of their 40 pre-services teachers paid more than $16 for an online resource or tool for student teaching. For the instructor, cost was not a factor in the decision making process as long as the

resource or tool satisfied other priorities they had. For example, Instructor E chose to purchase a tablet that she had previously used in online courses. The factors of comfortability and familiarity of the tool outweighed the cost of the tool. Instructor F also chose to pay for Notability, after discussing her needs with a colleague, who guided her to a tool that fit her needs.

The extension sub-domain was found to not be as important as the effectiveness and the efficiency of a resource or tool for the instructors. Extension was defined as the ability "to broaden or support learning opportunities" (Jung & Hong, 2016, p. 34). This is a different finding from Jung & Hong (2016), which found extension to be the second most important factor in the decision-making process. However, this study instructors considered the extension of a tool or resource as less of an influence than the effectiveness or efficiency.

The appeal sub-domain was also not found to be as important to the instructors as the effectiveness and the efficiency. Jung & Hong (2016) concluded that appeal was the third most important factor, which lined up with the current findings in this study. Appeal was defined as the "measure of continuing student enjoyment and participation in learning" (Jung & Hong, 2016, p. 34). Moreover, this study found that the instructor's appeal of the resource or tool was also relevant in the decision-making process. More specifically, instructors wanted tools and resources that increased their online presence, allowed them to visually see students, and the ability to write mathematical notation and symbols with ease. All these priorities were found to be a necessary in an online mathematics course. Trenholm & Peschke (2020) concluded the need for more modes of communications, including body language, to help with the learning process. One type of communication was through the ability to write mathematical notation and symbols

with ease. The instructors in this study spoke to the importance of using a tablet in their online courses to satisfy their appeal priority as a mathematics instructor.

Connecting Priorities to Activity Theory

In both the qualitative study and quantitative study, the instructors usually chose a resource or tool that satisfied more than one priority or at the least satisfied more than one sub-domain within a priority. For example, an instructor in the quantitative study discussed two reasons why they used Moodle quizzes. They stated, "I use Moodle quizzes, so that students can have immediate, detailed feedback, and to save time in grading." For this instructor, the priority was to provide timely feedback in their online mathematics course and the tool allowed the instructor to save time with the auto-grade feature of the learning management system quiz. Moreover, the priorities can be interposed in the Activity Theory, which looks at how individuals interact with different components that leads to an outcome.

To remind the reader, Engestrom's Activity Theory provided the theoretical framework for this study. Activity Theory looks at how people, in this case mathematics instructors, learn by interacting in an "activity system", such as designing an online mathematics course (Greeno & Engestrom, 2014, pg. 128). More specifically, research of an activity system focuses on "the ways the individual components act and interact with each other" (Greeno & Engestrom, 2014, 128). "Another characteristic of the activity triangle is that it is not static, because changes to any element…may impact and lead to further changes…" (Camargo-Henriquez, I., & Silva, A., 2022, p.4). This supports the idea that instructors will have multiple reasons, influences, and priorities on why they are choosing a certain resource or tool. A discussion of each of the components is below and their connection to the study and current research. Specifically,

Instructor's A decision making process of Desmos in her online asynchronous pre-calculus course is highlighted.

Activity Theory is constructed from six main components that are all interconnected leading and pushing towards the outcome. First the *subject* for our study represents the instructor teaching an online mathematics at the post-secondary level. The *instrument* represents the tool or resource that the instructor has chosen. *Rules* represent any departmental or university level governance the instructor may be constricted by, but also the instructor's own teaching philosophy they feel is important. *Community* represents the social context, more specifically this can include the influence of peers or students. *Division of labor* represents who participates in the activity and how they participate. The *object* represents the objective of the activity. All six of these components influence and shape the outcome of the activity, whether it's the intended outcome or not. Below we will look at Instructor's A decision-making process implementing Desmos in her asynchronous pre-calculus course.

It is important to note that Desmos was the most cited resource across all mathematics instructors in this study. Desmos is a free, interactive graphing applet that also offers the ability to create custom lessons or make use of pre-made lessons. For Instructor A, Desmos was a critical resource she implemented in her online mathematics course. She had eight critical factors or influences that shaped why she chose to use the tool and continue to implement in her online course. For Instructor A, Desmos satisfied the instructional priority, the individual priority, and the organizational priority.

Within the instructional priority, the effectiveness of Desmos was the most important. More specifically, Instructor A wanted a resource that could provide immediate feedback, give students the opportunity to interact with others, and allow students to interact with the content in

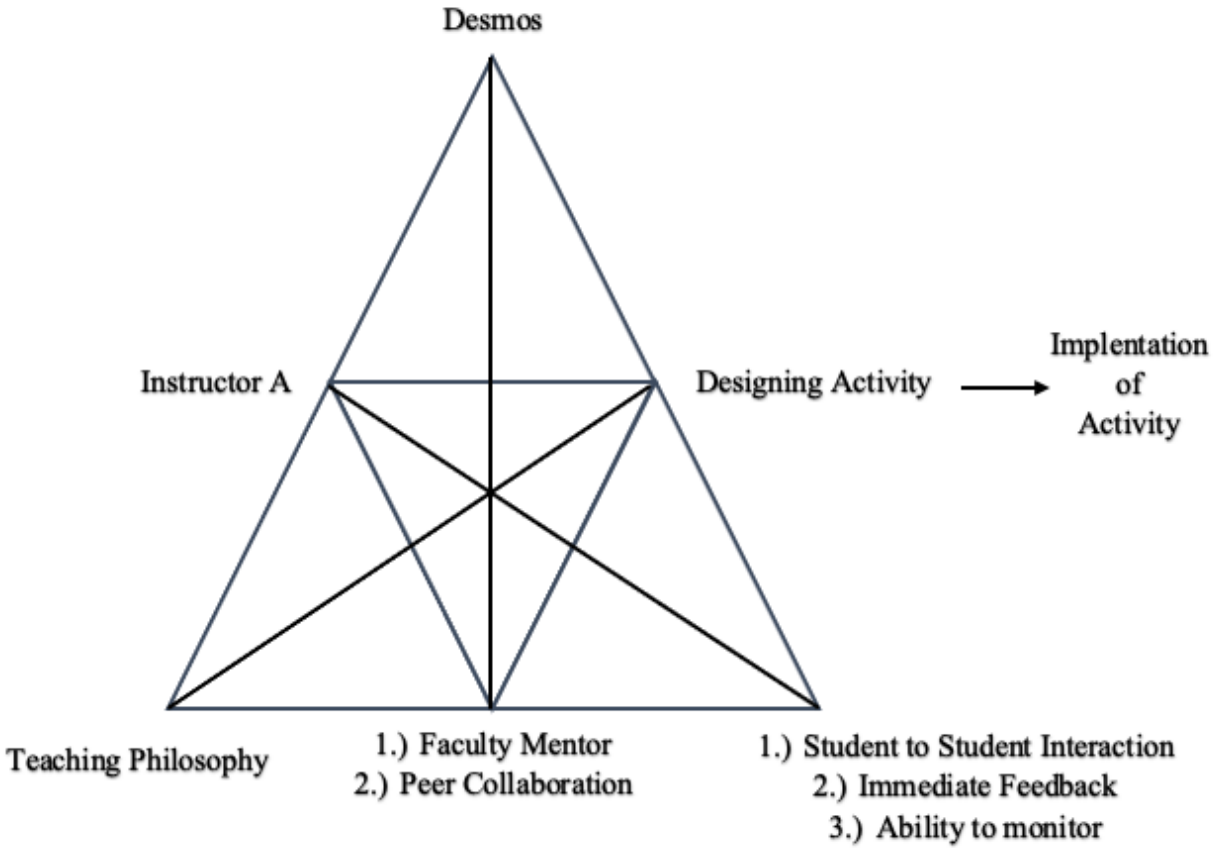
a dynamic way. She also wanted to be able to monitor students' progress throughout the semester. Within the individual priority, Instructor A was first introduced to Desmos by a faculty mentor during her graduate program. During this exposure, Instructor A helped with professional development for middle and high school teachers that was centered around the use of Desmos in the classroom. From her faculty mentor, she discovered that Desmos was much more than an interactive graphing applet. Because of the interactive features, Desmos aligned well with her own personal pedagogy. Within the organizational priority, Instructor A felt very supported by her department to try new things in the curriculum that have not been done before. She also worked closely with a colleague in the department to help design her activities within Desmos. Below are the eight reasons that led to Instructor A implementing Desmos in her asynchronous pre-calculus course.

1.) ability to provide immediate feedback to students on problems (*Division of Labor)*
2.) felt supported by mathematics department to try new things (*Community*)
3.) took personal initiative when curriculum did not line up with pedagogy (*Rules)*
4.) wanted students to actively discovery content (*Division of Labor)*
5.) wanted to increase student to student interaction (*Division of Labor)*
6.) wanted to monitor students' progress on activities *(Division of Labor)*
7.) ability to have peer collaboration on tool and resource (*Community)*
8.) introduced to resource by faculty mentor (*Community*)

The decision-making process of choosing Desmos for Instructor A was a dynamic, interconnected, and purposeful journey to implementation in her online mathematics course. Figure 6 showcases how Instructor A's decision-making process on Desmos aligns with the Activity Theory.

Figure 6

Instructor A's decision -making process on Desmos



The *subject*, Instructor A, wanted to create an activity for her online mathematics course (*object)* to implement that would meet the content standards of her pre-calculus course. She wanted to utilize a resource where students and she would be active participants in the activity based on her personal teaching philosophy (*Rules*). Explicitly, she wanted her students to interact with each other (*Division of Labor)* because the course was asynchronous. She also wanted to able to provide immediate feedback to students as well as the ability to monitor their progress through the activity (*Division of Labor)*. Because of these needs as an instructor, she recalled her experience as a graduate student working with a faculty mentor with providing professional development to public school teachers on the benefits of Desmos (*Community)*. She then decided to utilize this resource as the foundation of her activity for students. Instructor A was also able to

collaborate with a colleague on the activity to provide a more personalized touch for students (*Community*) and be able code for the immediate feedback she wanted students to have access to.

Priorities in Activity Theory

The four priorities embody the different reasons why the instructors chose resources and tools correlate with the components of the Activity Theory: *rules, community, and division of labor*. Figure 7 showcases how the priorities correlate to the components of the Activity Theory.

The instructional priority focused on active participation from both student and instructor through different interactions as well as active learning methods. For example, students interact with each other in discussion forums that the instructor sets up and monitors for completion. This type of activity correlates to the *division of labor* component because certain aspects of the activity require members to participate or provide a service.

Both the organizational and individual priorities correlate to the *rules* and *community* components within the Activity Theory. First the organizational priority had two major sub themes: requirements and peer collaboration. Some mathematics courses have set curriculum which include the required implementation of certain resources and tools. These *rules* influence the instructor, *subject*, on what resources and tools they use in their online mathematics course. The peer collaboration that can occur within the institution or more specifically a mathematics department parallel how the instructor's *community* can influence their choice of resource or tool.

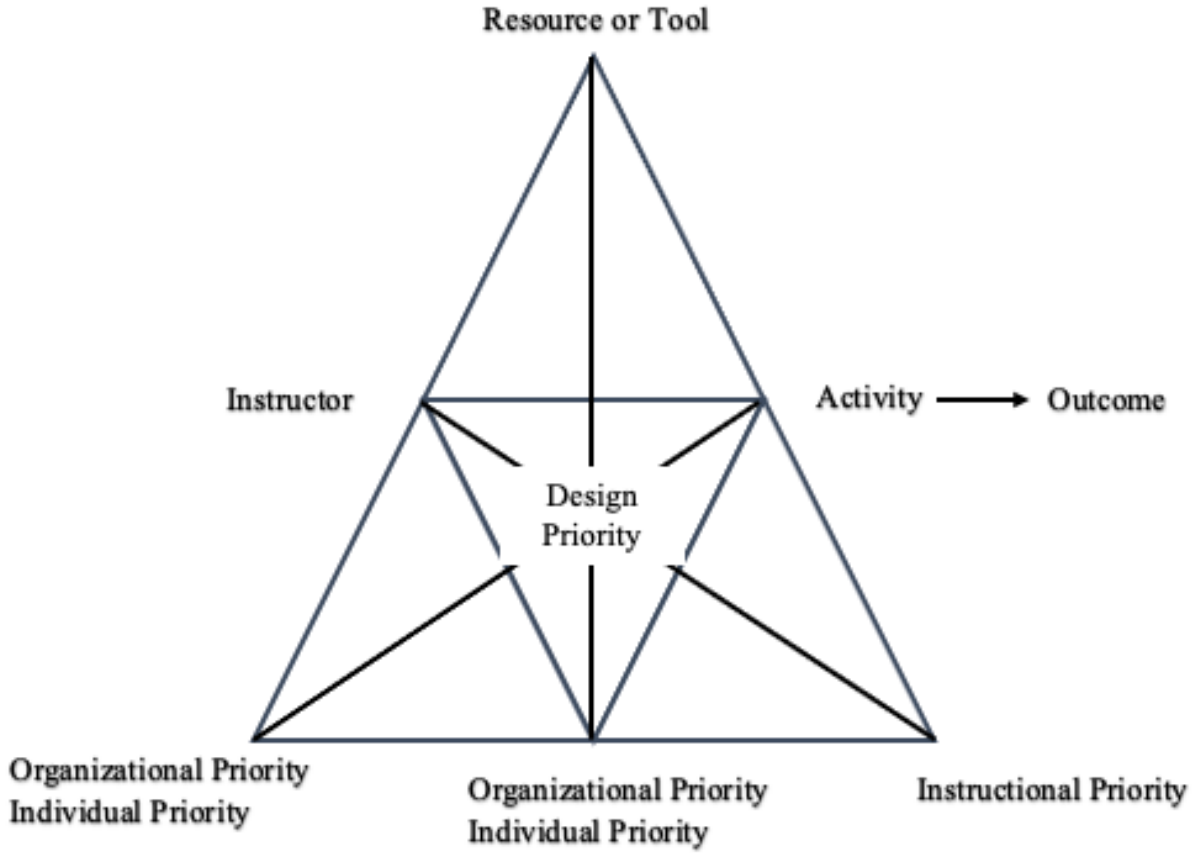
Second, the individual priority focused on how personal experiences shaped the decision making process. The instructors within this study discussed how past educational and teaching experience influenced their choice of resource and tool. The experiences helped form the instructor's personal pedagogy and how they wanted the course to be structured. For example,

Instructor B discussed how important it was to her that students were able to interact and discovery mathematics content through applets. Personal pedagogy parallels to the instructor's own set of *rules* they believe are important to follow when choosing resources and tools that reflect their pedagogy. Moreover, the experiences also tied in to the instructor's personal *community* outside of their institution. The instructors in this study discussed how mentors in their educational and teaching experiences shaped their decision making process.

Finally, the design priority centered on the overall layout of the online course. More specifically, the reasonings on the build of the online course and not on certain activities. The design priority relied on the type of online course, synchronous or asynchronous, as well as the layout and build of the learning management system for the course. Because of how central the learning management systems are to online courses, the design priority represents and captures the interconnections of the components at the center of the Activity Theory. The instructor explicitly or implicitly chooses certain resources or tools based on how they intend to design the online course. For example, Instructor F chose to use Google Jamboard in her online mathematics course for two explicit reasons. The first reason was to promote student interaction and collaboration. The second reason was the tool allowed her to monitor students progress. Both reasonings were classified under the instructional priority. However, Instructor F implicitly chose the Google Jamboard because the online class was synchronous, and the platform allowed for the student interaction and monitoring. Instructor F may or may not have chosen this tool if the course was face-to-face and therefore the design of the course influence the tool. Overall, the four priorities interact with each other in parallel to the components of the Activity Theory.

Figure 7

Priorities in Activity Theory



Implications

Researchers

For researchers, many of the data is driven from the student perspective. This study solely focused on the instructor's decision making process on tools and resources implemented. We found that the instructors' needs for a resource or tool were satisfied within the instructional priority, specifically the effectiveness of the tool or resource. This finding follows Jung & Hong (2018) study. However, this study found that the efficiency of the tool was the second most important factor for instructors. This is a different finding from Jung & Hong (2018), who found that the extension of the resource or tool was the second most important. Jung & Hong (2018)

only had 10 participants, compared to our 61 participants, from various regions in the world that participated, who did not all teach mathematics courses.

For researchers studying mathematics instructors at the post-secondary level it is important to understand two differences that were found. This study found that instructors look through different lenses in the decision-making process that Jung & Wong did not consider. First, the mathematics instructors discussed how the content influenced their choice in resources or tools, mainly through the distinct notation and symbols. For example, the simple implementation of a tablet allowed for instructors the ability to write the notation and symbols with ease. Second, the instructors also chose resources and tools based on their own singular needs with sometimes little to no influence from the student-perspective. For example, the instructors in the study were required to use certain resources or tools in their online courses, such as the online learning platforms. In contrast, Jung & Hong (2018) focused on how the student perspective influenced the instructors in their decision making process.

Moving forward, researchers need to collect data that reflects the whole picture of the instructor and their choices. The decision making process is dynamic and interconnected through usually more than one influence or priority. For example, a singular tool or resource could be utilized multiple times but for different reasons.

Administration

Administration has great influence when it comes to the resources and tools that an instructors could implement (Hora, 2012). Many of the instructors in this study were required to use at least one or more resource or tool in their online mathematics course, mainly an online learning platform that was used for homework and access to the online textbook. Administration also has a great responsibility of providing high-quality resources and tools that instructors

would have access to. Administration could make use of surveys or public forums to hear directly from faculty what their priorities are when it comes to resources and tools. Open communication between administration and faculty is important when a tool or resources has a negative influence on the student population. For example, Instructor E discussed how student came forward to administration and to her being uncomfortable with the use video-recording in the lockdown browsers

There is also the argument that instructors in the post-secondary level be trained to teach effectively in online courses. The COVID-19 pandemic exposed how necessary this skill is for all instructors. Faculty would benefit from training provided by the administration, such as Instructor A and Instructor E received by their community college.

Mathematics Instructors

The plethora of resources and tools instructors can choose from to implement in their online mathematics course may be overwhelming to navigate. Instructor F illuminated, "…we are mathematicians, we are not trained as educators." Professional development could guide instructors towards tools and resources that meet their needs or priorities. Instructor E stated, "…there are all these tools available that I don't know how to use. And some of it was learning to use them, but some of it was just learning when to use which tool." Particularly, professional development would alleviate some of the guess work on how well a resource or tool would work in an online mathematics course by providing the instructors on current research in the field.

Limitations

Overall, this research was conducted during the COVID-19 pandemic, where most universities and colleges across the country transitioned their courses to an online delivery method within a matter of weeks giving instructors very little time to plan and execute. Because

of the transition, some instructors in this study were teaching their very first online mathematics course at the post-secondary level leading to a decision making process that could have been affected by the stress of the short time frame. Meaning that these instructors may or may not have been aware of certain resources and tools that were available to implement. Other mathematics instructors may have had experience teaching online mathematics course, but their current mathematics course may have been a course solely delivered face-to-face. In this study, we also do not know if instructors had the choice of delivery for their online mathematics course. Again, this unknown for delivery could have impacted their decision making process when creating their online mathematic course.

The overall sample size of 61 is a very small representation of mathematics instructors at the secondary level across North Carolina. Moreover, the sample size represents only 8.7% of the instructors that were contacted for the survey and responded with information that was usable. Second, there was not equal representation of instructors teaching at four-year institutions (n=43) versus instructors at community colleges (n=18). Because of the difference, the data is skewed more to reflect the tools and resources utilized by instructors in a four-year institution. An equal representation of both types of post-secondary institutions would have given more insight into the commonalities and differences between the instructors. Thirdly, in this study, instructors self-reported their resources and tools they implemented in their online mathematics course. Instructors could have incorrectly represented their choices on resources and tools in the survey or left out resources and tools that they do implement. Also outside of the resources and tools utilized in their learning management system, the survey online provided instructors two chances to name and discuss their choice of resources and tools. The wording of the questions

limited the instructors to one resource or tool leading to a limited scope of the resources or tools implemented in their online mathematics course.

Lastly for the quantitative strand, most participants were white and for the qualitative strand, all the participants were white. Again, this does not give a full representation of instructors at the post-secondary level in North Carolina. The Southern Regional Education Board (2021) reported that only 14% of faculty across North Carolina were people of color. We can assume that percentage is smaller for mathematics instructor who are people of color. In the quantitative study, seven out of the sixty-one instructors were people of color resulted in 11% of faculty represented.

Suggestions for Future Research

This study took a wide lens on the decision-making process for instructors teaching an online mathematics course at the post-secondary level. Future research on the decision-making process, specifically for online courses, needs to have a narrower focus. From this study, instructors were found to have four priorities when choosing resources and tools to implement in their online mathematics courses. Implementing an instrumental case study on a few mathematics instructors to focus on just one of the priorities would provide a better perspective of the entire decision making process.

Even more specifically, research on the decision-making process on a synchronous versus asynchronous courses would be valuable to see if there is a shift in the priorities based on the modality of the course. While the six instructors did not explicitly state that the modality of the course was an influence, the delivery of the course was found to have an impact certain choices. It would be beneficial to conduct a case study on an instructor that teaches the same mathematics

course but in both modalities to see how their decision making process shifts when designing and implementing the mathematics course.

While some instructors may not agree with the choice of resource or tool by the department or institution, instructors did not mention that they refused to implement them in their online course. For example, an instructor from the quantitative study stated, “Pearson MyMathLab… I use it because I have to, not because I want to. It is awful.” A qualitative research study would be beneficial to see how the conflict with a resource or tool influences the implementation in the course. Do the instructors use the resource or tool as the department intended? The findings would provide insight into how instructors are utilizing the required resources and tools in their online mathematics courses. Departments would be able to make definitive choice on how to allocate funds for the resources or tools.

Since this study was self-reported by the instructors, their meaning of the effectiveness of the resource or tool could have varied from instructor to instructor. Our study never asked how the instructors defined the effectiveness and how their definition influences their decision making process. Example research questions would be: how does the instructor determine the effectiveness of the resource or tool? How does this definition change due to the modality of the course? A quantitative study would be able to provide a large-scale insight into how instructors define effectiveness of a resource or tool.

Overall, this study found that the instructors have four priorities that influence their decision making process. Research needs to hone in on each of the four priorities to provide a more inclusive, insightful findings of the decision-making process for mathematics instructors. Moreover, research on the delivery of the online mathematics courses influencing the four priorities would be beneficial.

Closing Remarks

Online mathematics courses present a different set of challenges for instructors as they navigate through the initial design or redesign of a course. Unlike in face-to-face courses, instructor and students are separated physically and may not have a set class time during the week. Therefore, instructors must make decisions on how students interact with the content as well as how to design the course for the student to navigate, usually through the learning management system. The resources and tools chosen helped in designing the course as well as how students engage in the course. Overall, instructors have the power in how students interact in the online mathematics course. This study provided a better understanding of how mathematics instructors choose certain resources and tools to implement in their online courses.

Mathematics instructors in North Carolina teaching online mathematics courses have a dynamic decision-making process on choosing resources and tools to implement. The instructors implemented a variety of resources and tools in their online mathematic courses, such as online learning platforms to tablets. The decision making process for the instructors is an every-changing, interconnected process. The instructors sought out tools and resources that satisfy four priorities: instructional, organizational, design, and individual. More important, the instructors sought out tools and resources that satisfied the instructional priority. Instructors looked for tools and resources that allowed for an interactive experience with the content and also provided feedback to students as they progress through the material.

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APPENDICES

Appendix A

Interview Protocol

Time of interview:

Date:

Place: Zoom

Interviewer: Taylor NeSmith

Interviewee: Instructor

Position of Interviewee: The person instructs an online mathematics course at a post-secondary school or college.

Description of Project: My goal of this project is to understand and provide insight into the resources and technologies instructors at the post-secondary level decide to use for their online mathematics courses

Questions:

1. Describe your overall instructional experience.
2. Describe your online mathematics course experience.
3. Describe your pedagogical philosophy.
    a. How does this affect your creation of your online course?
4. Does your institution affect your creation of your online course? If so, how?
5. Does your department affect your creation of your online course? If so, how?
6. Based on the survey, your online class was [insert delivery method used]. How was this choice made?
7. What resources and technologies are you using for your online course? Describe the decision process behind choosing these resources and technologies for your online course? (I will be using survey data for this question.)

   a. To clarify, you chose [insert mathematics course from survey] to discuss and this course was [insert delivery method].
   b. Can you elaborate on why you chose Discussion Forums for your online course? Can you give an example of a forum you have used or plan to use?
   c. Can you elaborate on why you chose to use polls? Can you give an example of a poll(s) you have used or plan to use?
   d. Can you elaborate on why you chose to use an online learning platform [insert specific name used]?
   e. Can you elaborate on why you chose to use [insert app/applet from survey] in your online course?
   f. Can you elaborate on why you chose to use [insert resource or tool from Question 9] in your online course?
8. What trainings or professional development have your participated in for online learning?
   a. Were they helpful?
   b. In what ways?
9. Describe the decision process behind creating content for your online course.
10. Describe your feelings of teaching an online course vs a face-to-face course for math.
11. Describe some of the activities and assignments that you utilize for your online course.
12. If you taught an online course again, what would you do the same and/or differently?
   a. Why?

Appendix B

Document Analysis Protocol

Collection of documents	The instructors that will participate in the qualitative strand will be asked to provide current syllabi for their online mathematics course.
Usefulness of documents	The syllabi will be analyzed for phases that indicate that the course is an online course. -online -hybrid -asynchronous -synchronous -virtually
Determining authenticity of documents	I will check the university or college for the instructor's courses and that they are listed as Instructor-On-Record.
Research questions	1.) How is the online course defined from the syllabus? 2.) What are the resources and technologies listed?

Appendix C

Instructor's Resource Choice Survey

You are being asked to complete a survey for research purposes. The survey is about the types of resources and technology that undergraduate mathematics instructors choose to use for their online course. Completing this survey is voluntary and you can stop at any time by exiting out of the browser.

You must be 18 years of age or older and reside in the United States to participate in this study.

There are minimal risks associated with your participation in this survey. You will receive or will not receive any payment for completing this survey.

If you have any questions about the survey itself, how it is implemented, or survey compensation, please contact Courtney Taylor NeSmith, (912) 294-6641, ctnesmit@ncsu.edu or Dr. Erin Krupa (Advisor), (919) 513-2803, eekrupa@ncsu.edu.

Please reference study number 23539 when contacting anyone about this project.

If you have questions about your rights as a participant or are concerned with your treatment throughout the research process, please contact the NC State University IRB Director at IRB-Director@ncsu.edu, 919-515-8754, or fill out this confidential form online.

If you consent to complete this survey, please click on the link below to access the survey.

Start of Block: Purpose of Survey

The purpose of this dissertation study is to understand what factors contribute to the instructor's decision-making process in choosing the resources and technology tools to use in their online mathematics course. This survey will ask you to provide what resources and technology tools you have used in your online mathematics course and why.

Q1 Do you consent to participating in this survey?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Do you consent to participating in this survey? = No

End of Block: Purpose of Survey

Start of Block: Required Information in order to take survey

Q2 Have you or are you teaching an online or hybrid mathematics course at the post-secondary level for Fall 2020 semester or Spring 2021 semester?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Have you or are you teaching an online or hybrid mathematics course at the post-secondary level f... = No

End of Block: Required Information in order to take survey

Start of Block: Resources and Technology

For the following section, please choose one online mathematics course that you taught for Fall 2020 semester or Spring 2021 semester.

Q3 Choose the mathematics course that you will be using to provide information about for the rest of the survey from the list.

- ○ College Algebra (1)
- ○ Statistics for non-math majors (2)
- ○ Trignomonetry (3)
- ○ Precalculus (4)
- ○ Calculus for non-math majors (5)
- ○ Calculus I (6)
- ○ Calculus II (7)
- ○ Calculus III (8)
- ○ Geometry (9)
- ○ Linear Algebra (10)
- ○ Differential Equations (11)
- ○ Modern Algebra (12)
- ○ Combinatorics (13)
- ○ Math Analysis (14)
- ○ Statistics for math majors (15)
- ○ Other (16) _____

Q4 Select the course delivery method that your mathematics courses was or is delivered.

Face to Face - This means throughout the semester you meet with your students physically on campus.

Hybrid - This means you throughout the semester you meet with your students part time on campus and part time online.

Asynchronous - This means throughout the semester the course was online and did not use any video/audio software to meet virtually for class.

Synchronous - This means throughout the semester the course was online and use any video/audio software to meet virtually for class at times.

- ○ Face to Face (1)
- ○ Hybrid (2)
- ○ Asynchronous (3)
- ○ Synchronous (4)

Q5 Do you use a learning management platform (i.e Moodle, Blackboard)?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Do you use a learning management platform (i.e Moodle, Blackboard)? = Yes

Q5a What features of the learning management platform to you use in your class? Click on all that applies.

- ☐ Discussion Forums (1)
- ☐ Polls (2)
- ☐ Quizzes (3)
- ☐ Tests (4)
- ☐ Class Announcements (5)
- ☐ Upload/link Files (6)
- ☐ Upload/Link Videos (7)
- ☐ Other (8) _____

Display This Question:

If What features of the learning management platform to you use in your class? Click on all that app... = Discussion Forums

Q5b Describe why and how you use the discussion forums in your class. If you can, provide an example of how you set-up a forum for students (i.e questions or activities).

_____

Q6 Do you have a website for your online course that is separate from a learning management platform?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Do you have a website for your online course that is separate from a learning management platform? = Yes

Q6a Describe why you chose to use your own website.

_____

Q7 Do you use an online learning platform (i.e MyMathLab)?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Do you use an online learning platform (i.e MyMathLab)? = Yes

Q7a Describe why and how you use the online learning platform in your course. Please provide the name of the online learning platform.

_____

Q8 Do you use any apps/applets for your online course?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Do you use any apps/applets for your online course? = Yes

Q8a Choose one app or applet that you use in your mathematics course. Describe why you chose this app or applet for you course.

_____

Q9 Choose one resource or tool that you use in your mathematics course. Explain why you chose this resource or tool for your course. Furthermore, describe how this is used in your course.

_____

End of Block: Resources and Technology

Start of Block: Teaching Experience

Q10 Total years of experience teaching at the post-secondary level.

_____

Q11 Years of experience teaching online at the post-secondary level.

_____

End of Block: Teaching Experience

Start of Block: Demographics

Q12 Gender

- Male (1)
- Female (2)
- Non-Binary (3)
- Other (4)

Q13 Age

- ○ 20-29 (1)
- ○ 30-39 (2)
- ○ 40-49 (3)
- ○ 50-59 (4)
- ○ 60-69 (5)
- ○ 70+ (6)

Q14 Ethnicity

- ○ White (1)
- ○ Black or African American (2)
- ○ American Indian or Alaska Native (3)
- ○ Asian (4)
- ○ Native Hawaiian or Pacific Islander (5)
- ○ Other (6) _____

Q15 Highest Level of Education

- ○ Bachelors's Degree (1)
- ○ Master's Degree (2)
- ○ Doctoral Degree (3)
- ○ Professtional Degree (4)
- ○ Other (5) _____

Q16 Type of institution currently employed at

- ○ Community or Technical college (1)
- ○ Four-year public institution (2)

Q17 Current Academic Rank

- ○ Adjunct Instructor (1)
- ○ Lecturer (2)
- ○ Assistant Professor (3)
- ○ Associate Professor (4)
- ○ Full Professor (5)
- ○ Visiting Professor (6)
- ○ Other (7) _____

End of Block: Demographics

Start of Block: Optional Follow up Interview

Q18 Would you be interested in a follow-up interview?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Would you be interested in a follow-up interview? = No

Q18a Please provide your full name.

_____

Q18b Please provide the best email to contact you with.

_____

End of Block: Optional Follow up Interview

Appendix D

Code – Tier 1	Code – Tier 2	Coding	Meaning
Learning Management System (LMS)	Moodle	A1	A software tool used for the organiztion of a course.
	Canvas	A2	
	Blackboard	A3	
	As U Learn	A4	
Online Learning System	MyMathLab	B1	A software used to facilitate learning.
	Sapling	B2	
	WebAssign	B3	
	WebWorks	B4	
	HAWKS	B5	
Audio/Video Conferencing software	Zoom	C1	A software used to communicate live in separate locations.
	Microsoft Teams	C2	
Applets/Apps	Desmos	D1	Interactive tools used for instruction
	GeoGebra	D2	
	Virtual Whiteboards	D3	
Physical Tools	Computer/Laptop	E1	Tools used for online instructional purposes.
	Tablet	E2	
	Phone	E3	
	Paper/Pen	E4	
	Calculator	E5	
	Internet Access	E6	
Recording Software	Zoom	F1	A tool used to record videos or live classes.
	Microsoft Teams	F2	
	Echo 360	F3	
	VidGrid	F4	
Content Resources	Files/Powerpoints	G1	Resources used for instruction.
	Links	G2	
	Course Manual	G3	
	Open Stacks	G4	
	Recorded Videos/Lectures	G5	
	Textbook	G6	

Assessments	Quizzes/Lab	AS1	Tools used to assess students understanding.
	Tests	AS2	
	Respondus LockDown Browser	AS3	
Human Resources	Online Study Groups	HR1	Resources where students can go to get help outside of class.
	Virtual Office Hours	HR2	
	Virtual Tutoring	HR3	
Communication Tools	Polls	H1	Tools used for communication for the course.
	Chat	H2	
	Discussion Forum/Board-LMS	H3	
	TEAMS-Channels	H4	
	FlipGrid	H5	
	Google Jamboard	H6	
	Emails	I2	
Descriptions	Current Course	K1	
	Education Experience	K2	
	Instructional/Teaching Experience	K3	
	PD/Training	K4	

Appendix D (Continued)

Themes	Sub-Domains	Code – Tier 1	Code-Tier 2	Coding	Meaning
Instructional Priorities	Effectiveness	Interactions	Promote Student to Student interaction (Jung & Hong, 2016)	L1	"…the extent to which the tool/resource helps achieve a learning outcome" (Jung & Hong, 2016)
			Promotes Student to Instructor interaction (Jung & Hong, 2016)	L2	
			Promotes Student to Content interaction (Jung & Hong, 2016)	L3	
		Active Learning Methods	Visualizations - "seeing the math"	M1	
			Discovery/exploration of content	M2	
			Instant Feedback on assignments for students	M3	
		Monitor	Ability to track Student Progress	N1	
			Instant formative assessments "Check ins"	N2	
	Efficiency	Time (Jung & Hong, 2016)	Requires less edits or adaptation (Jung & Hong, 2016)	O1	"..measure of time and/or cost involved with the resource or tool." (Jung & Hong, 2016, p.30)
			Requires no edits, ready to use (Jung & Hong, 2016)	O2	
			Saves time	O4	
		Tool/Resource capability	Multiple uses of tool/resource	P1	

			Ability to link to other resource/tool	P2	
			Ability to customize to fit needs	P3	
			Tech Support available	P4	
		Cost	Free cost to students (Jung & Hong, 2016)	Q1	
			Free cost to instructor (Jung & Hong, 2016)	Q2	
			Cost to Instructor	Q3	
			Cost to Student	Q4	
	Appeal	Student factors	Adds Relevance (Jung & Hong, 2016)	R2	"Measure of continuing student enjoyment and participation in learning" (Jung & Hong, 2016, p. 30). Measure of teacher enjoyment and participation in teaching.
			Ease of use for resource/tool	R3	
			Offers Variety (Jung & Hong, 2016)	R4	
		Teacher Factors	"see" student faces	EQ1	
			Increase instructor Presence	EQ2	
			Ability to "write" math	EQ3	
	Extension	Expanded Learning opportunities	Provide supplement materials	T1	"...to broaden or support learning

		(Jung & Hong, 2016)	Provide a space to get help or ask questions	T2	opportunities" (Jung & Hong, 2016, p. 30)
		Improving sharing and networking (Jung & Hong, 2016)	Promotes Collaboration Jung & Hong, 2016)	U2	
			Promote networking (Jung & Hung, 2016)	EQ4	
Design Priorities	Structure of Course		Ease of Navigation	V1	The framework or structure of the online course
			Organization of modules	V2	
			To promote interaction with Resource/tool	V3	
			Accessibility	V5	
	Delivery		Synchronous	J1	
			Asynchronous	J2	
Organizational Priorities (Hora, 2012)	Institutional or departmental governance (Hora, 2012)	Required	Tool or Resource	W1	The influence of the institution or department on the use of a tool or resource
			Professional Development/Trainings	W2	
			Testing Software	W3	
			Curriculum	W4	
		Optional	Tool or Resource	X1	
			Professional Development/Trainings	X2	
			Testing Software	X3	
			Curriculum	X4	
	Departmental influence		Feels like they have autonomy as an instructor (Hora, 2012)	Y1	
			Peer collaboration/relationship	Y3	

Individual Priorities and factors (Hora, 2012)	Innovation based on personal initiative (Hora, 2012)		Lack of content resources	AA1	Creation using a tool or resource based on needs
			improvement of course experience	AA3	
	Personal Experiences	Influence of teaching experience (Hora, 2012)	Past Resource/tool is not useful/working	AA4	Influence of past experiences on choosing a resource or tool
			Comfort of tool/resource	AA5	
		Influence of education experience (Hora, 2012)	Exposed to a resource or tool	AA6	
			Took an online course	AA7	
			Helped develop an online course in the past	AA9	
	Conflicts		Set Curriculum	CC1	Inner conflicts or disagreements instructors have
			Group work in online course	CC2	
			Not to Overwhelm students	CC3	
			Testing in online environment	CC4	
			Frustration with resource/tool	CC5	
			To appear "human" to students	S1	