Educative Curricular Supports Used to Improve High Cognitive Demand Task Implementation in High-Dosage Mathematics Tutorial

Halley Bowman

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Educative Curricular Supports Used to Improve High Cognitive Demand Task Implementation in High-Dosage Mathematics Tutorial

by

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Dedication

This dissertation is dedicated to my husband, Tyler, who did so many extra life chores so that I could work on my research. I appreciate and love you.
Acknowledgements

Thank you, Dr. Yee, for all the guidance and encouragement you have given me over the past three years. My research and dissertation are better because of you.

Thank you, Jen Kueter, for reading many, many, many drafts of this paper. I appreciate how thoughtful and thorough you always were with your feedback.

Thank you, Dr. Yow, Dr. Roy, and Dr. Meade, for the time you put into this process and for lending me your expertise.

Thank you, Chris Dupuis, for continuously encouraging me and caring about how my research and dissertation were progressing.

Thank you, Emily, Sammy, and Richard (pseudonyms), who were willing to go on this research adventure with me as my wonderful participants. I could not have asked for a better trio.
Abstract

This study used a qualitative, holistic case study to explore obstacles tutors faced when implementing high cognitive demand (HCD) tasks and the possibility of using embedded educative curricular supports to overcome them. Much prior research has explored using educative supports in classrooms with teachers (Davis et al., 2017), but more research is needed on using educative supports in the tutoring environment. Similarly, prior research has shown that HCD tasks lead to significant mathematical learning but are challenging to facilitate (Stein et al., 1996) in classrooms, but limited research explores these tasks in the tutoring environment. This study was a qualitative single-case design with three tutors in a high-dosage tutoring program in a large midwestern city comprising the case. This study used the theoretical framework that educators and curricular materials influence each other (Remillard, 2005) to expose how educative guidance could support tutors in implementing HCD tasks. Data was collected from a participant journal and focus group on what was most challenging for tutors in implementing HCD tasks. Then, tasks were revised to include educative supports in response to tutor requests. Data was then collected from observations of tutors facilitating the task with students using the Mathematical Tasks Framework (Stein et al., 1996), another participant journal, and a final focus group. Findings from this study suggest that educative supports helped tutors overcome planning and implementation challenges to facilitate a HCD task successfully with critical support from the tutoring curriculum provider. Supports found to be most beneficial for tutors were those that
assisted with planning and facilitation suggestions that were easily adapted for use at the time of tutor implementation.
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Chapter 1: Introduction

Tutoring has been a popular method of increasing student achievement for many decades, but little is known about what types of curricular materials create high achievement in tutorials (Nickow et al., 2020). More recently, data from randomized control trials have shown that high-dosage tutorials dramatically increase student achievement, with students growing an average of as much as three years in a single school year with added support (Ander et al., 2016; Cook et al., 2014; Guryan et al., 2021; Patrick et al., 2021; Robinson et al., 2021). High-dosage tutoring, also known as targeted intensive or high-impact tutoring, refers to a student working with the same tutor over an extended time (often all school year, every day) on academic skills (Patrick et al., 2021). Although there is a lack of empirical evidence, aligning high-dosage tutoring curriculum to classrooms’ curricula may be more effective for students than tutoring designed to be homework help. This direct alignment to classrooms can support teachers and reinforce learning (Robinson & Loeb, 2021).

A high cognitive demand (HCD) task is “less structured, more complex, and longer than tasks to which students are typically exposed” (Stein et al., 1996, p. 462). Research has shown these types of tasks engage conceptual understanding and effectively increase student understanding in the classroom setting (Allensworth et al., 2021; Boaler, 2015; Nohda, 2000; Shimada & Baba, 2012; Stein et al., 1996). Thus, it is natural to wonder if HCD tasks can be applied to the tutorial setting. However, HCD tasks are challenging to implement in the regular classroom due to the teachers’ lack of awareness.
of instructional strategies, experience, and training (Estrella et al., 2020; Schettino, 2016; Stein et al., 1996; Viseu & Oliveira, 2012; Wilhelm, 2014). Furthermore, when using a HCD task, teachers inadvertently can lower the bar by offering too much help, not considering students’ prior skills, focusing on reaching the correct answer over the process, and not allowing students time to think deeply (Stein et al., 1996). It might be assumed that if HCD tasks work well in classrooms, they would also work well in the tutorial space; however, tutors are not experienced or highly trained math educators and are often novices (Cook et al., 2014). Because teachers who have been in the classroom for years struggle with HCD tasks, asking tutors to implement HCD tasks may be unreasonable.

Using prior research on classroom-based HCD tasks, in this study, I explored if creating educative curricular supports for HCD tasks made them more feasible for tutors to enact in tutorial. Educative supports refer to the guidance in the educator-facing curriculum to promote learning about content and instructional best practices (Beyer & Davis, 2009). Educative curricular materials support educator and student learning by containing high-quality student-facing tasks and embedded educator-facing guidance. This guidance in the educator-facing materials clarifies how to enact the tasks in the classroom, including possible varying student responses, methods to represent ideas differently, common student misconceptions, implementation ideas, and methods for representing ideas differently (Ball & Cohen, 1996; Quebec Fuentes & Ma, 2018; Remillard, 2005). Educative supports can be general, giving overarching instructional strategies, or specific, providing pointed guidance relating to a particular lesson or task. Both can effectively aid educators with facilitation (Davis & Krajcik, 2005). In this
paper, I use the terms embedded supports, curricular supports, and educator guidance interchangeably to refer to educative supports.

This study found several educative supports that helped tutors better implement HCD tasks. These findings are significant to the tutoring field because various STEM tutoring programs could apply similar supports and include HCD tasks in their curriculum, bringing HCD tasks to more students in tutorial programs. Furthermore, curriculum designers could use supports exposed in this study to aid new teachers, tutors, and other novice educators in implementing HCD, creating differentiated support for beginning educators. Teacher training programs could use the findings to know what elements of HCD implementation to focus on with their novice educators, leaning into the areas of support illuminated in this study as being most crucial. Because many studies have shown that HCD tasks are difficult to implement due to a lack of training and experience (e.g., Estrella et al., 2020), it is valuable to the field to determine if additional educative curricular supports make these tasks more feasible for educators. This knowledge could ensure more students are exposed to successfully implemented HCD tasks and, in turn, could increase student conceptual understanding, problem-solving abilities, and deep understanding of mathematics (Hong & Choi, 2019). Conceptual understanding refers to connecting mathematical ideas that allow students to apply their learning to novel situations (Balka et al., 2014). Problem-solving is a skill that students use to find a solution to a routine or nonroutine problem (Schoenfeld, 1992a). Both conceptual understanding and problem-solving lead to increased student learning (Hong & Choi, 2019), making their inclusion in learning spaces vital for student success.
I was particularly interested in HCD tasks as I have observed them in practice both in the standard math classroom and in a tutorial setting. I have witnessed the deep engagement and mathematical discourse they produce when implemented effectively. In high-dosage tutorials, I have seen HCD tasks lead to a firmer conceptual understanding for students than problem sets, a variety of stand-alone math exercises focused on a specific skill (Schoenfeld, 1992a). For example, in one task I created and observed being implemented, students used rates, logic, and preference to compare the prices of items on a shopping trip and determine which choice they would buy. Students engaged in a deep conversation about why they might only buy three apples even though the bag of 20 was cheaper per apple (the apples would rot, they did not have enough money to buy all 20 at once, etc.). My observations indicated that at the end of this HCD task, students understood rates and how they might be applied to everyday situations. In addition, students gained an appreciation for math as a flexible tool used to arrive at one of many possible correct answers, a finding supported by prior studies (e.g., Stein et al., 1996).

However, to shift to using more HCD tasks in tutorials, I first needed to explore how tutors engaged at the start of the study, both with their students and on their own, and what types of supports might enable tutors to enact these types of tasks successfully. While many tutors in high-dosage programs are professional tutors and receive preservice training, they are not trained teachers, and most have no background or experience as educators (Cook et al., 2014). Because of these characteristics, tutors are like preservice teachers. In this paper, I refer to tutors and preservice teachers collectively as novice educators.
Over the past several years, I have noticed that many tutors skip the HCD tasks or lower their complexity, leading me to believe something must have been holding them back from using the tasks in their existing state. I did not know what specific guidance could be added to the tutor-facing curriculum to support their implementation or if such embedded supports would be sufficient for novice educators to implement HCD tasks successfully. It was possible that HCD tasks were too complex for tutors to implement without extensive training or that tutors should not be expected to use HCD tasks at all.

Through this study, I explored many embedded supports, uncovered several that supported tutors in successfully implementing a HCD task, and changed my practice as a result. As students generally do problem sets in math class, we should not replicate this in tutorial to mimic the same structure but instead do something different: attacking conceptual math understanding through open HCD tasks (Hong & Choi, 2019; Stein et al., 1996). The findings in this study exposed ways for me to shift my practice to support tutors in implementing HCD tasks and make using HCD tasks more feasible for tutors.

**Context on the High-Dosage Tutoring Organization Setting**

The organization at the heart of this action research study was a nonprofit, high-dosage math tutoring program that operated within the regular school day as an elective course. In high-dosage tutoring, students work with a consistent tutor on academic skills, building a trusting relationship over time (Patrick et al., 2021). Students took the tutoring course in addition to their regular math class, with a “regular math class” or “classroom” referring to students’ traditional math course. Even though tutoring took place in a physical classroom as part of the regular school day, in this paper, it is referred to as “tutorial” because a classroom teacher did not facilitate it.
Randomized control trials have shown high-dosage tutoring programs to have extraordinary results, with students learning an extra 2.5 years’ worth of math in one academic year, math class failures dropping by as much as 60%, and attendance increasing by as much as 18 days per year compared to peers not enrolled in the program (Ander et al., 2016). The program achieved these results using a structured, internally designed curriculum, primarily consisting of examples followed by problem sets. This type of structured curriculum has been shown to be more successful than unstructured homework help, especially for tutors who are not trained teachers (Ritter et al., 2009).

The tutors were part of a national service program and volunteered for a year, receiving a modest stipend. While the program did have tutors who returned for a second year of service, most of the tutors (over 90%) were in their first year in education. The tutors in this program had no specific qualifications or requirements besides having a high school diploma and passing a short mathematics assessment. They received two weeks of preservice training on various tutoring strategies (none on HCD tasks) and otherwise learned on the job with coaching support from organization staff. They implemented the program’s curriculum with small groups of students (typically with three students at a time) and supported regular mathematics classes by covering the same mathematical content.

Curriculum refers to materials used for instruction and includes both student-facing and educator-facing components. Curricular materials comprise curriculum and include texts, media, tasks, or questions for students and methods for educators to help students engage with the content (Cohen & Ball, 1999). The most used curriculum in the program’s tutorials was organization-created lessons, which addressed a specific math
topic and contained an opening and a few examples, followed by a set of practice problems and a formative quiz. The program used the term “problem set” to describe a group of stand-alone math exercises designed to have students practice a given skill (Schoenfeld, 1992a). While problems were varied in structure, most had students practice procedural knowledge, as demonstrated in the example problems explained by the tutor. These types of problems, where students use formulas, procedures, or algorithms in a way similar to that shown in an example or without connection or meaning, had lower cognitive demand (LCD; Stein et al., 1996). The main goal of the lessons was for students to complete several problems independently that demonstrated an understanding of skills mirrored in the examples. This structure showed student growth through tutorial (Robinson et al., 2021) but does not lead to student conceptual understanding the same way HCD tasks do (Allensworth et al., 2021; Hong & Choi, 2019). However, low cognitive demand problem sets were what most classroom teachers do and what many educators, including district partners, were accustomed to using (Serin, 2018). Additionally, I observed problem sets were feasible for tutors to implement.

A lesser-used part of the curriculum was HCD academic tasks intended to “focus students’ attention on a particular mathematical idea” (Stein et al., 1996, p. 460). The tasks typically consist of several questions. Additionally, many tasks were open, meaning the process, end product, or problem-solving methods could vary (Nohda, 2000).

**Problem of Practice**

Although HCD tasks were included in the curriculum, tutors often skipped these tasks in lieu of only using lessons or significantly lowered the intended cognitive lift for students on the tasks. With this research, I aimed to shed light on why this was the case
and what embedded supports could shift this practice. Students often complete rote problem sets in math class, and research indicates it benefits student learning to do higher cognitive tasks and practice applying mathematics in novel situations (Doyle, 1988; Stein et al., 1996). Students do not reach the level of learning where they discuss and explore mathematical topics using only lower cognitive demand tasks (Balka et al., 2014). High-level tasks have been shown to activate a deep conceptual understanding of mathematics for students and stretch their problem-solving skills (Boaler, 2016; Viseu & Oliveira, 2012). Consequently, shifting to HCD tasks in tutorials could lead to even more student learning.

My problem of practice was that there was a lack of research on implementing HCD tasks in tutorial. Thus, I did not know if educative curricular supports could help tutors successfully enact HCD tasks or what supports they might find the most effective. Therefore, I explored if embedded curricular supports impacted tutors to shift their practices to implement HCD tasks successfully. I investigated how tutors engaged with such materials and studied if there was a way to create enough supports within the curriculum to make executing HCD tasks possible for tutors without additional training sessions. Although HCD tasks have increased student engagement, problem-solving flexibility, and conceptual understanding, they are challenging to implement due to their complexity (Bragg & Nicol, 2011). Training can be an essential part of implementing HCD tasks well (Jansen et al., 2017); however, in my experience, tutors did not have the time to attend additional training sessions (synchronous or asynchronous). Instead, educative curriculum can support both educator and student learning (Beyer et al., 2009)
and might be a more efficient method of supporting tutors than training sessions. Through this study, I identified which supports emerged as the most necessary for tutors.

**Research Questions**

Despite many studies showing the benefits of HCD tasks (e.g., Hernández et al., 2016; Hung et al., 2008; Stein et al., 1996; Zohar & Dori, 2003), researchers had yet to learn if HCD tasks were effective in high-dosage tutorials and what curricular supports might make them possible. Structured curriculum works well in tutorials (Nickow et al., 2020) and many studies have shown educative curriculum can support educator learning (e.g., Ball & Cohen, 1996; Beyer et al., 2009; Beyer & Davis, 2009; Collopy, 2003; Davis et al., 2017; Granger et al., 2019; Petrie & Darragh, 2018; Quebec Fuentes & Ma, 2018; Williams et al., 2019). To address the problem of limited research on HCD tasks in tutorials, this study illuminated what educative supports could be added to structured, high-dosage tutoring curriculum to increase the likelihood that tutors could implement HCD tasks successfully.

This study addressed the following research questions:

1. How do tutors engage with high cognitive demand tasks?
2. How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?
3. What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?

I constructed the first question to gauge how tutors engaged with HCD tasks prior to and at the beginning of the study. Through journal entries and a focus group, tutor participants identified when they used HCD tasks in tutorials and what the barriers were
to implementation, giving me a window into their experience with HCD tasks. With the first research question, I discerned the different scenarios when tutors chose problem sets versus HCD tasks. Participants journaled their considerations on HCD implementation and explored their reflections further in a focus group. I also explored how tutors engaged with HCD as learners, having tutors complete a HCD task in a focus group. This task shed light on if they struggled to complete a HCD task themselves, leading them to be more reluctant to implement HCD tasks with their students. Through analyzing multiple data sources, I uncovered obstacles to implementing HCD tasks. This information pushed me towards possible curricular solutions to overcome these obstacles, addressing my problem statement and other research questions.

I crafted the second and third questions to expose curricular material improvements that could be taken to support tutor HCD task implementation. While exploring these two questions, I created educative curricular supports for one HCD task based on the findings from the first research question. Tutors implemented this revised task and completed a journal and a second focus group to share their thoughts. Additionally, I observed participants’ tutorials to see the HCD task in action. Through triangulated data analysis, I identified several embedded supports that bolstered successful tutor HCD task enactment.

Through these three questions, I identified educative curricular supports that made it more likely that tutors implemented HCD tasks effectively in high-dosage tutorials, addressing my problem of practice.
Theoretical Framework

This study is grounded in the theory that curricular materials and educators work together and influence each other to enact instruction (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et al., 2021; Stein et al., 1996). Additionally, it uses the conceptual Mathematical Tasks Framework, which details curriculum design and instruction elements that elevate or drop cognitive demand put on students (Stein et al., 1996).

Curricular Materials and Educator Relationship

Doyle (1988) established the theoretical framework of the connected relationship between curricular materials and educators. He noted what he viewed as the two most important factors affecting student learning: academic tasks and their implementation. First, how students learn in a classroom mostly comes from the tasks teachers assign. These tasks help students understand the subject matter by “directing their attention to particular aspects of content and by specifying ways of processing information” (Doyle, 1983, p. 161). Second, reflecting can help instructors determine what influences the work students complete and what conditions lead to high-quality task enactment. This reflection can help educators make the instructional changes necessary to improve instruction. Doyle (1988) stated it is necessary to look at the specific problems students are assigned and how teachers set them up because these two influence each other and affect student learning outcomes. Curriculum design must attend to the relationship curriculum has with teacher enactment to keep cognitive demand (the level of cognitive process students must use to work through the problem) high.
Remillard (2005) expanded the framework to make it multidirectional, emphasizing that curricular materials shape how educators implement curriculum; however, educators also influence how curriculum is designed. Specifically, educative supports can be designed to help support specific educators (Ball & Cohen, 1996; Beyer et al., 2009; Granger et al., 2019; Petrie & Darragh, 2018). This theory guided this research study, noting that novice educators have specific needs that must be addressed during curricular design to support their curriculum implementation (Beyer et al., 2009). Specifically, this study explored how educative supports guided tutors to implement HCD tasks successfully, despite how difficult HCD tasks are to implement well (Bragg & Nicol, 2011).

**Mathematical Tasks Framework**

Stein et al. (1996) built on Doyle’s (1988) theoretical framework to create a Mathematical Tasks Framework to explore the use of HCD tasks in the mathematics classroom. Their approach emphasized the importance of the tasks students are exposed to and how they affect instruction. It included three phases that influence student learning, adapted from Doyle and Carter (1984): first, the materials that are put in front of students; second, the setup of the task as created by the teachers; and third, the implementation of the task by students. Through these phases and their theoretical model, Stein et al. (1996) emphasized the interactions and interdependency between the materials and the instructor. In this study, I applied Stein et al.’s (1996) framework to tutors, as they were instructors who enacted curriculum and focused on the first two phases: the task design and setup by tutors. Specifically, I applied the Mathematical
Tasks approach to understand the cognitive load on students in an observed tutorial session to gauge the success of HCD task implementation.

**Purpose of the Study**

The purpose of this study was to explore the creation of educative curricular supports that could be used to guide tutors to implement HCD tasks effectively. I exposed which supports and guidance tutors found most helpful. Because HCD tasks are challenging to implement (Estrella et al., 2020; Stein et al., 1996), it was not clear if curricular supports existed such that tutors could implement HCD tasks well without additional training. HCD tasks have been shown to cause a deeper conceptual understanding of mathematics in classrooms (Boaler, 2016; Viseu & Oliveira, 2012), so learning how novice educators can be supported in implementing these types of tasks was critical. Knowing what curricular guidance was needed for novice educators to be better supported in implementing HCD tasks could lead to more educators using HCD tasks to increase student conceptual understanding. The results could give more educators (specifically novice educators) access to enacting HCD tasks to support their students.

**Overview of Methodology**

This section contains an overview of the methods used in this study. It begins with a brief rationale for action research, overviews research design and researcher positionality, and ends with a short description of the data analysis.

**Rationale for Action Research**

Action research can be used to improve educational practices and boost student learning (Clark et al., 2020). Its purpose is to end with a plan of action to improve a problem area in the researcher’s context (Herr & Anderson, 2014). This situated context
contributes to an insider perspective on the researcher's part (Efron & Ravid, 2019). This study was best completed with action research as I researched my organizational setting and improved the curricular materials my team and I developed to support tutors better.

I was passionate about the outcomes of this study and believed the results would spur conversations and contribute to the general knowledge about educative supports for tutors and HCD tasks use in tutorial, qualities of an action research dissertation (Efron & Ravid, 2019; Herr & Anderson, 2014). Knowing what educative curricular supports exist to help tutors implement HCD tasks in high-dosage math tutorials resulted in a plan of action for me. Additionally, it could create dialog among curriculum designs about what embedded supports might help novice educators better implement materials.

**Research Design**

This section briefly overviews the qualitative single-case design, the study setting, and the case participants.

**Single-Case Study.** This study followed a holistic single-case study structure, grounded in the theory that educators and curriculum impact and guide each other (Remillard, 2005). Case studies are a comprehensive analysis of a specific event (Creswell & Creswell, 2017) where relevant information that builds on prior theory is unsurfaced (Yin, 2018). The single case used in this study was a group of tutors serving in one city. Because this group was representative of other tutors in the program, a single case was used. Additionally, because I explored the experiences of tutors as a whole and not as individuals, I used a holistic rather than embedded approach (see Yin, 2018).

**Context and Setting.** This study occurred at two school sites where a high-dosage tutoring organization operated in a large midwestern city over six weeks in the
fall of 2022. The school sites were representative of other program sites. Tutors, completing a year of service as part of a national service program, tutored caseloads of an average of three students at a time, six periods a day. Tutors were in person, and tutorial was an elective course that supplemented the students’ regular math course. They used internally designed curriculum consisting of lessons (example followed by problem set) and HCD tasks. This study exposed how the tutors in this case engaged with HCD tasks and how embedded guidance within the task made it more likely for them to implement it successfully.

**Participants.** This single-case study defined the case as a group of three tutors within the tutoring program working in the same city. The tutors were voluntary and chosen based on availability, representing a convenience sampling (Creswell & Creswell, 2017). The participants were recent college graduates who majored in fields outside of education and mathematics, were not trained math teachers, and were novices to the classroom, as was typical of high-dosage tutors (Ates & Eryilmaz, 2010; Cook et al., 2014; Robinson & Loeb, 2021). They represented a variety of gender and childhood socioeconomic demographics.

**Positionality**

Positionality describes how a researcher relates to the study context, participants, and setting (Herr & Anderson, 2014). Herr and Anderson (2014) suggest an insider/outsider framework to model this positionality, in which researchers can locate themselves on both sides of the continuum. Regarding the setting and context, I saw myself as an insider due to my proximity to the study: I studied my organization of employment and aimed to improve my professional work as a result. However, I saw
myself as an outsider when considering the tutors who comprised my case. I was not a tutor and did not work within a school site, causing me not to experience the daily concerns of the tutors firsthand. Because I gathered data from tutors, I intentionally built a trusting relationship with them without interference from potential power dynamics. I acknowledged that I had a more influential position than them within the organization but had no bearing over their professional trajectory. I regularly collected direct feedback from tutors, demonstrating my trustworthiness.

Additionally, I took my cultural biases into this research, both as a white woman and a doctoral student. I was biased toward using HCD tasks, making me more likely to want to uncover ways HCD tasks could be effectively implemented rather than exposing that educative supports did not help tutors implement HCD tasks. I used a reflective journal, a critical friend, and reflections with colleagues to mitigate my biases (Herr & Anderson, 2014). Reflections on positionality are expanded in Chapter 3.

**Data Collection and Analysis**

In this qualitative, holistic single-case study, I collected multiple forms of data to determine the validity of my theoretically grounded research propositions. Having multiple data sources allowed me to triangulate data, creating study validity (Clark et al., 2020; Creswell & Creswell, 2017; Herr & Anderson, 2014; Yin, 2013, 2018). I used two focus groups, two journals, and one observation to collect data on my case. I coded data using first and second cycle coding (see Miles et al., 2018) and analyzed the data using pattern matching, frequency count, theme identification, and rival explanations (see Yin, 2018).
Participants began by completing a journal based on three open-ended prompts. Then, they participated in a semi-structured focus group. Based on thematic and pattern matching analysis of the first journal entry and first focus group, I created and embedded supports in a HCD task. Following, I observed tutors implement the task and tracked observations using the Mathematical Tasks Framework (Stein et al., 1996). After observations, tutors completed a second journal about their experience, and I led a second semi-structured focus group. Table 1.1 summarizes the alignment of study research questions, data sources, and analysis tools.

**Table 1.1 Research Question, Data Source, and Analysis Alignment Summary**

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Sources</th>
<th>Analysis</th>
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</thead>
<tbody>
<tr>
<td>1. How do tutors engage with high cognitive demand tasks?</td>
<td>Journals 1 &amp; 2</td>
<td>Inductive Themes</td>
</tr>
<tr>
<td></td>
<td>Focus group 1</td>
<td>Frequency count</td>
</tr>
<tr>
<td>2. How does tutor engagement with HCD tasks change with the inclusion of educative curricular supports?</td>
<td>Journals 1 &amp; 2</td>
<td>Pattern matching</td>
</tr>
<tr>
<td></td>
<td>Observation</td>
<td>Frequency count</td>
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<td></td>
<td>Focus groups 1 &amp; 2</td>
<td>Inductive Themes</td>
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<td>3. What educative curricular supports, if any, do tutors indicate make them more likely to implement HCD tasks?</td>
<td>Focus groups 1 &amp; 2</td>
<td>Pattern matching</td>
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<td>Observation</td>
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<td>Rival explanations</td>
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**Summary of Findings**

This study exposed that tutors often chose to use problem sets instead of HCD tasks. Additionally, when implementing HCD task materials, they frequently reduced the task complexity, transforming the HCD task into a series of lower cognitive questions. When tutors enacted a revised HCD task that had added instructional guidance centered on areas they identified as obstacles to implementation, they facilitated the HCD task
well, keeping the cognitive demand high on students. These findings suggest that embedding curricular support, such as differentiation tips and anticipated misconceptions, in lesson materials makes tutors more likely to implement HCD tasks with fidelity.

**Significance of the Study**

At the time of this writing, 10% of students (and rising) in the United States received high-dosage tutoring (Sparks, 2023). With the growing popularity of high-dosage tutoring, it is imperative that research attends to the various tutorial aspects to ensure tutoring best supports student learning, with curriculum use being one aspect. My tutoring organization already pushed the boundaries of what tutorials were (often considered homework help) by creating a professionally trained cohort of full-time tutors expected to prep and implement a tailored curriculum. The findings of this study could reinvent tutorials, thus making my organization an ideal context to have studied the problem of practice: if tutors in my organization with comprehensive professional preservice and ongoing training on how to facilitate effective tutorials could not successfully implement HCD tasks given tailored educative curricular supports, then likely tutors in other organizations could not either. However, this study identified curricular guidance that can be added to existing materials to make tutors more likely to execute HCD tasks effectively. Furthermore, the findings, practices, and curriculum can be shared with other organizations, making the discoveries transferable, assuming other organizations prepare tutors using the same training method.

In addition to directly benefiting my tutoring organization and our current students, these results have broader implications. It could create discussions among tutoring organizations with structured curricula to rethink using problem sets in favor of
shifting to using HCD tasks. The results of this study could start conversations among all curriculum writers about what educative guidance could be embedded within curriculum to support novice educators (both teachers and tutors) without years of experience. Students of low socioeconomic status and students of color are more likely to be in classrooms with novice educators (Kalogrides & Loeb, 2013). Therefore, further supporting educators new to the profession in implementing more difficult curricula (such as HCD tasks) could promote educational equity, exposing more students to effective teaching and tutoring practices and valuable curriculum that deepens their learning.

**Dissertation Organization**

This dissertation contains five sections. The first chapter, as seen above, includes an overview of the study, the research problem and questions, the theoretical framework, the purpose, methodology, significance, and definition of terms.

Chapter two is a literature review that overviews current research on high-dosage tutoring, HCD task implementation and its challenges, and educative curricular supports.

Chapter three describes the methods of the study. It contains justification for using an action research single-case study, detailed methods and procedures, an extended positionality and role of the researcher, and an overview of how data was analyzed.

Chapter four includes the study findings. The setting, participants, and analytic codes are detailed. Comprehensive findings are organized by research question and proposition.

Chapter five includes study implications, limitations, and suggestions for future research.
Definition of Terms

*Classroom* refers to students’ regular math course, as instructed by a teacher. Studies in this paper about findings from a classroom refer to traditional school settings where one teacher instructs a larger group of students.

*Conceptual Understanding*, as opposed to procedural knowledge, is the connection of mathematical ideas, concepts, and operations and the relationship among them, allowing students to apply mathematical learning to novel situations (Balka et al., 2014).

*Cognitive Demand* indicates the level of cognitive process students are required to use to work through the problem (Doyle, 1988).

*Curricular Materials* comprise *Curriculum* and include student materials and instructional materials for educators. They could include texts, media, tasks, or questions for students and methods for educators to help students engage with the content (Cohen & Ball, 1999). In this paper, I use curriculum and curricular materials interchangeably.

*Curriculum Use* “refers to how individual teachers interact with, draw on, refer to, and are influenced by material resources designed to guide instruction” (Remillard, 2005, p. 212).

*Educative Curricular Supports* are meant to support both educators and students. This embedded guidance gives educators ideas about varying student responses, possible student misconceptions, implementation suggestions, and tips on how educators and students could express ideas differently (Ball & Cohen, 1996). In this paper, I use educative supports, curricular supports, and embedded guidance interchangeably.
**Educator Learning** is applying pedagogical content knowledge (PCK) in context (Davis & Krajcik, 2005).

**Effective or Enacted Curriculum** is how the educator implements the curriculum and how students interact with it (Cohen & Ball, 1999). It is “what actually takes place in the classroom” (Remillard, 2005, p. 213).

**High Cognitive Demand (HCD) tasks** are “less structured, more complex, and longer than tasks to which students are typically exposed” (Stein et al., 1996, p. 462).

**High-Dosage Tutoring** is also known as targeted intensive or high-impact tutoring. It refers to a student working with the same tutor over an extended period (often all school year, every day) on academic skills (Patrick et al., 2021).

**Low Cognitive Demand (LCD) tasks** have students use formulas, procedures, or algorithms like that shown in an example or without connection or meaning (Stein et al., 1996).

**Mathematical Tasks** are a “classroom activity, the purpose of which is the focus students’ attention on a particular mathematical idea,” and an “activity is not classified as a different or new task unless the underlying mathematical idea towards which the activity is oriented changes” (Stein et al., 1996, p. 460).

**Novice Educator** refers to a preservice or beginning teacher, tutor, or instructor (Beyer & Davis, 2009). In this paper, I use educator and instructor interchangeably.

**Pedagogical Content Knowledge (PCK)** is an understanding of how to apply instructional and pedagogical practices within the context of a given content (Shulman, 1987).
Pedagogical Design Capacity is an educator’s ability to make intentional curricular decisions by applying PCK to best support their students (Davis & Krajcik, 2005).

Problem Sets consist of various stand-alone math exercises that allow students to practice a given skill or technique (Schoenfeld, 1992a).

Problem-Solving is a skill that students apply to find a solution to a routine or nonroutine problem (Schoenfeld, 1992a).

Quality Curriculum is student-centered and contextualized, creates connections, innovates, transfers learning, and is made through educational teamwork (Bédard et al., 2012).

Structured Tutoring Lessons referred to in this study consisted of a lesson opening, a few examples, a set of practice problems, and a ticket-to-leave formative quiz at the end.

Teacher Design Capacity includes creating instructional goals, integrating instructional principles, and the ability to respond to student needs during implementation (Pepin, 2018).

Traditional Mathematics Teaching is a teacher standing at the front of the room, presenting an idea to the class, detailing the steps to solve the problem, followed by the students practicing similar problems using the same steps (Chapko & Buchko, 2004).

Tutorial is a tutoring session facilitated by a tutor. High-dosage tutorials take place during the regular school day in addition to a regular math class as an elective course.
Tutoring is one-on-one or small-group instructional programming by teachers, paraprofessionals, or volunteers (Nickow et al., 2020).
Chapter 2: Literature Review

Overview of Study

Tutoring has been a proven tactic for improving student learning for years, yet little research exists on what types of tutorial curricular materials result in higher student achievement (Nickow et al., 2020). Recently, high-dosage tutorials have been shown to dramatically increase student achievement through randomized control trials, with students growing, on average, as much as three years in a single school year with the added in-person support (Ander et al., 2016; Cook et al., 2014; Guryan et al., 2021; Patrick et al., 2021; Robinson et al., 2021). A tutorial is individualized instruction delivered in a small-group setting (Ander et al., 2016). High-dosage tutoring is targeted, intensive tutoring and refers to a student working with a set tutor over a prolonged time (often every day, all school year) on academic skills (Patrick et al., 2021).

Through a meta-analysis, Robinson and Loeb (2021) uncovered that aligning high-dosage tutoring curriculum to classrooms seemed more effective for students than homework help. However, they found this lacked empirical evidence. They called for future studies to explore tutorial curriculum and its effects on instruction and student learning outcomes. Nickow et al. (2020) had previously called curriculum used in high-dosage tutoring a “black box” (p. 40) because little is currently known about it.

A curriculum structure that could be considered for high-dosage tutorials is high-cognitive demand (HCD) tasks, which have shown to be very effective in classrooms (Baba & Shimada, 2019; Boaler, 2015; Cohen et al., 2003; Estrella et al., 2020; Munroe,
2015; Nohda, 2000; Schettino, 2016; Shimada & Baba, 2012; Stein et al., 1996; Viseu & Oliveira, 2012; Yee, 2002; Zohar & Dori, 2003). However, with their unsystematic structure, these tasks have been shown to be very difficult for teachers to implement (Estrella et al., 2020; Schettino, 2016; Stein et al., 1996; Viseu & Oliveira, 2012; Wilhelm, 2014). It might be assumed that if HCD tasks are good in classrooms, they would also be good in the tutorial space. However, tutors are generally not trained math educators (Ates & Eryilmaz, 2010; Robinson & Loeb, 2021), and these types of tasks may be too difficult for novices in education to implement without extensive training when teachers, who have been in the classroom for years, struggle. Potentially, educative curricular supports could bridge the gap in veteran knowledge for tutors and other educators just beginning their careers (Beyer & Davis, 2009).

Literature on using HCD tasks in tutorials is lacking, as is research on educative supports needed to best support tutors. A few randomized control trials have shown the effectiveness of high-dosage tutorials (e.g., Ander et al., 2016), numerous studies have shown HCD tasks to be effective in classrooms (e.g., Baba & Shimada, 2019), and several studies have shown that educative supports can increase teacher learning (e.g., Granger et al., 2019). However, at the time of this writing, there is an overall lack of research on high-dosage tutorial curriculum or the use of educative curricular supports for tutors. This chapter explores literature on high cognitive demand tasks (HCD), educative supports, and high-dosage tutoring using the theoretical framework that curricular materials and educators impact each other concerning the implementation of content (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et
al., 2021; Stein et al., 1996). This literature review highlights that research is needed to explore the use of educative supports to increase the guidance given to tutors so they might better enact HCD tasks in high-dosage tutorials.

**Theoretical Framework**

The theory applied in this study was that curricular materials and educators do not work in isolation but influence each other. This theoretical structure assumes educators alter written materials and select tasks to fit the needs of their students. Additionally, it emphasizes that how curriculum is designed and the guidance included within directly influence how educators make these alterations (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et al., 2021; Stein et al., 1996).

**Curricular Materials and Educator Relationship Theoretical Framework**

Doyle (1988) theorized that student learning is rooted in the tasks teachers assign, developing the framework of the connection between curriculum and educators. How teachers implement these tasks affects how students perceive and therefore complete them. He observed that it is necessary to consider both the specific problems students are given and how teachers set them up to improve mathematics instruction.

Doyle (1988) studied two racially mixed middle school mathematics classes, one seventh and one eighth grade, selected because they regularly used HCD tasks. While both classroom teachers used HCD tasks, Doyle (1988) found their implementation was very different. One teacher implemented HCD tasks by demonstrating multiple models and had her students work through the HCD task flexibly using their knowledge of various problem-solving methods and mathematical representations. In contrast, the other
broke the HCD tasks into small, discrete skills to build to the complete task. In the analysis of data observations, student work, and student and teacher interviews, Doyle (1988) classified the tasks students worked on as familiar and novel, with familiar tasks being ones they were accustomed to and had seen before and novel tasks being problems that caused students to apply their skills in a new context. He found that two-thirds of tasks students completed in class were familiar, and only a third were novel, despite novel tasks being widely recommended to improve student learning outcomes. Doyle (1988) observed that teachers struggled with classroom management when they implemented novel tasks and, as a result, were more likely to assign familiar tasks as it made their jobs easier. In instances where the teachers did assign novel work and HCD tasks, Doyle (1988) noted they were likely to break it into tiny chunks that were practiced repetitively. Students were rarely offered much new information at once and did no synthesis of mathematical ideas; teachers focused on the answers rather than the solving process. As a result, when supposedly novel tasks were presented to students, they were not novel because students had learned how to do each step of the task through rote practice.

Doyle (1988) observed that teachers wanted to be efficient in their classrooms and have students complete many mathematical tasks quickly rather than dive in to consider fewer tasks deeply. He suggested that the depth of tasks and quality of instruction both affect the cognitive demand (level of cognitive process students engage in while problem-solving) put on students. Teachers lowered the rigor of tasks by providing too much guidance, emphasizing classroom management over rich mathematical discussions and less predictable unstructured tasks. He noted that student problem-solving skills were not
developed when the educators connected several small steps for the class rather than letting students struggle through the process of making the connection on their own.

Doyle (1988) concluded that student mathematical content understanding was affected by the tasks chosen by teachers and how teachers enacted the tasks in class. For higher-order learning to occur, the mathematical tasks must be HCD, and the instruction must be high-quality. He noted that good teaching is not knowing a series of instructional strategies but instead knowing how to use these strategies to implement a specific task. Student work comprised four parts, (1) the goal of the instructional task, (2) the problem or resources available to complete the task, (3) the steps needed to reach the goal, and (4) the value of the task for students, and teachers influence all four of these parts. Additionally, Doyle (1988) suggested that reflecting on how a task is enacted can help teachers identify factors that lead to high-quality task implementation and make instructional changes accordingly. According to this research, any curriculum changes must address the factors influencing the curriculum, such as teacher enactment.

Remillard’s (2000, 2005) work extended the theoretical framework posed by Doyle (1988) by making the relationship between curriculum and educators multi-direction. Not only do curricular materials affect teacher implementation, as Doyle (1988) theorized, but educators must affect how curriculum is designed. In the discussion of her case study, Remillard (2000) stressed that curriculum is best developed with teachers in mind, giving them guidance on how to choose and facilitate materials best. Remillard (2005) expanded this idea, suggesting how curriculum is designed directly affects how teachers use curriculum, so for curriculum to be implemented as intended, teachers must be taken into account.
Although this framework was designed with classroom teachers in mind, the study in this dissertation extended the relationship between curricular materials and teachers to tutors. As the theory states, curriculum design must attend to the audience implementing the materials (Remillard, 2000, 2005), so the structure applied to tutoring curriculum with relation to tutors as much as it would apply to standard classroom curriculum with regard to teachers.

**Mathematical Tasks Conceptual Framework**

Stein et al. (1996) created a conceptual Mathematical Tasks Framework to explore the use of HCD tasks, expanding on Doyle’s (1988) theoretical framework and work with mathematical tasks. This Mathematical Tasks Framework looks at HCD tasks through three previously established task phases: first, the materials put in front of students; second, the setup of the task created by the teachers; and third, the implementation by students (Doyle & Carter, 1984). In their structure, Stein et al. (1996) highlight the connection among task phases and how they influence subsequent steps. When moving from the first phase, curricular materials design, to the second phase, the mathematical tasks as enacted by classroom teachers, they noted three factors that influenced this transition: teacher goals, teacher knowledge of the subject matter, and students. In the transition from teacher task enactment to completion by students, they noted four factors that influenced this transition: classroom norms, task conditions, teacher instructional strategy habits and dispositions, and student learning dispositions and habits. They discussed the importance of the mathematical materials students are exposed to and how these materials affect student learning. They also emphasized that it is not tasks alone that affect student learning but how educators enact them.
Stein et al. (1996) analyzed three years of classroom observation data in three different teachers’ classrooms, with observations focused on the mathematical tasks used in class, the actions the teachers took to set up the task, and the resulting student behaviors around the tasks. They found that 39% of the materials used in class were not published but created by the teachers, and 63% of the mathematical tasks used were abstract, with no connection to the real world. Task materials ranged in intended cognitive demand level, with 18% doing procedures without connections (low-cognitive demand), 34% doing procedures with connections (HCD), and 40% doing mathematics (HCD). However, Stein et al. (1996) found that the higher the cognitive level of the task, the more likely it was for the teachers to lower the difficulty throughout the lesson. In 96% of the procedures-without-connections tasks (low-cognitive demand), the cognitive demand on students stayed consistent throughout the lesson. When tasks involved the “procedures with connections” level of intended cognitive demand (HCD), rigor was lowered 53% of the time. With the highest level of cognitive demand, doing mathematics, the cognitive expectation for students was reduced 62% of the time. Stein et al. (1996) saw that rigor commonly declined through the implementation phase of the task due to several factors, listed in order of influence:

- The problems became too rote and reduced to a series of simple tasks, often because the teachers provided too much help.
- Teachers used tasks that students were not interested in or did not have the necessary background skills to access.
- Teachers created a classroom culture emphasizing the answer instead of the solving process.
• Teachers rushed students through the task, not allowing for enough time for students to think deeply and make mathematical connections.

While these teacher actions lowered the demand on students, Stein et al. (1996) also observed that several teacher actions could keep cognitive demand high throughout task enactment. In order of importance, they were:

• Teachers selected a task that built on existing student knowledge.
• Teachers did not pressure students to work quickly and allowed adequate time to think and explore mathematical concepts.
• Teachers provided high-quality modeling of multiple methods and justifications, either their own or exemplar student responses.
• Teachers pushed justifications, explanations, and meaning through their questioning.
• Teachers scaffolded tasks and had students make conceptual connections (or selected tasks that did so).

Stein et al.’s (1996) research showed that both the mathematical task and how teachers implement it affect the cognitive demand students experience. They observed that if the cognitive demand of the original task was low, it was never raised by teachers; if the cognitive demand of the selected task was high, it was common for teachers to lower the complexity of the task throughout their realized lesson. For example, in tasks created to have multiple solutions, students only gave or used multiple solutions 69% of the time, suggesting the likely difficulty for teachers to implement tasks with numerous solutions. From their observations, Smith et al. (1996) noticed that HCD tasks were difficult for teachers because of (1) the need to monitor, understand, and analyze varying
student approaches, (2) the need to decide when to intervene, and (3) the need to have confidence in not knowing what approach students will use or at answer students will arrive.

In a later study, Stein and Smith (1998) recommended that educators use the Mathematical Tasks Framework as a tool for reflection. They suggested that educators could reflect on the mathematical tasks they use in their classroom to gain insight into their instruction by analyzing their task selection and critiquing their facilitation to improve teaching. Using the Mathematical Tasks Framework, teachers could reflect on what makes a task high-level and what instructional strategies help keep the task high-level.

While Stein et al.’s (1996) and Stein and Smith (1998) focused on teacher use of HCD tasks and observations, my study will apply the Mathematical Tasks Framework to collect observation data to explore if tutors are successfully keeping cognitive demand high on students or if their actions are lowering rigor. This conceptual framework emphasizes conditions required for students to engage with a task at a high cognitive level, which I propose applies no matter what type of instructor is enacting the task.

**Curriculum**

This section explores literature regarding the current mathematical education landscape, student learning and conceptual understanding, high cognitive demand tasks, and educative curricular supports.

**Mathematics Curriculum Landscape**

Over the past many decades, the pattern in math classes has been for teachers to present a problem, explain an algorithm for solving it, then have students complete a very
similar problem set using the same algorithm individually at their desks (Hart & Carriere, 2011; Polly et al., 2015; Porter, 1989; Serrano Corkin et al., 2019; Stodolsky, 1988). This type of instruction is often thought of as traditional mathematics teaching, defined as a teacher standing at the front of the room presenting an idea to the class, detailing the steps to solve the problem, followed by the students practicing similar problems using the same set of steps (Chapko & Buchko, 2004). Schoenfeld (1992b) argued that teacher-centered lessons do not create conditions for students to reason and think mathematically. Instead, they create an environment where students believe there is only one way to solve: how the teacher presents the problem. Students do not expect to figure out methods or reason through a problem on their own, and they do not find a need to determine if their work or answers seem reasonable (Schoenfeld, 1992b). As a result, most students do not conceptualize math concepts and cannot comprehend mathematical ideas past procedural steps (Schoenfeld, 2007).

This type of traditional mathematics teaching is known as teacher-centered instruction and is a common way of teaching, even when reforms have emphasized that it does not produce results (Hart & Carriere, 2011). It is especially prevalent in urban, low-income schools (Serrano Corkin et al., 2019), with teachers relying on teacher-centered and textbook learning due to behavior issues that may arise (Serin, 2018). Even with the rapid change away from using only textbooks to teachers supplementing with online resources (Pepin, 2018; Rezat et al., 2021), the teacher-centered approach has not changed (Serrano Corkin et al., 2019). Despite the dominance of teacher-centered teaching models, research has indicated that better lesson structures exist for student learning (Boaler, 2015).
One indication of student mathematical understanding is students' ability to think and apply math in context (Boaler, 2015). Needing students to be able to think in context is not a newly documented problem. “For a long time, the mathematics education community has sought to embed the learning of mathematics in actual or concrete problems” (National Research Council, 2010, p. 26). For example, Carpenter et al. (1983) looked at the results from a real-world National Assessment of Educational Progress (NAEP) test problem that involved a set number of people traveling on a bus and discovered that a large proportion of students concluded they would need a fraction of a bus to get the people where they needed to go. This result suggested that students did not relate their procedures and numerical answer to the context of the problem and understood math as disconnected from the real world (Carpenter et al., 1983). The math students need in the real world involves more critical thinking than following procedures, and there is a mismatch between what is happening in math classrooms and what math is required outside school (Lesh & Zawojewski, 2007).

The National Council of Teachers of Mathematics (NCTM, 2000, 2014) currently recommends that students be consistently exposed to math tasks that are worthwhile and meaningful to them. Tasks must be genuine problems rather than the same algorithms used to solve various problems. NCTM (2000, 2014) guidance recommends that students need to use structure and meaning when solving problems, as do the Common Core State Standards (CCSS, National Governors Association, 2010). Students need to be free to make decisions about their solving method, analyze their solving method and solution, and determine if they are reasonable. Students learn from sharing and justifying their
solving methods and solution both in writing and orally (NCTM, 2000, 2014). NCTM points out that these types of tasks often have more than one valid solving strategy, and students can represent solutions in multiple ways (2000, 2014). For many years, NCTM and the Program for International Student Assessment (PISA) have emphasized problem-solving, mathematical literacy, and exposure to problems in context (NCTM, 2000; OECD, 2016).

Several studies have emphasized the importance of the mathematical tasks students are exposed to (e.g., Boaler, 2016). Stein et al. (1996) stated that the mathematical tasks students are exposed to are about more than the mathematical content. They found that tasks formed how students think about math, use it, make sense of it, and develop mathematical reasoning. Boaler (2015) posited that the best tasks allow students to explore and play with mathematics, make mistakes, use multiple ways to solve, and dive into conceptual understanding.

Conceptual Understanding. As opposed to procedural knowledge, conceptual understanding is the connecting of mathematical ideas, concepts, and operations and the relationship among them, allowing students to apply mathematical learning to novel situations (Balka et al., 2014). In Stein et al.’s (1996) study, they saw that building conceptual understanding allowed students to engage in deep thinking the way mathematicians do: identifying problems and creating solutions, explaining and justifying, identifying patterns, determining limitations, analyzing and drawing conclusions from data, creating inferences and conjectures, sharing ideas and challenging others. Because students who used HCD tasks were found to gain conceptual
understanding over their starting point, Stein et al. (1996) recommended using open, high-cognitive demand tasks to build student conceptual understanding.

Estrella et al. (2020) found that students using HCD tasks built conceptual understanding. She explained, “maintaining high cognitive demand allows students to perform mathematics, which means that they engage in activities that involve exploring, representing, observing, conjecturing and detecting relations and constants as well as justifying and communicating results” (Estrella et al., 2020, p. 295). Allensworth et al. (2021) noted that conceptual understanding could be built by having students explore and engage with the mathematical practices outlined in the CCSS, such as making sense of problems and persevering in solving them, reasoning both quantitatively and abstractly, and creating justifications (see National Governors Association, 2010). Boaler (2016) observed that conceptual, open-ended tasks generated more student engagement and equity of learning over closed problem sets. These findings and recommendations suggest that HCD tasks successfully build student conceptual understanding, supporting learning and understanding mathematics.

**High-Cognitive Demand (HCD) Tasks**

A mathematical task is an activity used to focus students on a specific mathematical topic (Stein et al., 1996). Tasks can be categorized as either high-cognitive or low-cognitive demand, with the cognitive demand level representing the cognitive load on students throughout their problem-solving process (Doyle, 1988). These align with Bloom’s taxonomy with lower cognitive tasks using memorization and following set procedures and higher cognitive tasks involving synthesis and developing various solving methods (Anderson & Krathwohl, 2001). Students regurgitate facts in low cognitive
demand tasks and perform routine algorithms or procedures without conceptual understanding. Higher-demand tasks often have open answers that require more than a numerical answer from students and involve justifying, explaining, or modeling. They are typically not brief and are ill-structured with mathematical complexities. In high cognitive demand tasks, students connect to mathematical themes and ideas, justify and explain, generalize, and use multiple problem-solving methods (Stein et al., 1996). Various types of tasks can be considered high-cognitive demand if they demonstrate higher-order thinking skills (Resnick & National Research Council (U.S.), 1987) and are more advanced than the information and comprehension level of Bloom’s taxonomy (Gagne, 1970). In line with Bartell et al.’s (2017) suggestions on equitable math teaching and materials, HCD tasks work best when they build on student’s prior knowledge, support students as capable learners, push for student success, develop students' mathematical thinking, create student discourse and questions, have students engage with each other, and provide opportunities for students to engage with societal and sociopolitical issues.

The purpose of HCD tasks is to increase student mathematical sense-making and problem-solving by exposing students to challenging and worthwhile problems (Stein et al., 1996). This problem type has been found to create more student mathematical discourse than low cognitive demand tasks, allowing educators to address misconceptions and strengthen student conceptual understanding (Boaler, 2016). This discourse and deep mathematical connection-building have been shown to lead to a higher cognitive lift for students (Hong & Choi, 2019; Viseu & Oliveira, 2012). Furthermore, HCD tasks have been shown to create more student engagement and equity of learning among students.
over closed problem sets in classroom settings (Boaler, 2016). They can support self-guided inquiry skills in students (Brophy et al., 2008). Several studies have emphasized the importance of the mathematical tasks to which students are exposed and how these tasks are facilitated (e.g., Beyer & Davis, 2009). Additionally, many studies have found that how the materials are structured and how teachers enact tasks are paramount to the student's success; however, this teacher role is difficult due to the complexity of skillfully facilitating HCD tasks (e.g., Estrella et al., 2020).

Zohar and Dori (2003) explored the idea that teachers often thought higher-order thinking skills, such as those needed to complete HCD tasks, were only appropriate for previously high-achieving students. Zohar and Dori (2003) examined whether low-achieving students had academic gains during HCD tasks. They used four different studies to compile results, looking at four science courses in Israel that spanned 45 classes in 7th, 9th, 10th, 11th, and 12th grades. The results indicated that students who had previously shown higher achievement scored higher on the HCD tasks than their previously low-achieving peers. However, both groups showed significant improvement. In one of their four studies, the growth between pre-and post-assessments was much higher for previously low-achieving students. Results supported that high-cognitive demand tasks create meaningful learning experiences for all students, not only students who have previously shown high success.

**Open-Ended Tasks.** One type of HCD task is open-ended tasks. Open-ended tasks are problems without a straightforward procedure or correct solution, potentially with missing information and multiple solving methods (Munroe, 2015). Viseu and Oliveira (2012) created a qualitative student that observed and interviewed two 7th-grade
teachers in Portugal. They analyzed student tasks to examine the relationship between communication and the tasks assigned to students. The teachers were both experienced and in their thirteenth year in the classroom. Almost half of the students had failed their previous math class. Viseu and Oliveira (2012) found that when the teachers used open-ended tasks with higher cognitive load, it created more student discourse. Additionally, they found that being a part of mathematical discourse and working through HCD tasks made students understand the purpose of their time in the classroom was to learn and help those around them learn. Viseu and Oliveira (2012) named the use of HCD tasks as bringing about the change in student learning and outlook.

In a case study of two Japanese teachers, Munroe (2015) looked at the teachers' instructional techniques to encourage an open-ended approach. From his observations, he created recommendations for teachers to support student understanding. Recommendations included supporting students in understanding and applying mathematical knowledge. The approach had teachers take students through thinking about the mathematical tasks, building conceptual understanding, evaluating and reflecting on their work, applying concepts to real-world applications, and connecting thinking to other mathematical ideas. The study underlined that the teacher's facilitation of the process depended on how well teachers could guide and question students given the mathematical task. When teachers followed Munroe’s (2015) outlined recommendations, this study found improved student learning, that students were more willing to work in groups, that there was respect built among the class, and that mistakes from classmates were not looked down upon.
**HCD in Tutorial.** Exploring outside the traditional classroom, Ates and Eryilmaz (2010) studied the effectiveness of one type of HCD task in a college engineering lab. They found in a case study that open-ended problem-based learning could increase student investment in tutorials. The researchers collected data from tutors at an undergraduate university through observations and interviews. They noted that for problem-based learning to be effective in tutorials, tutors must balance pushing student thinking and allowing students to direct their own thinking. Their findings suggested that tutors were most effective when they adapted problem-based learning to their students and had more content expertise. They found that tutors struggled with knowing when or how much to intervene when guiding student thinking. The factors that most contributed to successful problem-based learning in tutorials were the tutors’ disposition towards problem-based learning, their content expertise, the quality of the academic tasks, and how well tutors were trained to implement problem-based learning.

**Implementation Challenges with High Cognitive Demand Tasks.** Although HCD tasks can support student learning (Boaler, 2016; Hong & Choi, 2019; Munroe, 2015), how educators facilitate lessons directly affects the impact tasks have on students (Hong & Choi, 2019; Remillard, 2005). Studies have shown that despite wanting to improve their teaching and support conceptual understanding (Jansen et al., 2017), teachers struggle to implement HCD tasks (Estrella et al., 2020; Stein et al., 1996). Generally, seasoned educators have more success facilitating open-ended HCD tasks, and new educators find them highly challenging (Beyer & Davis, 2009; Munroe, 2015).

Many instructional skills intended to keep cognitive demand on students are nuanced and difficult to implement. Challenging strategies to implement include:
• exposing students to the limitations of class models, pushing them to think deeper about when strategies and models can be used,

• providing students with necessary background information (National Research Council, 2009),

• helping students explore the mathematical concept, interpret mathematical ideas, and connect knowledge to problem contexts (Fan et al., 2021), and

• balancing teacher talk (Johnson et al., 2015) without providing too much information (Stein et al., 1996).

Additional challenges that have been shown to lead to lowering cognitive load for students include:

• timing constraints, such as students not being provided enough time to work through the task (Bieda, 2010),

• lack of teacher knowledge and the teacher’s concept that mathematics should be learned in a way incompatible with HCD tasks, such as rote practice (Wilhelm, 2014),

• teacher difficulty involving students in discussions (Viseu & Oliveira, 2012), and

• teachers being unsure of how to create suitable learning environments to promote HCD (Jansen et al., 2017; Schettino, 2016).

Stein et al. (1996) noticed that the higher the cognitive level of the task, the more likely it was to be lowered in rigor throughout the implementation process. The task could decline into using procedures without meaning or fall into a nonmathematical activity. Throughout their study, Stein et al. (1996) identified factors that created the decline in the cognitive demand level. They found cognitive demand dropped when the
problem became routinized, reduced in ambiguity or complexity, or when the teacher offered too much help. In addition, when students lacked interest, motivation, or required prior skills, the cognitive demand declined. Cognitive demand also decreased when there was too much focus on getting a correct answer over process and meaning or when teachers moved too quickly and did not give students enough time to think deeply.

Doyle and Carter (1984) previously found results similar to Stein et al.’s (1996) in a case analysis of three middle school English classes taught by the same experienced and highly-skilled teacher. Doyle and Carter (1984) exposed that the teacher had difficulty implementing higher-order tasks with students. To maintain classroom order throughout task implementation, the teacher being observed gradually did more of the cognitive load for students, suggesting educators struggled to balance classroom management and cognitive load on students during HCD tasks.

Despite HCD tasks being shown to work for students with differing degrees of background preparation (Zohar & Dori, 2003), teacher mindset around student ability has been shown to lower rigor for students (Hong & Choi, 2019). Hong and Choi (2019) used the Mathematical Tasks Framework (Stein et al., 1996) to observe opportunities college students had to maintain cognitive demand throughout five calculus lessons on limits taught by one teacher. They found the teacher lowered the rigor through questioning because the teacher thought steps and procedures were best due to a lack of student preparation. Hong and Choi (2019) suggested that even if the teacher thought students needed procedural knowledge to succeed, students could have opportunities to build this knowledge through conceptual tasks that allowed students reasoning and high cognitive demand. This demand could be kept high by focusing teacher questioning on concepts.
rather than procedures, and students’ lack of background knowledge did not have to be detrimental to cognitive demand (Hong & Choi, 2019).

Hernández et al. (2016) found HCD challenging because teachers needed to visualize how the task would look in class and what student actions would be occurring, with which many struggled. Studying mathematical modeling (a HCD task) in high school, they saw the most successful implementation of HCD modeling started with appropriate scaffolding and ended with revisiting major points covered in the task. They defined modeling as using math to provide insight into real-world math by representing, analyzing, making predictions, and involving messy, open-ended problems requiring students to make choices. Hernández et al. (2016) recommended a series of questions they found effective when teachers asked themselves while preparing to facilitate a HCD mathematical task. Questions include, “What kinds of questions will the students have about the context?” and “How can I help students feel comfortable about making assumptions?” (Hernández et al., 2016, p. 339).

In addition to task implementation, task selection has also been shown to affect the cognitive load on students (Estrella et al., 2020; Stein et al., 1996). For example, in their study in Chile, Estrella et al. (2020) found that most students performed at a low level because most tasks selected by teachers had low cognitive engagement for students. They created a lesson study group with eight participants that ran for six months. In this group, they prepared a lesson for implementation. Then, teachers reflected on their lesson facilitation with the researchers using Smith and Stein’s (1998) framework. Estrella et al. (2020) used observational data from two third-grade teachers in the lesson study group. They found cognitive demand was low due to the routinization of tasks by the teachers.
They suggested that teachers assigned low-level tasks because they had trouble implementing HCD and found teachers had difficulty inspiring deep thinking instead of turning the problems into a routine. The study theorized that for teachers to implement HCD successfully, they needed to be constantly aware of the cognitive demand on students, which can be challenging. However, the study found that by reflecting on and refining their practice over the six-month study, the teachers became more successful at implementing HCD tasks.

The studies outlined in this section suggest HCD is difficult to implement well in the classroom, even by experienced educators. There are many task-related factors teachers need to be aware of, from selecting the task (Estrella et al., 2020; Stein et al., 1996) to appropriately facilitating implementation (Doyle & Carter, 1984; Estrella et al., 2020; Hernández et al., 2016; Hong & Choi, 2019; Schettino, 2016; Stein et al., 1996; Viseu & Oliveira, 2012). When teachers have attempted to facilitate HCD tasks, they have pointed to inadequate guidance and implementation suggestions within the curricular materials as a leading cause for their struggles (Munroe, 2015). These findings underline the critical relationship between the educator and the curricular materials.

**Successful HCD Tasks.** Even though HCD tasks are challenging to implement, several studies have pinpointed common characteristics of successful HCD tasks and implementation. They have included:

- scaffolding with questioning and feedback (Estrella et al., 2020; Stein et al., 1996) and challenging students with stretch information above grade level (Munroe, 2015);
- modeling a variety of high-quality exemplars by the teacher or students (Estrella et al., 2020; Munroe, 2015; Stein et al., 1996);
- conceptual understanding and connections (Stein et al., 1996) to remind students of previous and similar concepts (Munroe, 2015);
- encouragement of student explanations, justifications, reasoning, understanding (Estrella et al., 2020; Munroe, 2015; Stein et al., 1996), questions, and finding generalizations (Munroe, 2015);
- adequate time to explore ideas (Stein et al., 1996) through discourse (Munroe, 2015);
- intentional choice of task to build on prior knowledge (Stein et al., 1996), including necessary information to solve (Munroe, 2015);
- student use of many solutions and solving methods on tasks that applied to everyday life (Munroe, 2015);
- student self-monitoring (Stein et al., 1996); and
- encouragement of using mathematical terms, models, and a written summary (Munroe, 2015).

These findings show that the overall task quality relies on the materials being used and the enactment of the materials, accentuating the theoretical framework of the profound relationship between curricular materials and educators.

**Educative Curricular Supports**

Several studies have emphasized the many considerations and talents educators need to design and implement HCD tasks (e.g., Munroe, 2015). To support educators in developing skilled techniques to implement HCD tasks, educative curricular supports
could be used and could be an effective method of encouraging teacher learning (Ball & Cohen, 1996; Beyer et al., 2009; Beyer & Davis, 2009; Cohen et al., 2003; Collopy, 2003; Davis & Krajcik, 2005; Pepin, 2018; Putnam & Borko, 2000; Quebec Fuentes & Ma, 2018; Remillard, 2000, 2005; Remillard & Heck, 2014; Rezat et al., 2021).

Educative supports are intentionally designed alongside student-facing curriculum as guidance embedded within the curriculum for teachers to promote learning about both the content and pedagogical practices (Beyer & Davis, 2009). Educative supports for teachers have been found to be effective because they situated teacher learning within their everyday context of lesson planning, connected theory to relevant practice (Beyer & Davis, 2009; Putnam & Borko, 2000), provided ongoing support (Beyer & Davis, 2009; Collopy, 2003; Pepin, 2018), and were scalable (Beyer & Davis, 2009). These embedded supports can be more efficient and scalable than other types of professional development (Beyer et al., 2009; Collopy, 2003) and can help promote teacher learning (Collopy, 2003).

Educative supports can be both general and lesson specific. General supports help educators learn instructional strategies that relate to multiple lessons and apply across various contexts. Lesson-specific support provides targeted guidance for instructors related to particular lesson content by giving examples of general strategies in the context of the task (Beyer & Davis, 2009). Lesson-specific supports have been found to help teachers judge which instructional methods will work best given their students (Beyer & Davis, 2009; Remillard, 2000). Davis and Krajcik (2005) suggested that curriculum designers create educative guidance that assists educators with both specific planning process decisions and general instructional strategy knowledge.
The idea of embedded curricular guidance is grounded in the theoretical framework of the relationship between educators and curriculum (Remillard, 1999). The assumption that educators tailor curricular materials to meet the needs of their students is foundational to these types of supports. As such, educative curricular supports can help educators learn about different instructional considerations and techniques they might employ while developing lesson plans (Beyer & Davis, 2009). They can guide educators to anticipate student responses, provide multiple methods to model concepts, identify common student errors and misconceptions and how to address them, and provide suggestions on implementation based on varying classroom contexts (Ball & Cohen, 1996).

Educative Supports Background. Ball and Cohen (1996) first introduced the idea of educative supports, proposing that embedded guidance could aid educators in their lesson implementation and support ongoing educator learning. Their work focused heavily on the directional relationship from instructional materials to educator lesson enactment. Cohen and Ball (1999) extended this concept, linking instructional materials, students, and teachers in a triangle. They established that teaching does not happen in a vacuum, nor does curricular materials creation. Curricular materials comprise “curriculum” and include both materials students use during instruction and instructional materials educators use to guide their planning process and facilitation. These materials can consist of texts, multimedia, tasks, instructional strategies, suggestions on differentiating, and tips to help students engage with the content. Cohen and Ball (1999) stated that teachers must interpret curricular materials to tailor their lessons to meet the needs of individual students. Teachers must consider the experiences and prior
knowledge of their students. Additionally, teachers bring their skills and beliefs when interpreting curricular materials and facilitating curriculum. Cohen and Ball (1999) noted that curricular materials are often created in advance, but how the teacher implements the curriculum and how students interact with it comprise the “effective curriculum” (p. 4). All three (materials, teachers, students) must be considered collectively. They suggested that including educative supports in curricular materials could effectively and efficiently build teacher learning capacity and help support teacher development.

Materials that focus only on student learning assume teachers will deliver a lesson and not affect the implementation process through their facilitation choices, which discourages teachers from engaging with materials, learning from materials, and tailoring materials to meet their students’ needs best (Beyer et al., 2009; Remillard, 2000). Remillard (2005) recommended that curriculum designers ground their material creation in the assumption that teachers need to and will modify curriculum during lesson enactment, as it is impossible for curriculum developers to know the context of classrooms with students they have not met. Curricular materials communicate with educators. The design and layout, implications of what teachers might do with the instructional suggestions, and the framing are important, especially considering the theoretical framework of the relationship between teachers and curriculum (Remillard, 2005). Educative supports that give implementation guidance imply teachers will tailor materials and be a part of the process (Beyer et al., 2009; Beyer & Davis, 2009; Collopy, 2003; Remillard, 2000).

In a case study of two fourth-grade math teachers, Remillard (2000) found that teacher learning happened when teachers enacted tasks in their classrooms. Most teacher
learning happened as teachers had to analyze the texts to make curricular decisions to support their students and when teachers adapted the curriculum, not using it verbatim. These findings suggested that curricular materials could support teacher learning and facilitate instructional and pedagogical change. Teachers' disposition and funds of knowledge can change when curricular materials support instructional decision-making. Curricular materials lead to teacher learning when they guide instructional strategies teachers can use and guidance on how to prompt students to reach a given academic goal. Additional teacher learning can happen when curricular materials include information about potential student responses and teacher actions that can be taken to reply to these responses. The audience for guided curricular materials is educators, not students. As such, curricular materials must speak to educators and help guide them with recommendations and suggestions on how to make the best decisions about what tasks to enact and how to implement these tasks given their students’ needs (Remillard, 2000). Remillard (2000) stated that curriculum development must be considered part of teacher development.

Granger et al. (2019) compared the success of elementary science teachers using professional development and educative curriculum with those using only professional development and non-educative curriculum using a randomized cluster design to study teacher growth. The study included fourth and fifth-grade teachers, with 66 in the treatment group and 59 in the control group, randomized by teacher. They used Remillard’s (2005) relationship between materials and teachers as the theoretical framework for their study, connecting educative materials and how they affected preparation for lesson enactment. They found that educative supports increased teacher
content knowledge, beliefs about reform and science inquiry, and raised self-efficacy. Interestingly, teachers who started with higher self-efficacy resulted in lower teacher and student learning. Granger et al. (2019) noted this result as surprising and suggested the effectiveness of educative supports and professional development varied based on teachers’ beginning beliefs and knowledge. They advocated for the continued examination of the effects of using only educative curriculum not combined with professional development.

A big draw of using educative curricular supports is that they are sustainable, efficient, and scalable support for teacher learning, situated within the context of teachers’ practice. Educative materials can help promote teacher learning despite the realities of individual school and classroom constraints (Collopy, 2003). In a case study, Collopy (2003) analyzed observations and interviews of two experienced elementary school teachers to explore the use of curricular supports and no additional professional development for elementary mathematics teachers. Her study found that curricular supports designed to bolster subject matter and pedagogical content knowledge (PCK) could support teacher learning in context. PCK is knowing how to apply pedagogical best practices given specific content (Shulman, 1987). One of the teachers that was followed over a school year changed her teaching practices to align with what curriculum developers pushed for in their reform materials. The other teacher in the study, a more veteran educator, did not change her approach and continued emphasizing memorization and procedural knowledge. Based on these findings, Collopy (2003) assumed that supports were not as helpful in developing ongoing learning for experienced educators but could be for more novice educators. The veteran teacher who did not change her
practice could not overcome her prior assumptions about student abilities or beliefs about her ability to grow as an educator. Collopy (2003) called for further research into how educator learning from curricular supports changes with experience and how these educative supports can be designed to gain the attention of educators best and facilitate use.

Like the premise of Collopy’s (2003) study, Petrie and Darragh (2018) searched for a method to support teachers without additional professional development. They grounded their study in the framework of the interconnectedness between curriculum materials and teacher lesson implementation based on Remillard’s (2005) work. Petrie and Darragh’s (2018) study followed rural high school English teachers in Nicaragua over five years. They found that teachers consistently asked for professional development and supports but had little opportunity for synchronous or asynchronous training sessions. Because the rural schools often did not have textbooks or the internet, Petrie and Darragh (2018) created tailored educative materials to support the teachers directly. They found these educative materials had mixed success in generating teacher learning. They exposed that some guidance embedded within the curricular materials was insufficient due to the lack of formal teacher education and teacher content knowledge. They suggested that the supports might have been more helpful if the teachers in their study had preservice teacher training or a firmer grasp of the content. Although their supports were not entirely successful, they proposed a process for assessing whether educative materials might work based on context.
Davis and Krajcik (2005) recommended a series of qualities to make educative curriculum most effective. According to their analysis of materials, educative curriculum is most effective when it:

- guides educators to “anticipate and interpret” (Davis & Krajcik, 2005, p. 5) students’ possible thought processes and responses and give suggestions on how to respond,
- includes instructional representations,
- supports educator learning of the subject matter and disciplinary practices,
- guides educators on ways to connect content throughout the year,
- includes objectives for student learning,
- lays out the curriculum creators’ pedagogical judgments,
- promotes autonomy,
- connects theory with practice, considering educators’ individual situations, and
- support educators in adapting curriculum (Ball & Cohen, 1996; Davis & Krajcik, 2005).

Davis and Krajcik (2005) noted that the purpose of including curricular guidance is to support teaching-learning, which they defined as applying PCK in context. In mathematics, for example, this could be getting students to create arguments and communicate their mathematical ideas effectively. Davis and Krajcik (2005) recommend that educative supports help teachers develop PCK by supporting their decision-making around best-assisting students and supporting learning new instructional strategies and how to apply them, referred to as teacher pedagogical design capacity. However, Davis
and Krajcik (2005) noted that educative supports have some limitations. Overall, the effectiveness of the educative guidance depends on how teachers see their role concerning the materials. Factors other than educative supports influence how curriculum is enacted, including the type of learning task, the teacher’s dedication to reading and applying suggestions in materials, the teacher’s existing knowledge around PCK and the content, the teacher’s beliefs about learners and what teaching means, the alignment of teacher beliefs and those portrayed in the curriculum, and the teacher’s ability to reflect on practice. Other limitations of embedded guidance occur when too many choices are included (Davis & Krajcik, 2005; Remillard, 1999) or the guidance is too prescriptive (Davis & Krajcik, 2005). Underpinning the entire educative structure is that for educative curricular supports to be effective, the student-facing mathematical tasks and curriculum must be high-quality (Collopy, 2003; Davis & Krajcik, 2005; Remillard, 1999).

Davis et al. (2017) completed a meta-analysis of studies on educative supports to address gaps in how to design educative supports identified by Davis and Krajcik (2005) best. This study looked at elementary science curriculum but suggested the uncovered principles were transferable to all content and grades. When looking at what works best for science teachers, Davis et al. (2017) compiled four design principles for creating educative supports:

- Teachers adapt curricular materials based on their students. For these adaptations to be high-quality, educative supports must suggest adjusting the materials for varying student needs.
- The supports are most effective when they include samples of content and teaching strategies being used in practice. Educative supports are meant to
create learning situated in teachers’ planning, so examples of how to do this must be modeled within the materials.

- Supports must highlight important content, attend to teacher subject knowledge, and use multiple forms and approaches to support teacher learning.
- Teachers have varying needs, and the supports need to serve them accordingly.

Quebec Fuentes and Ma (2018) used the structures of educative supports (Ball & Cohen, 1996), PCK (Shulman, 1987), and pedological design capacity (Brown, 2009; Davis & Krajcik, 2005) to create a framework, Teacher Learning Opportunities in Mathematics Curriculum Materials (TLO-Math), for assessing the quality of educative supports. Their framework included seven components, each evaluated for if it is included, whether there is rationale behind it, and whether there is implementation guidance. The factors comprise:

- mathematical content knowledge for teaching, which includes making connections between lessons and units of study,
- teacher knowledge of student thinking, including what misconceptions might occur and how to address them,
- teacher knowledge of math discourse, including how to facilitate discussion,
- teacher knowledge of math assessment and how to use assessment data to make decisions,
- teacher knowledge of differentiation,
• teacher knowledge of technology and how to use it strategically, and
• teacher knowledge of math community and how to build community
  around doing HCD tasks.

Pepin (2018) also built on the concept of pedological design capacity (Brown,
2009; Davis & Krajcik, 2005), using the theoretical framework of the relationship
between teachers and materials (Remillard, 2005). She noted there exists ample research
on curriculum supporting student learning, but there was far less on it supporting teacher
learning. Pepin (2018) emphasized the need to increase teacher design capacity, including
creating instructional goals, integrating instructional principles, and responding to student
needs during implementation. Pepin (2018) suggested teachers must be intentional as
they plan and enact their lessons. Educators must consider why they choose to implement
in a specific way, what their goals are, who their particular audience is, what resources
they will provide students, and how they will evaluate the effectiveness of their lesson.
Pepin’s (2018) suggestions for educative guidance included:

• Educative materials must support teacher lesson planning, lesson
  enactment, and continued learning about instructional strategies and
  productive mindsets.
• Planning guidance could include timing, how to group students, options of
  tasks to select from, and possible study responses.
• Content guidance could include what mathematical concepts relate, where
  the ideas will ultimately build to, what is relevant for students now
  compared to later, and what tools are most beneficial given the content.
• Guidance around lesson enactment could include how to give instructions, what questions to ask, when to hand out materials, and suggestions for various classroom scenarios.

• Evaluation suggestions could include examples of student assessments.

Through her work, Pepin’s (2018) emphasized the need for educative supports in addition to materials for students, advocating for these supports to be flexible and address various possible classroom conditions.

**Educative Supports for Novice Educators.** Curricular materials influence how educators understand and implement the content (Beyer & Davis, 2009; Cohen & Ball, 1999). Specifically, novice educators are greatly influenced by the materials provided in curriculum as they heavily rely on the supports provided in the materials to construct their curricular plans. Educative supports have been shown to help novice educators apply learning principles and help bolster and build a toolbelt of instructional strategies they could use throughout their careers. In addition, embedded guidance can help connect theory to practice by scaffolding and situating educator learning (Beyer & Davis, 2009).

Beyer and Davis (2009) found adapting curriculum was challenging for novice educators and that many did not adjust the curriculum to meet their students’ needs. Furthermore, novice educators did not realize they might need to or should make these adjustments. Beyer and Davis (2009) suggested educative supports could help illuminate various curricular decisions educators need to make that might not occur to novices. They found when unseasoned educators adjusted curriculum, some inadvertently worsened materials and decreased student learning. As such, Beyer and Davis (2009) noted novice
educators are the most in need of support in increasing their pedagogical design ability, which could be developed through the use of educative supports.

Educative supports have been found to develop PCK; for example, how to apply instructional strategies with particular mathematical content or tailor instruction to differentiate for individual students (Beyer & Davis, 2009; Collopy, 2003; Remillard, 2000). Because new teachers often lack PCK (Shulman, 1987), this embedded guidance can favor novice educators. Through a metanalysis, Davis and Krajcik (2005) found that novice educators tended to lack the principles and frameworks of education that come with experience, were unsure how to organize their ideas, and frequently struggled to visualize what a lesson might look like in practice. Davis and Krajcik (2005) proposed a set of heuristics that could be used to create educative curricular supports. They recommended that materials have tips around building PCK and supports on generalizing strategies so teachers could add them to their toolkit of instructional tactics.

Beyer and Davis (2009) found that preservice teachers used lesson-specific supports more often than general supports. The specific supports helped them picture the lesson enactment and see where it could be adjusted. The supports led the preservice teachers to recognize tailoring to student needs was part of their job. Educators have varying skills, mindsets, and needs; educative supports must be created to suitably address these variations (Davis et al., 2017).

**Supporting HCD Tasks with Embedded Guidance.** When designing HCD tasks, there are many factors to consider in supporting successful implementation by educators. Foundational to this support is the theory that curricular materials and teacher task enactment are intertwined and influence each other (Pepin, 2018; Remillard, 2000).
The tasks must be very carefully designed to accomplish the right mathematical ideas (Mathis et al., 2018) and be of quality (Bédard et al., 2012). Bédard et al. (2012) defined quality curriculum as student-centered, contextualized, creating connections, innovative, transferring learning, and made through educational teamwork. It is difficult to create a high-cognitive demand task for students starting with a low-cognitive demand problem (Davis & Krajcik, 2005; Remillard, 1999; Stein et al., 2009). Hung et al. (2008) found that curriculum design can change how students activate prior knowledge, and curriculum was more effective when students intentionally connected their learning to background skills. Carlson and Sullivan (2004) found that when students could be creative and focus on the process rather than the end student product, it led to equity in student learning and students feeling part of a more inclusive environment. These findings emphasize the importance of beginning with a high-quality task structured to be inclusive for students.

Through the instructional process, high-cognitive demand tasks can be lowered to low-cognitive demand tasks (Stein et al., 2009). How teachers define tasks and how students engage with tasks have been shown to be significant influencers in student performance and learning (Cohen et al., 2003), and curricular materials affect how teachers enact tasks (Remillard & Heck, 2014). “A curriculum is a tool, and a tool is only effective in the hands of those who can wield it effectively” (Schoenfeld, 2007, p. 94). Educative curriculum can support how teachers define tasks and help support students engaging with tasks (Ball & Cohen, 1996).

There are many challenging areas to implementing HCD tasks, and educative supports can help educators better overcome these challenges (Ball & Cohen, 1996). Educators need to know the content and how it relates to students and teaching. To
effectively implement curriculum, educators must be able to interpret student thinking and evaluate various instructional strategies and mathematical representations (Ball et al., 2008). Educators can be helped with these interpretations and evaluations with educative curricular guidance, which can affect how well they implement the curriculum (Guzey et al., 2016). Teachers new to the field of education struggle more with task enactment and have lower PCK (Beyer & Davis, 2009). Brophy et al. (2008) found that educators uncomfortable with the content found it more difficult to implement the intended curriculum with fidelity. Educators with insufficient mathematical knowledge often have difficulty understanding the materials they are intended to teach. Additionally, they are not inclined to participate in synchronous training activities (Lambert et al., 2007). Educative supports tailored to educators' specific needs and struggles to enact HCD tasks could help novice educators implement HCD tasks more successfully (Pepin, 2018).

**Tutoring**

One set of novice educators to consider is tutors. Like other novice educators, tutors who are not teachers often lack PCK and experience tailoring curriculum to meet varying student needs (Ates & Eryilmaz, 2010; Robinson & Loeb, 2021). Tutoring is one-on-one or small-group instructional programming by teachers, paraprofessionals, or volunteers (Nickow et al., 2020). In a systematic literature review and meta-analysis of studies involving tutoring conducted in the past several decades, Nickow et al. (2020) suggested the purpose of tutoring was to improve the efficiency and equity of student learning. They concluded that tutoring was powerful and versatile, finding that tutoring consistently impacted learning across the studies reviewed, with an estimated average effect size of 0.37 standard deviations. In addition, they found that programs that run
during the school day tended to have a more significant impact than after-school programs.

A decade and a half earlier, Bloom (1984) summarized several randomized control trials in elementary and middle schools where students were taught unfamiliar subjects, like cartography. He found that students who received tutoring in up to three-on-one groupings had higher test scores by two standard deviations than the control group. In addition, being in regular tutorials increased student time on task and attitudes towards the subject. These findings suggest that tutoring is a consistently effective way to boost student achievement.

Aspects that Make Tutoring Most Effective

In a meta-analysis of results from studies of nationwide high-dosage tutoring programs, Patrick et al. (2021) determined that high-dosage tutoring was more effective than standard, non-high-dosage tutoring. High-dosage tutoring is also known as targeted intensive or high-impact tutoring. It refers to a student working with the same tutor over an extended time (often all school year, every day) on academic skills. Patrick et al. (2021) established that tutoring during the school day was more effective than after-school tutoring, and tutoring conducted daily for an entire school year led to more student learning than tutoring that happened during part of the year.

Several studies have suggested that structured, skill-building curriculum in tutorials was more effective than homework help (Patrick et al., 2021). High-quality materials aligned with regular math classes were found to be more effective than tutoring with a separate scope and sequence and allowed tutors to support teachers’ instruction (Robinson et al., 2021; Robinson & Loeb, 2021). Several studies showed that tutorial
students tended to work better with a consistent lesson structure (Robinson & Loeb, 2021). Additionally, trained volunteers working as tutors instead of peer tutoring, a smaller student-to-tutor ratio, and ongoing tutoring training and supervision were found to make for the most effective tutorials (Patrick et al., 2021). Tutoring programs that used data to improve continuously were more effective than those that did not (Robinson et al., 2021). In line with what has been theorized in many studies about the impact curricular materials and teacher facilitation have on student learning in classrooms (e.g., Remillard, 2005), these findings suggest the curricular materials and how they are implemented also matter in tutorials.

**High-Dosage Tutoring**

High-dosage tutoring has been found effective by several studies. In a meta-analysis of 40 years of qualitative case studies in New York City charter schools, Dobbie and Fryer (2013) uncovered high-dosage tutoring as one possible cause of charter school effectiveness. Most charter schools in the studies they reviewed offered some tutoring, and high-achieving ones were more likely to provide high-dosage tutoring. Specifically, 28% of high-achieving elementary schools compared to 18% of low-achieving ones offered high-dosage tutoring, and 20% of high-achieving middle schools versus 0% of low-achieving ones did. Dobbie and Fryer (2013) recommended that non-charter schools adopt high-dosage tutoring to support student achievement.

**Saga Education.** One of the most studied high-dosage tutoring programs is Saga Education, a nonprofit program that runs mathematics tutoring courses within the regular school day as a credit-bearing elective. Several randomized control trials have shown the effectiveness of this program. Students enrolled in the program took the tutoring course
in addition to their regular math class and grew academically beyond what was typical in a year (Ander et al., 2016; Cook et al., 2014; Guryan et al., 2021).

Cook et al. (2014) looked at the effects of Saga Education (then called Match) in combination with the Becoming A Man (BAM) mentoring program using a small-scale randomized control trial conducted with 106 ninth and tenth-grade boys at one high school on the south side of Chicago. Participants were 95% Black and 99% eligible for free or reduced-price lunches and were randomly assigned to either the tutoring program or a control group. Cook et al. (2014) saw students in the program increase their math test scores by 0.65 standard deviations compared to the control group and 0.48 standard deviations in the national distribution. This increase in test scores reduced the black/white test score gap by 60%. Researchers observed a “mismatch” (Cook et al., 2014, p. 1) between the support underserved students needed and what the students were provided. Cook et al. (2014) tested a notion they commonly heard in educational spaces that it was too late to help high schoolers who were behind. However, they discovered this hypothesis untrue in their randomized control trial and found that older students grew academically with tutoring. Based on their study results, Cook et al. (2014) advised that a few years of high-dosage tutoring might close achievement gaps.

Ander et al. (2016) studied the Saga program at more scale and without the BAM program using a randomized control trial to look at student growth during the first few years the organization was in multiple school sites across Chicago. The study identified 2,718 male ninth and tenth graders across 12 Chicago high schools that were classified by the district as being at increased risk of dropping out. Ninety-five percent were Black or Latino, and 90% were eligible for free or reduced-price lunch. In the prior school year,
they averaged a 2.2 GPA on a 4-point scale and a month of absences. Half of the participants had failed a course, and 20% had been arrested. Students were randomly selected to be in the tutoring program or the control group. Those in the program were tutored 2:1 daily for 50 minutes. They grew 1-2 years beyond what typical high schoolers grew in one year and went from testing in the 34th percentile to the 42nd percentile on national standardized tests. Student scores improved by 0.19 to 0.30 standard deviations on standardized tests, with 0.27 representing one-third of the black/white test score gap. Ander et al. (2016) found such promising results in their study that they recommended that all districts adopt a tutorial program using a high-dosage tutorial model, where tutors work consistently with a small group of students as part of a year-long tutoring class during their regular school day.

Guryan et al. (2021) performed a larger randomized control trial to measure the effects of Saga Education across many Chicago sites to test the program’s ability to scale. They followed 2,633 ninth and tenth-grade students across 12 schools that took Saga tutoring. Over 90% of student participants were Black or Latine, 90% received free or reduced-price lunch, and their average GPA was 2.11 on a 4-point scale. Guryan et al. (2021) found that students in the program increased their test scores by 0.16 standard deviations compared to the control group. When they replicated their study with 2,710 students of similar demographics across 15 schools, they found an increase of 0.37 standard deviations, suggesting the program successfully scaled in Chicago.

In their meta-analysis, Robinson and Loeb (2021) discussed how very few randomized control trials evaluate high-dosage tutoring in middle and high school, and this small number of studies made it hard to generalize claims. Nevertheless, they noted
that the large-scale study on Saga Education had promising results that showed high-dosage tutoring was likely very effective for students, especially for traditionally underserved students.

In addition to increasing test scores, Saga Education’s high-dosage tutorials improved math class grades (Ander et al., 2016; Cook et al., 2014; Guryan et al., 2021). Cook et al. (2014) found the program increased math class grades by 0.67 standard deviations, and Ander et al. (2016) found grades increased by 0.58 points on a 4-point scale and cut math class failures in half. Furthermore, the effects of Saga Education’s high-dosage tutorials extended to grades outside of math class, even though students only receive tutoring in math (Ander et al., 2016; Cook et al., 2014; Guryan et al., 2021). Ander et al. (2016) discovered it cut a quarter of failures in all other subjects, and Guryan et al. (2021) found it consistently increased non-math grades.

Outside of scores, students were more likely to indicate they liked math after enrolling in Saga Education’s high-dosage tutoring program (Ander et al., 2016). While the results are inconclusive, in one study, the program seemed to have increased the expected graduation rate by 14 percentage points to 46% (Cook et al., 2014).

**Saga Education Replicated.** High-dosage tutoring has been shown to be effective in Europe as well as the United States. De Ree et al. (2021) conducted a randomized control trial of 49 students in Amsterdam. The students were 12 and 13 years old and received one tutoring period for the first 16 weeks of the school year. They found a treatment effect of 0.44 standard deviations over the control group on a math test with word problems and 0.72 standard deviations on a math test without word problems. The effect size of 0.72 standard deviations showed that students who received high-dosage
tutoring made more gains in one semester than the control students in the entire school year. This program was modeled after the program used by Saga Education, suggesting high-dosage tutoring can be replicated with success.

Conclusion

There is ample research showing that HCD tasks, when well executed, lead to increased student conceptual and higher-order learning (Allensworth et al., 2021; Estrella et al., 2020). However, several studies also show that HCD tasks are difficult for teachers to implement in the classroom without inadvertently lowering the cognitive load for students (e.g., Stein et al., 1996).

As Nickow et al. (2020) noted, aspects of curriculum that work well in tutorial are mostly unknown, and there is a lack of research on what types of curricula might be effective in tutorials. After uncovering in a metanalysis that aligning high-dosage tutoring curriculum to classroom content seemed the most effective curricular strategy, Robinson and Loeb (2021) called for future studies to explore more about tutorial curriculum and its effects on instruction.

HCD tasks could be an effective tutorial curricular structure to increase student mathematical understanding, as these tasks have been shown to improve classroom learning and engagement (Boaler, 2016). Educative supports have been shown to help novice educators build their instructional strategy repertoire (Beyer & Davis, 2009). They can support situating instructor learning in their everyday practice without additional professional development (Collopy, 2003). Additionally, educative supports can help bring about educational change (Rezat et al., 2021).
This qualitative case study, grounded in the theory that curricular materials and educator enactment influence each other (Remillard, 2005), explored if educative supports co-designed with tutors could improve the implementation of HCD tasks in high-dosage tutorials. While there is a lack of research surrounding which embedded supports might best support tutors, some of the guidance shown to help educators (and some specifically to help novice educators) in Table 2.1 created the basis for exploration in this study.

**Table 2.1 Educative Guidance Shown to Improve Educator Learning and Tasks Implementation**

<table>
<thead>
<tr>
<th>Embedded Support</th>
<th>Support Examples</th>
</tr>
</thead>
</table>
| 1. Planning guidance | - How to scaffold tasks (Stein et al., 1996) and differentiate (Quebec Fuentes & Ma, 2018) without routinizing (Doyle, 1988; Estrella et al., 2020) based on student background knowledge (Cohen & Ball, 1999)  
- Anticipating common misconceptions and how to address them (Ball & Cohen, 1996; Hernández et al., 2016; Quebec Fuentes & Ma, 2018; Remillard, 2000)  
- Which tasks might be beneficial based on student profiles (Cohen & Ball, 1999; Davis et al., 2017; Pepin, 2018), indication that curriculum developers expect educators to make adjustments (Beyer & Davis, 2009) with recommendations of what alterations might be best for different students (Ball & Cohen, 1996; Davis & Krajcik, 2005; Remillard, 2000)  
- How to develop a learning goal for tutorial students (Davis & Krajcik, 2005; Doyle, 1988; Pepin, 2018; Remillard, 2000) aligned with the content they are covering in their mathematics class (Robinson & Loeb, 2021) |
| 2. Examples of how to apply instructional strategies in the context of the task (Beyer & Davis, 2009; Davis et al., 2017; Pepin, 2018; Remillard, 2000) | - Anticipating possible student responses and suggestions on how to respond (Davis & Krajcik, 2005)  
- Strategies for modeling and encouraging student mathematical discourse (Bartell et al., 2017; Munroe, 2015; Quebec Fuentes & Ma, 2018; Viseu & Oliveira, 2012)  
- Tips to get students to engage with mathematical thinking (Cohen & Ball, 1999) and be concerned with the process and not only the answer (Carlson & Sullivan, 2004)  
- How to create conceptual connections (Munroe, 2015; Stein et al., 1996)  
- Suggestions on how to balance pushing student thinking and allowing students to think on their own (Ates & Eryilmaz, 2010) |
3. Building of teacher content knowledge (Ates & Eryilmaz, 2010; Granger et al., 2019; Wilhelm, 2014) and mindsets (Hong & Choi, 2019)

- Information on how mathematical concepts relate and build (Davis et al., 2017; Pepin, 2018) and connect to other ideas (Davis & Krajcik, 2005; Munroe, 2015; Quebec Fuentes & Ma, 2018)
- How background skills support access to content and tasks (Bartell et al., 2017; Hung et al., 2008; Stein et al., 1996)
- Necessary mindsets around students’ need for conceptual instead of procedural tasks, no matter their background knowledge (Hong & Choi, 2019)
- How to model high-level performance (Stein et al., 1996) using multiple methods (Ball & Cohen, 1996; Davis et al., 2017; Davis & Krajcik, 2005; Munroe, 2015)

4. Task enactment guidance

- Specific questions to ask (Pepin, 2018) to push for justifications (Stein et al., 1996)
- How to interpret student thinking (Ball et al., 2008) and adjust during task implementation, making choices to support student needs that arise, including suggestions for possible alterations (Baba & Shimada, 2019; Pepin, 2018)
- How to structure timing to allow students to think deeply (Bieda, 2010; Pepin, 2018; Stein et al., 1996)
- How to build a culture where students feel competent (Azevedo, 2006; Bartell et al., 2017) and a valuable part of a community (Quebec Fuentes & Ma, 2018)
- How and when to give students feedback (Azevedo, 2006)
- Options for providing students power and choice (Schettino, 2016) to create student autonomy (Davis & Krajcik, 2005) and allow students the freedom to decide their solving method (NCTM, 2000)

When considering how to best support tutors in this study, it was vital to remember the audience of educative curricular materials was the tutors, not the students (Remillard, 2000). However, the curriculum needed to include high-quality student tasks (Bédard et al., 2012; Mathis et al., 2018) that build skills (Patrick et al., 2021). One concern was the vast number of options for best supporting tutor learning through educative supports. Educative guidance needed to balance the pitfall of having too many choices with not being too prescriptive (Davis & Krajcik, 2005).

The assumption might be made that if HCD tasks work well in classrooms, they would also work in tutorials. However, tutors are generally not trained math educators, and these types of tasks may be too difficult for novices in education to implement.
without extensive training when teachers, who have been in the classroom for years, struggle. Potentially, educative curricular supports could bridge the gap in veteran knowledge for tutors and other educators just beginning their careers (Beyer & Davis, 2009). Unfortunately, literature on using HCD tasks in tutorials is lacking, as is research on educative supports needed to best support tutors.

**Research Questions**

It might be beneficial to use HCD tasks to increase student conceptual understanding and minimize procedural tasks in tutorials (Allensworth et al., 2021; Estrella et al., 2020). However, these types of tasks have been shown to be difficult for educators to implement (Stein et al., 1996) and especially difficult for novice educators (Beyer & Davis, 2009; Munroe, 2015). This study explored if tutors, who are generally not trained math educators and are just beginning their careers (Ates & Eryılmaz, 2010; Robinson & Loeb, 2021), could successfully enact HCD tasks in tutorial with embedded curricular guidance. If successful, this embedded guidance can be more effective, efficient, and scalable than additional training (Beyer & Davis, 2009). There is a general lack of research on using HCD tasks in tutorials and developing educative supports for tutors. To explore this topic and expose educative supports that may help tutors implement HCD tasks, this study was guided by the following research questions:

1. How do tutors engage with high cognitive demand tasks?
2. How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?
3. What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?
Chapter 3: Methods

This chapter details the research considerations and methods for this qualitative, action research, single-case study. The case bound was established around three tutors in a tutoring program in a large midwestern city during a six-week study. For ease of reading, the chapter begins with propositions aligned with the research questions. Information on the timeframe, setting, and participants involved in the study immediately follows to orient the reader to the details of the study context. Next, justifications for why action research and a case study design are the most appropriate are detailed. Then data collection instruments, including details of the multiple data sources (journals, focus groups, and an observation) and validity considerations, are explained, along with the role of the researcher, including an expanded positionality. Finally, the data analysis techniques are described.

Overview of Study

Problem of Practice & Theoretical Framework

The problem of practice of this study was that there was a lack of research on high-cognitive demand (HCD) task usage in tutorials. Tutors in the studied program, when planning and implementing curriculum with their students, often skipped or modified HCD tasks, instead choosing or creating problem sets. This research was conducted to shed light on why tutors omitted HCD tasks and explored if educative curricular supports could help shift tutor implementation of these tasks without additional training.
This study was grounded in the theory that curricular materials and educators influence each other. Specifically, curriculum designers help guide educators in modifying materials to meet their students’ needs by giving implementation tips, and, in turn, educators provide feedback to designers, which drives curriculum revisions (Remillard, 2005). This study built on prior studies that indicated HCD tasks are powerful for student learning in the classroom; however, they are challenging to implement (Bragg & Nicol, 2011). These prior findings, combined with the theory of the symbiotic relationship between curriculum creators and educators, indicated potential shifts might be needed in designing the current curricular materials to support tutors in selecting and facilitating HCD tasks. However, these findings and theory have been based on teachers, not tutors, thus establishing the need to explore these ideas further as they apply to tutors.

**Purpose of Study**

The purpose of this study was to understand the barriers tutors identified in implementing HCD tasks and explore possible educative supports that may help alleviate these barriers. High cognitive demand tasks have been shown to be difficult to implement (Estrella et al., 2020; Stein et al., 1996), so, in addition to identifying educative supports that help tutors in facilitating HCD tasks, this study aimed to expose additional barriers that could be explored in future studies.

**Research Design Overview**

This study is action research using a holistic, explanatory case study. I designed the study to improve a situation in my place of work, as is typical of action research (Herr & Anderson, 2014) and conducted a qualitative analysis of a targeted event over a
contained time, as is ideal for a case study (Creswell & Creswell, 2017). Further elaboration on the chosen case study design is in the Action Research Design section, found later in this chapter after more context around the setting and participants are developed.

**Research Propostitions**

Yin (2018) identified five components to designing research methods for a case study: research questions, propositions, a defined case, linking data to the propositions, and data interpretation criteria. Research questions, propositions, and the defined case for this study are described in this section. Study data is linked to propositions and interpretation criteria are detailed in Chapter 4. The case in this study was the small group of three high school mathematics tutors from a high-dosage tutoring organization in a large midwestern city. The case was bounded to explore these three tutors’ interactions with HCD tasks over six weeks in the fall of 2022.

Yin (2018) suggested using a single-case study to determine the validity of research propositions. The propositions, grounded in the study’s theoretical framework and prior literature, guided data collection and analysis. The investigated propositions for this study are listed under each research question in Table 3.1, and the validity of each is explored in the study analysis in Chapter 4 in Table 4.4.
Table 3.1 Research Questions and Aligned Propositions

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Proposition</th>
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<tbody>
<tr>
<td>(1) How do tutors engage with high cognitive demand tasks?</td>
<td>(1a) Tutors do not fully engage with HCD tasks due to the same difficulties in implementation identified by teachers, such as:</td>
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<tr>
<td></td>
<td>• timing (Bieda, 2010),</td>
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<td></td>
<td>• not having sufficient pedagogical content knowledge (Wilhelm, 2014),</td>
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<td></td>
<td>• struggling to facilitate mathematical discussions (Viseu &amp; Oliveira, 2012),</td>
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<td></td>
<td>• not knowing how to set up a productive learning climate (Schettino, 2016),</td>
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<td></td>
<td>• being unsure how to select appropriate tasks (Estrella et al., 2020),</td>
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<tr>
<td></td>
<td>• getting unexpected student responses to the content (Hernández et al., 2016),</td>
</tr>
<tr>
<td></td>
<td>• not knowing how to scaffold and differentiate appropriately (Stein et al., 1996).</td>
</tr>
<tr>
<td></td>
<td>(1b) Tutors do not fully engage with HCD tasks because they are uncomfortable with them (National Research Council, 2009; Wilhelm, 2014).</td>
</tr>
<tr>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
<td>(2) Educative supports help tutors engage with HCD tasks by • building their content and pedagogical knowledge (Granger et al., 2019) and • helping them visualize the tasks in action (Davis et al., 2017).</td>
</tr>
<tr>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
<td>(3) Supports for tutors will match prior educative guidance shown to be effective in encouraging the enactment of HCD tasks. (See Table 2.1 at the end of Chapter 2 on planning guidance, examples of how to apply instructional strategies, building educator content knowledge, and task enactment guidance.)</td>
</tr>
</tbody>
</table>

Timeframe

This single-case study occurred for six weeks in the fall of 2022 at two tutoring sites in a large midwestern city. It consisted of varying types of data collection each
week, as shown in Table 3.2. A detailed outline of what each week entailed is included under the Data Collection Instruments section later in this chapter.

**Table 3.2 Study Outline by Week**

<table>
<thead>
<tr>
<th>Week</th>
<th>Study</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>Tutor Journal 1</td>
</tr>
<tr>
<td>Week 2</td>
<td>Focus Group 1</td>
</tr>
<tr>
<td>Week 3</td>
<td>Researcher creation of supports in HCD task</td>
</tr>
<tr>
<td>Week 4</td>
<td>Observation</td>
</tr>
<tr>
<td>Week 5</td>
<td>Tutor Journal 2</td>
</tr>
<tr>
<td>Week 6</td>
<td>Focus Group 2</td>
</tr>
</tbody>
</table>

**Setting**

The setting for this case study was a tutoring organization that operated at several school sites in a large midwestern city. This study was designed to select potential tutor participants from tutoring sites with minimal competing factors. For ease of data collection and scheduling, having all tutor participants at one school site would work well; however, the case bound depended on tutors being from the same organization, not reliant on the school site, so this was not a necessity. Additionally, research questions could be answered by creating a case with a small group of tutors from one school site or several school sites across the organization, as this study investigated tutors’ general experiences with HCD tasks using a single-case design and did not explore the unique experiences of varying tutors.

Pseudonyms are used throughout this paper, and tutor and school names remain confidential to protect the identity of the participants and setting.
**Case Screening**

Yin (2018) recommended screening potential cases before selecting one. When selecting a group of three tutors from the tutoring organization, the trio was selected based on conversations and recommendations from the city program lead. Tutors who served at a fully staffed site (to eliminate the stressors caused by having an increased student caseload), served students who mostly attended class and were not emergent multilingual learners (not to compound student needs), and worked with students in-person (not to conflate needs for online learning) were eligible. There was one school site where three eligible tutors served together, which the city program lead thought would be ideal for scheduling. Additionally, the program lead knew these three tutors to be reliable and invested in the organization, making them more likely to participate in all study activities. All three tutors eagerly volunteered to be part of the case, establishing the bounded case.

**Necessary Adjustments to Setting**

Because of yearly hiring changes that affect placement of in-person tutors, the assessment of if it were possible to have all tutor participants from one site was done at the beginning of the school year, a few weeks before the study began. As described above, tutor participants were initially chosen from a single school site. However, as detailed in Chapter 4 Findings, when one participant was relocated to a different site to cover a staffing shortage, this move did not affect the bounds of the case or the ability to answer the study research questions. Both the original school site and the second school site had an established relationship with the tutoring organization and were Title 1
schools. Tutors worked with ninth graders at both school sites. Demographic information and observational setting data are expanded upon in Chapter 4.

**Tutoring Site Makeup**

The tutoring program in this study operated in multiple cities. I chose to focus this study on the program in only one city because this city’s program was the most established and had the fewest external barriers.

The tutoring program attempted to hire as many in-person tutors as possible. However, due to in-person staffing shortages, many school sites in this program had a split of remote and on-site tutors. Furthermore, team configurations changed throughout the school year as tutor attrition occurred. A typical site in this city supported ninth-grade algebra and operated in one classroom with four or five tutors and one tutor coach known as a site director. In-person tutors were spaced around the classroom, each with a small group of students. Students with remote tutors worked in the tutorial classroom on computers. Students within this tutoring program typically came from various backgrounds, many of whom were people of color and of low socio-economic status.

**Tutoring Organization**

The tutoring organization at the center of this study was a nonprofit, high-dosage math tutoring program, which has been shown through several randomized control trials to increase student achievement among program participants compared to control groups (Ander et al., 2016; Cook et al., 2014; Guryan et al., 2021). Unlike after-school tutoring, this high-dosage program was a credit-bearing, elective course that students had daily as a part of their regular school schedule, a tutoring format that has been shown to be the most effective structure (Nickow et al., 2020). This organization had more than 40 Title 1
school sites with historically underserved student populations, spanning five large cities, each with tutors who were professionally trained, full-time, and completing a year of service.

The tutoring organization in this study used structured, internally-designed curriculum because structured curriculum has been shown to lead to higher student learning results in tutorials over tutoring that consisted of unstructured homework help, especially for tutors who are not trained teachers (Ritter et al., 2009). This curriculum consisted of two types of materials: lessons and HCD tasks.

A lesson was structured to include a lesson opening and a few examples, followed by a set of practice problems and a “ticket-to-leave” formative quiz at the end. The main goal of a lesson was for students to independently complete several problems from the problem set that demonstrate an understanding of skills mirrored in the examples. The organization defined a “problem set” as a group of individual math exercises on which students practiced a specific mathematical skill (Schoenfeld, 1992a). Problems in the problem sets had structural variety; however, most emphasized procedural knowledge, emulating examples demonstrated by the tutor. Within the problem set, problems were stand-alone, meaning they could be done in any order. The lesson structure using a problem set was what most classroom teachers did and what many educators, including district partners, were accustomed to using and was feasible for tutors to implement. Problems in these types of lessons, for which students use formulas, algorithms, or procedures to replicate a modeled problem, or solve without making connections or mathematical meaning, are lower cognitive demand tasks (LCD; Stein et al., 1996). LCD tasks and problem sets do not allow students to gain a deeper conceptual understanding of
mathematics like HCD tasks (Allensworth et al., 2021; Boaler, 2015; Hong & Choi, 2019).

In contrast to the lesson structure, the organization also designed open HCD tasks to supplement lessons. An academic task has been defined as a “classroom activity, the purpose of which is to focus students’ attention on a particular mathematical idea” and an “activity [that] is not classified as a different or new task unless the underlying mathematical idea towards which the activity is oriented changes” (Stein et al., 1996, p. 460). An open task is one where the process, end product, or problem-solving methods can vary (Nohda, 2000). Following this definition, a HCD task in this organization’s curriculum typically consisted of several questions targeting a central mathematical idea.

However, tutors often skipped these HCD tasks in lieu of using only lessons from the curriculum. One beginning study proposition for this omission was lessons had a robust tutor version: an educative guide that helped tutors use best-practice tutoring approaches, such as using multiple problem-solving strategies and checking for student understanding throughout the learning process. HCD tasks from this curriculum did not contain such educative supports.

At the study sites, as with all school sites in the organization, the tutors implemented the organization’s curriculum in small groups (typically with three students at a time, in-person at most schools and online at some schools) and supported regular math classes by covering the same content (most commonly 9th-grade Algebra). Site teams (site directors and tutors) selected from the program’s several hundred lessons and HCD tasks on various topics to align with the concepts students covered in their regular math classes the few days before the tutoring session. Tutors that served at the same site
used the same curricular materials on the same days when it was appropriate for students to collectively prepare for tutorials. This case study explored ways to support tutors’ more frequent use of HCD tasks to improve student mathematical understanding using two tutoring sites with in-person tutors as the setting for this research.

**Participants**

All tutors in the studied program were service year members rather than employees: volunteer tutors who served nine hours each school day and received a living stipend instead of a salary. They adhered to all service year guidelines, including completing 1700 hours of service work over the school year. Service members who earned sufficient hours received an education grant to help pay for their student loans or future education. Typical tutors in the program were early in their career (80% were recent college graduates) and of diverse genders, ethnicities, races, childhood socioeconomic statuses, and college majors, most of which were not mathematics-related or education-related. There was typically no more than one returning tutor with prior tutoring experience at each school site. During the study, the three tutor participants tutored in person and self-reported demographic information, detailed in Chapter 4.

This single-case study defined the case as a group of three tutors serving in the same tutoring organization who provided context around their HCD task uses over six weeks in the fall of 2022. As described above, tutors were selected based on their experience representing the typical tutor experience, minimizing confounding constraints. Using convenience sampling, participants were selected based on availability (Creswell & Creswell, 2017) and ease of being at the same site. To mitigate possible bias in participant selection, all in-person tutors at the selected site who wished to participate in
the case were invited to do so. As it happened, all three in-person tutors at the school elected to join the study. Had not enough tutors volunteered to be part of the case, additional tutors from the organization would have been identified to join. Participants were not coerced, as, ethically, candidates for participation need the opportunity to opt-out (Parson, 2019). Tutors earned service hours for participating in the study and received a thank-you gift at the end of their time. They did not receive compensation for being part of this study.

**Research Design**

*Justification for Action Research Design*

The purpose of action research is to create an action plan to improve a situation around the researcher as a result of implementing the plan (Herr & Anderson, 2014). It is meant to occur in the researcher’s setting to improve their practice. In contrast with traditional research, action researchers can give an insider perspective (Efron & Ravid, 2019). This study was best completed using action research as I aimed to improve my practice within my work setting. As the academic director for the tutoring organization being studied, I had a local perspective within the organization and have directly applied the study results to my work (Herr & Anderson, 2014), improving the existing design of internally-created curricular materials. Exploring what educative curricular supports exist to help tutors implement HCD tasks in high-dosage mathematics tutorials through this study resulted in a plan of action for supporting my tutoring organization and our students.

Action research is “constructivist, situational, practical, systematic, and cyclical” (Efron & Ravid, 2019, p. 7), and this study embodied each characteristic. This study
created new findings (constructivist), was situated within a unique study context (situational), was designed around a problem of practice (practical), was methodically organized (systematic), and was cyclical in that it started with research questions and created actions that ended with further questions to investigate. Additionally, in action research, the researcher is involved and passionate about the study and its outcomes (Efron & Ravid, 2019). Thus, action research is connected to the researcher’s values (Herr & Anderson, 2014). I strongly felt educators should expose students to HCD tasks, so I was not neutral and strived to uncover supports that made these tasks work in my setting. Although biased towards HCD tasks, I understood that not all educators might feel this way. I intentionally crafted my research questions first to explore tutor opinions and engagement with HCD tasks.

A dissertation should contribute to general knowledge or create a conversation (Herr & Anderson, 2014), and this action research dissertation does both. The findings may open a dialog within other tutoring organizations with structured curricula to think beyond the problem set. They could create conversations among all curriculum writers about what guidance to embed within curricular materials to support novice educators without years of educational experience.

**Justification for Case Study Design**

For multiple reasons, a case study, an in-depth analysis of a specific event or program over a particular time (Creswell & Creswell, 2017), was the ideal structure for this study. First, case studies are a qualitative, empirical method best used for current, real-world explorations (Yin, 2018), and this study explored a present issue of tutors, from my observations, not engaging with HCD tasks as much as they do with problem
sets. Next, case studies uncover relevant information about the case and benefit from building on prior theory (Yin, 2018). Following this guidance, this study was grounded in the idea that curricular materials and teachers influence each other, and educative supports can help guide teacher implementation (Remillard, 2005). Finally, Yin (2018) described case studies as being ideal for addressing “how” and “why” questions through an explanatory study. This study sought an explanation with the first two research questions: (1) How do tutors engage with HCD tasks? and (2) How does tutor engagement with HCD tasks change with the inclusion of educative curricular supports? A qualitative case study design was ideal for discovering how tutors engage with HCD tasks because it allowed the opportunity to explore participant perspectives through focus groups. An experiment with a control and treatment group could have been used to investigate if tutor engagement changed with HCD tasks with and without educative supports, but to explore how it changed, a qualitative case study worked best (Yin, 2018).

The last research question (What educative curricular supports, if any, do tutors indicate make them more likely to implement HCD tasks?) required the most in-depth analysis to determine that a case study was the best fit to answer it. Yin (2018) explained that “what” questions could be addressed using experiments, surveys, or exploratory case studies. I chose a case study because I wanted to dig into participant ideas using focus groups (Yin, 2018), and an experiment or a survey would not offer as rich findings. While I had propositions that I thought might work for successful educative supports based on a literature review, I wanted to hear in their own words what supports participants believed they needed to assist their curriculum implementation best. I was unsure which of the multiple supports tutors would find the most useful, so I wanted to
narrow down and possibly supplement the list of valuable tactics found in Table 2.1 through a focus group before entertaining the idea of testing various forms of curricular guidance in an experiment.

This study used a single-case design, which works well when various situations within a context are similar and not unique (Yin, 2018). Each tutoring site team was similar in its base structure (as previously described), so a single case worked well to represent the tutoring organization. Future multi-case studies could be conducted to gather additional information investigating if barriers to implementing HCD tasks across more site teams are like barriers identified in this study. Because tutors' experiences as individuals were not explored in this study, an embedded approach (see Yin, 2018) was not used. This study focused on the holistic supports needed for a typical tutor, not different supports that might help individual tutors given their unique backgrounds and characteristics; thus, a holistic single-case study was ideal.

**Data Collection Instruments and Validity**

Study validity has four components: construct, internal, external, and reliability. These components must be addressed to ensure the study's validity (Yin, 2018). This section attends to these four components and the associated data instruments used.

**Multiple Sources of Data and Construct Validity**

Multiple sources must be used to create construct validity (Yin, 2018). Using numerous data sources is essential in a qualitative study (Creswell & Creswell, 2017) and allows for data triangulation, which brings validity to the findings (Yin, 2013). This study involved focus groups, journals, and observations from which data was triangulated among three participants. Table 3.2 shows the order in which data was collected (no data
was collected in week 3 of the study). It should be noted that at no point during the study did participants have professional development on how to implement HCD tasks or on qualities that keep cognitive demand high, as the purpose was to explore the use of educative supports without professional development.

**Table 3.2 Study Outline by Week**

<table>
<thead>
<tr>
<th>Week</th>
<th>Study</th>
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<tbody>
<tr>
<td>Week 1</td>
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<tr>
<td>Week 4</td>
<td>Observation</td>
</tr>
<tr>
<td>Week 5</td>
<td>Tutor Journal 2</td>
</tr>
<tr>
<td>Week 6</td>
<td>Focus Group 2</td>
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</tbody>
</table>

**Journals.** Participants responded to journal prompts the week before each focus group (two journal entries total). The journal structure served the individual tutors in the case, allowing them time to collect their thoughts before participating in a focus group, where they constructed collective ideas. The journal entries were analyzed as an additional data source to validate data collected during the focus groups. In some case studies, a survey could be used to corroborate interview responses (Clark et al., 2020; Yin, 2018), but the journal structure in this study allowed tutors to be more open in their responses and less confined by a survey. The journals were collected through Google Forms (*Google Forms*, 2023) and provided insight into their thought processes. Each journal ended with an open question asking what additional information participants would like to add about their context or reflections. Researchers need to be aware that if they are not asking the correct questions, they may not reach the solutions to the problem.
they are hoping to address (Parson, 2019), and the open-ended question aimed to remedy this potential pitfall.

Journal one (see Appendix D) addressed the research question (1) How do tutors engage with high cognitive demand tasks? It asked tutors to reflect on when they used problem sets compared to HCD tasks using three open-response questions. It occurred in the first week of the study before tutors had used a HCD task with educative supports.

Journal two (see Appendix E) addressed research questions (2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports? and (3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks? It occurred after tutors used a HCD task with educative supports designed based on their first focus group reflections. The journal had four open-response questions that asked tutors to reflect on how they experienced using the embedded curricular supports.

Focus Groups. The small group of tutors in the case was appropriate for holding focus groups (Yin, 2018). Two focus groups were conducted as loosely guided conversations around initial questions. The semi-structured protocol can benefit focus groups and allow the researcher to explore ideas that surface with less rigidity than with a structured interview (Clark et al., 2020). Focus groups explored individual views (Yin, 2018) and allowed participants to build ideas off each other (Clark et al., 2020). This process maximized the number of surfaced thoughts (Clark et al., 2020).

Focus group one (see Appendix A) addressed research questions (1) How do tutors engage with high cognitive demand tasks? and (3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive
demand tasks? It occurred in the second week of the study before tutors had implemented a HCD task that included educative supports. Questions asked in this focus group prompted participants to reflect on when they chose HCD tasks, what barriers they faced, and what types of supports they would prioritize including in tutor versions of the curriculum. In addition to answering open-ended questions, tutors engaged with a HCD task (see Appendix B) during this session. This process gave insight into their struggles and strengths in completing a HCD task themselves and guided their thinking around what supports might be the most helpful in implementing the same task with their students.

Focus group two (see Appendix C) addressed research questions (2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports? and (3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks? It occurred after tutors had implemented a HCD task with educative guidance. The questions asked in this focus group prompted tutors to reflect on their experience implementing a HCD task with embedded supports created based on the supports they identified as helpful in the first focus group.

Like the journals, focus groups ended with an open question asking what additional information participants would like to add. This open question allowed participants the chance to address their context and experiences better (Parson, 2019).

One limitation of focus groups is the mutual influence between the interviewer and interviewee, known as reflexivity (Yin, 2018). During the focus group process, I used my role as a researcher to be adaptive, listen, and ask good questions while noticing how
my line of questioning might have influenced participants and adjusted accordingly. As the researcher, I actively monitored my behavior through self-reflection and researcher journaling to ensure I was hearing what participants were saying and not what I wanted to hear. I also openly reflected with participants at the beginning of the focus groups, naming I was present as a researcher while acknowledging my role within the organization. Between the first and second focus groups, I reflected on the recording of the first focus group to determine if any of my researcher actions and biases could have implications for the study. Continually examining my positionality throughout the study helped construct validity (Locke, 2019).

**Observation.** Two types of observations occurred during this study. First, a formal observation used Stein et al.’s (1996) framework to record instances when tutors kept cognitive demand high and lowered it during a tutorial session. As educators do not always reflect accurately on their classroom behaviors or correctly assess student learning (Thiede et al., 2019), this observation helped triangulate and corroborate the information gathered during the focus group and journal entries. This observation addressed research questions (2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports? and (3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks? Occurrences of the following aspects were tallied during observations (see Appendix F) as they were the areas Stein et al.’s (1996) identified as leading to high or low cognitive demand during implementation:

Kept cognitive demand high:

- Scaffolding,
• Modeling of high-quality exemplars,
• Conceptual understanding with connections,
• Building on prior knowledge,
• Sufficient time,
• Student self-monitoring, and
• Push for explanations, justifications, and demonstrated understanding (Stein et al., 1996).

Lowered cognitive demand:
• Routinization,
• Reduction in complexity or ambiguity,
• Too much instructor intervention,
• Lack of student interest,
• Lack of student background skills,
• Focus on answer over process, and
• Not adequate time for students to think deeply (Stein et al., 1996).

Second, casual observations were collected throughout the study about participants’ behaviors. This data did not include intentional observational areas, but instead, I recorded noticings in the researcher's journal, particularly if behaviors of note occurred during the focus groups (Yin, 2018).

**Additional Construct Validity**

In addition to having multiple forms of data, construct validity is created using a chain of evidence: the case study follows a logical thread from beginning to end, and each step influences and aligns with the steps before and after it. The chain used in this
study included creating research questions, designing a research protocol, collecting data, compiling a case study database, and analyzing findings (Yin, 2018). During the findings stage, participants were invited to review drafts of the results, leading to additional construct validity (Locke, 2019; Yin, 2018).

**Internal, External, and Reliability Validity**

Internal reliability is created using pattern matching and addressing rival explanations during data analysis (Yin, 2018). Both were done and are discussed in the Data Analysis section below. A single-case study must be grounded in a theoretical framework to develop external validity (Yin, 2018), which this study established. This study was grounded in the framework that curricular materials and educators who enact the materials mutually influence each other (Remillard, 1999, 2005). Research procedures must be explicit, and a case study database must be established to create reliability within a case study. This database includes all study materials and allows others to investigate findings and see raw data (Yin, 2018) and creates an “audit trail” (Locke, 2019, p. 120). This study’s database contains tutor journal entries, video recordings of the focus groups, observation notes, and researcher notes.

**Data Collection Procedures**

Case study procedures include how to access interviewees, resources needed while collecting data, input and guidance needed from colleagues, a schedule for data collection, and potential unanticipated events (Yin, 2018). This section details each below.

Additionally, a researcher journal was kept to record observations and noticings, a key component of action research (Herr & Anderson, 2014). This memoing is a record of
the researcher's “thoughts, feelings, and impressions” (Herr & Anderson, 2014, p. 98) and notes choice points, ethical decisions, and their possible ramifications throughout the study (Miles et al., 2018).

**Access to Interviewees**

The case in this study was defined as a group of three tutors from a tutoring organization operating in a large midwestern city. The tutors served in two different school sites. Access to this organization and participants was obtained through the researcher’s role. As part of my role within the organization, I regularly gathered input from and observed tutors, so conducting this research was not overly intrusive or unusual. To respect the tutors’ time, completing the short journals was done at any time they chose during the first week of the study, during their regular working hours. Focus groups were held directly after school at a time and on a day selected by participants to minimize disruptions. All interviews were virtual to allow for flexibility of location for all involved and for the ability to record sessions to reference during analysis (Sturges & Hanrahan, 2004; Sullivan, 2012).

**Resources to Collect Data**

Tutor journals were completed digitally using Google Forms (Google Forms, 2023) to compile and share responses easily. Tutors needed an estimated 15 minutes to record their thoughts during the two weeks of journaling. Focus groups were conducted virtually, so participants needed computers with the Internet and access to Zoom (Zoom, 2022), which they had through their employment. Focus groups each required a 60-minute time block. During observations, I, as the observer, used a printed version of the observation protocol tool (see Appendix F) to record instances of HCD and LCD put on
students. Tutors had access to tutor and student versions of the HCD task that I revised the week before the observation to include educative guidance.

**Guidance from Colleagues**

Throughout the research process, a critical friend was used to give feedback (Yin, 2018). This critical friend was chosen from my cohort of fellow doctoral students, which gave her knowledge of the research and dissertation process. This knowledge had the advantage of causing her to be in a critical space with her own research and better able to look for discrepancies and holes in mine. Additionally, she had a different background from mine (educational, professional, and social), which added a differing vantage point to critique my work.

Before each step of the study, my advisor, a mathematics and mathematics education professor who works with collegiate tutoring programs, and my critical friend were consulted about study intentions to get their input. I collected feedback from my advisor synchronously in virtual meetings and asynchronously through emails and document comments. Additionally, a qualitative research professor, experienced in helping doctoral students through the dissertation process, gave feedback on multiple drafts and iterations of the study and write-up through asynchronous comments and synchronous meetings. Before running the study and collecting data, my defense committee, consisting of my advisor, and three additional professors specializing in secondary mathematics education, middle school pre-service educators, and mathematics, respectively, reviewed, gave feedback on, and approved the research proposal. They again gave input on a complete draft of this dissertation.
Colleagues assessed this study for points of bias not already addressed, which can lead to study validity (Locke, 2019). After each step of the process (problem of practice identification, research question creation, positionality formation, literature review, proposed methods, data collection, data analysis, revision of methods, and final dissertation write-up), the critical friend gave ample input as to improvement areas, questions, and possible alterations, helping vet the study design, enactment, and write-up for biases, discrepancies, and weaknesses.

**Schedule for Data Collection**

Table 3.3 details the data collected each week of the study, the actions needed for data collection, and aligned research questions. Data was compiled from participant journals and demographic surveys during the first week. In the second week, focus groups were recorded and transcribed. During week three, no data was collected, and I, as the researcher, modified the HCD task tutors engaged with and gave input on during week two’s focus group. I analyzed data from the first journal and focus group to upgrade the task, identifying supports to embed in the task and adding each support tutors identified as potentially helpful. In week four, data was collected from observations of tutors implementing the task that included the embedded tutoring strategy guidance. In week five, data from a second tutor journal was collected. A second focus group was recorded and transcribed in the last week of the study.
Table 3.3 Data Collection and Researcher Actions by Week

<table>
<thead>
<tr>
<th>Week of Study</th>
<th>Data Collected</th>
<th>Researcher Actions</th>
<th>Research Question Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Journal 1, Participant Demographics</td>
<td>Distributed journal prompts and demographic surveys to tutors in case</td>
<td>(1) How do tutors engage with high cognitive demand tasks?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
<tr>
<td>Week 2</td>
<td>Focus Group 1</td>
<td>Scheduled and held focus group with tutors in case</td>
<td>(1) How do tutors engage with high cognitive demand tasks?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
<tr>
<td>Week 3</td>
<td>None</td>
<td>Modified HCD task materials, embedding curricular supports based on analysis of Focus Group 1 and Journal 1</td>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
<tr>
<td>Week 4</td>
<td>Observation</td>
<td>Observed tutors in case implementing HCD task with newly created supports</td>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
<tr>
<td>Week 5</td>
<td>Journal 2</td>
<td>Distributed journal prompts to tutors in case</td>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
<tr>
<td>Week 6</td>
<td>Focus Group 2</td>
<td>Scheduled and held final focus group with tutors in case</td>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
</tbody>
</table>
Role of the Researcher

According to Yin (2018), a case study researcher must have several characteristics. They include:

- Asking quality questions throughout the study,
- Being a good listener and leaning into what interviewees say, and responding accordingly,
- Being adaptive and digging into unexpected thinking that might emerge in interviews or during other data collection,
- Having a solid knowledge of the issues to be able to interpret data and gathered information, and
- Attending to ethics, such as gaining informed consent from study participants, not deceiving participants in any way, maintaining participant privacy, paying particular attention to the rights of vulnerable groups such as students, and having an equitable selection process.

Throughout my research, I strived to maintain all these characteristics, planning for each intentionally. I started the study by doing an in-depth literature review to be knowledgeable about the topic of study. Specifically, I was knowledgeable about struggles educators have had implementing HCD tasks (e.g., see Stein et al., 1996) and specific educational supports that have been shown to help novice educators (e.g., see Beyer & Davis, 2009). I reflected in my research journal about my experience with focus groups. Additionally, I recorded my focus groups and used them to examine my work as a researcher, reflecting on where I could be more adaptative, listen better, and ask better questions for future focus group interactions.
Expanded Positionality

This section further expands the positionality overviewed in Chapter 1, referencing details from the study method discussed above.

**Insider Traits.** Herr and Anderson (2014) argued that positionality is critical to research because it indicates who the researcher is in relation to the research participants and the setting. They suggest using an insider/outsider framework (p. 40) to interpret positionality. According to this framework, I saw my position as an insider because I studied my practice and, through my research, aimed to improve my professional setting (Herr & Anderson, 2014). I led a team in writing the curriculum used in our tutoring program. As such, I needed to know if the type of curriculum we provided worked for tutors and created educational equity for students and what further support we might need to add. Additionally, my insider positionality and experience writing curriculum for the tutoring organization augmented my ability to create educative supports and alter the HCD task in week 3 of the study. Based on the study outcomes, I refined my practice and how I led my team to create curriculum.

**Outsider Traits.** A researcher can exist in two places on Herr and Anderson’s (2014) positionality continuum, carrying both insider and outsider traits. I viewed myself as an outsider regarding the parts of my research where I observed current behaviors occurring in the organization (Herr & Anderson, 2014). Tutor participants could have seen me as an outsider because I was not part of a site-based team and did not implement the curriculum with students. I was aware of this perspective while conducting focus groups, identifying when my positionality shifted from insider to outsider, and considering how this might have affected data collection through memoing (Parson,
As a leader in the organization, I carefully built relationships during focus groups to combat any possible power dynamics that could have caused tutors not to give complete or honest responses. Additionally, building a positive relationship within the focus groups created a trusting researcher-participant relationship throughout the study.

An asset I brought that helped build relationships quickly was having an open-door policy for all tutors and regularly gathering feedback directly from them as part of my job within the organization. Tutors habitually took advantage of giving me unvarnished feedback, indicating the strength and trust of the relationship I have built with tutors in my organization. Even though I was several levels up in the organization from the tutors, I was not their supervisor and had no bearing over their evaluation or employment status. My position as a researcher was only to uncover possible barriers to HCD use and explore possible educative supports to overcome these barriers. These findings aided the participants in their roles as tutors, likely giving them confidence in my role as a researcher. These qualities allowed me to collect reliable data during the research process.

**Societal Positionality.** Throughout the study, I considered my position within society and the education field as a white woman working in traditionally underserved communities of color and as someone pursuing a doctorate. I was in a societal position of power due to my race, age, and education, and I had biases that may perpetuate marginalization or discrimination. Identifying researcher positionality can help determine where the research may marginalize or discriminate against participants (Parson, 2019) and help lessen these issues. Because I did not grow up within the communities my organization served, I critically examined my interview interpretations and observations.
to ensure I accurately represented what happened and was not seeing events through a skewed lens based on societal influences or my cultural differences. The tutor participants for this case came from various backgrounds, with some traits overlapping and some different from mine. I offered member checking (Strunk & Locke, 2019) to ensure that participants’ interpretations of focus groups and events were the same as mine, providing open access to all data and findings throughout the data collection and analysis process.

As detailed previously, I kept a journal and reflected with a critical friend and colleagues about how my biases might affect my work. I had a critical friend from a different cultural and pedagogical background from mine who was also going through the research process, so she had a trained critical eye. One consideration that often arose was ensuring I accurately portrayed the research data, even when it was potentially unfavorable to the tutor participants. While the tutors should not feel bad if they did not enact something perfectly (as they were not expected to), I was keenly aware that I was more hesitant to detail instances where participants had a misconception or had a missed opportunity in their tutorials and was thrilled to document occurrences where they had an exceptional insight or enacted a tutoring move well. I was aware of many biases I had and, as such, could openly discuss their possible implications through my data collection and analysis and worked actively to mitigate them (Efron & Ravid, 2019).

**Bias Towards HCD Tasks.** I entered this research believing that mathematics is exciting and engaging, all about seeing it in the world around us and exploring patterns. Shaped by my experiences as an educator, I believed HCD tasks were an excellent method to get students talking and engaged. I wanted to see my program use more HCD
tasks because I have seen success in student achievement when it is done. However, throughout the research process, I used my journal and reflections with colleagues to ensure I was not pushing this idea and remained objective in data collection and analysis.

In the six years I taught in underserved schools, I primarily worked with students of color who were of low socioeconomic status. In the nine years I had written math curriculum, I had worked with the same general student population. I have seen how students light up when discussing open-ended math problems. From my prior observations, students appeared to have more connections to the work and viewed mathematics as more valuable when using HCD tasks. In these moments, they acted like mathematicians solving meaningful problems, not computers performing algorithmic calculations. My proclivity for using HCD tasks could have impacted the research; I was more likely to want to find ways to make HCD tasks feasible than accepting the possibility that they were too tricky for tutors to implement. However, I recognized that if no educative supports were found that offered enough guidance for tutors to implement HCD tasks well, then this finding would still be valuable and help guide future studies. This finding could mean HCD tasks are too complex for tutors, and we should not expect tutors to implement them, which could guide further research into varying supports for novice educators and realistic expectations for tutorials. Throughout my research process, I kept a journal and had knowledgeable, unbiased colleagues monitor my analysis to minimize my biases and keep them from affecting my research (Herr & Anderson, 2014).
Ethical Considerations

The institutional review board (IRB) approved this study, giving an outside review of possible ethical considerations. All tutor participants volunteered to join the case study and were provided their rights as participants (see Appendix G).

Power Dynamics. While I was higher up in the organization than tutors, my position was to create curriculum that supported tutor and student learning. I did not influence tutor standing or evaluation; however, I was aware of the possible power dynamic that could influence tutor behaviors. Parson (2019) recommends considering “one’s role, placement, and motivation” (p. 15) and how these affect the ethics of a study and the researcher’s privilege and power over the participants. I was reflective of my position of power compared to my research participants throughout the study and offered member checking, which helped mitigate the unethical treatment of tutors in my case study (Parson, 2019). While it was a privilege that I had access to the research site, this privilege came with an insider’s knowledge of the program (ideal for action research (Efron & Ravid, 2019)) and motivation for improving the tutoring experience of the participants.

Risk to Participants. Overall, the risks to tutor participants in this research were minimal. During the study, tutors were not required to work outside regular hours; all focus groups, journal entries, and observations were conducted during their normal service hours. All actions required of them to be study participants were actions they already performed as part of their regular tutoring job or formalizations of these actions. For example, they regularly reflected on their tutorials but did so in a written journal for this study. If participants felt uncomfortable during the study, they could drop out. Tutor
names remained confidential during data collection, and pseudonyms were used in reported study results.

In addition to tutor participant approval, I gained permission from site staff and alerted school leaders to this study and intended outcomes. I was forthright and transparent about the intentions of this study to not deceive participants.

**Risk to Students.** Although students were not the subjects of this study, they were involved during tutorials. To protect their privacy, I did not record tutorial observations using audio or video equipment and did record student names in observation notes. Additionally, I considered that if tutors attempted to implement HCD tasks as part of this study and did not implement them well, it could take away student learning time. However, this implementation attempt could still be a learning experience from which tutorial enactment could be improved, benefiting students in the long run.

**Data Analysis**

In this qualitative, single-case study, I analyzed data from tutor journals, focus groups, and tutorial observations using convergent data triangulation (Yin, 2018). Meaning after collecting and coding all data types separately, I analyzed and coded the three sources of data together to create a holistic picture of the case, triangulating both the data sources and perspectives (Yin, 2013) instead of looking at each data source separately, drawing a conclusion, and then compiling the findings (Yin, 2018). With this triangulation method, I approached the work with a realist view, assuming there was a single reality (Yin, 2018). This view aligned with my holistic single-case study research methodology because I wanted to understand tutors as a whole and not the differing opinions of tutors as individuals. My main goal in using data triangulation was to bring
validity to the data (Clark et al., 2020; Creswell & Creswell, 2017; Herr & Anderson, 2014; Locke, 2019; Yin, 2013, 2018). Furthermore, study results are often more generalizable when using multiple sources for validity than when using a single source (Yin, 2018).

Case studies can use several analytic strategies (Yin, 2018). I applied two techniques Yin (2018) described: displaying all data to look for themes and using count frequencies. In doing so, I relied on the theoretical framework, research questions, and propositions to guide analysis. Examples and excerpts from the analysis process are included Table 4.1 and detailed in Chapter 4. To create themes, I coded the data using Dedoose software (Dedoose, 2022) and first cycle and second cycle coding techniques (see Miles et al., 2018). To best capture what tutors expressed in focus groups and journals, I used emergent and in vivo coding, using language from tutors to create first cycle codes (Miles et al., 2018). In creating emergent data codes, I reflected on what bits of the data reminded me of, then considered what else it reminded me of, extending my self-questioning at least twice. This technique was grounded in the study research questions and helped expose barriers to HCD task enactment tutors experienced and the supports they believed would be most beneficial. I used second cycle coding to cluster the first cycle codes to see themes and draw conclusions (Miles et al., 2018). During the second cycle coding, I organized initial codes into categories and found they naturally aligned with research questions and propositions. Additionally, I used frequency counts to analyze the occurrence of themes, noting if a theme occurred more often, it was likely more important to participants. I also used frequency counts to analyze observation data
on when tutors kept the cognitive load high and lowered it according to the Mathematical Tasks Framework (Stein et al., 1996).

After coding data and arranging by research question and proposition, I analyzed using pattern matching based on findings from the literature review. Pattern matching looks for correlations between the study data and results from other researchers (Yin, 2018). Applying this technique, I explored the validity of my propositions, which I created based on prior research, and how they were supported in the data.

Finally, to strengthen my analysis, I applied the strategy Yin (2018) described as “rival explanations” (p. 172). This strategy examines alternative explanations for the study results and rules each out. As Yin (2018) stated, this technique can help strengthen claims supporting the original hypothesis if insufficient evidence is found and often arise during data collection. These alternative interpretations create study trustworthiness, as do data triangulation, reflexivity (Efron & Ravid, 2019), using a critical friend to validate findings, and using a researcher journal (Miles et al., 2018).

Table 1.1 summarizes the study research questions, data sources, and analysis tools.

**Table 1.1 Research Question, Data Source, and Analysis Alignment Summary**

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Sources</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do tutors engage with high cognitive demand tasks?</td>
<td>Journals 1 &amp; 2</td>
<td>Inductive Themes</td>
</tr>
<tr>
<td></td>
<td>Focus group 1</td>
<td>Frequency count</td>
</tr>
<tr>
<td>2. How does tutor engagement with HCD tasks change with the inclusion of educative curricular supports?</td>
<td>Journals 1 &amp; 2</td>
<td>Pattern matching</td>
</tr>
<tr>
<td></td>
<td>Observation</td>
<td>Frequency count</td>
</tr>
<tr>
<td></td>
<td>Focus groups 1 &amp; 2</td>
<td>Inductive Themes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rival explanations</td>
</tr>
<tr>
<td>3. What educative curricular supports, if any, do tutors indicate make them more likely to implement HCD tasks?</td>
<td>Focus groups 1 &amp; 2</td>
<td>Pattern matching</td>
</tr>
<tr>
<td></td>
<td>Journal 2</td>
<td>Frequency count</td>
</tr>
<tr>
<td></td>
<td>Observation</td>
<td>Inductive Themes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rival explanations</td>
</tr>
</tbody>
</table>
*Reflecting with Participants on Data*

Member checking involves sharing observation notes and interview transcripts with study participants and can add to the validity of a study (Efron & Ravid, 2019). To add to the validity of this research and to ensure an accurate representation of participant contributions, I let participants know in email exchanges and at the close of focus groups that they were welcome to see any data or written reports at any time. I offered to share a draft of this dissertation with participants and welcomed input on my findings. Participants did not share input other than being excited about being part of the process.

**Summary**

This qualitative single-case study explored the experiences a case of three tutors had with HCD tasks. The study was set in a high-dosage tutoring program in a large midwestern city, and data were collected over six weeks in the fall of 2022. Study procedures included tutors journaling about their experiences using HCD tasks, a focus group discussion, HCD task alterations done by the researcher, an observation of tutors implementing the task, and a final tutor journal and focus group to reflect on their experiences. Data from participant journals, focus groups, and the observation were analyzed using first and second cycle coding.
Chapter 4: Findings

This chapter begins with a summary of the purpose of the study, the problem of practice, the theoretical framework, and the research questions from Chapter 1, and an overview of the research design and methods from Chapter 3. Following, this chapter details the findings of this study. First is a detailed description of the setting and research participants. Then, is an explanation of the codes created to analyze the data. Next, the analysis findings are aligned with the research question and associated proposition. The chapter ends with an overview of the findings.

Overview of Study

Purpose of Study

The purpose of this study was to shed light on the obstacles tutors expressed in implementing high cognitive demand (HCD) tasks and to investigate possible embedded curricular supports that could help overcome these obstacles.

Problem of Practice

Prior evidence suggested tutors in the studied program often skipped HCD tasks or modified them to make them no longer HCD, preferring problem sets instead. This study explored why this preference occurred and if educative curricular materials could support tutors in implementing HCD tasks without additional professional development training sessions.
**Theoretical Framework**

This study was rooted in the theoretical framework that curricular materials and educators influence each other. This framework says curriculum designers can support implementation choices for educators by embedding tips and strategies in the educator-facing materials so educators can make alterations to best support their students (Remillard, 2005). This study was also informed by research that showed HCD tasks can be high-quality learning tools; however, they are difficult for educators to implement (Bragg & Nicol, 2011). The combination of the theoretical framework and prior findings on HCD tasks indicated that potentially changes were needed to the design of tutoring materials to assist tutors in augmenting their HCD task use.

**Research Questions**

Through a qualitative case study design, I explored the following questions:

1. How do tutors engage with high cognitive demand tasks?
2. How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?
3. What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?

**Design**

This action research was an explanatory study completed using a qualitative single-case study design. The single case comprised three tutor participants who tutored across two different sites in a major midwestern city. The case was bounded over the six-week study to data surrounding HCD task use.
Methods

Data were collected over six weeks in the fall of 2022, as shown in Table 3.2. Participants journaled about their experiences with HCD tasks, then participated in a focus group where they completed a HCD task themselves and answered questions about what embedded supports they might find helpful to facilitate the task with students. Following, as the researcher, I modified a HCD task to include their suggested supports and observed participants implementing the revised task. Finally, participants journaled about their experiences using the HCD task and shared in a second focus group, offering additional insight into what embedded strategies might support future task implementation.

Table 3.2 Study Outline by Week

<table>
<thead>
<tr>
<th>Week</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Tutor Journal 1</td>
</tr>
<tr>
<td>Week 2</td>
<td>Focus Group 1</td>
</tr>
<tr>
<td>Week 3</td>
<td>Researcher creation of supports in HCD task</td>
</tr>
<tr>
<td>Week 4</td>
<td>Observation</td>
</tr>
<tr>
<td>Week 5</td>
<td>Tutor Journal 2</td>
</tr>
<tr>
<td>Week 6</td>
<td>Focus Group 2</td>
</tr>
</tbody>
</table>

Expanded Setting Details and Setting Observational Findings

This study was conducted at two sites within a tutoring program in a large midwestern city: Cortez High School and Bennett High School (pseudonyms). Initially, all three tutors in the case were serving together at Cortez High School. As described in Chapter 3, this convenience sampling was intentional to simplify data collection and coordination of tutor participation. However, one of the tutor participants was moved to a
different site to cover a staffing shortage the week before the study began, so the study setting was expanded to include a second site, Bennett High School.

**Cortez High School**

The Cortez High School site was typical for the tutoring organization based on multiple factors that affected the organization’s sites in the 2022-2023 school year, such as staffing structures, student demographics and enrollment, school engagement with the program, and tutor experience. Cortez’s tutoring program staffed two in-person tutors, three remote tutors, and one site director, who coordinated with teachers and coached the tutors. Tutors tutored six periods daily, with approximately 25 ninth-grade students enrolled in each class period. Cortez was a Title 1 school that enrolled 1400 students, was 74% Latine and 16% Black, was 80% free or reduced-price lunch, and had a 72% graduation rate. The tutoring organization had been operating at Cortez for four years, tutoring approximately 200 students a year, and had an established, positive rapport with the teachers and the school administration. The program’s city leadership indicated Cortez would be a good setting for the study due to its site characteristics.

On the day of the study observation, more than half of the students in the Cortez tutoring room were on computers, some communicating with the sites’ three remote tutors and some working on a math learning platform. The rest of the students worked with one of the two tutors in the room, both participants in this case study. The classroom setting was such that there were several tardy students, which the site director said were difficult to combat due to school culture. The general culture in this setting was such that most students were consistently focused on learning with minimal distractions. For example, phone distractions were frequent but not prolonged and predominantly appeared
to be a quick change to a playlist, as listening to music on headphones while working independently was permitted. Students periodically peered at the light snow falling outside from the slightly cold room but quickly returned focus to their work.

**Bennett High School**

Bennett High School was like Cortez in that it was a Title 1 school, although it had a smaller student body of 640 students and a more mixed student population (39% Black, 35% Latine, 17% Asian/Pacific Islander). Bennett had a 75% graduation rate, and 91% of students received free or reduced-price lunch. The tutoring program had been operating at Bennett for seven years, tutoring approximately 130 ninth-grade students yearly. There was a strong relationship between the tutoring organization and the school administrators and teachers. The most notable difference between Bennett and Cortez was that Bennett High School had many student language needs. These language needs were not typical for a tutoring site within the organization but did not affect the purpose of the study or data collection. One participant was shifted from Cortez to Bennett due to a staffing shortage (creating the need to add Bennett to the setting). In journal 1 and focus group 1, he noted little structural difference between the two school sites besides the inability to print materials at Bennett.

On the day of the observation, the tutoring classroom at Bennett High School was a warm and welcoming environment, with students and tutors smiling and greeting each other. The program staffed two in-person tutors (one was a study participant), two online tutors, and one site director. A handful of students were on computers, working with a remote tutor. The rest of the students worked in larger groups with one of the two tutors in the room. The setting environment was structured such that students were generally
focused and engaged, with some seeming bored and disengaged. Additionally, the setting structure made the two in-person tutoring groups look more like small-group instruction than tutoring, with the tutors standing at the board and working through examples. The site director circulated the room, redirecting students periodically. The setting of the tutoring room was such that the environment felt happy and supportive, and students often helped each other, especially students with shared home languages.

At both school sites, choices in what curriculum tutors used with their students were restricted due to administrative policies. Tutors could choose how to enact materials (e.g., whether to use a HCD task or simplify it to a problem set) but had limited choices on the content and range of materials they were approved to use. In focus group 1, one participant noted tutors were given a “blueprint” by their site director, and another participant stated tutors didn’t “get much of a say about what lessons [they] taught on what day,” which was different from past years when tutors had more agency.

**Participants**

The study case comprised three tutors who volunteered to participate in this research. They were selected as eligible to volunteer because they were considered by city leadership as having a tutoring experience typical for the organization. As previously noted, for convenience, the case of tutors was initially serving at one site together. However, the case shifted to serving across two sites between when the participants were selected and the study began. Because the case was defined around the group of tutors in the same city willing to facilitate the same modified HCD task, adding an additional site did not alter the case validity or ability to answer the research questions. Pseudonyms were used to protect participant identities.
Emily was a bilingual, white female and a first-year tutor at Cortez. Emily used she/her pronouns. She worked as a Spanish tutor throughout college, an experience she enjoyed that inspired her to continue tutoring after graduation. Throughout her college studies, Emily was most interested in language acquisition and the cognitive process of learning. She grew up in the southeastern United States around the poverty line, with one parent working a low-paying hourly job. In high school, she worked to help support her family. She attended an immersion elementary school where she learned math and science in Spanish. From there, she gained the opportunity to go to a secondary charter school that emphasized academics and completed many hours of college credits before graduating from high school. This experience helped her attend college in the Midwest, where she graduated with a BA in Spanish and a BS in psychology. From study observations, Emily knew mathematics deeply, as evidenced by her ability to pivot quickly and give detailed, relevant explanations. She appeared less confident in her own solving methods when experimenting with the HCD task herself, preferring a few additional moments to consider her answer before sharing it with others. She welcomed input from others and did not shy away from asking for help while solving the HCD in the focus group.

Sammy was a white non-Latino, nonbinary tutor in their second year at Cortez and, as the only second-year full-time tutor of the participants, the most experienced educator of the group. Sammy used they/them pronouns. Throughout this paper, when it is unclear if “they” refers to Sammy or the collective group of tutors, it is indicated as “they (Sammy)” to clarify. They had a BA in comparative literature and were a high school teaching assistant for four years before joining the tutoring organization. Although
they had a degree in literature and not mathematics, they believed in the power of education, which drew them to this tutoring program. They grew up in a middle-class, white suburb and have always been interested in classrooms and learning. They loved college classrooms and working with professors. Discussing college classrooms in the first focus group, Sammy noted they “aspire to be back there soon.” In the first focus group, Sammy shared about their learning disabilities and attention deficit hyperactive disorder (ADHD) and said they used their learning experiences to relate to what students might be feeling. Sammy could confidently lead students through a mathematical discussion during tutorial and appeared confident in their own solutions when working on the HCD task, willing to jump in and add ideas without hesitation. Despite explicitly noting they did not focus on mathematics during their education, Sammy’s mathematical foundation seemed strong. Their reported lack of mathematical training did not appear to affect their ability to tutor or complete mathematics, as they did not waiver when guiding students, and they were mathematically accurate in their discussion contributions.

Richard was a nonbinary white tutor who began tutoring at Cortez and was transferred to Bennett two months into the school year. Richard used he/they pronouns and chose to be referred to using “he” pronouns in this paper. He willingly shifted to another school to fill a vacancy, wanting to continue serving the organization's mission in any capacity. He was neurodivergent and grew up very low middle class, just above the poverty line. He had degrees in English and communications and media and worked as a writing tutor in college. When tutoring in college, he focused on supporting fellow students on foundational, academic, and professional writing skills. He described the tutoring program in this study as his first professional education job. During observations
in this study, Richard was patient and kind to his students, often offering encouragement. He appeared less confident and comfortable with mathematics than the other two participants, not diving into justifications or deep explanations during his tutorials or when he solved the HCD task himself.

**Analytic Strategy of Data**

As described in the Data Collection section in Chapter 3, there were three data sources in this study: journal entries, focus groups, and observations. To analyze the data, I used convergent data triangulation. Meaning after collecting and coding all data types separately, I analyzed and coded the three sources of data together to create a holistic picture of the case, triangulating both the data sources and perspectives (Yin, 2013) instead of looking at each data source separately, drawing a conclusion, and then compiling the findings (Yin, 2018).

I used several analysis strategies. I analyzed the data based on the study research questions and propositions and organized the analysis under these categories. I used frequency of events, suggesting that if a theme emerged more often in the data, it was more relevant in the analysis (Yin, 2018). Additionally, I used rival explanations to consider alternative justifications for the data findings (Yin, 2018). This strategy helped me extend my thinking and more deeply contemplate the causes and explanations emerging in the data.

I applied two analytic techniques. First, I used explanation building to explain an occurrence in a study. The process includes making propositions and comparing them against collected data (Yin, 2018). Second, I used pattern matching, comparing findings against prior literature findings (Yin, 2018).
In completing the analysis, I made a few decisions for clarity of analysis and reading. First, I decided that when tutors nodded or added a quick one-word agreement (such as “yes”), I would count this as an agreement for analyzing the focus groups. Second, when speaking, tutor participants often referred to HCD tasks as “activities” because that is what they were referred to within the tutoring organization. For ease of reading, I changed all mentions of “activities” to “tasks.” I put these modifications in brackets to clarify when I changed a direct quotation. Third, the tutors occasionally referred to themselves as teachers, and I chose to leave these instances in their own words.

**Analytic Codes**

To complete data analysis, I used an inductive coding process guided by first and second cycle coding as defined by Miles et al. (2018). Data analysis begins with coding (Miles et al., 2018) and involves breaking data into chunks, coding, and organizing data into common categories (Efron & Ravid, 2019).

I used several types of codes during the inductive coding process, as using multiple can be appropriate for research analysis (Miles et al., 2018). I used emergent codes to capture what tutors said rather than what I wanted to hear. Emergent codes appear during data collection and analysis (Miles et al., 2018). For example, I did not pre-plan that I would look for mentions of differentiation. Instead, I saw that many tutors mentioned differentiation during data collection, so “differentiation” emerged as a code. I used in vivo codes to capture phrases directly from participants (Miles et al., 2018). For example, “check for understanding question” was a phrase used by participants that became a code. Based on the research questions, this process helped me uncover the
tutors’ barriers to implementing HCD tasks and what they thought the most valuable supports would be. Additionally, I employed descriptive coding, which means creating a list of topics (e.g., task for review), process coding, which uses gerunds and actions (e.g., digging in), and evaluation coding, which assigns judgment (e.g., observation tally chart for instance of HCD versus LCD; Miles et al., 2018).

I did a preliminary analysis as I was collecting data, an emergent analysis meant to help shape the rest of the study and subsequent data collection (Efron & Ravid, 2019). Miles et al. (2018) recommended analyzing data throughout the study, which I did. Preliminary analysis of the first journal informed the first focus group, analysis of the first journal and first focus group informed the HCD task revision that tutors implemented during the observation, and the observation and second journal informed the final focus group. To analyze the transcripts of focus groups, I removed filler words to make them more readable (Miles et al., 2018).

First Cycle Codes

After collecting all data, I created codes using first and second cycle coding by reflecting on the text (Miles et al., 2018). To complete the first cycle codes, I started with the second focus group transcript to get initial topic ideas and generated codes around these ideas. I then coded the rest of the data using the inductive coding process, adding more codes as needed. Table 4.1 shows the first cycle codes and how I defined them.
<table>
<thead>
<tr>
<th>First Cycle Code</th>
<th>Code Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task for review</td>
<td>Mention tasks are best for review or as a supplement to a problem set</td>
<td>“It’s a supplement to the lesson that we’re doing.” – Richard, Focus Group 1</td>
</tr>
<tr>
<td>Independent work time</td>
<td>Mention of the importance of students working independently as reason for using or not using a task</td>
<td>“I use problem sets in all my lessons because I think it is important that they have independent time to work through problems on their own without using me as a guide or crutch.” – Richard, Journal 1</td>
</tr>
<tr>
<td>Task too hard</td>
<td>Indication tutor thought a task was too difficult, so they scaled back the cognitive demand and turned the task into a problem set</td>
<td>“The students were struggling to solve equation in general, so the added direction card felt overwhelming.” – Emily, Journal 1</td>
</tr>
<tr>
<td>Controlled environment</td>
<td>Mention behavior management challenges with a task</td>
<td>“Using the problem set created a more controlled and focused environment.” – Emily, Journal 1</td>
</tr>
<tr>
<td>Digging in</td>
<td>Tutor exploring underlying math concepts while completing HCD task</td>
<td>“I was just going to flip everything around, but the zero changes that.” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>Hesitant</td>
<td>Tutor acting hesitantly while completing HCD task</td>
<td>“You could do…no. Oh wait, that rounds to 70?” – Emily, Focus Group 1</td>
</tr>
<tr>
<td>Misconception</td>
<td>Tutor misconception while completing HCD task, either during solving process or having slight confusion during an explanation</td>
<td>“It has to be 30.67 because if you did 76 you’re closer to 31.” – Richard, Focus Group 1</td>
</tr>
<tr>
<td>Change in tutor engagement</td>
<td>Tutor engagement changing with the inclusion of supports</td>
<td>“I felt more comfortable and adaptable with the support.” – Emily, Focus Group 2</td>
</tr>
<tr>
<td>Planning process</td>
<td>Mention of planning process or lesson preparation time</td>
<td>“if I’m behind on lesson planning, and need to whip up a really quick Do Now and Ticket to Leave for a [task], I don’t have enough time to dive into the [task] myself, and understand what are the skills actually being tested.” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>Use of materials</td>
<td>Observation of how curricular materials were used during tutorial</td>
<td>“Altered given Do Now.” – Observation notes from Richard</td>
</tr>
<tr>
<td>Student enjoyment</td>
<td>Indication of student enjoyment during task; includes tutor mentioning that a student might like or did not like a task or that they think students find a task more engaging than a problem set</td>
<td>“The [task] was a nice change for the students.” – Emily, Journal 2</td>
</tr>
<tr>
<td>Keeping cognitive demand high</td>
<td>Observation of cognitive demand being kept high during tutorial</td>
<td>“Pushed why constantly.” – Observation notes for Emily</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Observations</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lowering cognitive demand</td>
<td>Observation of cognitive demand being lowered, intentionally or not, during tutorial</td>
<td>“Gave routine of how to find place value without asking students for ideas first.” – Observation notes for Richard</td>
</tr>
<tr>
<td>Check for understanding question (CFU)</td>
<td>Indication of embedded questions as a support, used to drive conversation and access understanding</td>
<td>“Pushed CFUs to build more understanding.” – Observation notes from Emily</td>
</tr>
<tr>
<td>Differentiation</td>
<td>Mention of differentiation tips as embedded support</td>
<td>“I really liked the extension and differentiation sections of the lessons because sometimes I struggle to think of ways in the moment to go deeper within the concept because I either wasn't expecting them to understand or I was expecting the lesson to take longer than it actually did.” – Richard, Journal 2</td>
</tr>
<tr>
<td>Do Now (DN)</td>
<td>Indication of assessing background information</td>
<td>“The included DN questions did a very efficient job communicating to me the most important prerequisites for the [task] to be successful.” – Sammy, Journal 2</td>
</tr>
<tr>
<td>Key points</td>
<td>Mention of listing key points in curricular materials</td>
<td>“Having a list of key ideas to concentrate on as a point of discussion would be helpful. What are we trying to accomplish by the end of the task?” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>Misconceptions</td>
<td>Indication of anticipated misconceptions as a support</td>
<td>“Common misconceptions table as a heads up for me.” – Sammy, Journal 2</td>
</tr>
<tr>
<td>Pedagogical content knowledge (PCK)</td>
<td>Conversation around PCK as support</td>
<td>“Pedagogical resources, I think, would be more helpful for me rather than necessarily the math.” – Emily, Focus Group 1</td>
</tr>
<tr>
<td>Scaffolding</td>
<td>Indication of scaffolding ideas as an embedded support</td>
<td>“Scaffolding tips stood out to me.” – Emily, Focus Group 1</td>
</tr>
<tr>
<td>Ticket to Leave (TTL)</td>
<td>Indication of ending formative assessment</td>
<td>“I find the do now and ticket to leave very helpful.” – Emily, Journal 2</td>
</tr>
<tr>
<td>Visual scaffold</td>
<td>Indication of embedded visual scaffolds</td>
<td>“The decimal chart, and then, having that number line visual were the biggest supports for me.” – Emily, Focus Group 2</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>Mention of vocabulary as embedded support</td>
<td>“Vocab definitely does help what I’m trying to teach.” – Richard, Focus Group 1</td>
</tr>
<tr>
<td>Not helpful supports</td>
<td>Indication a support was not helpful</td>
<td>“I don’t really care about standards or know what they actually mean for the students.” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>Too many supports</td>
<td>Mention of too many supports being overwhelming</td>
<td>“Tutors might see the 12 pages in a plan and get overwhelmed.” – Sammy, Focus Group 2</td>
</tr>
<tr>
<td>Discourse</td>
<td>Indication of student conversations or math discourse</td>
<td>“We don’t always have that sort of time for discussion.” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Lacking background skills</td>
<td>Indication students lacked background skills needed to engage in the task</td>
<td>“I would definitely do it again if given the change to give the kids more background information beforehand.” – Richard, Journal 2</td>
</tr>
<tr>
<td>Timing</td>
<td>Conversation around including support on how to structure tutorial time or what to skip if running short on time</td>
<td>“For me, timing is never helpful.” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>Site Director</td>
<td>Mention that site director chose tasks</td>
<td>“It’s mostly at the discretion of the site director what is being taught.” – Sammy, Focus Group 1</td>
</tr>
<tr>
<td>Tutor background</td>
<td>Information that sheds light onto the background of the participants</td>
<td>“I have ADHD and learning disabilities.” – Sammy, Focus Group 1</td>
</tr>
</tbody>
</table>

**Second Cycle Codes**

After coding all data with first cycle codes, I created second cycle codes following the inductive coding process, where I grouped codes into categories (Miles et al., 2018). I looked for patterns of what code topics made sense together, focusing on my research questions and propositions, as recommended by Efron and Ravid (2019). I condensed data into causes and explanations around the research questions and propositions because this is an action research study focusing on exposing barriers for tutors in implementing HCD tasks and curricular supports to overcome them. Furthermore, I hope to change my practice by applying the study findings, so knowing the causes and explanations was vital. Table 4.2 shows second cycle codes. To distinguish between first and second cycle codes, in this paper, first cycle codes are called such, and second cycle codes are called “categories.” This section describes how I condensed first cycle codes into eight categories.
### Table 4.2 Second Cycle Codes (Categories) Aligned by Research Question

#### Research Question 1: How do tutors engage with high cognitive demand tasks?

<table>
<thead>
<tr>
<th>Category</th>
<th>First Cycle Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning uses of HCD</td>
<td>Task for review</td>
</tr>
<tr>
<td>Beginning uses of HCD</td>
<td>Independent work time</td>
</tr>
<tr>
<td>Beginning challenges of HCD</td>
<td>Task too hard</td>
</tr>
<tr>
<td>Beginning challenges of HCD</td>
<td>Controlled environment</td>
</tr>
<tr>
<td>Tutors doing HCD</td>
<td>Digging in</td>
</tr>
<tr>
<td>Tutors doing HCD</td>
<td>Hesitant</td>
</tr>
<tr>
<td>Tutors doing HCD</td>
<td>Misconception</td>
</tr>
</tbody>
</table>

#### Research Question 2: How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?

<table>
<thead>
<tr>
<th>Category</th>
<th>First Cycle Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement changes</td>
<td>Change in tutor engagement</td>
</tr>
<tr>
<td>Engagement changes</td>
<td>Planning process</td>
</tr>
<tr>
<td>Engagement changes</td>
<td>Use of materials</td>
</tr>
<tr>
<td>Engagement changes</td>
<td>Student enjoyment</td>
</tr>
<tr>
<td>HCD enactment</td>
<td>Keeping cognitive demand high</td>
</tr>
<tr>
<td>HCD enactment</td>
<td>Lowering cognitive demand</td>
</tr>
</tbody>
</table>

#### Research Question 3: What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?

<table>
<thead>
<tr>
<th>Category</th>
<th>First Cycle Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful supports</td>
<td>Check for understanding question (CFU)</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Differentiation</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Do Now (DN)</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Key points</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Misconceptions</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Pedagogical content knowledge (PCK)</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Scaffolding</td>
</tr>
<tr>
<td>Useful supports</td>
<td>Ticket to Leave (TTL)</td>
</tr>
</tbody>
</table>
Research Question 1 Categories. The first research question explored how tutors engaged with HCD tasks. This research question covered two aspects of tutor engagement on tasks: first, how they identified they used tasks with their students, and second, how they engaged with a HCD themselves.

Beginning Uses of HCD and Beginning Challenges of HCD. I saw two patterns emerge from the first cycle codes that explained how tutors used HCD tasks with their students. First, descriptions of how they used HCD tasks, and second, the challenges they described in using them. I separated uses and challenges into two separate categories, condensing the first cycle codes for “task for review” and “independent work time” under the beginning uses of HCD category and “task too hard” and “controlled environment” under the “beginning challenges of HCD” category. Keeping these two categories separate allowed me to identify how tutors initially engaged in two different ways to answer research question one. These two categories let me explore the first proposition that tutors do not fully engage with HCD tasks for the same reasons teachers have identified in previous literature.

Tutors Doing HCD. I condensed three first cycle codes surrounding tutors engaging with the HCD task themselves (“digging in,” “hesitant,” “misconception”) into a single category (“tutors doing HCD”) because they all led to addressing the same
proposition that tutors not fully engaging with HCD tasks because they were uncomfortable with them. All three first cycle codes emerged during the first focus group when tutors worked through the task. The code “digging in” was used when tutors explored underlying math concepts, “hesitant” was used when tutors were reluctant to share their ideas, and “misconception” was used when tutors expressed an idea that contained a mathematical inaccuracy.

**Research Question 2 Categories.** The second research question explored how tutor engagement with HCD tasks changed with the inclusion of embedded supports. While analyzing first cycle codes, I saw two patterns emerge that led to answering this question. First, tutors’ engagement changes concerning their mindsets, feelings, planning, and willingness to use HCD tasks and second, observational data of how tutors implemented the HCD tasks.

**Engagement Changes.** To best answer the second research question, I combined four first cycle codes (“change in tutor engagement,” “planning process,” “use of materials,” and “student enjoyment”) under the category “engagement changes.” “Change in tutor engagement” was used when tutors expressed a positive or negative change in disposition towards the task after supports were added. “Planning process” noted tutors mentioning the time it took or difficulty of preparing for their tutorial. “Use of materials” was a first cycle code used for observational data that shed light on how tutors used curriculum with students. “Student enjoyment” coded instances when tutors mentioned students enjoyed a task. Combining these first cycle codes allowed me to consider all aspects of tutor engagement changes and whether one was more profound than another.
**HCD Enactment.** The first cycle codes, “keeping cognitive demand high” and “lowering cognitive demand,” came from observational data and were guided by Stein et al.’s Mathematical Tasks Framework (1996). To analyze these two aspects, I combined them under one category, “HCD enactment.” I needed to consider how often tutors kept cognitive demand high versus lowered it while tutoring to triangulate data and verify if tutor enactment was as successful as they described. This consideration helped me answer my second research question.

**Research Question 3 Categories.** The third research question explored what supports helped tutors implement HCD tasks. Three categories emerged when examining the first cycle codes that shed light on this area. First, several first cycle codes indicated supports tutors found useful. Second, there were first cycle codes indicating unhelpful supports. Last, a few first cycle codes demonstrated instances where it was unclear whether a support was helpful.

**Useful Supports.** Many first cycle codes noted guidance tutors found supportive. To answer the third research question, I considered these supports together. I condensed “check for understanding question,” “differentiation, “do now,” “key points,” “misconceptions,” “pedagogical content knowledge,” “scaffolding,” “ticket to leave,” “visual scaffold,” and “vocabulary” under a single second-cycle category, “useful supports.” These first cycle codes all indicated instances where tutors suggested one of these support types was helpful. All except “pedagogical content knowledge” were in vivo codes based on how tutors described these elements. “Do now” and “ticket to leave” were in vivo codes that tutors used to signify the opening background skill questions and...
closing formative assessment questions, respectively, that they used in almost every tutorial session.

**Not Useful Supports.** To support the third research question, I also considered supports that tutors did not find helpful. I grouped these first cycle codes (“not helpful supports” and “too many supports”) under the category “not useful supports.”

**Lingering Challenges.** There were several first cycle codes where it was unclear from the coded data whether a support was helpful. I created a separate “lingering challenges” category for these codes. These first cycle codes noted areas where there was disagreement among participants or when a trialed support was marginally helpful but not wholly successful. Grouping these first cycle codes helped me see where further research and exploration were needed in subsequent studies.

**Jotting and Memoing**

The coding process can trigger analytic thoughts, and jotting and memoing capture these thoughts (Miles et al., 2018). Jotting is a recording of the researcher’s personal thoughts and reactions. It creates transparency in the research and analysis process, helping the researcher reflect on their emotions. In jotting, a researcher might indicate how a particular analysis feels (e.g., I am frustrated as I read this) and record their reactions and commentary (Miles et al., 2018). I used my researcher journal in google docs (*Google Docs*, 2023) to complete jottings. I considered how various data made me feel, which helped me recognize when I was skewing analysis or reporting based on my feelings rather than what the data said.

Analytic memoing is like jotting, as it happens during data analysis. It differs because it is not the researcher’s personal feelings but thoughts about the data. For
example, it could include notes on why a chunk of data was coded a certain way, so the researcher knows their initial thoughts if they later revise their coding definitions. I added analytic memoing to the data while coding using Dedoose software (Miles et al., 2018). I used these memos to create succinct codes with clear definitions.

**Research Question 1: How do Tutors Engage with High Cognitive Demand Tasks?**

This section starts by exploring data that aligns with proposition 1a on why tutors do not fully engage with HCD tasks, then explores data aligned to proposition 1b that tutors are uncomfortable with HCD tasks. The section ends with a summary of how well the data supported the two propositions and areas where the data did not support the propositions.

**Proposition 1a: Beginning Uses & Challenges of HCD Tasks**

The initial proposition was that tutors do not fully engage with HCD tasks due to the same difficulties in implementation identified by teachers, such as timing (Bieda, 2010), not having sufficient pedagogical content knowledge (Wilhelm, 2014), struggling to facilitate mathematical discussions (Viseu & Oliveira, 2012), not knowing how to set up a productive learning climate (Schettino, 2016), being unsure how to select appropriate tasks (Estrella et al., 2020), getting unexpected student responses to the content (Hernández et al., 2016), or not knowing how to scaffold and differentiate appropriately (Stein et al., 1996).

**Beginning Uses of HCD Tasks.** As shown by journal 1 and focus group 1 data, participants did engage somewhat with HCD tasks. Mostly, tutors used HCD tasks as a review or supplement. The same theme emerged with all participants: they viewed the
tasks as additive, not a means to introduce a concept or be used as an alternative to a problem set. It was mentioned twelve times and at least three times by each participant.

From journal 1, I found tutors used HCD tasks as a supplement after students were skilled in the central mathematical concept. Emily stated she used HCD tasks “when we’ve been working on [a concept] for a week or two.” Richard said he moved to a HCD task “because they (the students) had been doing well in the lesson the day before.” I found the same sentiments in Sammy’s journal, where they mentioned, “lessons are helpful to introducing new concepts.” These findings were supported by the first focus group, where Richard said he used HCD tasks as a “supplement to the lesson that we’re doing,” and Sammy added, “when students have a slight understanding of the concept but really need to get it down, that’s when I find a [task] really, really helpful, not to introduce a new topic.” In journal 2, Richard noted, “I was really nervous about giving the [task] because it was a topic that they hadn’t covered yet in class,” emphasizing the tutor mindset that HCD tasks work best as review. These findings suggest that before the study, tutors may have used HCD tasks only as supplemental review and not to introduce or practice a new topic.

I found in journal 1 that tutors did not view HCD tasks as working well when too much backfill was needed. Sammy said, “I generally don’t give students [HCD tasks] if I determine that half or more of the class time would be needed for scaffolding prerequisite skills needed for the [task].” Tutors liked the idea of using HCD tasks to work on foundational skills. They expressed in the first journal and focus group that they preferred to use them when students had seen the concepts before and were reviewing them. I found that when the task was centered on a background skill, tutors felt more successful
with it. This successful feeling is evidenced by a focus group 1 comment from Sammy, who said they liked HCD tasks “as an opportunity to go back and work on foundational skills;” this is when they found the tasks “most helpful.” Emily’s comments in focus group 1 supported these findings: she stated she liked to use HCD tasks as “review, like with fractions or something that is entirely foundational” and noted this was when she found them “usually really successful.” These findings may suggest that before the study, tutors may have found success with HCD tasks when students had a firm understanding of the concepts addressed on the task but not if students were unfamiliar with the topic.

In the data, there was one mention of it being more challenging to control the environment with a task than a typical lesson with a problem set. In journal 1, Emily wrote, “some [tasks] get the students more riled up and distractible because of the sense of a game, so using the problem set created a more controlled and focused environment.” This sentiment could indicate that Emily chose problem sets over HCD tasks because of the ease of implementation with regard to behavior management. However, the sense of control was not mentioned again, so I did not weigh this potential challenge heavily in the analysis.

In sum, the same theme of HCD tasks being used as supplements or review emerged across all three participants and in both journal 1 and focus group 1. While one mention of it being easy to control the environment was noted, the idea of HCD tasks as supplementary review was most frequent. A potential alternative explanation is tutors were unsure how to use HCD tasks, so they have had bad experiences implementing them. As such, they have concluded that they should only be used as review, which could create less cognitive struggle and likely more success. From the data analysis, I did not
find that tutors were entirely resistant to using HCD tasks and found that they seemed to use the tasks only to revisit a topic.

**Beginning Challenges.** Tutors identified challenges they had with HCD tasks based on the materials they had without embedded supports (see Appendix B) in the first journal and first focus group. These findings aligned with some of the same challenges teachers identified in prior research. Tutors identified that the tasks were too hard for students, they were unsure of the key takeaways, had inadequate planning time, and could not predict misconceptions.

**Tasks Too Hard for Students.** I found in journal 1 and focus group 1 that tutors thought the HCD tasks were too hard for their students, and occasionally tutors thought they needed to shift to using a problem set. In journal 1, Emily wrote about using one HCD task and described, “the students were struggling to solve the equations in general, so the added [task] directions felt overwhelming.” In focus group 2, she described priorly used tasks stating that “some of the [tasks] were derailed, and we had to change to problem sets.” Richard expressed beliefs in focus group 1 that language learners needed procedures incompatible with HCD tasks. He stated, “especially for my kids that are the ELL learners, ambiguity doesn’t work. They need procedures. They need step-by-step instruction.” These findings may suggest Emily and Richard thought some HCD tasks were too difficult for their students.

**Lack of Differentiation and Scaffolding.** In focus group 1, I found tutors expressed that planning time was too difficult or time-consuming, and inadequate supports around differentiation and scaffolding made planning challenging for tutors. In focus group 1, tutors identified many support areas lacking in the starting curricular
materials. All three tutors in the case mentioned a lack of differentiation and scaffolding advice as presenting a challenge when planning. Emily discussed an issue with scaffolding in other curriculum stating, “one thing I have noticed on extensions and extension problems is I feel like sometimes the extension is too difficult to use. It’s set too high in some [tasks] that I found because there’s a range in some of our pods where they should be getting extended, but trying to use that, it’s just too big of a jump for some of them. So maybe if there were two possible extensions, one that is just one step above and then one that’s two steps above.” Sammy discussed the lack of possibilities and alterations in the materials made it difficult to plan, emphasizing they (Sammy) “always want to have a plan B, and then C, and D.” Richard pointed to the lack of differentiation inhibited his ability to plan effectively, elaborating that “having a [task] where they (students) have to think in more than one way or see a problem that’s different than what they’re used to is very helpful [when planning].” Sammy also noted the lack of scaffolding and differentiation led to students “not being challenged at the right level.” In journal 1, Emily supported the ideas shared in focus group 1. She wrote, “I found that the problem set was more effective as the first problems were easier and they got increasingly difficult, so it was easier for me to assign students appropriate problems.” These findings may suggest the difficulty tutors had scaffolding and differentiating HCD tasks appropriately for their students led to challenges in planning them effectively.

*Lack of Check for Understanding Questions.* Tutors discussed check for understanding questions (CFUs) and how they found the ones included in the tutor versions of lessons within the organization’s curriculum helpful. They found the lack of CFUs in task materials an obstacle. In focus group 1, Emily said, “I really like the CFUs
that I find on every lesson. I usually highlight them, and I write them down to make sure I ask them. CFUs on the [tasks] would probably be useful.” Richard and Sammy nodded agreement that CFUs on tasks would be a helpful support. This finding may suggest adding CFUs to task materials could be useful for the tutors in this case.

**Lack of Identified Main Takeaways.** Through comments Emily and Sammy made during focus group 1, I found that they might have had difficulty knowing the main mathematical ideas students should take away from a task, and therefore, it was challenging for them to know what key points to emphasize with their students. Emily noted, “even working through it (the task), it took me a minute to see the takeaways.” Sammy explained why having key mathematical points listed on the tutor version would be helpful, saying, “if I’m behind on lesson planning, I don’t have enough time to dive into the [task] myself and understand what the skills are actually being tested.” I, as the researcher, followed up on Sammy’s comment, stating in focus group 1, “it sounds like you’re saying that it’s hard just glancing at the questions to figure out what the main takeaways are and that you really have to work through it yourself to figure that out. But that’s time-consuming to work through it all yourself.” Sammy agreed, saying, “yeah, I think that explains it exactly. I started to understand the [task] a little bit more after working through it myself.” These findings may indicate it is difficult for tutors to readily identify task takeaways without them being listed on a tutor version.

**Lack of Identified Background Skills and Formative Assessment Questions.** Tutors identified another challenge with planning was a lack of aligned background skills to begin tutorial with (called a Do Now in the tutoring organization) or formative assessment questions to end with (called a Ticket to Leave in the tutoring organization).
The lack of provided questions presented a timing challenge when planning. An alternative explanation I considered was that it would be hard for tutors to create background skills questions or formative assessment questions if they were unsure of the key takeaways of the task, so a lack of support in other areas may have caused this issue. In focus group 1, Sammy said, “having two or three pre-built Do Now questions like we have in lessons, that would, I think, make it so much easier to streamline, to go much easier back and forth between a typical lesson versus a [task].” Emily noted that one thing she would like added to the tutor version of the HCD task was “a Do Now. Maybe that goes over how to round, specifically thinking about that being a struggle. Because if they don’t know how to round, they won’t be able to do [the task].” In focus group 1, Sammy added, “having Ticket to Leave questions would be helpful.” These findings may indicate it is challenging for tutors to plan questions to start and end a tutorial that uses a HCD task, and it might be supportive to add these to the tutor materials.

**Lack of Anticipated Misconceptions.** Tutors seemed to find it challenging to have a lack of support around anticipating student misconceptions. In focus group 1, Richard said he would like added support, “anticipating student responses and how to respond. I know we have the misconceptions section for planning guidance [in the organization’s lesson materials], but students are very unpredictable, so being given some advice for that [on HCD tasks] would be useful.” Emily and Sammy nodded in agreement. This finding may suggest they struggled to anticipate student misconceptions and would appreciate guidance.

Richard continued that knowing what vocabulary might be challenging for students would be helpful. He said in focus group 1, “vocab definitely does help what I’m
trying to teach because then they can recognize that word and know what’s going on even if the math is confusing.” Emily elaborated on Richard’s idea in focus group 1 that “the main vocabulary that was mentioned [in the task] was place value and vocab with tens and tenths, so maybe having a Do Now [question] that focuses on rounding, and a bit of vocabulary” would be helpful. These statements could indicate Richard and Emily wanted support in identifying students’ starting points on their comprehension of academic vocabulary used in the task.

**Lack of Mathematical Content Supports.** Another area I found presented a planning challenge for tutors was a lack of supports surrounding general mathematics. As Richard explained in focus group 1 after being asked if content support would be helpful in tutor materials, “I was an English major in college, and math definitely was not on my list of priorities. I’m good at math, but this is the first time I’ve done math in maybe three years. So, it would be nice to have extra support.” In focus group 1, Emily nodded agreement when asked if vertical alignment describing the progression of mathematical ideas students learn across grade levels might help support mathematical content knowledge. These findings may suggest additional content support, such as vertical alignment, might support tutors if it were included in the tutor version of HCD tasks.

**Beginning Challenges Summary.** The theme of supports lacking and thus making planning HCD tasks a challenge emerged from all tutor participants. Differentiation and scaffolding were the most frequently mentioned. Data showed that tutors thought HCD tasks were too difficult for students. A rival explanation to this finding is that this mindset might have been because tutors were unprepared to facilitate, and thus the tasks were too hard for them as tutors, not for their students.
Proposition 1b: Tutors Engage with HCD Task Themselves

The second proposition aligned with the first research question was tutors do not fully engage with HCD tasks because they are uncomfortable with them (National Research Council, 2009; Wilhelm, 2014). During the first focus group, tutors solved a HCD task (see Appendix B). The task was the same one they facilitated with their students during week 4 of the study when the observation occurred. While tutors completed the task, casual observations were made around tutor behaviors, an observational data source common during focus groups (Yin, 2018).

Engagement with the Task. I found some tutors engaged much more than others during the process of solving HCD tasks during the first focus group. However, data indicated no tutor was disengaged entirely, and all appeared to have tried their best. These findings align with the proposition that tutors were uncomfortable with the task. Tutors occasionally dug into the mathematical reasoning and the “why,” sometimes they were hesitant, sometimes they had misconceptions, and rarely did they have conversations amongst themselves. Each tutor had a slightly different disposition during the task, as evidenced by casual observations. Sammy appeared interested in learning and exploring but was not entirely relaxed and did not drive discussion with others. Emily was willing to participate, discuss her confusions, and explore when she was uncertain. Richard was quiet, reserved, and seemed to prefer to share after others did. There were instances where the tutor participants engaged deeply, exploring concepts and digging into what happened mathematically. Sammy did this most often, and Emily did it occasionally. Richard did not engage this way but nodded in agreement when Sammy or Emily shared. For example, Sammy explored the use of zero in the task,
saying when moving from the largest to smallest number, “I was just going to flip everything around, but the zero changes that.” They (Sammy) also explored which problems had one solution versus multiple, saying, “I think there’s only one answer for this.” Emily stretched Sammy’s idea and noted, “‘largest’ and ‘smallest’ indicate there’s only one solution.” These instances highlighted points where tutors were fully engaged with the HCD task.

Often Emily was hesitant when solving, as evidenced by her verbal processing and questioning, such as when she said, “that’s in the tens place, right?” Additionally, when I asked, “Is there another answer to that one?” she responded uncertainly with “you could do…(trailed off)…no. Oh, wait, that rounds to 70?” Through casual observations, this lack of confidence in some areas did not appear to stifle Emily as she was engaged and promoting discussion by contributing her ideas and asking questions of others. This active discourse differed from how Richard and Sammy engaged, as they appeared only to engage when confident of their contribution, speaking with statements instead of questions.

Throughout the solving process, several misconceptions about rounding surfaced. Emily had a misunderstanding because she misinterpreted a prompt, saying, “I was thinking 67.3 would round to 67,” and not understanding immediately that 67.3 also rounds to 70. She elaborated, “I thought for that one when it said a number that rounds to seventy, in my mind, I was thinking rounds up to 70,” which showed further confusion as 67.3 does round up to 70 when rounding to the tens place. Richard seemed to have misconceptions about how to round, rounding some numbers by rounding digits twice. For example, he rounded 70.36 to 70.4 and then to 70 instead of rounding 70.36 to 70.
(This technique results in the same answer for 70.36 but is not mathematically accurate. For example, using this technique, 70.46 would round to 70.5, which would round to 71, suggesting inaccurately that 70.46 rounds to 71.) He explained, “you could do 70.36 because technically the .36 rounds to .4, but that wouldn’t round any further, so you’d be stuck at 70.” When creating a number closest to another number, Richard correctly knew there was only one possible solution; however, he explained it in terms of rounding: “I think the ones that have only one answer are the questions that are asking us to create a number that’s closest to 6 or whatever number they’re asking for, because you have to order in a specific way so that if you round you still get that number.” There were other instances of Richard having the correct answer but a misconception in the explanation. For example, when creating a number closest to 30, Richard correctly made 30.67 but reasoned, “it has to be 30.67 because if you did 30.76, you’re closer to 31,” when both 30.67 and 30.76 are closer to 31 than 30. These findings may show that Emily and Richard had mathematical misconceptions about rounding, which surfaced while solving the task.

The same themes did not emerge across participants when analyzing how tutor participants engaged with the task. Sammy was most likely to dig into concepts and go deeper into the mathematical reasoning. Emily was most likely to talk out her hesitations. Richard was most likely express misconceptions. These findings may suggest each tutor’s starting point in engaging with a HCD task might differ, and therefore, could suggest the need for different support tailored to individual tutor needs.

Another consideration when analyzing the data is that these three tutors had worked together in person for two months and appeared relaxed when expressing their
ideas to each other. They seemed comfortable discussing and disagreeing. However, there was not much discussion about mathematics during the task completion, and the conversation felt stunted. This change was noticeable as through other parts of focus group 1, the group of tutors appeared happy to actively discuss and engage in dialog, often building ideas off each other. This finding may suggest tutors were uncomfortable with the HCD task and discussing their mathematical ideas. They might have felt awkward playing a student or unsure what a productive mathematical discussion looks and sounds like.

One alternative explanation in this area is that I was acutely aware the tutors were not students as I facilitated the task and made intentional choices not to make them feel like such, as I was concerned it might feel condescending. There were times that I would have given more explicit directions on engaging in a discussion had I been working with students. For example, I would have given students more precise instructions on how to interact, such as, “don’t tell me, tell your groupmates,” and “what did you think about what [name] said?” that I did not do with the tutor participants. This choice could have contributed to the tutors having a less interactive discussion around the HCD task.

**Research Question 1 Findings Summary**

Proposition 1a, that tutors did not fully engage with HCD tasks due to the same difficulties as teachers (see Implementation Challenge with High Cognitive Demand Tasks in Chapter 2), was mostly supported in the data. The challenges addressed by tutors were not identical to those identified by teachers; however, many aligned. Additionally, the overarching idea that a lack of supports led to implementation challenges was the same.
Alignment in Challenges Identified by Tutors and Teachers. Tutors in this study articulated insufficient support and knowledge of general mathematics or vertical alignment as a challenge, and related, teachers have identified inadequate pedagogical content knowledge as a struggle (Wilhelm, 2014). Tutors noted not being able to anticipate student misconceptions was challenging, which is aligned with prior findings of teachers being unsure how to respond to student responses (Hernández et al., 2016). Tutors in this study and teachers in previous research have identified scaffolding and differentiating as challenging for HCD tasks (Stein et al., 1996). This study’s findings show tutors noted planning time to identify background and formative assessment questions as an obstacle, while teachers have identified selecting appropriate tasks as a challenge (Estrella et al., 2020).

Misalignment in Challenges Identified by Tutors and Teachers. Tutors identified tasks as being too difficult, planning taking too much time, needing model questions to check for student understanding, and a list of the task takeaways as challenges to their successful planning and enactment of HCD tasks. Teachers in prior studies have identified lesson timing (Bieda, 2010), the struggle to facilitate discussions (Viseu & Oliveira, 2012), and the ability to set up a productive learning climate (Schettino, 2016) as challenges. While not explicitly aligned, tutors may not recognize needing exemplar questions to ask students and needing to know the takeaways of a task as necessary factors to facilitating a productive discussion or learning environment.

Engagement with Task. Proposition 1b was supported by the study findings that tutors did not fully engage with the HCD task because they were uncomfortable with them (National Research Council, 2009; Wilhelm, 2014). While there were glimpses of
full engagement in the data, no tutor demonstrated they were entirely comfortable
discussing the task, and they did not attempt to engage or explore the topic more than
minimally necessary.

**Research Question 2: How does Tutor Engagement with HCD Tasks Change with
the Inclusion of Educative Curricular Supports?**

The proposition aligned with the second research question was that educative
supports help tutors engage with HCD tasks by building their content and pedagogical
knowledge (Granger et al., 2019) and helping them visualize the tasks in action (Davis et
al., 2017). After preliminary data analysis, I altered the original HCD task tutors engaged
with to include embedded supports in the areas tutors identified as needing it during
journal 1 and focus group 1. I analyzed data from observations of the tutors facilitating
the task that included the embedded supports, a second tutor journal where they reflected
on their experience using the task, and a second focus group where they shared their
thoughts on the task supports.

This section first details the task alterations, then explores the changes in tutor
engagement found in journal 2 and focus group 2 and observational findings from tutors
enacting the revised task. This section ends with a summary of how the findings support
proposition 2.

**Task Alterations**

From the first focus group, the tutor participants suggested several areas where
additional guidance might be helpful in their implementation of HCD tasks. This section
describes how I created the embedded task supports. First is the original task. Then, a
section about each alteration made includes the thinking from the first focus group and a
description of the embedded supports I added. (Tutor reactions to the supports were explored in journal 2 and focus group 2 and are discussed later under findings from research question 3.) All the supports are for the same task and were intentionally designed to be abundant to meet the needs of varying tutors and students. While planning and implementing, tutors could pick and choose the support they needed and skip the others. Additionally, supports were designed to be easily implementable without additional preparation work by a tutor new to education who does not have a mathematics background. Figures of the alterations are included in each section below, and the complete revised task is in Appendix H.

**Original Task.** As seen in Figure 4.1, the initial task contained only the student-facing questions and the solutions.
**Create a Number Activity**

*Materials:* Cut out the 5 cards for each student to use as manipulatives.

![Card Values: 0 | 3 | 6 | 7 | .]

*Instructions:* Using all 5 cards, create a number that satisfies each of the following problems. You must have at least one digit on either side of the decimal.

1. Create a number with a 7 in the tens place.  
   Answers will vary. Sample response: 376.0

2. Create a number with a 7 in the tenths place.  
   Answers will vary. Sample response: 630.7

3. Create the largest possible number.  
   763.0

4. Create the smallest possible number.  
   036/7

5. Create a number less than 6.  
   Answers will vary. Sample response: 3.670

6. Create a number between 600 and 700.  
   Answers will vary. Sample response: 607.3

7. Create a number between 60 and 70.  
   Answers will vary. Sample response: 63.70

8. Create a number that rounds to 70.  
   70.36

9. Create a number that rounds to 4.  
   3.670

10. Create a number that is as close as possible to 30.  
    29.67

11. Which questions had multiple answers? Which had only one? Justify your answer.  
    Note: Students justify their answers by showing that there are other (or no other) possible numbers for questions 1-10.

**Figure 4.1 Original HCD Task**

**Key Takeaways.** In focus group 1, tutors identified that they struggled to know the key takeaways from a task. To support this area and address the focus group concerns, I embedded the purpose of the task and key points students should take away from completing it (see Figure 4.2). The purpose orients the tutor to the type of task and why students should engage with it. The key points are the three minimal mathematical takeaways students should have after completing the task. Within the key concepts, I
included examples to make the guidance more user-friendly to tutors who might not have a solid mathematical background, which Richard indicated in focus group 1 could be an issue for him. These supports intended to address the need expressed in focus group 1 that tutors could not readily identify task takeaways.

**Figure 4.2 Purpose of the Task and Key Points**

**Mathematical Background.** In focus group 1, tutors suggested it would be helpful to have more background on the mathematical direction of the task. To address this concern, I included an overview and vertical alignment (see Figure 4.3). These items were intended to help tutors see the mathematical progression of the skills worked on so tutors could connect this task to students’ prior and future mathematical content, which has been shown to support student learning (Stein et al., 1996). Additionally, I added an explanation of what types of students the task might work best for, which was intended to help tutors assess if the task would be appropriate for a given student’s mathematical progress.

**Purpose:** This activity is a non-traditional, tactile way for students to practice place value and rounding skills. Creating numbers using limited digits is higher-level than typical place value identification or rounding a given-number problems.

**Key Points**

1. Multiple numbers can have the same digit in a given place value. For example, 184 and 382 both have 8 in the tens digit.
2. Rounding means creating an approximation of a number (to simplify it or make it more convenient) by seeing which boundary number it is closest to. Boundary numbers are created based on the place value we are rounding to. For example, if we are rounding 1.57 to the tenth, our boundary numbers are 1.5 and 1.6, and we can determine 1.57 is closer to 1.6.
3. Multiple numbers can round to the same number. For example, when rounding to the tenth, 1.57 and 1.63 round to 1.6.
Figure 4.3 Overview and Vertical Alignment

**Misconceptions.** Journal 1 and focus group 1 findings suggested tutors struggled to identify misconceptions students might have, what they should do when these misconceptions occurred, and what questions they could ask to assess student learning. To address these needs, I added a chart to the beginning of the task outlining the most common misconceptions. I included tutoring strategies to address these misconceptions and check for student understanding (see Figure 4.4). The tutoring strategies were designed to be easily implementable without additional preparation for the tutors. The check for understanding questions were created to guide student thinking and conceptual understanding and were intentionally not binary (yes/no) questions.
<table>
<thead>
<tr>
<th>Potential Misconceptions &amp; Common Errors</th>
<th>Tutoring Strategies</th>
<th>Checks for Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students may round incorrectly or not understand what rounding means conceptually.</td>
<td>Use a number line to model closeness to boundary numbers. For example, 76 is closer to 80 than 70 (if we're rounding to the nearest ten).</td>
<td>- What are the two possibilities for rounding to the tens?</td>
</tr>
<tr>
<td>Students may mix up place values, especially similar-sounding ones, like tens and tenths.</td>
<td>To help students remember place values, have them compare the decimal name for each place value with the fraction name using the chart below.</td>
<td>- How do the fractional representations of each place value help us determine what the place value is called? - What is the difference between the tens and tenths place?</td>
</tr>
<tr>
<td>Students may be confused about there being multiple correct answers.</td>
<td>Understanding will come from discussing and sharing ideas with peers. Try a build-share-compare protocol, where students build their numbers individually, share their ideas, and compare their results.</td>
<td>- How did you build your number? - Did your podmate get a different number? Does their number also work?</td>
</tr>
<tr>
<td>Students may be unclear about when they can start their number with a zero in standard numerical form and when they can't.</td>
<td>A zero can be the first digit if it is the only digit to the left of the decimal. A zero can always be to the right of the decimal.</td>
<td>- When is a zero a necessary placeholder? - When is a zero a not necessary placeholder?</td>
</tr>
<tr>
<td>Note: Numbers not in standard form aren't &quot;wrong,&quot; just not ideal.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decimal names for place value groups</th>
<th>Ten Thousands</th>
<th>Thousands</th>
<th>Hundreds</th>
<th>Tens</th>
<th>Ones</th>
<th>Tenths</th>
<th>Hundredths</th>
<th>Thousandths</th>
</tr>
</thead>
<tbody>
<tr>
<td>80,000</td>
<td>1,000</td>
<td>500</td>
<td>50</td>
<td>5</td>
<td>.5</td>
<td>.05</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>Fraction names for place value groups</td>
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<td>1,000</td>
<td>300</td>
<td>20</td>
<td>2</td>
<td>1/10</td>
<td>1/100</td>
<td>1/1000</td>
</tr>
</tbody>
</table>

Encourage students to read decimals using place values. For example, when reading 0.23, instead of saying "zero point two three," say "twenty-three hundredths."

**Figure 4.4 Common Misconceptions and Tutoring Strategies to Address Them**

**Differentiation and Scaffolding.** Tutors noted in focus group 1 that they struggled to differentiate and scaffold tasks. To support these two areas, I added several
overarching strategies tutors could use to differentiate and scaffold based on student needs (see Figure 4.5). The first differentiation strategy addresses students who need a lower entry point to the task and includes prompts tutors can implement directly (instead of having vague or general ideas). The second tip includes differentiation for students who would benefit from a more difficult task. It contains an example to clarify the guidance for tutors. The last differentiation strategy addresses student choice, which can support student learning by engaging student voice in the task (Nagro et al., 2019).

<table>
<thead>
<tr>
<th>Differentiation strategies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) To scaffold the task for students who need a lower entry point, begin with only the digits 3, 6, and 7. Start with a few problems: create a number with a 7 in the tens place, create the largest possible number, and create a number that rounds to 640. Then add in the decimal card and repeat the few problems. Do the same with the zero card. Then, move into the full activity.</td>
</tr>
<tr>
<td>a. If individual questions seem too difficult during the activity, take away or alter cards, as needed, to scaffold up to the written question.</td>
</tr>
<tr>
<td>b. Note: The zero digit can be more difficult for students than the decimal.</td>
</tr>
<tr>
<td>(2) To scale up the difficulty, for each problem, have students determine if they can alter the digits on the cards so there is only one viable answer (if there are multiple) or multiple solutions (if there is only one). For example, the only way to have one answer for creating a number with a 7 in the tens place would be to swap the 3 and 6 for 0s, giving us 70.00.</td>
</tr>
<tr>
<td>(3) Have students decide their rules for decimal use to create student choice. For example, can there be a lingering decimal so numbers like &quot;0.3670&quot; or &quot;7306.&quot; are okay? Or does there need to be a digit on either side of the decimal, as in &quot;0.367&quot; and &quot;736.0?&quot;</td>
</tr>
</tbody>
</table>

Figure 4.5. Differentiation and Scaffolding

**Vocabulary and Language Needs.** In focus group 1, tutors identified they were unsure what vocabulary words students might struggle with and did not know how to support students with language needs. To address these concerns, I added the key terms students need to engage with the task (see Figure 4.6). Additionally, I added a few strategies that could be used to support emergent multilingual learners. These tips were intended to help tutors avoid two common language misconceptions (under notes in
Figure 4.6). The sentence frames and starters were created for tutors to use directly with students to guide written and oral communication in English.

<table>
<thead>
<tr>
<th>Key terms: round, decimal, place value, tens place, tenths place, digit</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>ELL/EML Supports</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes</td>
</tr>
<tr>
<td>In some countries, commas and periods are used in reverse. For example, 1,2 means one and two tenths, and 1.200 means one thousand two hundred. Clarity this for students during the Do Now or the first problem of the activity if it causes confusion.</td>
</tr>
<tr>
<td>Emphasize the sound “-ths” when saying the decimal place value names. This extra pronunciation can help alleviate confusion between “tens” and “tenths.” If additional support is needed, use a place value chart (see table above), and point to the place value as you say it.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sentence starters</th>
</tr>
</thead>
<tbody>
<tr>
<td>___ is in the ___ place.</td>
</tr>
<tr>
<td>___ rounds to ___ because...</td>
</tr>
<tr>
<td>I found a different number that works. I found ___.</td>
</tr>
<tr>
<td>My number works because...</td>
</tr>
</tbody>
</table>

Figure 4.6 Key Terms and Emergent Multilingual Learner Strategies

**Background Skills and Formative Assessment.** Tutors indicated in focus group 1 that they struggled to plan background skills to start the tutorial with and formative assessment questions to end with. I added sample questions with answers in both areas.

For the background skills, I included problems for tutors to assess students’ background knowledge of place value and of rounding. For ease of use, I linked to other materials within the curriculum that could be used to further bolster these skills (see Figure 4.7).

For the formative assessment, I created four questions for tutors to end the tutorial with (see Figure 4.8). The first question was intended to have students reflect on their learning.

Then, there were two questions that mirrored the skills needed on the task, one question involving place value and one involving rounding. The final question was a challenge question so tutors could differentiate as needed. I included notes of how tutors could create a quick discussion around the question by extending student thinking (see bullets and “note to Fellow” in Figure 4.8).
### Background Skills/Do Now

(See Lesson **F1.6 Place Value**)

1. Find the digit in each place value listed below in 352.04.
   - a) tens place
     - 5
   - b) tenths place
     - 0
   - c) hundreds place
     - 3
   - d) unit (ones) place
     - 2

(See Lesson **F1.7 Rounding**)

2. a) Round each number below to the indicated place value.
   - i. 25 to the tens
     - 30
   - ii. 29.78 to the ones (units)
     - 30
   - iii. 30.02 to the tenths
     - 30.0

   b) What do you notice?
   They all rounded to 30, even though we started with different numbers and rounded to different place values.

---

### Figure 4.7 Opening Background Skill Assessment

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### Ticket To Leave

1. Which number was hardest for you to create? Why?
   Answers will vary. Students should explain which question or group of questions was hardest for them to find a solution for and why it was challenging for them.

   **Note to Fellow:** After students answer this question is an excellent opportunity to discuss growth mindset and how they persevered through a challenge!

2. Using the digits and decimal below, create a number with an 8 in the tens place.

   - **.578**
   - 85.7 or 87.5; or if your group decided lingering decimals are okay, 785. or 587.
     - **Challenge:** List all possible answers.

3. Using the digits and decimal below, create a number that rounds to 9.

   - **.578**
   - 8.75 or 8.57
     - **Challenge:** List all possible answers.

4. **Challenge:** Create your own "create a number" question to answer using digits and decimal below and answer it.

   - **.468**
   - Answers will vary. Student response should have both a question and a number answer. For example, what is the number closest to 40 we can build? 46.8

---

### Figure 4.8 Ending Formative Assessment
**Tutoring Strategies.** In the first journal and focus group, participants said they would appreciate embedded questions they could use to check student understanding, suggestions on how to extend student thinking and push discussion, and tips on how to differentiate. I added problem-specific tutoring strategies throughout the student problems in the task to address this tutor request (see Figures 4.9 and 4.10). I also added notes on mathematical conventions tutors might be unaware of, such as not beginning numbers with a zero. These embedded supports were intended to be quickly and easily implementable by tutors who may not have a background in mathematics or education, as was the case for the tutors in this case study.

1. Create a number with a 7 in the tens place.
   
   *Answers will vary. Any number with 7 in the tens place is okay. Sample response: 376.0*  
   - How did you build your number?  
   - Did you get a different answer from your podmates? Are both solutions okay? Why?  
   - What digits in your number could move around? Which is required to be where it is?

   *Note to Fellows:* If students create a number that begins with a zero, encourage them to move the zero to the end behind the decimal. For example, if they write 076.3, encourage them to write 76.30 instead, which is the standard way of writing that number.

2. Create a number with a 7 in the tenths place.
   
   *Answers will vary. Any number with 7 in the tenths place (right of the decimal) is okay. Sample response: 63.07*  
   - How is your number different than your previous number?  
     - What digit did you have to move? Could you have left everything else where it was?  
   - *Extension:* How would your number change if this said hundredths place? Unit place?  
     - Could you make a number with a digit in the thousands place? Thousandths? Ten-thousands?

---

**Figure 4.9 Problem-Specific Tutoring Strategies**
6. Create a number between 600 and 700.
603.7, 607.3, 630.7, 637.0, 670.3, or 673.0

- Which digit must we have to create a number between 600 and 700? 6 in the hundreds place
  - Scaffolding: Is 367.0 between 600 and 700? Why not?
- How do you know your number is between 600 and 700? How can you show this visually? could plot on a number line.
- Extension: Find all possible numbers we can create between 600 and 700.

Differentiation: If students struggle to place their digits, create blanks on a whiteboard to fill in. For example, once we’ve determined we need a 6 in the hundreds digit, to make it a hundreds digit, we know we need two more digits to the right of it before the decimal: 6 ___ ___ . ___

Figure 4.10 Problem-Specific Tutoring Strategies

**Extension.** In focus group 1, Emily mentioned the extension problems in much of the organization’s curriculum were too difficult. In response to this concern, I created extension problems and clarified if the extension was for time or challenge (see Figure 4.11). These extensions were intended to meet the needs of various tutorial situations and student needs, such as tutors wanting to extend the task to be longer to fit their schedule better or to be more challenging for students.

**Extension for time:** If you want the activity to take more time, try the same problems again using different digits. Discuss which answers change.

  - With different digits, is there still an answer to all questions? *there might not be*
    - If there’s not a possible answer, how might we alter the wording so there is? *will vary based on digits selected, e.g., might create number with 5 in the tens digit or a number between 50 and 60*
  - Which solving strategies did you use again?

**Extension for challenge:** Don’t require that students use all cards/digits for each number created. Have students discuss which questions would have additional or changed responses (e.g., the smallest number would be 0 now).

  - Is it easier or harder not to have to use all the cards? *students will likely think it’s much easier*

**Extension for challenge:** Have students create digit cards and 3ish questions. They can decide the “rules” for their problems (e.g., do you have to use all the cards for each number?). Students should make sure their questions have at least one answer. Then, have students swap digit cards and questions.

Figure 4.11 Extension for Time or Challenge
Changes in Tutor Engagement

The tone of the second focus group was noticeably different than the first. While tutors seemed open and willing to discuss in the first focus group, they did not express enthusiasm while speaking. In focus group 2, tutors exuded excitement, noted in casual observations through their uplifting and animated tone, engaged body language, and frequent smiles. The focus group flowed smoothly and felt conversational. There were no noticeable stalls in conversation or hesitations, suggesting tutors were comfortable sharing; however, Sammy and Emily shared more than Richard. This section details the themes that emerged in the tutor engagement changes.

Task More Enjoyable. Journal 2 and focus group 2 findings suggest tutors found the task with educative supports enjoyable and were happy their students enjoyed it.

Richard changed from having a negative view of HCD tasks to enjoying this task with embedded guidance. In focus group 1 he mentioned, “sometimes the kids just don’t care. They know the [task] is math-related, and even though we call it a game, they know it’s still math-involved, so they still don’t want to do it.” In his second journal, Richard had a happier disposition saying, “I had a lot of fun with the [task]” and “I loved watching [the students] move the post-it notes around on the whiteboard and seeing their expressions when they got it right or when they were told no and had to rethink.” In focus group 2, he continued, saying, “that one was fun” and “as much as I would have liked to spend more time on the conceptual part, I was just happy they were having a good time” and “it seemed like [the students] had a really good time.” These findings suggest Richard may have been more excited about the HCD task that had embedded supports and he enjoyed seeing his students engage with it.
Sammy found their students did not want to give up, which caused them to enjoy tutoring using this task. In journal 2 they elaborated, “even students who struggled didn’t seem to want to give up easily when they didn’t know how to put the pieces together in a way that followed the instructions. Students who I typically struggle to keep engaged bought into the [task] fairly easily.” Emily expressed similar excitement around the HCD task with embedded supports. In focus group 2 she said, “I really enjoyed teaching with this [task] and felt as if the student did, too.” These findings suggest the embedded supports in the task may have created conditions so that the task more enjoyable for students and, in turn, more enjoyable for the tutors.

**Planning Process Easier.** I found in focus group 2 that tutors thought the planning process was more manageable with embedded supports, leading them to be more engaged in the task. During focus group 2, Emily and Sammy emphasized planning was easier. I found this change in engagement supported by struggles they expressed in the first focus group (previously discussed under research question 1). Richard nodded in agreement frequently during the focus group but did not add any specifics on planning.

Emily expressed several times in focus group 2 how confident she felt preparing for and implementing the HCD task with the embedded supports. Emily agreed the planning process went smoother, noting, “this one was very smooth sailing for me” and “I felt more comfortable, more able to adapt with the supports.” She added, “It made me feel more prepared for whatever was to come. It made me feel more adaptable because, with other [tasks] in the past, I found the student will either run through the [task] really quickly or it’s not clicking, and I sometimes have felt more unprepared.” These findings may suggest the embedded supports helped Emily feel prepared for her tutorial.
Sammy had similar sentiments to Emily and agreed having the extra support made it more likely they (Sammy) would implement a task. Sammy explained that in previous tasks they used, they had to “be ready for all the different things.” However now with the added supports, they said, “with all of this laid out, I found it really helpful.” These findings may suggest Sammy had an easier time planning because of the embedded guidance.

Sammy expressed that they appreciated the ample supports and could skip to the supports most relevant to them. In the second focus group they said, “any [supports] I didn’t look at, it didn’t waste any of my time or overwhelm me” and that “all of the supports were lined up and exactly where I would expect.” They elaborated, “I know what each part does to help me. I like having all that information there because I know exactly where to go for the things that I want.” These findings may suggest Sammy could navigate the embedded guidance and find supports they needed.

**Changes in Engagement Summary.** From the second journal and second focus group, I found enjoyment of the HCD task went up with embedded supports because tutors felt their implementation and planning were more successful. Tutors expressed they felt more prepared due to the supports embedded in the task materials. The findings from research question 1 suggested tutors thought HCD tasks were too difficult for their students and too challenging to plan. The change in disposition may indicate that embedded educative supports can positively influence tutor engagement with HCD tasks. An alternative explanation for these findings is the task tutors implemented was potentially enjoyable and easier to plan because we had done the task together in focus group 1. The preview of the task could make this task an unfair comparison to other tasks
tutors might plan without working through it first. However, I found from focus group 2 that tutors mentioned the embedded supports as leading to their feeling of ease, not the preview of the task in focus group 1. I found the theme of planning being easier and tutors being happy students enjoyed the task across journal 2 and focus group 2 and for all participants.

**Observation of Task Enactment**

To triangulate and verify data self-reported by tutors, I observed tutors enacting the revised task using Stein et al.’s (1996) rubric (see Appendix F). The purpose of the observation was to see if tutors were implementing a HCD task or lowering the task’s cognitive demand for students (intentionally or inadvertently). Observation data showed tutors kept the cognitive demand high, suggesting the task students engaged with was HCD and not an LCD task. I observed that when tutors used suggestions from the tutor versions of materials, it led to higher cognitive demand on students.

I observed Emily and Sammy frequently referenced a tutor version of the task during facilitation that they had annotated. Richard was reading problems off a tablet. In the tutoring organization, only student versions of the materials were loaded on tablets, so while I did not see what he was looking at, I assumed it was the student version of the task. In observation notes, I recorded Sammy “had tutor version and plans up to reference” and that Emily “had annotated tutor version pulled up to reference and referred to the prompts and tutoring strategies.” I also noted that Emily “followed points on the materials well and kept cognitive level high.” These findings could suggest Emily and Sammy referenced the embedded guidance as they were facilitating tutorial and Richard did not.
I observed Sammy used the scaffolding strategies, check for understanding questions, and misconception tips from the embedded supports. In my observation notes, I recorded Sammy made “good use of scaffolding and scaling questions when students were confused” and that they “used scripted CFUs appropriately.” Additionally, I observed they had a “great use of addressing misconceptions in the way the tutor version suggested,” for example, when students struggled with rounding concepts, Sammy used a number line to model rounding visually. These findings may suggest Sammy implemented the embedded tutoring guidance effectively.

**Observational Setting Details.** Sammy’s tutorial at Cortez High School had two male students who looked at the student version of the task on a tablet and used notebooks and notecards to complete the task. Sammy started the tutorial with a personal check-in and by letting the students know I was observing them (Sammy) and not the students. Sammy and the two students sat at a group of desks pushed together into a table. Emily’s tutorial took place in the same classroom as Sammy’s. Her students also referenced the student version of the task on a tablet and used notebooks and notecards. Emily’s tutorial had two girls who actively debated mathematics and helped each other achieve mathematical understanding throughout the period. One of Emily’s students was 8 minutes tardy, which she said was common because the class was immediately after lunch. Once the two students were seated, Emily moved to sit next to them. Richard’s tutorial took place at a different school, Bennett High School. His tutorial was the largest, with five students set up in a semi-circle so they could see and hear each other. The students had notebooks and sticky notes for the task. Students did not see the student version of the task, and Richard read the prompt aloud.
HCD Rubric Tally Data. I analyzed observational data collected using Stein et al.’s (1996) rubric for HCD task implementation (see Appendix F) and found all three tutors in the study case took more actions that kept cognitive demand high than actions that lowered it (see Appendix I). The rubric divides educator actions into two categories: those that keep cognitive demand on students high and those that lower cognitive demand. For example, providing students with sufficient time is an educator action that leads to keeping cognitive demand high, and reducing the complexity of a task is an action that lowers cognitive demand. The actions that lower cognitive demand may be intentional or inadvertent on the part of the educator. During observations, I tallied instances when tutor actions fell into one of the categories identified by Stein et al. (1996). This section overviews the frequency tutor actions fell in each category, as measured by the tally data from the rubric. The following sections detail the specific tutor actions that led to high or low cognitive demand.

In each of the three tutorial observations (one per participant), I sat near the tutorial group and tallied tutor actions that lowered or kept cognitive demand high on a print-out of Stein et al.’s (1996) rubric. The tutors did not see the rubric beforehand, so they were unaware of the specific moves that created HCD or LCD that I was looking for. I wanted to see if embedded supports inherently created HCD task facilitation without further information. Tutor coaching around what specific tutor actions could produce or lower the cognitive demand would be additional training, and the goal of this study was to explore the effects of embedded supports that could be used without added training sessions.
Observational tally data showed the frequency of various tutor actions varied by participant (see Appendix I). I observed Richard did each of the moves on Stein et al.’s (1996) rubric to keep cognitive high, although at a lower frequency than the other two tutors. Richard also did almost all the actions that lead to LCD. He was most successful in scaffolding and least successful in routinization and focus on the answer over process.

I found through observational data that Emily did each of the HCD moves multiple times. She had LCD moves at the beginning of the tutorial when addressing lack of adequate student background skills and too much intervention. After the beginning of the tutorial, Emily did not repeat these LCD moves. Emily was most successful pushing explanation, justification, and demonstrated understanding, and building conceptual understanding with connections. She was least successful in the areas of too much instructor intervention and lack of student background skills.

Sammy performed each move that led to HCD for students multiple times. I only observed one instance of Sammy lowering cognitive demand. Sammy told me after my observation that the pair of students I saw were their (Sammy’s) most difficult to engage, and the students were much more engaged than usual during the tutorial I saw. This anecdote was supported by the observational findings that the only area of LCD Sammy encountered was a lack of student engagement. They were most successful with scaffolding and pushing for explanations, justification, and demonstrated understanding. As noted, Sammy was least successful in the lack of student engagement.

The findings from the observational rubric frequency counts suggest that the three tutors in this case were able to keep cognitive demand high on students when they implemented the HCD task that included embedded tutoring guidance.
Examples of Keeping Cognitive Demand High. To support the frequency counts from Stein et al.’s (1996) rubric, I recorded the most notable tutor actions that led to high or low cognitive demand. I noted several examples of when tutors kept cognitive demand high. Both Sammy and Emily referred to the number line when rounding, which showed pushing conceptual understanding. When observing Sammy, I noted they were “rounding connected to the number line” and “rounding to tens place, so counting by tens on the number line.” For Emily, I noticed she had students “round with number line and not memorize” and that she “pushed ‘why’ constantly,” asking for clarification and demonstrated understanding from her students. I observed Richard’s students were “engaged, took notes, asked questions, and checked in with each other to make sure they understood.” From the observation, I found both Richard and Emily allowed sufficient time for students to solve. Richard “allowed time for everyone to finish,” and Emily “dug in and didn’t rush the answer, giving students sufficient time and asked lots of CFUs.” I observed that Sammy “referred to prior questions to build on prior knowledge.” Sammy also “pushed multiple answers” with their students during the observation. These observational findings may suggest each tutor in this case was able to use instructional moves that kept cognitive demand on students high.

Examples of Lowered Cognitive Demand. I found in the observations that each tutor made at least one facilitation choice that lowered cognitive demand. Emily and Sammy lowered cognitive demand at the beginning of their tutorials but not throughout, while Richard had tutor actions that reduced cognitive demand throughout his tutorial. All three tutors struggled to start the lesson and assess background skills quickly. I noted Richard “altered the given Do Now questions and changed them to be procedural over
conceptual.” With Emily’s tutorial, I observed a “lack of student background skills was evident on the Do Now but not during the task,” indicating it may have been challenging for her to assess their beginning skill set. Lack of student background skills lowers cognitive demand for students (Stein et al., 1996); however, the students seemed to struggle with the isolated background skill questions, but as soon as they began applying the background skills in the task, they appeared to have no issues. In Sammy’s observed tutorial, “students were disinterested during the Do Now and became mildly more engaged as the task began.” Lack of student interest leads to lower cognitive demand for students (Stein et al., 1996), suggesting Sammy’s students may have been experiencing lower cognitive demand than if they had been more engaged.

Throughout the observed tutorial, I noted Richard had “many missed opportunities to push understanding” and keep cognitive demand high. For example, from observation notes, he “said 5 in 352.04 was in the tens place but never related this to representing 50.” Additionally, he “gave notes on how to find place values without asking for student ideas first,” and “during the Do Now, students gave answers but weren’t pushed to explain.” I observed Richard seemed hesitant to explore problems deeply, preferring to move through problems quickly. I noted he had “more high-cognitive moves than lowered” cognitive moves but “kept [the task] surface-level, which appeared it was because he was uncomfortable with the conceptual understanding himself.” These findings may suggest the embedded supports alone were insufficient for Richard to facilitate conceptual understanding.

During the observation of Emily’s tutorial, I noted she “asked most of the questions (instead of her students) and worked hard to keep the cognitive demand on the
students.” This observational data illustrates and example of too much instructor intervention lowering cognitive demand (Stein et al., 1996). However, I noticed the balance of who was speaking got better throughout the task as students began to understand better what was expected of them. This finding may suggest that if Emily and her students did more HCD tasks together, they might become more comfortable engaging as they become accustomed to the task structure and higher cognitive demand.

**Observational Data Summary.** I observed tutors were willing to try the HCD tasks with embedded supports and mostly kept the cognitive demand high. When they used the supports more closely, it created a higher cognitive demand for students. When tutors altered the task, it resulted in a lower cognitive demand for students. Most missed opportunities for keeping demand high were instances where supports were not used. This finding may suggest that when used, the educative supports might have created the right conditions for tutors to be able to successfully implement a HCD task.

Possible explanations for the occurrence of missed opportunities for keeping demand high are potentially there were too many supports to keep track of, potentially it was unclear how to use the supports, or potentially a tutor did not see the value (cause and effect relationship) of a given support. However, focus group 2 data did not support the first two explanations and partially supported the third. Sammy mentioned the large number of supports but said they could navigate them well while Richard and Emily did not name this as an issue, suggesting there were not too many supports. No one mentioned an instance they thought a support was unclear, suggesting lack of clarity was not an issue. Richard indicated language learners did better with procedures, which could have led him to not see value in supports that pushed cognitive demand, suggesting
potentially not seeing the value or purpose of a support could have led to missed opportunities to keep cognitive demand high for one of the participants. A further possible explanation is potentially it is not reasonable to expect a HCD task to be facilitated without a single instance of the instructor lowering cognitive demand and having a majority of tutor moves lead to HCD could be considered a successful HCD task.

A theme that emerged in observational data was that what tutors excelled and struggled with were not uniform. However, when they used the supports, cognitive demand was higher and facilitation of HCD successful. Pattern matching analysis shows this aligns with prior research that embedded supports can help instructors implement curriculum with fidelity (Davis et al., 2017). Another theme that emerged was starting the task by assessing background skills was the most difficult for tutors to navigate. There were no directions embedded on how to facilitate this time, so this finding could suggest the lack of guidance on how to spiral background skills throughout the task created a challenge for tutors.

While I had observed many prior tutorials, I had not observed these three tutors. An alternative explanation to their success in the study observations is potentially they consistently implemented HCD tasks well, whether there was embedded tutorial guidance or not. However, based on journal 1 and focus group 1 data, their initial disposition towards HCD tasks was unfavorable, suggesting this was not the case. Additionally, a vast majority of the tutorials I have seen in the past several years through my work have been low cognitive demand, so it would be an unlikely coincidence if the three tutors in this case facilitated tutorials with consistently higher cognitive demand than their peers.
Another alternative explanation for these findings is some aspects of facilitating HCD tasks might need coaching or training, and potentially not every one can be perfected using embedded supports. Direct coaching or reflecting on video recordings (as done in Stein and Smith’s study (1998)) might help in addition to the embedded supports. However, this explanation does not mean the educative supports were not helpful.

Using frequency counts, the most successful tutor moves that kept cognitive demand high were scaffolding, pushing for explanations, justifications, and demonstrated understanding, and creating conceptual understanding with connections. The areas the tutors struggled the most with were routinization, focusing on the answer over process, too much instructor intervention, lack of student background skills, and lack of student interest.

**Research Question 2 Findings Summary**

The proposition that educative supports help tutors engage with HCD tasks by building their content and pedagogical knowledge (Granger et al., 2019) and helping them visualize the tasks in action (Davis et al., 2017) was supported by the data. Findings from focus group 2 and observations may indicate that tutor mathematical content and pedagogical knowledge increased with the inclusion of embedded supports, as they were able to successfully implement the HCD tasks. Additionally, in focus group 2, participants indicated planning was easier, which could suggest they were better able to visualize the task in action. However, tasks were not implemented perfectly, and each tutor performed at least one action that lowered cognitive demand. Overall, tasks were kept at a high cognitive level, which Stein et al.’s (1996) study showed did not happen
This finding may suggest the embedded supports helped tutors engage with and implement the HCD task.

**Research Question 3: What Educative Curricular Supports, if any, do Tutors Indicate Make Them More Likely to Implement HCD Tasks?**

The proposition explored under the third research question was that supports for tutors would match prior educative guidance shown to be effective in encouraging the enactment of HCD tasks, such as

- planning guidance (Beyer & Davis, 2009; Quebec Fuentes & Ma, 2018),
- examples of how to apply instructional strategies (Beyer & Davis, 2009; Davis et al., 2017; Pepin, 2018; Remillard, 2000),
- building educator content knowledge (Ates & Eryilmaz, 2010; Granger et al., 2019; Wilhelm, 2014), and
- task enactment guidance (Baba & Shimada, 2019; Pepin, 2018).

This section explores findings on helpful supports, not helpful supports, and lingering challenges. It ends with a summary of how the findings support the third research question proposition.

**Helpful Supports**

In focus group 1, tutors brainstormed and discussed embedded guidance they might find supportive in better implementing HCD tasks. In the observations, I indicated instances of tutors using embedded supports that led to higher cognitive lifts for students, which could suggest these supports were helpful. In journal 2 and focus group 2, tutors discussed which supports they found useful for planning and in practice. Each support tutors found helpful is explained with aligned findings below, organized in order of how...
frequently each support was mentioned throughout the data as being helpful (see Table 4.3), except scaffolding and visual scaffolds, which are discussed together.

**Table 4.3 Frequency Count of Tutors Mentioning a Support was Helpful**

<table>
<thead>
<tr>
<th>Support</th>
<th>Frequency Count of Tutor Mention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background skills</td>
<td>15</td>
</tr>
<tr>
<td>Scaffolding</td>
<td>11</td>
</tr>
<tr>
<td>Differentiation</td>
<td>10</td>
</tr>
<tr>
<td>Visual scaffolds</td>
<td>9</td>
</tr>
<tr>
<td>CFUs</td>
<td>6</td>
</tr>
<tr>
<td>Anticipated misconceptions</td>
<td>5</td>
</tr>
<tr>
<td>Key points</td>
<td>5</td>
</tr>
<tr>
<td>Formative assessment</td>
<td>3</td>
</tr>
<tr>
<td>PCK</td>
<td>2</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>2</td>
</tr>
</tbody>
</table>

**Background Skills.** Tutorials in the organization typically started with a four-question review to assess proficiency on background skills. This set of questions was referred to as the Do Now. Tutors used the terms prerequisites and background skills interchangeably and often referred to this set of background skill questions as the Do Now.

In focus group 1, Emily discussed additional supports she would find helpful saying “a Do Now, maybe that goes over how to round, specifically thinking about that being a struggle. Because if they don’t know how to round, a decent amount of those questions [in the task] they wouldn’t be able to do.” Sammy expressed a similar view in focus group 1 that having background skill questions would be helpful for planning,
saying they would appreciate “a Do Now with the prerequisites for these skills. Because the prerequisites for this [task] is making sure kids know the ten and tenths place. That’s the first big hurdle to achieve before being able to do this. Even a list of the prerequisites probably wouldn’t even be as helpful as a Do Now that shows the tutor as they’re starting the lesson plan what their students need to know before moving on to the [task].” Sammy continued, “having two to three-ish pre-build Do Now questions would make it so much easier to streamline.”

The initial tutor thoughts around the helpfulness of background skills were supported by findings in journal 2 and focus group 2. In journal 2, Sammy mentioned how helpful having background skill questions was saying, “the included Do Now questions did a very efficient job communicating to me the most important prerequisites for the [task] to be successful.” This finding was supported in focus group 2 when Sammy said, “just the idea that the Do Now and Ticket to Leave are there communicated so much knowledge to me in such little space. It tells me everything from prerequisites and things that I might want to spend more time on. All of those are communicated just by placing those questions there. So, it’s a really powerful tool.” Sammy continued that time to plan was “always a factor when doing a [task] because [in the past] I’ve had to write my own Do Now and Ticket to Leave [questions] and be ready for all the different things. With all of this laid out, I found it really helpful.”

Emily expressed similar sentiments to Sammy, writing in journal 2 “I find the Do Now and Ticket to Leave very helpful” and “the Do Now problems allow us to see where the students are in understanding place value, and it is a refresher for most of them without being too challenging.” She elaborated in journal 2 that “the rounding question
[in the Do Now] was beneficial as most students struggled with the concept of rounding, and this background skill was useful in the [task].” She reiterated her ideas in focus group 2, saying, “I found the Do Now really helpful to have a good basis of a way to gauge knowledge and a good introduction that was seamless compared to [tasks] where we don’t have that.” Emily explained that she used the background skills to help her know which students might do the extension, writing “I also used [the] rounding [background question] as an extension for a lot of students, and this question allowed me to see which students would be able to extend the [task].” Throughout the second focus group, Richard did not specifically mention anything about the background skills, but nodded agreement to both Sammy and Emily’s thoughts around the helpfulness of the support. Findings from focus group 1, journal 2, and focus group 2 may suggest tutors found the background skills helpful in planning and facilitating a HCD task.

When tutors implemented the HCD task, I observed pacing issues during the Do Now time. When observing Emily, I noted that “pacing on Do Now review seemed slow” and the “tutor seemed reluctant to start the task without having all background skills solidified.” For Richard, I observed that “students did better on the task than on the Do Now.” This finding may suggest that even thought all participants agreed having background skill questions was a helpful support, potentially they needed additional clarity on how to implement it effectively.

**Scaffolding.** Scaffolding refers to adding support to help students build up to a problem when they might struggle to begin with its entirety (Cho & Kim, 2020). It is related to differentiation in that it can be used as a differentiation strategy where an instructor might scaffold for one student and not another based on student needs.
All participants agreed in focus group 1 that they would appreciate scaffolding tips. When considering a list of possible supports, Emily stated, “scaffolding tips stood out to me.” Sammy prioritized various supports they would include saying, “anticipating misconceptions, scaffolding tips, those would be higher.” Richard added he was unsure of how to “simplify [conceptual tasks] in a way that would still be beneficial for [students]” without scaffolding supports.

In focus group 1, Sammy mentioned a task they used in the past and found successful was because of the scaffolding, saying that task “does have really good scaffolding. I love that [task].” This finding may suggest Sammy would appreciate if other tasks had better scaffolding suggestions. This finding is supported by Emily describing a task she liked in journal 1 writing, “the [task] built on itself difficulty-wise.” She expanded in journal 1 mentioning a task she did not find success with because it had “less of a variety of difficulty levels.” Emily mentioned in journal 1 that she found some problem sets easier to implement than tasks because scaffolding was built in. She wrote, “I found that the problem set was more effective as the first problems were easier and they got increasingly difficult, so it was easier for me to assign students appropriate problems.” This may suggest if tasks included scaffolding, Emily would find them more effective.

Observational data indicated Sammy used the scaffolding suggestions in the revised tasks. I noted Sammy had a “good use of scaffolding and focusing questions when students were confused.” These findings may suggest scaffolding is a helpful embedded support for the tutors in this case.
**Visual Scaffolds.** Visual scaffolds were a specific type of scaffold that emerged as a theme in the data. Visual scaffolds in this study include a graphic element that could help students understand a task or concept better. I observed Emily using a visual scaffold successfully, noting she “used [a] place value anchor chart with what place values represented, e.g., [in] 123.456 the 2 means 2 tens which represents 20.” Emily mentioned this place value chart in journal 2, writing that she “used a place value chart like the one provided in the [task] plan (materials), which was extremely helpful for students.” She furthered her thoughts in focus group 2, stating the visuals “were a helpful tool for us to implement” and that she “really enjoyed the visuals that were included in the support.” These findings may suggest Emily felt the visual scaffolds embedded in the task were helpful and valuable.

In journal 2, Richard suggested “being provided with more visual/manipulative driven [task]/teaching ideas” in response to the prompt asking about what additional or different supports might be helpful. In focus group 2, he elaborated that visual scaffolds particularly help with his students that are language learners, saying “they’re English language learners so they’re trying to learn math from a teacher who doesn’t speak their native language and they don’t speak my native language. I try to rely heavily on pointing and visuals when I’m doing lessons and [tasks]. Anything in that realm would definitely help anyone who needs that kind of learning.” I found the theme of visual scaffolds being helpful when Emily mentioned “the decimal chart, and then, having that number line visual were the biggest supports for me, at least for my students” in focus group 2. Richard agreed in what supports were most helpful saying, “I agree with Emily,
definitely the visual aids.” These findings may suggest visual supports were helpful for tutors.

**Differentiation.** Differentiation was included in the task in the form of tips on what tutors could do differently with different students. The purpose of differentiating is to meet varying student needs (Pozas et al., 2020). Three types of differentiation themes emerged in the data: extension, manipulatives, and strategies for pivoting.

**Extension.** All three participants stated they appreciated the extension supports. As previously noted, in focus group 1 while discussing the problem with extensions she has found in other materials, Emily shared she thought some of the extensions were “too difficult to use” and that they were “too big of a jump for some” students. She shared she wanted “two possible extensions, one that is just one step above and then one that’s two steps above.” In journal 2, Emily indicated she did not get a chance to use the extension on the task in action, writing, “I did not use the extensions in any of my groups. Due to time constraints, I was struggling to finish all ten of the [task] questions, so there was no time for extensions.”

In journal 2, Richard wrote, “I really liked the extension and differentiation sections of the [task] because sometimes I struggle to think of ways in the moment to go deeper within the concept because I either wasn't expecting them to understand or I was expecting the [task] to take longer than it actually did.” I found similar sentiments from Sammy when in focus group 1 they said students “not being challenged at the right level” was one reason tasks had not worked in the past and why they would appreciate differentiation and extension support. These findings may tutors liked having extension suggestions, even if they were not always used.
**Manipulatives.** I found two instances suggesting tutors found tips on how to use manipulatives helpful. Manipulatives are tactile objects students can move around to enhance their learning and investigate concepts. They are intended to meet various student needs and learning preferences (Bartolini & Martignone, 2020). In focus group 1, Sammy indicated that students liked a “physical aspect of holding cards or rolling dice” and in focus group 2 Richard noted students enjoyed “moving the cards.” These findings may suggest embedded tips indicating possible manipulatives to use could be supportive to tutors.

**Methods for Pivoting.** I found in focus group 1 that tutors wanted suggestions of alternative paths to take with the task based on student needs that arose during the tutorial. As previously mentioned, Sammy noted in focus group 1 that they “always want to have a plan B, and then C, and D in the background.” This idea was further supported when they said they “like [the idea of including] possible alterations.” When asked in focus group 1, “if this is newer, do this, if this is review, do this, would guidance like that be helpful?” Richard responding, “yeah, yes it would.” Emily expanded that she had been able to adjust one task she did based on how students were responding in tutorial. She noted that when done well, “you’re [as a tutor] able to manipulate [a task] in a lot of good ways.” She explained how one task worked saying, “when we did [a task] a few weeks ago, there were some groups where I was like, okay we’re only going to add and subtract. And then there were some [other groups] where it was like, okay, let’s multiply and divide.” She said she differentiated “as they went on,” specifically as people were excelling, “to make the [task] last longer.” The finding that including methods for pivoting and adjusting to specific students may be helpful were supported in focus group
2 when Richard said, “the differentiation strategies that were listed before the [task]
started and then listed in between the questions really helped me.”

**Check for Understanding Questions.** In the materials, check for understanding
questions (CFUs) were included as bullets. Tutors could ask students these questions to
assess or focus their understanding (Lemov, 2015). The questions were intended to be
used as written without additional preparation needed from tutors. CFUs were already
included on other materials tutors used (like the organization’s lesson materials), so they
were accustomed to how to implement the questions in tutorial.

In focus group 1, Emily indicated she found CFUs helpful on previous materials
she had used, saying, “I really like the CFUs that I find on [other materials]. I usually
highlight them, and I write them down to make sure to ask them. CFUs on [tasks] would
probably be useful.” I recorded in my observation notes that Emily “pushed CFUs to
build more understanding,” suggesting she used and applied the CFUs well and that they
likely were helpful. This finding was supported with Emily’s focus group 2 statement,
“for the CFUs that were in the [task], I remember I asked every single one. So that was
on support that I found really, really helpful.”

I observed Sammy using CFUs well and they mentioned they appreciated having
the CFUs in journal 2. I recorded that Sammy “used scripted CFUs appropriately” in my
observation notes and they (Sammy) wrote in journal 2 that helpful supports included
“CFU bullet points, a big one that helped me extend the [task] into a conversation.”
These findings may suggest that like Emily, Sammy found CFUs a helpful support.

Richard indicated in journal 2 that CFUs were not helpful, saying “the CFUs
under each question were not helpful because the ELL (English language learner)
students have a hard time grasping the conceptual portion of the lesson, and I tend to lean more towards a procedural way of teaching because sometimes questions can be too abstract.” I observed Richard skipping CFUs and not pushing understanding, noting, “students gave answers but were not pushed to explain.” However, when Emily expressed how helpful the CFUs were during focus group 2, Richard nodded in agreement that CFUs were helpful. These findings may suggest that Richard might not have found CFUs as helpful because he was unsure of their value and when he heard Emily express their helpfulness, he reconsidered.

These findings may indicate that CFUs were helpful in supporting high-quality HCD task implementation for Emily and Sammy. Additionally, observational data exposed that when Emily or Sammy used included CFUs, it led to high cognitive demand for students, and when Richard skipped CFUs, it created a missed opportunity to stretch student learning.

**Anticipated Misconceptions.** In the revised HCD task, the anticipated misconceptions detailed what students might misunderstand as they complete the task. I included suggestions of how tutors could address the misconception, including tutoring strategies and questions to focus student understanding. The strategies were intended to be ready for tutors to implement without additional preparation.

The helpfulness of anticipated misconceptions was mentioned in both focus groups and journal 2 and was mentioned at least once by all participants. Additionally, I observed the strategy being used in tutorial. In the first focus group, Richard indicated “anticipating student responses and how to respond” would be helpful to include. He continued that “students are very unpredictable, so being given some advice for that
would be helpful.” Sammy agreed in focus group 1 naming “anticipating misconceptions” as a support they would prioritize “higher.” In my observation notes, I wrote Sammy had a “great use of addressing misconceptions in the way the tutor version suggested,” indicating they (Sammy) were able to apply the suggested strategies in the embedded supports. In journal 2, Sammy responded that the “common misconceptions table as a heads up for me” was a helpful support. In focus group 2, Emily mentioned she found most supports helpful and said, “I found most of them very helpful because I had it (the tutor materials) open and was looking at what kind of misconception or error is aligned so I can try and use the suggestions.” These findings may support that anticipated misconceptions and how to address them are helpful to embed in tutor materials.

**Key Points.** On the revised tutor version of the HCD task, key points gave more detailed information than the objective or standard. They included the academic purpose of the task and the main ideas students should take away from it.

In the first focus group, Sammy and Emily identified key points as being a helpful support to add. Emily explained the struggle she had saying, “even working through [the task], it took me a minute to see the takeaway.” Sammy agreed that they also struggled to identify the key points of the task but “started to understand the [task] a little bit more after working through it myself.” Emily explained that at a minimum, “having the purpose or objectives at the top of the [task materials] can be helpful.” Sammy said, “having a list of key ideas to concentrate on as a point of discussion would be helpful [showing] what we are trying to accomplish by the end of the [task].” These findings may suggest key points of a task were a helpful support for Emily and Sammy, which was
supported by Sammy’s second journal where they wrote “key points as a general idea of the most important things students should try to discover” was a helpful support.

**Formative Closing Assessment.** Most tutorials in the organization ended with a formative two-question quiz to assess students’ proficiency in the content covered during the tutorial. The purpose of this assessment was to inform tutors of how successful their facilitation was and provide data to inform their next tutorial session (Lemov, 2015). The organization called this ending assessment the Ticket to Leave. Most data supporting the helpfulness of the formative assessment questions showed tutors thought of the background skill questions (Do Now) and ending questions (Ticket to Leave) collectively. Sammy said in focus group 1 that “having Ticket to Leave questions would be helpful,” which was supported by Emily’s journal 2 entry where she said, “I find the Do Now and Ticket to Leave very helpful.” In focus group 2, Sammy indicated the closing assessment questions were helpful and “communicated so much knowledge to me in such little space.” They noted the planning time saved when the assessment questions were provided, saying in focus group 2 that “with all of this laid out, I found it really helpful.”

Observation data showed that all participants used the provided ending assessment but indicated not all tutors were clear on its purpose. In observations, Emily and Sammy reviewed the ending assessment with their students, giving feedback and gathering data for their next tutorial. Richard had his students complete the final questions but did not look at or review their responses. These findings may suggest tutors felt supported in their planning with the inclusion of a formative closing assessment but not all tutors were clear on how to implement it effectively.
**Pedagogical Content Knowledge (PCK).** In the first focus group, I asked participants if pedagogical or content knowledge would be helpful to include or, by extension, if pedagogical content knowledge would be. Pedagogical content knowledge (PCK) is understanding how to apply instructional strategies within the context of the content (Shulman, 1987). I found this area of support was briefly mentioned as a possible helpful support in focus group 1 and was not mentioned again. I observed Emily and Sammy could pivot and dive deeply into the mathematical ideas of the task. It was unclear if this was due to their prior background knowledge or if it resulted from the vertical alignment I included in the revised HCD task. In the first focus group, I found participants did not seem to understand the concept of PCK and kept the ideas of pedagogical and content resources separate. Emily said, “pedagogical resources would be the most helpful for me rather than necessarily the math.” Richard explained in focus group 1 that “I was an English major in college, and math definitely was not on my list of priorities. I’m good at math, but this is the first time I’ve done math in maybe three years. So, it would be nice to have extra support.” These findings may suggest PCK could be helpful but could be too abstract of a concept for tutors to identify it as an essential support.

**Vocabulary.** Key vocabulary terms were listed on the revised HCD task, and words necessary for the task were defined. The helpfulness of vocabulary was mentioned in focus group 1 by two participants and was not mentioned again. I observed that all three participants used the background skill questions with vocabulary embedded, which could indicate tutors found the support of assessing and previewing vocabulary helpful. Richard said in the first focus group, “vocab definitely does help what I’m trying to
teach.” In focus group 1, Emily suggested weaving vocabulary into the background skill questions, saying, “the main vocabulary that was mentioned was place value with tens and tenths, so maybe having a Do Now that focuses on rounding and a bit of vocabulary” would be helpful. These findings could indicate including vocabulary in the background skill questions was helpful, yet it may be unclear if the additional embedded vocabulary supports (such as a key term list) were useful.

**Not Helpful Supports**

I found participants indicated that too individualized or generalized supports were not helpful. The findings suggest supports with too many nuances may not be beneficial.

**Student-Dependent Support.** In focus group 1, tutors considered a list of potential educative guidance (see Appendix A). In this focus group, Emily said, “I don’t know if a structured plan would be good or not. Relative to the bottom four options [on the list], I feel like that it’s student-dependent and individualized.” Emily was referring to the four support options (1) how to adjust during implementation, make choices during facilitation, and possible alterations, (2) building a culture where students feel competent and valued, (3) how and when to give students feedback, and (4) options for student choice, autonomy, freedom. This finding may suggest Emily did not think tips around general tutorial structure or how to interact with students would be helpful. Other participants did not mention this area of support, and I did not include these support types in the revised HCD task.

**Mindsets.** In focus group 1, Sammy questioned what “mindsets” meant on the list of possible supports asking if it meant students mindsets. I, as the researcher, explained, “mindset can also mean things like you have to have a growth mindset about your
students. If you ask a question this way, it can shut students down. If you ask a question this way, it can open them up and show them you believe that they can do it.” Sammy replied with, “yeah, those are really good things to help me grow as a tutor, but it’s not something that I’m going to learn from a plan developed by you guys. It’s something that I learn from experience in the field.” This finding may suggest Sammy did not find including necessary educator mindsets helpful to embed in materials. Other participants did not mention mindsets and I did not include them on the revised HCD task.

**Standards.** Sammy and Richard reflected they would not find including standards helpful to their implementation. In focus group 1, when asked if they would find the inclusion of standards supportive, Sammy said, “not really, because I don’t really care about standards, or know what they actually mean for the students.” In revising the task, I opted to include Common Core State Standards (National Governors Association, 2010) as I thought it could be helpful to site directors or other educators who were searching for materials on specific standards. In journal 2, Richard wrote, “the standards I didn’t really read for time’s sake.” These findings may suggest the included standard was not helpful to Richard or Sammy.

**Student Profiles.** In focus group 1, Sammy indicated they would not find student profiles helpful. Student profiles were suggested in focus group 1 as a support that could let tutors know what type of students a task might work best for. Sammy stated they might find it helpful “if the student profile was simply ‘for someone who struggles with level two’ or ‘who does well with level two’ like that. Something as simple as short as that could be dirty, quick, and easy that I can very quickly take off a [task] plan.” They continued that “the student profile would be second priority” to include. This finding may
suggest a brief student profile could be supportive, but a longer one might not. I added a short student profile in the HCD task revision; however, no one mentioned it was helpful. This finding could suggest student profiles might not be beneficial for tutors. An alternative explanation for this finding could be that a student profile would be most useful when deciding which task would work well for particular students, and tutors in this study were not given a choice of which task they would use, so they did not need this support.

**Too Many Supports.** Sammy mentioned several times (in focus group 1, journal 2, and focus group 2) that having too many supports might overwhelm some tutors. They elaborated that too many supports did not overwhelm them (Sammy) and were making assumptions about others. Sammy thought they (Sammy) were not overwhelmed because they were a second-year tutor.

In focus group 1 Sammy reflected on the list of potential supports (see Appendix A), saying, “having every single thing on this list can be overwhelming, and I definitely can feel that sometimes in the tutor version [of lessons].” Although Sammy also suggested that it was better to have too many supports than not enough, saying “for me, it’s always better to have it.” Journal 2 findings suggest Sammy did not use all the supports but appreciated their existence, writing that the part of the materials they did not heavily use, they still looked at. They wrote, “everything else I glanced at briefly since I found it helpful but did not thoroughly analyze it.” In focus group 2, they said, “I know what each part of a [task] plan does to help me. I like having all that information there because I know exactly where to go for the things that I want. But that might say more about my experience tutoring.” Sammy expressed additional concern for other tutors
saying, “tutors who might see twelve pages in a [task] plan and get overwhelmed.” The tutor version of the task with embedded guidance was seven pages. Sammy continued in focus group 2 that they appreciated that the task structure was like the lesson structure tutors were used to. They said, “any [embedded guidance] I didn’t look at it didn’t waste any of my time or overwhelm me. But then again, that might have to do more with how I feel about the lessons in general. The fact that all of the supports were lined up and were exactly where I would expect it because it looks so much like the lessons. Making the lessons and [tasks] look similar with similar features probably made it easier for me to go through the [task] and not feel like I have to read all the parts of it.” This finding may suggest Sammy was concerned others might be overwhelmed by the number of supports, however, was not overwhelmed themself.

Emily and Richard were first-year tutors and did not mention being overwhelmed by the number of supports. Emily stated in focus group 2 that she “found most of them (the supports) very helpful.” This finding may suggest that potentially too many supports could be overwhelming, although more exploration is needed.

**Lingering Challenges**

Three themes emerged as lingering challenges to embedded guidance leading to HCD task facilitation. These themes did not have clear findings and require more investigation to uncover if they are helpful tutoring supports or not. First, suggestions around leading students to have mathematical discussions had conflicting results among participants. Second, students lacking background skills presented as a challenge in observations. Third, tutors thought timing would not be helpful in focus group 1 and appeared to change their minds in focus group 2.
**Discussion and Mathematical Discourse.** Conflicting information about student discourse guidance came from different participants. Sammy indicated in focus group 1 that they did not think educative support around driving mathematical discussion would help, saying, “how to engage students in conversations, it’s just going to be so drastically different for each type of student. So, I feel this section can turn into a lot of information, or it can turn into oversimplified information that might not be helpful for me.” I found later in focus group 1 that Sammy seemed to change their mind saying it would be helpful to have “questions for discussion. To know what to focus on and what to cut to leave for another conversation another time.” In focus group 1, Sammy also noted the timing challenges of having discussions saying, “we don’t always have that sort of time for discussion.” These findings may suggest it is unclear if Sammy thinks discussion guidance is helpful or not.

Richard named discourse supports as very helpful in focus group 1; however, he did not apply the suggested strategies during the observation. In focus group 1, he said, “definitely how to model and encourage discourse [would be helpful], because the [students] will have conversations with me but trying to get them to have conversations with each other is difficult.” This finding may suggest he thought discussion supports would be helpful, but the supports did not aid him in facilitating a discussion.

I found the most consistency in Emily. She thought supports around student discussion would be helpful in focus group 1, I observed her implementing the strategies well, and she again named them as beneficial in focus group 2. In focus group 1, Emily said, “how to model and encourage discourse can be good.” I noted during the observation that Emily’s “students [were] super engaged and actively discussed.” In
focus group 2, she explained, “we didn’t even go through all the questions because good conversation was coming up amidst the questions.” These findings may suggest Emily found the embedded guidance around leading a mathematical discussion helpful.

The varying findings from the three participants may suggest discussion tips could be helpful, but tutors may need more guidance to know how to apply the strategies consistently.

**Students Missing Background Skills.** I found students lacking background skills was challenging for tutors. Findings may suggest the added background questions were an insufficient support, despite tutors naming the inclusion of these questions very helpful (as previously discussed). Sammy shared in focus group 1 that they used knowledge of background skills as a gauge for if a task is appropriate to attempt: “if scaffolding is required for more than half the time, then that’s an indicator for me that doing [the task] at all during that time might not be the best use of that day.” In journal 2 and focus group 2, Richard discussed that his students lacked the necessary background skills to engage with the task. “I would definitely do it again if given the chance to give the kids more background information beforehand,” he wrote in journal 2. In focus group 2, he shared, “I would have rather focused more on the place value aspect of the [task] rather than the rounding because they haven’t seen either of those topics before, so I should have just picked one or the other.” He elaborated that “I would have liked to spend more time on the [task], but I had to spend time reteaching them rounding and place value quickly so they could experience the [task].” This finding may suggest Richard struggled to engage his students with the task because they lacked background skills.
In observations, I noted that reviewing initial background skills took a large percentage of the 45-minute tutorials. Richard spent 20 minutes on the background skill questions before beginning the task (44% of the tutorial), Emily spent 20 minutes (44%), and Sammy took 15 minutes (33%). In the organization, it is expected tutors take no longer than 10 minutes total to assess and review background skills at the beginning of the tutorial, and preferably much less time. Tutors appeared reluctant to move to the task before students showed complete proficiency in the background skills. I did not observe tutors weaving in extra review of background skills throughout the task. In my observation notes for Emily, I wrote, “pacing on the [background skill] review seemed slow; tutor seemed reluctant to start the task without having all background skills solidified.” This finding may suggest there was inadequate guidance on how tutors should support students throughout the task on background skills on which students still needed development. It might also indicate tutors were most comfortable with the task opening and reluctant to move to the rest of the task.

**Timing.** During the first focus group, tutors indicated timing would not be a helpful support. However, in focus group 2, they expressed areas around timing where guidance could be beneficial.

In focus group 1, Emily stated, “sometimes when we try and time things out, sometimes I’ll go through a whole lesson, and then do it differently for a different group. So timing is something that I think is hard to have. It’s something I come up with on my own.” Sammy agreed, saying, “for me timing is never helpful.”

In focus group 2, Sammy and Emily noted aspects of timing that could be helpful. Sammy stated, “it was a place value and rounding [task], so if I need to cut something, it
needs to be the rounding part. I see how it could be helpful to have that spelled out in the [task materials]. Make it more clear for tutors that the ‘between’ stuff is more important to talk about than the rounding stuff.” Emily agreed, saying, “I like the idea of having a note saying if you’re short on time, emphasize question 7 because of this reason if there is a distinction. But at the same time, I think that I was able to gauge this group is struggling on understanding what ‘between’ means on a number line, so I’ll just skip to the ‘between’ ones.” These findings may suggest that added guidance on what to emphasize and what to skip due to timing constraints could be helpful, while having suggestions of how long tutors should spend on specific sections might not be.

**Research Question 3 Findings Summary**

Research question 3 explored the educative curricular supports that made tutors more likely to implement a HCD task. The aligned proposition was that supports tutors identified as helpful would match educative guidance that had been shown to be effective for teachers in prior literature. The proposition was that supports would include planning guidance (Beyer & Davis, 2009; Quebec Fuentes & Ma, 2018), examples of how to apply instructional strategies (Beyer & Davis, 2009; Davis et al., 2017; Pepin, 2018; Remillard, 2000), building educator content knowledge (Ates & Eryilmaz, 2010; Granger et al., 2019; Wilhelm, 2014), and task enactment guidance (Baba & Shimada, 2019; Pepin, 2018). The findings may suggest tutors did find many supports successful that prior research has found effective for teachers. Table 4.4 details the alignment between previous research findings and findings from this study. It shows many areas overlap, with a few exceptions.
Table 4.4 Alignment Between Proposition 3 and Study Findings

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<th>Supports Study Findings May Suggest are Helpful</th>
<th>Supports Study Findings May Suggest are not Helpful</th>
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<td>Planning guidance (Beyer &amp; Davis, 2009; Quebec Fuentes &amp; Ma, 2018)</td>
<td>Key points of task</td>
<td>Student profiles</td>
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<td>Examples of how to apply instructional strategies (Beyer &amp; Davis, 2009; Davis et al., 2017; Pepin, 2018; Remillard, 2000)</td>
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<td>Creating mathematical connections through visual scaffolds</td>
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<td>Building educator content knowledge (Ates &amp; Eryilmaz, 2010; Granger et al., 2019; Wilhelm, 2014)</td>
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<td>Task enactment guidance (Baba &amp; Shimada, 2019; Pepin, 2018)</td>
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The most frequently mentioned supports were background skills, scaffolding, differentiation, visual scaffolding, and check for understanding questions (see Table 4.3). This frequency may suggest these are the most helpful supports for tutors. Other supports, such as PCK and vocabulary, were mentioned less often, which may suggest they need further investigation. Through analysis, the theme emerged that participants found the guidance more helpful when supports would work for multiple students and could be directly implemented without additional preparation. Conversely, when supports were too general, so not easily implementable, or too individualized, so did not apply to multiple students, participants did not find these supports as helpful. An alternative explanation for these findings is that potentially the supports explored worked well on the
HCD task used in this study, and different supports would emerge as most helpful on another task.

**Summary of Results**

I found through data analysis that before the study, tutors were willing to engage with HCD tasks in tutorial but did not fully engage because they did not know how to plan or implement effectively. When completing a HCD task, tutors varied in how they interacted with it. Analysis suggested tutors struggled with areas like those teachers have identified in previous studies. Study findings may indicate that embedded, educative supports helped combat these struggles. All three tutors in the case implemented a HCD task by facilitating using more tutor actions that led to HCD for students than LCD. I found tutors in this case indicated certain supports may be more helpful than others. Supports I found may be beneficial through data analysis were the inclusion of background skill questions, scaffolding and differentiation tips, specific visual scaffolding ideas, questions that could be used to check for student understanding, anticipated student misconceptions and how to address them, key takeaways from the task, formative assessment questions, PCK tips, and listing key vocabulary.
Chapter 5: Discussion

This chapter begins with a review of the problem of practice, theoretical framework, research methods, and findings. It then discusses the study’s findings relative to existing literature, organized by research question. After, practice recommendations, an action plan, study limitations, and suggestions for future research are detailed. It ends with a concise summary of the outcomes of this study.

Overview of Study

Problem of Practice & Study Purpose

This study aimed to shed light on obstacles tutors faced when implementing high cognitive demand (HCD) tasks and uncover possible educative guidance that could support their implementation. The problem of practice was two-fold: first, tutors often skipped or cognitively lowered HCD tasks, and second, existing literature on HCD tasks and educative support use in tutorials were lacking.

Theoretical Framework

The theoretical framework that informed this study was that educators and curricular materials have an interdependent relationship, each informing the other. Thus, curriculum designers must consider their materials’ audience (Remillard, 2005). Additionally, this study was rooted in literature that shows HCD tasks lead to student learning; however, they are challenging to facilitate (Bragg & Nicol, 2011). These two ideas suggested that tutor-specific curricular guidance might be needed to enhance HCD task facilitation in tutorials.
Research Questions

Using a holistic case study design, I explored the following questions:

(1) How do tutors engage with high cognitive demand tasks?

(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?

(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?

Methods & Design

This study was explanatory, action research using a qualitative, holistic, single-case design. The case was bounded around three tutors’ experiences with HCD tasks during six weeks in the fall of 2022. The tutors tutored for the same organization in a major midwestern city at two different school sites.

Participants first journaled about their experiences using HCD tasks and then joined a focus group to expand on their thoughts. In the focus group, the tutors completed a HCD task themselves and brainstormed educative supports they might find helpful in facilitating the task with students. Next, I modified the task from their suggestions and observed tutors facilitating it. After the observation, tutors journaled about their experience using the embedded supports with the task and joined a final focus group to share which guidance they found the most helpful.

Findings

Tutors identified planning and implementation challenges as obstacles to feeling comfortable facilitating HCD tasks. The three tutors engaged to varying degrees when completing a HCD task, but none engaged fully. Nevertheless, data suggested tutors
successfully implemented the HCD task with the inclusion of embedded supports.

Although some helpful educative guidance overlapped with areas identified as beneficial for teachers in prior literature, supports found most useful for tutors were those that helped with planning and involved implementation suggestions. Helpful guidance included providing background skill questions, differentiation and scaffolding suggestions, questions to assess student understanding, possible student misconceptions and how to respond when they happen, and critical task ideas students should takeaway.

Table 5.1 details findings aligned with the study propositions.

Table 5.1 Research Questions, Aligned Propositions, and Findings

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Proposition</th>
<th>Finding</th>
</tr>
</thead>
</table>
| (1) How do tutors engage with high cognitive demand tasks? | (1a) Tutors do not fully engage with HCD tasks due to the same difficulties in implementation identified by teachers, such as:  
- not having sufficient pedagogical content knowledge (Wilhelm, 2014),  
- getting unexpected student responses to the content (Hernández et al., 2016),  
- being unsure how to select appropriate tasks (Estrella et al., 2020),  
- not knowing how to scaffold and differentiate appropriately (Stein et al., 1996),  
- timing (Bieda, 2010),  
- struggling to facilitate mathematical discussions (Viseu & Oliveira, 2012), or  
- not knowing how to set up a productive learning climate (Schettino, 2016). | (1a) Proposition partially supported: Tutors did not engage fully due to some of the same difficulties identified by teachers. However, not all difficulties aligned.  
- **Aligned**  
  o Insufficient PCK  
  o Unable to anticipate misconceptions  
  o Unsure how to select tasks  
  o Difficulty scaffolding and differentiating  
- **Misaligned**  
  o Tutors struggled with how much time it took to plan, the need for specific questions to ask, and the need for the mathematical task takeaways.  
  o Tutors did not indicate lesson timing, discussions, or creating a productive learning environment as significant barriers. |
| (1b) Tutors do not fully engage with HCD tasks because they are uncomfortable with them (National Research Council, 2009; Wilhelm, 2014). | (1b) Proposition supported: Tutors partially engaged with a HCD task themselves and did not fully engage with the task. |
**Results Relating to Existing Literature**

This section relates the findings from Chapter 4 to the existing literature explored in Chapter 2, organized by research question.

**Research Question 1: How do Tutors Engage with High Cognitive Demand Tasks?**

This study started by exploring how tutors engaged with HCD tasks. Journal 1 and focus group 1 findings showed that tutors did not fully engage with HCD tasks initially because they struggled to plan the tasks given their limited pedagogical content knowledge. Specifically, they were unsure how to differentiate and scaffold tasks and did not know how to anticipate or respond to student misconceptions. For example, in the first focus group, Richard expressed the challenge that “students are very unpredictable, so being given some advice for [how to respond to] that would be useful.” Because of their struggles, tutors chose only to use HCD tasks for review and did not engage with novel concepts they had not already covered with students. These findings are supported

<table>
<thead>
<tr>
<th>Research Question 1: How do Tutors Engage with High Cognitive Demand Tasks?</th>
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<tbody>
<tr>
<td>(2) How does tutor engagement with high cognitive demand tasks change with the inclusion of educative curricular supports?</td>
</tr>
<tr>
<td>(2) Educative supports help tutors engage with HCD tasks by • building their content and pedagogical knowledge (Granger et al., 2019) and helping them visualize the tasks in action (Davis et al., 2017).</td>
</tr>
<tr>
<td>(2) Proposition supported: Educative supports helped tutors engage with a HCD task by building their repertoire of tutoring strategies (pedagogical knowledge) and making planning easier (visualize in action).</td>
</tr>
<tr>
<td>(3) What educative curricular supports, if any, do tutors indicate make them more likely to implement high cognitive demand tasks?</td>
</tr>
<tr>
<td>(3) Supports for tutors will match prior educative guidance shown to be effective in encouraging the enactment of HCD tasks.</td>
</tr>
<tr>
<td>(3) Proposition partially supported: Many supports shown to be effective for teachers were helpful for tutors, but not all categories were aligned.</td>
</tr>
</tbody>
</table>
by prior research that has found teachers have struggled to implement HCD tasks due to inefficient pedagogical content knowledge (Wilhelm, 2014), inability to scaffold and differentiate (Stein et al., 1996), and being unsure of possible student responses (Hernández et al., 2016).

In journal 1 and focus group 1, tutors identified they did not need assistance with task timing, facilitating discussions, creating a productive learning environment, or selecting tasks. Prior research has shown task timing (Bieda, 2010), inability to facilitate mathematical discourse (Viseu & Oliveira, 2012), not knowing how to set up a productive learning climate (Schettino, 2016), and being unsure how to select appropriate tasks (Estrella et al., 2020) have been obstacles for teachers in facilitating HCD tasks. Observation data showed tutors struggled with the timing of starting the task and moving away from background skill review, spending an averaged of 41% of their tutors on background skills. Additionally, they named in focus group 2 that additional help facilitating discussions could be supportive. These findings suggest these areas were difficult for tutors; however, they were unaware of their difficulty at the beginning of the study or were unwilling to share due to researcher outsider positionality. This finding indicates many layers of HCD task facilitation build on each other, making some pedagogical areas of struggle easier for tutors to identify than others. They were most likely to identify areas of struggle that were easiest to implement. For example, in focus group 1, tutors could identify they struggled to ask the right questions and would find embedded check-for-understanding questions helpful in their planning. They did not recognize their struggle to facilitate discussions. However, if they could not ask appropriate questions, they would not be able to facilitate mathematical discourse, as
facilitator questions are vital to the quality of the discussion (Viseu & Oliveira, 2012). There was no substantial change in the struggles tutors addressed throughout the study, which underlines their needs for basic implementation guidance over complex pedagogical strategies.

When the tutors in the case engaged with and completed the HCD task themselves in focus group 1, they did not fully engage with the process. They answered questions but did not create a rich discourse around the topic and appeared hesitant to do so. While they could all arrive at solutions for the task independently, their mathematical reasoning behind their solutions varied in accuracy. Tutors did not confidently share thoughts with their peers, respond in back-and-forth conversations to what others said, or volunteer additional thoughts without being probed. The stunted conversation was noticeably different from the rest of the first focus group, where participants actively responded to and added to each other’s ideas. The hesitancy in the discussion around solving the HCD task suggests that the tutors were uncomfortable with it. Prior research had found that when educators were uncomfortable with HCD tasks, they were less likely to use them with their students (National Research Council, 2009; Wilhelm, 2014). The combined findings from this study and prior research suggest that for tutors to engage more with HCD tasks, they need to become more comfortable with solving them and engaging in discussion around them as learners. Observational data from this study supports the idea that the more comfortable tutors become with completing and discussing HCD tasks themselves, the more successful they will be at facilitating them. Specifically, Richard struggled the most doing the HCD himself and lowered the cognitive demand put on
students the most, and Sammy showed the highest level of task comprehension and engagement and kept the cognitive demand on their students the highest.

Curricular materials and educators have an interdependent relationship, with educators depending on curricular materials for guidance and curriculum developers needing to attend to their audience when creating materials (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et al., 2021; Stein et al., 1996). Based on this framework, it is vital to acknowledge tutors’ starting point when creating tutoring curriculum. Findings for the first research question in this study support that this starting point is less pedagogically skilled than that of an experienced teacher. For example, findings suggested tutors’ engagement with HCD tasks was foundational in that they wanted support with lower-skilled pedagogical tasks, such as asking questions instead of leading discussions (Walshaw & Anthony, 2008). These findings align with tutors, who are not certified educators, being less experienced and skilled than teachers (Nickow et al., 2020). Thus, this beginner educator level must be considered when creating educative supports for tutors.

**Research Question 2: How does Tutor Engagement with High Cognitive Demand Tasks Change with the Inclusion of Educative Curricular Supports?**

To explore how tutor HCD task engagement changed by including educative curricular supports, I created and embedded instructional guidance in a HCD task based on tutor-identified areas of struggle. Tutors facilitated the task with students and shared their experiences in journal 2 and focus group 2. Observational data analysis showed that tutors successfully implemented the HCD task, as measured by Stein et al.’s (1996) HCD
task implementation rubric. This finding indicates that with the inclusion of educative guidance, tutors can feasibly implement HCD tasks. This outcome is significant because teachers with years of experience have been shown to have trouble implementing HCD tasks (Estrella et al., 2020; Stein et al., 1996), so the finding that the tutors in this study were able to implement the task, keeping cognitive demand on students high, is meaningful and novel.

These findings could have been possible because tutors directly identified needed support, and I adjusted the curricular materials accordingly. Rather than assume what struggles tutors would have, I listened to their needs and adapted using their needs as formative feedback. Research question two findings imply that using professional development sessions with pre-planned scopes may not best attend to the needs of novice educators. Instead, listening to educators and acknowledging their funds of knowledge (Moll, 2019), then using their experiences as a base for creating supports, could better support them in implementing HCD tasks. Through this process, I asked guiding questions and adapted to responses, treating tutors as we would want them to treat students: assessing their starting point without judgment and providing scaffolding to push them further in their learning journey. This process could have created the conditions for tutors to be willing to engage in HCD tasks because I put effort into meeting their needs. Such reciprocity could be an asset, as it might have caused tutors to be more likely to modify and adapt the HCD task for their students. Replicating this process necessitates a group of novice educators and a more experienced educator willing to adapt based on educator needs.
In addition to observational data showing tutors could facilitate the HCD task, journal 2 and focus group 2 findings showed a change in tutor disposition towards HCD tasks. In the first focus group, tutors indicated planning time and difficulty were their most significant obstacles to using HCD tasks. In the second focus group, tutors noted planning was less time-consuming and more accessible with the included educative supports. This finding is supported by prior literature, which has shown educative supports can help educators visualize the task in action (Davis et al., 2017), a component of planning and anticipating how to facilitate the task best. Tutors talked energetically about the HCD task and showed excitement, such as when Emily said in focus group 2 that she “really enjoying teaching with this [task] and felt as if the students did, too.” The other participants mirrored Emily’s excitement. Richard noted in his second journal that he “had a lot of fun with the [task]” and enthusiastically said in focus group two that the task “was fun,” which was a significant shift from the first focus group, where he appeared defeated and said, “sometimes the kids just don’t care.” Overall, these findings suggest the inclusion of educative supports helped tutors feel more confident in their ability to plan and facilitate the task and aided them in being able to keep cognitive demand high during tutorials. This confidence and success with the task changed their disposition towards HCD tasks to be more positive. This change may lead the tutors in this case to use HCD tasks more often moving forward, as prior research has shown individuals are motivated by and more likely to replicate conditions with which they have found success (Graham, 2020; Weiner, 1985).

While the findings from the second research question indicate educative supports helped tutors implement a HCD task, unanswered questions arose. Curriculum must
attend to the needs of the educators it is designed for, as curriculum and educators mutually influence each other (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et al., 2021; Stein et al., 1996). Challenges surfaced in this study that were not remedied by the embedded supports. One participant, Richard, struggled with the mindset around his language learners’ abilities to engage with conceptual components of HCD tasks. As a result, he had lower expectations for his students and lowered the cognitive demand on his students more than other participants. Prior research on the Pygmalion effect has shown lower educator expectations lead to lower student achievement (Szumski & Karwowski, 2019). From this study, it did not appear the educative support influenced Richard’s mindsets around his students' abilities, although specific supports around mindsets were not tested. Prior research has found educative supports helpful in guiding teacher mindsets (Hong & Choi, 2019), which could indicate different and additional types of embedded supports that specifically address mindsets could benefit tutors. Conversely, these findings could indicate other methods need to be used to combat negative mindsets, including additional practice, training, or direct coaching, and educative supports alone will not remedy the issue.

Overall, tutor engagement with HCD tasks changed positively from before educative supports were included to after they were embedded. The embedded guidance gave tutors a fresh view of HCD tasks and made them feel they could implement them well. For example, in focus group 2, Emily stated, “I felt more comfortable, more able to adapt with the supports,” and the supports “made me feel more prepared.” Sammy added
the supports helped them “be ready for all the different things” and that “with all of this laid out, I found it really helpful.”

With continued iterations of listening to tutor needs and embedding supports accordingly, potentially challenging mindsets could be addressed. However, the question remains if creating tailored supports is sustainable and scalable. Two options for creating a sustainable model include, first, that the struggles of tutors and associated useful supports could be similar enough that once quality support is identified for a given area of difficulty, a bank of all possible supports could be created from which tutors could pull the supports they need. Second, more experienced tutors or site directors (tutor managers) could be coached to identify the needs of tutors and create additional supports that vary from a baseline set of supports. Such coaching could be scalable using case-based exemplar videos demonstrating tutors needing support with HCD tasks and the associated guidance that could be provided.

**Research Questions 3: What Educative Curricular Supports, if any, do Tutors Indicate Make Them More Likely to Implement High Cognitive Demand Tasks?**

Many educative supports have been found to be helpful for teachers in implementing curriculum (Davis et al., 2017). This study’s findings indicate many of these same supports helped tutors implement a HCD task; however, not all are aligned. Table 5.2 aligns study findings around helpful tutor supports with prior literature around useful supports for teachers. This table builds on all parts of Table 2.1 from Chapter 2 relevant to the third research question. The third column of the table references sections in Chapter 4 under the Research Question 3 section of this paper that detail study findings.
<table>
<thead>
<tr>
<th>Embedded Educative Guidance Category</th>
<th>Examples from Literature on Helpful Educative Supports for Teachers</th>
<th>Do the Study Findings Support Prior Literature that What is Helpful for Teachers Applies to Tutors?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning guidance</td>
<td>How to scaffold tasks (Stein et al., 1996) and differentiate (Quebec Fuentes &amp; Ma, 2018) without routinizing (Doyle, 1988; Estrela et al., 2020) based on student background knowledge (Cohen &amp; Ball, 1999)</td>
<td>Yes, found helpful in journals 1 and 2, focus groups 1 and 2, and the observation (see helpful supports &gt; scaffolding, visual scaffolds, differentiation)</td>
</tr>
<tr>
<td></td>
<td>Anticipating common misconceptions and how to address them (Ball &amp; Cohen, 1996; Hernández et al., 2016; Quebec Fuentes &amp; Ma, 2018; Remillard, 2000)</td>
<td>Yes, found helpful in focus groups 1 and 2, and journal 2 (see helpful supports &gt; anticipated misconceptions)</td>
</tr>
<tr>
<td></td>
<td>Recommendations of what alterations might be best for different students (Ball &amp; Cohen, 1996; Davis &amp; Krajcik, 2005; Remillard, 2000)</td>
<td>Yes, found helpful in focus groups 1 and 2 (see helpful supports &gt; methods for pivoting)</td>
</tr>
<tr>
<td></td>
<td>Which tasks might be beneficial based on student profiles (Cohen &amp; Ball, 1999; Davis et al., 2017; Pepin, 2018),</td>
<td>No, found not helpful in focus group 1 (see not helpful supports &gt; student profiles)</td>
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<td></td>
<td>How to develop a learning goal for tutorial students (Davis &amp; Krajcik, 2005; Doyle, 1988; Pepin, 2018; Remillard, 2000) aligned with the content they are covering in their mathematics class (Robinson &amp; Loeb, 2021)</td>
<td>No, found not helpful for tutors in focus group 1 and journal 2 (see not helpful supports &gt; standards)</td>
</tr>
<tr>
<td>2. Examples of how to apply instructional strategies in the context of the task (Beyer &amp; Davis, 2009; Davis et al., 2017; Pepin, 2018; Remillard, 2000)</td>
<td>Anticipating possible student responses and suggestions on how to respond (Davis &amp; Krajcik, 2005)</td>
<td>Yes, found helpful in focus groups 1 and 2, and journal 2 (see helpful supports &gt; anticipated misconceptions)</td>
</tr>
<tr>
<td></td>
<td>Strategies for modeling and encouraging student mathematical discourse (Bartell et al., 2017; Munroe, 2015; Quebec Fuentes &amp; Ma, 2018; Viseu &amp; Oliveira, 2012)</td>
<td>Inconclusive, different outcomes from different tutors ranging from yes to no found in focus groups 1 and 2, and the observation (see lingering challenges &gt; discussion and mathematical discourse)</td>
</tr>
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<td></td>
<td>Tips to get students to engage with mathematical thinking (Cohen &amp; Ball, 1999) and be concerned with process and not only the answer (Carlson &amp; Sullivan, 2004)</td>
<td>Conditionally, PCK found helpful in focus group 1 and the observation, however, being concerned with process and not answer not explicitly addressed through educative supports in this study (see helpful supports &gt; PCK)</td>
</tr>
<tr>
<td>3. Building of teacher content knowledge (Ates &amp; Eryilmaz, 2010; Granger et al., 2019; Wilhelm, 2014) and mindsets (Hong &amp; Choi, 2019)</td>
<td>Information on how mathematical concepts relate and build (Davis et al., 2017; Pepin, 2018) and connect to other ideas (Davis &amp; Krajcik, 2005; Munroe, 2015; Quebec Fuentes &amp; Ma, 2018)</td>
<td>Yes, found helpful in focus group 1 and journal 2 (see helpful supports &gt; key points, PCK)</td>
</tr>
<tr>
<td></td>
<td>How background skills support access to content and tasks (Bartell et al., 2017; Hung et al., 2008; Stein et al., 1996)</td>
<td>Yes, found helpful in focus groups 1 and 2, and journal 2 (see helpful supports &gt; background skills, vocabulary)</td>
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<td></td>
<td></td>
<td>• Note, there were lingering challenges with more support needed around background skills noted in the observation (see lingering challenges &gt; student missing background skills)</td>
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<td></td>
<td>Necessary mindsets around students’ need for conceptual instead of procedural tasks, no matter their background knowledge (Hong &amp; Choi, 2019)</td>
<td>No, found not helpful in focus group 1 (see not helpful supports &gt; student-dependent support &amp; mindsets)</td>
</tr>
<tr>
<td>4. Task enactment guidance</td>
<td>Specific questions to ask (Pepin, 2018) to push for justifications (Stein et al., 1996).</td>
<td>Yes, found helpful in focus groups 1 and 2, observation, and journal 2 (see helpful supports &gt; check for understanding questions)</td>
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<td></td>
<td>Specific formative assessment questions also found helpful in focus groups 1 and 2, and journal 2 (see helpful supports &gt; formative closing assessment)</td>
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<td></td>
<td>How to interpret student thinking (Ball et al., 2008) and adjust during task implementation, making choices to support student needs that arise; including suggestions for possible alterations (Baba &amp; Shimada, 2019; Pepin, 2018)</td>
<td>Yes, found helpful in focus groups 1 and 2, and journal 2 (see helpful supports &gt; anticipated misconceptions, differentiation)</td>
</tr>
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<td></td>
<td>How to structure timing to allow students to think deeply (Bieda, 2010; Pepin, 2018; Stein et al., 1996)</td>
<td>Inconclusive, found not helpful in focus group 1, then found potentially helpful in focus group 2 (see lingering challenges &gt; timing)</td>
</tr>
<tr>
<td></td>
<td>How to build a culture where students feel competent (Azevedo, 2006; Bartell et al., 2017) and a valuable part of a community (Quebec Fuentes &amp; Ma, 2018)</td>
<td>No, found not helpful in focus group 1 (see not helpful supports &gt; student-dependent support)</td>
</tr>
<tr>
<td></td>
<td>How and when to give students feedback (Azevedo, 2006)</td>
<td>No, found not helpful in focus group 1 (see not helpful supports &gt; student-dependent support)</td>
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<td></td>
<td>Options for giving students power and choice (Schettino, 2016) to create student autonomy (Davis &amp; Krajcik, 2005) and allow students the freedom to decide their solving method (NCTM, 2000)</td>
<td>No, found not helpful in focus group 1 (see not helpful supports &gt; student-dependent support)</td>
</tr>
</tbody>
</table>
This study exposed that tutors found educative guidance helpful in the same general areas as teachers: planning advice (Beyer & Davis, 2009; Quebec Fuentes & Ma, 2018), examples of how to apply instructional strategies (Beyer & Davis, 2009; Davis et al., 2017; Pepin, 2018; Remillard, 2000), building educator content knowledge (Ates & Eryilmaz, 2010; Granger et al., 2019; Wilhelm, 2014), and task enactment guidance (Baba & Shimada, 2019; Pepin, 2018). However, it is notable that they thought fewer of the supports were helpful. The supports they mentioned the most frequently (see Table 4.3) were having specific questions to assess students’ prior attainment on background skills, scaffolding and differentiation tips, including ideas for visual scaffolds, and having exact questions they could ask during task enactment to check for student understanding. Additionally, findings suggest having planning guidance around which student misconceptions to anticipate and how to respond when the misconception happens and having laid out mathematical takeaways from the task supported tutors’ ease of planning. The educative guidance found most helpful has the common theme of being readily implementable.

The supports not found helpful for tutors included higher-level pedagogical concepts, such as addressing educator mindsets, building a positive student culture, and content alignment. The educative supports tutors thought were most supportive included tutoring strategies that could be applied without additional planning. This finding suggests the most pressing struggle for tutors is baseline HCD task implementation, so educative supports should focus on these areas. Tutors may not be concerned with deeper pedagogical strategies. Additionally, because tutors in this program had a site director as a leader in their room, they may not have needed to create an overall positive classroom
environment, as that fell to the site director. The findings suggest that general supports that could be used for teachers to build pedagogical skills over time were not helpful for tutors. This finding underlines the importance of considering tutors, and potentially other novice educators, separately from experienced educators when designing curriculum to meet their needs. Tutors may not see the benefit of building their skills over time, as they often only tutor for a few years (Cook et al., 2014).

One concern that arose was the abundance of possible curricular supports. Sammy mentioned in focus groups 1 and 2 and journal 2 that they were concerned new tutors might be overwhelmed by the number of supports. This concern is supported by cognitive load theory, which states that we can only keep a limited number of items in our working memory (Sweller, 2011). It is also supported by research on educative guidance showing that too many choices within the materials can hinder educators’ use of them (Davis & Krajcik, 2005; Remillard, 1999). As tutors’ skills build over time, they can access new pedagogical skills. However, until they are comfortable with the baseline skills, the abundance of additional supports would overload them. This potential overload could explain why tutors suggested that the more advanced educative supports, such as creating student autonomy, would not be helpful when prior studies found the supports helpful for teachers (Davis & Krajcik, 2005). It is notable that the two newer tutors, Emily and Richard, did not mention being overwhelmed by the educative guidance included in the HCD task during this study. This finding suggests the curricular guidance embedded in this task balanced the need for additional support without being overwhelming.

This study addressed only some educative guidance that prior literature has found helpful for teachers because, as noted, there is an abundance of possible valuable
supports. It prioritized supports that addressed emerging needs from tutor journals and focus groups. Educative supports around how to create conceptual connections (Munroe, 2015; Stein et al., 1996) and using multiple methods (Ball & Cohen, 1996; Davis et al., 2017; Davis & Krajcik, 2005; Munroe, 2015) have been shown to be helpful for teachers and were loosely include in differentiation suggestions in this study, however, were not directly addressed. Guidance that indicates that curriculum developers expect educators to make adjustments (Beyer & Davis, 2009), suggestions on how to balance pushing student thinking and allowing students to think on their own (Ates & Eryılmaz, 2010), and tips on how to model high-level performance (Stein et al., 1996) were briefly mentioned in the first focus group as being not helpful and were not fully addressed in this study.

**Lingering Challenges.** The purpose of this study was to find educative supports that would allow tutors to feasibly implement a HCD task without needing additional training. However, it surfaced during data analysis that tutors may not implement a strategy if they do not see its importance.

For example, Richard named in focus group 2 that he did not believe his students, who were language learners, could complete the conceptual pieces of the task. The idea that language learners need more procedural content is invalid, and language learners benefit from equal exposure to conceptual mathematics (Moschkovich, 2015). Had Richard known the importance of conceptual learning for all students in building their mathematical understanding (Boaler, 2016), potentially, he would have implemented the strategies presented in the task. However, mathematics instruction for language learners is challenging (Prediger, 2019), and it can take years for teachers to develop adequate
skills to address student language needs in the mathematics classroom (Lucas & Villegas, 2013). Further research is needed to explore how helpful educative supports might be in aiding tutors of language learners.

Findings from focus group 1, journal 2, and focus group 2 suggest Emily and Sammy understood the purpose and how to use the embedded background skills, as they used the questions as written. Richard, in contrast, altered one of the background skill questions so that it no longer assessed the intended skill. This action shows that each question's intended purpose was unclear, and further guidance could be helpful.

The challenge remains that if curriculum designers were to include a justification for every question and suggestion, it might become cognitively overwhelming. These findings suggest tutors may need more guidance and coaching around why the embedded strategies are important and aid student learning and how to select which strategies are most applicable for their students. Tutors need adequate background knowledge to access and use the embedded task guidance, mirroring students’ need for sufficient background knowledge to engage with a HCD task (Stein et al., 1996). This finding suggests educative supports alone may have a limit and to continue growing tutors’ skills, training or coaching around the purpose of each support may be needed.

Educator effectiveness grows over time (Burroughs et al., 2019), and tutors lack ample time to expand their skill set as they often only tutor for a year or two (Cook et al., 2014). The frequency of teachers’ learning opportunities has also been shown to lead to higher student achievement (Burroughs et al., 2019). Despite the limitations, findings suggest there is hope that educative supports could provide tutors with continuous and ongoing learning opportunities to improve their knowledge and skill set. Educative
supports embedded in curricular materials may be the best option for improving tutor skills in the limited time. This proposition is supported by prior research that has found embedded supports helpful for developing ongoing learning for novice educators (Collopy, 2003). Additionally, preservice teachers have been shown to develop skills at varying rates (Vagi et al., 2019), and educative supports could let tutors develop at their own pace by self-selecting which supports to use, building their pedagogical repertoire over time. The lingering challenge remains that because of the short career span of a tutor, it is unclear how much tutor skills can grow before they end their tutoring tenure. Further research is needed to understand where the ceiling is for tutor skills and how it differs from that of teachers.

Alignment with Mathematical Tasks Framework. The educative supports found to help guide tutors to implement a HCD task well in this study were measured using a combination of tutors sharing opinions and observational data. Stein et al.’s (1996) Mathematical Tasks Framework used to collect observational data contains instructional actions educators take to keep cognitive demand high or lower cognitive demand. Table 5.3 aligns the components with findings on which educative supports were helpful to tutors.
### Table 5.3 Components of Mathematical Tasks Framework Aligned with Educativ Support Findings

<table>
<thead>
<tr>
<th>Mathematical Tasks Framework Component (Stein et al., 1996)</th>
<th>Do the Study Findings Show Educativ Support Helpful in this Area?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actions that Keep Cognitive Demand High</strong></td>
<td></td>
</tr>
<tr>
<td>Scaffolding</td>
<td>Yes, scaffolding and visual scaffolds found helpful</td>
</tr>
<tr>
<td>Modeling of high-quality exemplars</td>
<td>Modeling not fully addressed in this study</td>
</tr>
<tr>
<td>Conceptual understanding with connections</td>
<td>Creating conceptual connections not fully addressed in this study; pieces under differentiation found helpful</td>
</tr>
<tr>
<td>Building on prior knowledge</td>
<td>Yes, background skills and vocabulary found helpful</td>
</tr>
<tr>
<td>Sufficient time</td>
<td>Inconclusive, found varying results about timing</td>
</tr>
<tr>
<td>Student self-monitoring</td>
<td>No, creating student autonomy found not helpful</td>
</tr>
<tr>
<td>Push for explanations, justifications, and demonstrated understanding</td>
<td>Yes, check for understanding questions to push student learning found helpful</td>
</tr>
<tr>
<td><strong>Actions that Lower Cognitive Demand</strong></td>
<td></td>
</tr>
<tr>
<td>Routinization</td>
<td>Yes, differentiation tips on differentiating without routinizing found helpful</td>
</tr>
<tr>
<td>Reduction in complexity or ambiguity</td>
<td>No, mindsets around need for conceptual instead of procedural tasks not found helpful</td>
</tr>
<tr>
<td>Too much instructor intervention</td>
<td>No, brief mention that balancing pushing students and when to give students feedback was not helpful</td>
</tr>
<tr>
<td>Lack of student interest</td>
<td>No, student profiles found not helpful</td>
</tr>
<tr>
<td>Lack of student background skills</td>
<td>Yes, background skills found helpful</td>
</tr>
<tr>
<td>Focus on answer over process</td>
<td>Yes, check for understanding questions that pushed understanding the process found helpful</td>
</tr>
<tr>
<td>Not adequate time for students to think deeply</td>
<td>Inconclusive, found varying results about timing</td>
</tr>
</tbody>
</table>
It is notable that not every area of the Mathematical Tasks Framework (Stein et al., 1996) had an associated educative support that was found helpful for tutors. However, despite this incomplete alignment, observation data showed tutors could keep cognitive demand on students high as they facilitated the HCD task. In their research, Smith et al. (1996) found teachers struggled with HCD tasks because (1) they were unsure how to monitor, understand, and analyze varying student approaches, (2) they needed to decide during facilitation when to intervene, and (3) they lacked confidence knowing what approaches students might take. Several of these struggles could have been remedied for tutors with the inclusion of anticipated student misconceptions and how tutors could address them. From the supports tutors found most valuable, scaffolding, differentiation, check-for-understanding questions, and anticipated misconceptions could aid in their ability to foresee, understand, and analyze student work and determine how to facilitate best. This finding supports that tutors can facilitate HCD tasks without direct support in each area of the Mathematical Tasks Framework (Stein et al., 1996).

**Educative Supports Findings Summary.** HCD tasks can support student learning (Boaler, 2016; Hong & Choi, 2019; Munroe, 2015), however, how educators facilitate these tasks directly affects how much students learn from the tasks (Hong & Choi, 2019; Remillard, 2005). Therefore, it is vital for curriculum designers to take into account the educators that will use their materials and intentionally design the materials to suit educator needs (Remillard, 1999, 2000). This study extended prior research on educative supports for teachers and exposed several educative supports that helped guide tutors to facilitate a HCD task. The most prominent were those that were easily implementable and aided in the planning process, including background skills,
scaffolding, differentiation, check-for-understanding questions, key mathematical takeaways, and anticipated misconceptions. These findings show when these educative supports are included in tutor-facing materials, tutors find it feasible to implement a HCD task.

**Practice Recommendations**

The relationship between educators and curricular materials is vital in the successful implementation of curriculum. In the most successful state, educators make adjustments to curriculum based on the needs of their students and curriculum designers attend to the needs of educators by providing suggestions and recommendations on how to adjust and implement the curriculum best (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et al., 2021; Stein et al., 1996). For this relationship to work smoothly, varying audiences of educators and their specific needs must be considered when creating curriculum, which includes tutors and their needs. This study used a co-design process where conversations with tutors about their perspectives guided the creation of prototypes that tutors gave feedback on after trying in their tutorials (Scornavacco et al., 2022). It exposed that tutors could implement a HCD task when tailored and co-designed educative supports were added to curriculum materials. This finding implies the organization in this study can expect tutors to implement HCD tasks and not only problem sets if provided appropriate tutoring guidance. Based on the outcomes of this study, it is recommended the organization overhaul their HCD tasks to include educative guidance throughout the curriculum. Additionally, they should
continue to iterate on this study and co-design with varying groups of tutors and varying tasks, to fine-tune the list of most essential educative supports for tutors.

These findings are transferable to other high-dosage mathematics tutoring organizations that prepare tutors and structure their programs like the organization in this study. Two pathways could exist for these other organizations to apply these results: (1) they could iterate on the educative supports found helpful in this study with their tutors using a skilled and experienced curriculum design team, or (2) they could use the curriculum designed by the organization in this study to support tutors in implementing HCD tasks. (It should be noted the organization’s curriculum is available for free, making the second pathway a viable recommendation.)

While the findings are not directly transferable to teacher training programs, other types of tutoring organizations, or other curricula, they could be used as a catalyst for exploring how novice educators in different contexts are supported through educative guidance. The findings that the baseline, easily implementable supports were found the most useful for tutors could be interesting in these areas, as the finding implies educative supports could be differentiated as educator skills build.

Discussions around supporting novice educators are meaningful because students of color and those of low socioeconomic status are likelier to experience novice educators (Kalogrides & Loeb, 2013). Furthermore, educators generally have lower expectations for students of lower socioeconomic status, making it more likely they will receive rote and unchallenging work (Szumski & Karwowski, 2019). These findings, coupled with new educators finding HCD tasks more challenging than experienced educators (Beyer & Davis, 2009; Munroe, 2015), could potentially lead to historically underserved students
being less likely to have HCD tasks successfully implemented in their classroom. The learning opportunities for traditionally underserved students will remain inequitable without remedying the issue by supporting novice educators to facilitate HCD tasks.

**Action/Implementation Plan**

The purpose of educational action research is for educators to improve their practice to support student learning (Efron & Ravid, 2019), which I will do by applying the results of this study to my context. I shared the findings from this study with my organization and team, and we have begun to revise HCD tasks in the curriculum accordingly. I plan to iterate on this study with varying groups of tutors using different types of HCD tasks to refine further the list of educative supports found to be the most helpful for tutors. Given their needs, I will continue to explore how embedded support, training, and coaching can work together to guide tutors. Additionally, my organization has started to design a prototype to explore how technology-enhanced curriculum could assist tutors in lowering their cognitive load during planning.

I have discussed findings at a National Council of Teachers of Mathematics (NCTM) conference to share results outside my organization. Additionally, I will share the findings in this dissertation and will submit a paper for journal publication.

**Limitations and Challenges**

This section outlines the limitations of this study that could be considered when interpreting results or designing future studies.

**Timeframe**

The limited timeframe in this study posed several challenges. The study was designed with a six-week timeframe because it aimed to expose if using educative
supports suggested HCD tasks were feasible for tutors. It was meant to see if it was realistic to ask tutors to use HCD tasks, assuming more in-depth studies would be needed if findings showed educative supports helpful. The study was designed to be iterative with information collecting, task revision, and feedback gathering. However, having multiple iterations within the study could have been beneficial. For example, it could have been helpful to revise another task after participants shared their thoughts in focus group 2, observe tutors implement the second task, and collect another round of feedback. This extended process could have allowed for a more refined set of educative supports for tutors.

The short timeframe allowed an iteration on a single HCD task. Due to school site structure limitations, the HCD task in this study centered on background skills for the ninth-grade students (rounding and place value). Tutor participants indicated in journal 1 and focus group 1 that they only used HCD tasks for review. Because of the timing limitation, this study did not expose shifting tutor mindsets around using HCD tasks as much as it could have. While tutors indicated in journal 2 that the task content was a new topic for some of their students, the impact could have been different had a variety of HCD tasks on various topics been included. For example, different supports could have been identified had the mathematical content been very challenging for tutors. Furthermore, the supports were only created for one HCD task structure because only one task was used. The task in this study involved creating numbers by manipulating cards with various digits. Potentially different supports would be helpful on a different task structure.
The iteration with a single task over six weeks from late October to early December allowed for a comprehensive snapshot of tutors’ experiences with educative supports. However, tutors are likely more skilled at tutoring later in the year and less proficient at the start of the year. Therefore, studying tutor needs and what educative guidance would be helpful at multiple distinct points during the year could have exposed how much tutors' needs change throughout the year, assuming their skills grow.

The structure of this study created space for participants to complete the HCD task with me before implementing it in their tutorials. It is not realistic or sustainable for me to review each HCD task with tutors. A subsequent iteration of tutors implementing a different HCD task that we did not work through together first could expose different implementation obstacles.

**HCD Mathematical Tasks Framework Rubric**

A few challenges emerged while using the Mathematical Tasks Framework (Stein et al., 1996). First, I assumed that if most tutor actions fell under that kept cognitive demand high, that meant tutors successfully implemented a HCD task. It was unclear from the rubric what was considered “good enough.” Likely, perfection with all educator actions falling under HCD tasks is not expected and growth over time is most important. More guidance around what is “good enough” to significantly affect student learning would have been helpful.

Another challenge with the Mathematical Tasks Framework (Stein et al., 1996) that emerged while collecting data was that the rubric double-counts some items and not others. For example, if sufficient time is given, that counts towards a HCD action. The converse is also listed; if inadequate time is given, that counts towards a LCD action.
Meaning if tutors did well or poorly around giving students appropriate time, both actions made the tally count. The same is not true of other components. For example, if tutors scaffolded well, the HCD actions category was given a tally. However, if they did not scaffold well, no tally was given to LCD actions. Similarly, if students were disinterested in the task, a tally was given to LCD actions. No similar tally was given if students appeared very interested in the topic. This single tally could imply student disinterest lowers cognitive demand for a task, but it does not necessarily keep cognitive demand high when students are very interested. However, the misalignment in HCD and LCD actions seemed to weigh items that were double counted (like timing) more than items that were not (like scaffolding or student interest). A revised rubric that aligns all items in actions that create HCD tasks with a counterpart in acts that lower cognitive demand could be helpful.

Convenience Sampling and Participants

The convenience sample (see Creswell & Creswell, 2017) used to gather participants in this study resulted in a case that was not diverse in some aspects. Because of the lack of racial diversity, the case in this study may not represent the needs of all tutors. Additionally, by happenstance, tutors in the case could have had less varied abilities or dispositions towards education that were not representative of all tutors. Outside of the lack of racial diversity, the group did not include any tutors that were later in their careers (retirees and mid-career tutors make up approximately 13% of the tutor population in the organization). Future iterations of this study could use various sampling types, including systematic and random, to uncover if the convenience sampling in this study was representative or not.
I considered additional limitations when designing the study and took intentional precautions to avoid challenges. These potential challenges could be considered when designing future studies. Volunteer participants could have been difficult to find. Fortunately, all three tutors first identified as eligible participants agreed to join the study. Participants were chosen several weeks before the study began to mitigate the potential issue, allowing for time to select additional participants if necessary. Another possible participant issue was that tutors might not have fully engaged with the study, not completing journals or joining focus groups. A week was given to complete journals, and multiple reminders were sent to mitigate this risk. Focus groups were scheduled at a time chosen by participants that worked optimally for all three case members. An additional concern was tutors in the case could have resigned from their position during the study. Tutor attrition in the studied program was around 40% over the year, so tutor resignation was a considerable concern. As it happened, all three participants were fully engaged throughout the research and expressed enjoyment at having been a part of the process during the final focus group. Were this study to be done again, an additional participant would have been added to the case to mitigate the risk of a tutor resigning mid-study.

Observations

Observations in this study occurred smoothly, and observational data were collected without interference. The only challenge that occurred was during data analysis: due to student privacy concerns, I did not record tutorial sessions, so had to rely only on my notes when analyzing and could not rewatch tutorials to gather additional information. I may have found additional data to support or refute my findings had I been able to rewatch multiple times.
Many additional challenges were possible, and I designed the study intentionally to diminish risks. These challenges and intentional design choices could be considered when designing future studies. First, the window for capturing observation notes was only a few days because travel was required to observe. If students were absent, the planned HCD task was not used on the observation day, or unforeseen school disruptions happened, the study timing would have needed to be altered. To mitigate these possible issues, site directors selected the day and class periods that would be best for observation to optimize the chances of a disruption-free class period.

Second, tutors were used to being observed, and usually, they received feedback from the observation, as the purpose of observations was generally tutor coaching. Because this study investigated tutors’ base understanding of and ability to implement HCD tasks, tutors did not receive feedback post-observations. Feedback flowed only from tutors, as tutors were not meant to have felt their tutoring techniques were being critiqued as a part of this study. Moreover, giving additional tutoring tips throughout the process could have conflated the data, and it might have been unclear if it was the verbal suggestions or written curricular supports that helped tutors. However, this could have caused tutors to have mixed feelings about being observed without receiving improvement advice to which they were accustomed. The observation’s purpose was explained to case participants before and after so tutors knew what to expect. However, at the end of the second focus group, one participant (Richard) asked what I, as the observer thought about the tutorials, indicating he did find it difficult to be observed without readily knowing the observer’s take.
Lastly, challenges could have occurred with the task. The tutoring program in this study aligned its internally designed curriculum with individual classroom teachers. If a teacher changed course, the task developed during week three might no longer align with what students did in their math class. To avoid this potential event, the HCD task used in this study covered foundational skills that could be used at any point as review, making alignment to teachers matter less. However, the schedule could have been thrown off if teachers decided to have a test on an unexpected day, and tutors needed to review topics aligned to the test in tutorial instead of completing the planned task with intentionally embedded educative supports. Had this happened, the data collection schedule would have needed to be shifted a week.

**Recommendations for Future Research**

This section explores recommendations for future research that could extend the findings of this study. Variations in study design, exploring the use of technology, and differentiated supports are discussed.

*Multiple and Varying Iterations*

This study could be expanded to include multiple iterations. Iterations could consist of using different HCD tasks, exploring tutor needs at various times during the school year, and exploring the needs of larger groups of tutors. An experimental design could be used where each type of support found helpful to tutors in prior literature could either be included on a task or not, and data collected to expose if the support helped tutors implement the task.

Lingering questions were left after data collection in this study and could be the focus of future studies. For example, observational data showed students lacked
background skills for the task. However, this task was on rounding and place value, so if ninth graders lacked these background skills, they would likely be missing background skills for many tasks. This study uncovered that better guidance on weaving background skills throughout a task was needed so that tutors would feel confident proceeding before students showed proficiency in all background skills. Additionally, in focus group 1, tutors said that timing was not helpful; however, they indicated it might be beneficial during focus group 2. Future iterations of this study continue to explore tutor needs and fine-tune the recommended educative supports found most helpful for tutors.

This study aimed to explore only embedded supports without using additional professional development and training. This purpose was established because tutors lack time to attend synchronous training or complete asynchronous training. Future studies could investigate the feasibility of including additional training on implementing tutoring strategies or HCD tasks. Studies could explore the use of small microlearning materials or sessions to combat the issue of timing.

**Technology’s Impact on Educative Supports**

The use of technology during tutorial was not investigated during this study outside of students and tutors referencing task prompts on tablets. Future research could explore whether varying types of educative supports are needed for tutorials held online instead of in person.

Additionally, future studies could explore if creating interactive curricular materials could help lessen the cognitive load on tutors. For example, a pop-up window could provide additional educative supports for each part of the task, and only tutors who
click on it would see it. Research could explore if this use of interactive online curriculum would make it easier for tutors to use embedded educative guidance.

**Differentiated Educative Supports and Continued Learning**

This study focused on creating a single set of supports that could apply universally to tutors in the studied program. However, differentiated supports for different types of tutors could be explored in future studies. Future research could investigate if varying supports might be used for tutors who intend to become teachers, retired educators who tutor, or second-year tutors. Additionally, studies could explore if using HCD tasks in tutorials makes tutors more likely to enter the teaching profession.

**Conclusion**

Through an exploratory, single-case design, this study exposed that HCD tasks are implementable by tutors if adequate curricular supports are embedded in materials. Data showed the leading obstacle tutors faced in implementing HCD tasks was the inability to efficiently prepare for a tutorial session. The time it took tutors to plan and prepare to implement made using these tasks unappealing. Following, the study uncovered the most helpful educative supports for tutors were those that aided their planning and were readily implementable, including background skills, scaffolding, differentiation, check for understanding questions, key mathematical takeaways, and anticipated misconceptions.

This study was rooted in the framework that curriculum and educators mutually influence each other (Beyer & Davis, 2009; Brown, 2009; Cohen & Ball, 1999; Doyle, 1988; Pepin, 2018; Quebec Fuentes & Ma, 2018; Remillard, 1999, 2005; Remillard & Heck, 2014; Rezat et al., 2021; Stein et al., 1996), underlining the need for tutoring
curriculum to attend to the specific needs of tutors. There is a lack of literature on the topic of HCD task use in tutorials, educative supports for tutors, and tutoring curriculum in general. The findings of this study begin to fill this gap in research and add to the existing literature on HCD tasks and educative curricular supports by showing educative guidance assists tutors in successfully implementing HCD tasks.

The outcomes of this study are significant because they indicate that HCD tasks are feasible for tutors and, thus, can be used in tutorials, adding to the number of situations where students could be exposed to such tasks. Providing more exposure to HCD tasks for students can support student learning, student engagement, and learning equity (Boaler, 2016). To create access to HCD tasks for both tutors and, by extension, students, the educative supports found in this study can be embedded in tutoring curriculum to supports both tutor and student learning. Creating accessible pathways for more educators to use HCD tasks with students will afford more students the opportunity to engage with these tasks, enriching their learning and deepening their understanding of mathematics (Stein et al., 1996). As such, supporting all educators in implementing HCD tasks is paramount to creating equitable access for all students, including those with novice educators.
References


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https://doi.org/10.26300/QF76-RJ21


https://doi.org/10.1177/002205741619600202


Shimada, I., & Baba, T. (2012). *Emergence of students’ values in the process of solving the socially open-ended problem*. 4, 75–82.


Appendix A: Focus Group One Questions

1. When do you choose to use problem sets? When do you choose to use activities? What guides your choice about the curriculum you choose to use?

Initial findings and notes from journal 1 to reference:
- Chose problem set over activity because students needed more practice and are struggling
  - Generally don’t do activities if need more than half of class time to scaffold
  - Did activity when was review topic
- Switched from activity to problem set because not most efficient way to practice the type of problems
  - Problem sets are varying difficulties so easier to assign
  - Game or cards can feel like a less controlled environment
  - Used activity for fractions because seemed more approachable
  - Activity can be nice change of pace
- Used lessons so they have time to get independent practice
  - Couldn’t print puzzle pieces for activity so unable to implement
  - Needed to have them working the entire class period independently

2. What barriers and successes do you notice to implementing activities?

3. What reflections do you have from working through the given activity yourself?

4. What types of supports would you prioritize in including in the curricular materials? For example, would more background information on the topic be helpful? more differentiation tips? etc.

Possible supports from research to reference (list shown to participants after they exhausted the ideas they brainstormed):
- Planning guidance
  - Alignment with learning goals
  - What student profiles an activity might be good for
  - Scaffolding tips
  - Differentiation tips
    - How to differentiate based on background knowledge
    - How to differentiate without making a routine/rote
  - Anticipated misconceptions and how to address
- Examples of how to apply tutoring strategies
  - How to create conceptual connections
  - How to model and encourage discourse
• Anticipating student responses and how to respond
  • Tips to get students engaged in mathematical thinking; process over answer
    • Balancing heavy lifting

- Building content knowledge
  • How concepts relate and build; connecting to other ideas
  • Background skills that support access to content
  • How to model high-level performance and multiple methods
  • Necessary educator mindsets

- Enactment guidance
  • Structure time
  • Specific questions to ask (CFUs)
  • How to adjust during implementation, make choices during, possible alterations
  • Building culture where students feel competent and valued
  • How and when to give students feedback
  • Options for student choice, autonomy, freedom

5. What additional information would you like to provide that would give more context to your experiences? What additional questions do you wish I had asked?
Appendix B: Original HCD Task

Create a Number Activity

Materials: Cut out the 5 cards for each student to use as manipulatives.

0 3 6 7

Instructions: Using all 5 cards, create a number that satisfies each of the following problems. You must have at least one digit on either side of the decimal.

1. Create a number with a 7 in the tens place.
   Answers will vary. Sample response: 376.0

2. Create a number with a 7 in the tenths place.
   Answers will vary. Sample response: 630.7

3. Create the largest possible number.
   763.0

4. Create the smallest possible number.
   0.367

5. Create a number less than 6.
   Answers will vary. Sample response: 3.670

6. Create a number between 600 and 700.
   Answers will vary. Sample response: 607.3

7. Create a number between 60 and 70.
   Answers will vary. Sample response: 63.70

8. Create a number that rounds to 70.
   70.36

9. Create a number that rounds to 4.
   3.670

10. Create a number that is as close as possible to 30.
    30.67

11. Which questions had multiple answers? Which had only one? Justify your answer.
    Note: Students justify their answers by showing that there are other (or no other) possible numbers for questions 1 - 10.
Appendix C: Focus Group Two Questions

1. What reflections do you have from your experience with the new activity?
   - Possible follow up: How did the planning process go?

2. Did you use the supports that were included? If so, which supports did you find most helpful? If not, why not?

   Initial findings and notes from journal 2 to reference:
   - Most helpful
     - DN
     - TTL
     - Visual place value chart
     - Key points to focus lesson
     - Common misconceptions as heads up
     - CFUs to guide conversation
     - Differentiation for ideas on starting points + harder to go deeper in the moment
     - Extension because hard to think of on the fly
   - Interesting that some said CFUs were helpful and others said they weren’t
   - What alterations would make to the included supports?
   - Were the supports easy to skim to pull what was most needed?

3. Did the supports change your feelings about or towards this task? If so, how?

4. What additional supports might be helpful?

   Initial findings and notes from journal 2 to reference:
   - Links to F1.6 & F1.7 for additional problems – does this mean at the top of the page?
   - More visuals/manipulatives ideas
   - Need advice on which questions to skip if running out of time and what to focus on?

5. What additional information would you like to provide that would give more context to your experiences? What additional questions do you wish I had asked?

   Housekeeping items to address at the end:
   - Big thank you for participating
   - Member checking – access to any data or notes or drafts anytime
Appendix D: Journal One Prompts

1. When this week did you use problem sets with your students? Why did you make this choice?

2. When this week did you choose to use activities with your students? Why did you make this choice?

3. What additional reflections would you like to share?
Appendix E: Journal Two Prompts

1. Reflect on your experience using the modified activity this week. What was it like for you? What did it seem to be like for your students?

2. Which supports and tips in the activity were useful? Which ones were not useful? Please explain.

3. What additional or different supports might be helpful?

4. What additional reflections would you like to share?
## Appendix F: Observation Protocol and Notes Template

### Actions that keep cognitive demand high (Stein et al., 1996)

<table>
<thead>
<tr>
<th>Item</th>
<th>Tallies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaffolding</td>
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</table>

**Notes**

### Actions that lower cognitive demand (Stein et al., 1996)

<table>
<thead>
<tr>
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</thead>
<tbody>
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<td></td>
</tr>
<tr>
<td>Not adequate time for students to think deeply</td>
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</table>

**Notes**

**Additional Notes**
Appendix G: Participant Consent Form

This document serves as record that I am voluntarily agreeing to participate in Halley Bowman’s research study in the fall of 2022. Signing means:

- I am participating in this research willingly.
- I understand I have the right to withdraw my participant at any time.
- I understand I have the right to refrain from answering any questions.
- The purpose of the study was explained to me and I understand it.
- I understand I will be asked to complete the 2 journal entries, participate in 2 focus groups, and will be observed while implementing a selected activity.
- I agree to my journal entries, transcripts from my focus groups, and observation notes being kept for academic record, and understand my identity will be kept confidential so that I am anonymous in all write ups and discussion that happen as a result of this study.
- I agree my direct quotations that are collected throughout the research process may be used during write ups and discussion that happen as a result of this study.
- I understand I have the right to review any analysis done from data collected during this study and review any drafts of papers at any time.
- I understand results of this study will be shared publicly, including by not limited to in a written dissertation, in a dissertation defense and in published papers, and understand my identity will be confidential.

Participant signature: _________________________________ Date: ____________
Appendix H: Revised HCD Task with Educative Supports

Create a Number Activity

This activity aligns with lessons F1.6 Place Value and F1.7 Rounding.

5.NBT.A.4 Use place value understanding to round decimals to any place.

Purpose: This activity is a non-traditional, tactile way for students to practice place value and rounding skills. Creating numbers using limited digits is higher-level than typical place value identification or rounding-a-given-number problems.

Key Points

(1) Multiple numbers can have the same digit in a given place value. For example, 184 and 382 both have 8 in the tens digit.
(2) Rounding means creating an approximation of a number (to simplify it or make it more convenient) by seeing which boundary number it is closest to. Boundary numbers are created based on the place value we are rounding to. For example, if we are rounding 1.57 to the tenth, our boundary numbers are 1.5 and 1.6, and we can determine 1.57 is closer to 1.6.
(3) Multiple numbers can round to the same number. For example, when rounding to the tenth, 1.57 and 1.63 round to 1.6.

Activity Overview

In this activity, students manipulate cards to create numbers using four digits and a decimal. They are given varying prompts that build from place value to rounding skills.

This activity works best with students who have a beginning understanding of place value and rounding and need additional (or different) practice to solidify the skills. If students need a refresher on place value and rounding basics, do so as you’re reviewing the Do Now.

Vertical alignment: Additional rounding and place value practice can be weaved into grade-level content when performing operations, checking answers, and estimating answers before solving. As students continue to build place value proficiency, they use it to perform operations, which is important for manipulating numbers and algebraic expressions. For example, understanding place value can help students know 65 + 72 = 60 + 70 + 5 + 2. Rounding helps students estimate and check the reasonableness of their answers in higher-level math.
<table>
<thead>
<tr>
<th>Potential Misconceptions &amp; Common Errors</th>
<th>Tutoring Strategies</th>
<th>Checks for Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students may round incorrectly or not understand what rounding means conceptually.</td>
<td>Use a number line to model closeness to boundary numbers. For example, 76 is closer to 80 than 70 (if we're rounding to the nearest ten).</td>
<td>• What are the two possibilities for rounding to the tens?</td>
</tr>
<tr>
<td>Students may mix up place values, especially similar-sounding ones, like tens and tenths.</td>
<td>To help students remember place values, have them compare the decimal name for each place value with the fraction name using the chart below.</td>
<td>• How do the fractional representations of each place value help us determine what the place value is called? • What is the difference between the tens and tenths place?</td>
</tr>
<tr>
<td>Students may be confused about there being multiple correct answers.</td>
<td>Understanding will come from discussing and sharing ideas with peers. Try a build-share-compare protocol where students build their numbers individually, share their ideas, and compare their results.</td>
<td>• How did you build your number? • Did your denominator get a different number? Does their number also work?</td>
</tr>
<tr>
<td>Students may be unclear about when they can start their number with a zero in standard numerical form and when they can't.</td>
<td>A zero can be the first digit if it is the only digit to the left of the decimal. A zero can always be at the right of the decimal.</td>
<td>• When is a zero a necessary placeholder? • When is a zero a not necessary placeholder?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>standard form of a number</th>
<th>not standard from</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.367</td>
<td>036.7</td>
</tr>
<tr>
<td>3.670</td>
<td>306.7</td>
</tr>
</tbody>
</table>

Note: Numbers not in standard form aren't "wrong," just not ideal.
Differentiation strategies:
(1) To scaffold the task for students who need a lower entry point, begin with only the digits 3, 6, and 7. Start with a few problems: create a number with a 7 in the tens place, create the largest possible number, and create a number that rounds to 640. Then add in the decimal card and repeat the few problems. Do the same with the zero card. Then, move into the full activity.
   a. If individual questions seem too difficult during the activity, take away or alter cards, as needed, to scaffold up to the written question.
   b. Note: The zero digit can be more difficult for students than the decimal.

(2) To scale up the difficulty, for each problem, have students determine if they can alter the digits on the cards so there is only one viable answer (if there are multiple) or multiple solutions (if there is only one). For example, the only way to have one answer for creating a number with a 7 in the tens place would be to swap the 3 and 6 for 0s, giving us 70.00.

(3) Have students decide their rules for decimal use to create student choice. For example, can there be a lingering decimal so numbers like "3.670" or "730.6" are okay? Or does there need to be a digit on either side of the decimal, as in "0.367" and "736.0"?

Key terms: round, decimal, place value, tens place, tenths place, digit

ELL/EFL Supports

Notes
In some countries, commas and periods are used in reverse. For example, 1,2 means one and two tenths, and 1.200 means one thousand two hundred. Clarity this for students during the Do Now or the first problem of the activity if it causes confusion.

Emphasize the sound "ths" when saying the decimal place value names. This extra pronunciation can help alleviate confusion between "tens" and "tenths." If additional support is needed, use a place value chart (see table above), and point to the place value as you say it.

Sentence starters
__ is in the __ place.
__ rounds to __ because...
I found a different number that works. I found __.
My number works because...

Materials: Cut out or create the five cards for each student to use as manipulatives.

**Connect Tip:** Use the cards on Connect. If you have students who prefer tactile experiences, you can have them create the cards using a sheet of paper. Even though you won’t be able to see what they are moving around, it may help students explore the numbers.
### Background Skills/Do Now

<table>
<thead>
<tr>
<th>(See Lesson F1.6 Place Value)</th>
<th>(See Lesson F1.7 Rounding)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Find the digit in each place value listed below in 352.04.</td>
<td>2. a) Round each number below to the indicated place value.</td>
</tr>
<tr>
<td>a) tens place 5</td>
<td>i. 23 to the tens 30</td>
</tr>
<tr>
<td>b) tenths place 0</td>
<td>ii. 29.78 to the ones (units) 30</td>
</tr>
<tr>
<td>c) hundreds place 3</td>
<td>iii. 30.02 to the tenths 30.0</td>
</tr>
<tr>
<td>d) unit (ones) place 2</td>
<td>b) What do you notice? They all rounded to 30, even though we started with different numbers and rounded to different place values.</td>
</tr>
</tbody>
</table>

### Instructions:
Create a number that satisfies each of the following problems using all five cards.

![0367](image)

1. Create a number with a 7 in the tens place.
   - Answers will vary. Any number with 7 in the tens place is okay. Sample response: 376.0
   - Did you get a different answer from your podmates? Are both solutions okay? Why?
   - What digits in your number could move around? Which is required to be where it is?

   **Note to Fellows:** If students create a number that begins with a zero, encourage them to move the zero to the end behind the decimal. For example, if they write 076.3, encourage them to write 76.30 instead, which is the standard way of writing that number.

2. Create a number with a 7 in the tenths place.
   - Answers will vary. Any number with 7 in the tenths place (right of the decimal) is okay. Sample response: 630.7
   - How is your number different than your previous number?
   - What digit did you have to move? Could you have left everything else where it was?
   - **Extension:** How would your number change if this said hundredths place? Unit place?
   - Could you make a number with a digit in the thousands place? Thousandths? Ten-thousands?

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Activity — Create a Number
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3. Create a number less than 6.
   Answers will vary. Any number with 3 or 0 in the unit (ones) place and all other digits to the right of the zero is okay.
   Sample response: 3.570
   - Did you have to change your answer from the previous question?
   - Which is the most critical place value to consider in this problem? unit (ones) place
   - Extension: Whose number is closest to 6? Can you make one closer?
     - Would any of your numbers round to 6? Can you make one that's less than 6 that rounds to 6?
     - Why not? What if we wanted a number less than 7 instead of less than 6?

4. Create the largest possible number.
   763.0 (or 7630, depending on decided-upon decimal placement rules)
   - What was your strategy for creating the biggest possible number? Did different people have different strategies?
   - Are there multiple answers to this one? Why not?
     - Extension: If we switched the digits cards for different digits, could there be multiple possible answers? Why not?

5. Create the smallest possible number.
   0.367 (or 0.0367, depending on decided-upon decimal placement rules)
   - How does this one relate to the previous problem? reversed the order of the digits
   - What number is in the tenths digit of your number? the hundredths?

6. Create a number between 600 and 700.
   603.7, 607.3, 630.7, 637.0, 670.3, or 673.0
   - Which digit must we have to create a number between 600 and 700? 6 in the hundreds place
     - Scaffolding: Is 367.0 between 600 and 700? Why not?
   - How do you know your number is between 600 and 700? How can you show this visually? could plot on a number line
   - Extension: Find all possible numbers we can create between 600 and 700.

   Differentiation: if students struggle to place their digits, create blanks on a whiteboard to fill in. For example, once we’ve determined we need a 6 in the hundreds digit, to make it a hundreds digit, we know we need two more digits to the right of it before the decimal. 6 __ __ . __

7. Create a number between 60 and 70.
   60.37, 60.73, 63.07, 63.70, 67.03, or 67.30
   - How is this problem like the previous one? How is it different?
   - What is the smallest change we can make from the last number to this one? move decimal
     - Extension: Would moving only the decimal still work if we were going from creating a number between 300 and 400 to a number between 30 and 40? Why?
       - Under what conditions does this work? What does this have to do with scaling up and down by 10?

Note to Fellows: It can be tempting to have students figure out the decimal trick first. However, let them fiddle with their digits and find a new number before discussing the efficiency of moving the decimal. This will help students realize the decimal “trick” is only one strategy, not the only strategy.
8. Create a number that rounds to 70.
   70.36 if rounding to the ones place; 67.00, 67.30, 70.38, 70.63, 73.06, or 73.60 if rounding to the tens place
   - What does it mean to round?
     - If we're rounding to the nearest unit (one), why does 70.36 round to 70 but 70.63 does not?
   - What place value did you round to that gave you 70?
     - Extension: Is there an option of getting 70 if we round to the hundreds place? No. What about the
       tenths? Not with the digits we have; we'd need two 0s and to assume 70 and 70.0 are the same (e.g., 70.03
       rounds to 70.0).

   **Differentiation:** As students compare answers, they might discover they've rounded to different place
   values (ones vs. tens). This is great! If all students have rounded to the ones or the tens, push
   students to round to the other option. If students need more scaffolding, give them a place value to
   round to (ones or tens).

   **Differentiation:** Use a number line to demonstrate rounding as finding the nearest given increment (in
   this case, one or ten) to a number.

9. Create a number that rounds to 4.
   3.607, 3.670, 3.706, or 3.760
   - Are there multiple place values we could round to for this one?
     - How do we know we have to be rounding to the ones place?
     - Extension: Could we be rounding to the tenths if we had different digits? Yes, if we had a 4 instead of
       a 6 (or 7) and assumed 4 and 4.0 were equivalent (e.g., 4.004 would round to 4.0).
   - Extension: Create all possible numbers that round to 4.

10. Create a number that is closest to 30.
    30.67
    - Does this one have multiple possible answers? Why not?
    - Create one new digit (replacing a digit you have) to make your number closer to 30.

    **Extension:** Connect "closest" to rounding. The concepts are related but not identical, given our
    restricted set of digits. Show both on a number line to compare the two ideas. Emphasize that we
    could create a number closer to 30 that would round to 30, but we weren't given the correct digits for
    that:
    - Extension: Does your number round to 30, rounding to the nearest unit (ones)? No
      - How can it be closest to 30 if it doesn't round to 30? We only have set digits to use, and they happen not
        to round to 30.

11. Which questions had only one possible answer? Which had multiple? Why?
    Problems 4 (largest), 5 (smallest), and 10 (closest) had only one answer because there cannot be two different numbers
    that are biggest or smallest. And there's only one possible closest number given this set of digits.

    **Note to Fellow:** There could be two closest numbers if we had different digits or rules for creating the numbers. For
    example, 4.9 and 5.1 are equally "close" to 5.
    - For which problems did different people get different answers?
    - For which ones did everyone get the same answer, but were there other possible answers?
    - For the numbers with only one possibility, what different strategies did people have to find it?
Extension for time: If you want the activity to take more time, try the same problems again using different digits. Discuss which answers change.

- With different digits, is there still an answer to all questions? (there might not be)
  - If there's not a possible answer, how might we alter the wording so there is? (It will vary based on digits selected; e.g., might create number with 5 in the tens digit or a number between 50 and 60)
- Which solving strategies did you use again?

Extension for challenge: Don’t require that students use all cards/digits for each number created. Have students discuss which questions would have additional or changed responses (e.g., the smallest number would be 0 now).
- Is it easier or harder not to have to use all the cards? (Students will likely think it’s much easier)

Extension for challenge: Have students create digit cards and 3ish questions. They can decide the “rules” for their problems (e.g., do you have to use all the cards for each number?). Students should make sure their questions have at least one answer. Then, have students swap digit cards and questions.

---

### Ticket To Leave

<table>
<thead>
<tr>
<th>1. Which number was hardest for you to create? Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answers will vary. Students should explain which question or group of questions was hardest for them to find a solution for and why it was challenging for them.</td>
</tr>
</tbody>
</table>

**Note to Fellow:** After students answer this question, it is an excellent opportunity to discuss growth mindset and how they persevered through a challenge.

<table>
<thead>
<tr>
<th>2. Using the digits and decimal below, create a number with an 8 in the tens place.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>5 7 8</em></td>
</tr>
</tbody>
</table>

- 85.7 or 87.5; or if your group decided lingering decimals are okay, 785. or 587.
  - **Challenge:** List all possible answers.

<table>
<thead>
<tr>
<th>3. Using the digits and decimal below, create a number that rounds to 9.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>5 7 8</em></td>
</tr>
</tbody>
</table>

- 8.75 or 8.57
  - **Challenge:** List all possible answers.

<table>
<thead>
<tr>
<th>4. Challenge: Create your own “create a number” question to answer using digits and decimal below and answer it.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>4 6 8</em></td>
</tr>
</tbody>
</table>

Answers will vary. Student response should have both a question and a number answer. For example, what is the number closest to 40 we can build? 46.8

---

Have feedback on this activity? Please provide it here.

Activity – Create a Number
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### Background Skills/Do Now

<table>
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<tr>
<td>b) tenths place</td>
<td>ii. 29.78 to the ones (units)</td>
</tr>
<tr>
<td>c) hundreds place</td>
<td>iii. 30.02 to the tenths</td>
</tr>
<tr>
<td>d) unit (ones) place</td>
<td>b) What do you notice?</td>
</tr>
</tbody>
</table>

3. Review from Yesterday

4. Spiral Review

Create a number that satisfies each of the following problems using all five cards.

```
0 3 6 7 .
```

1. Create a number with a 7 in the tens place.
2. Create a number with a 7 in the tenths place.
3. Create a number less than 6.
4. Create the largest possible number.
5. Create the smallest possible number.
6. Create a number between 600 and 700.
7. Create a number between 60 and 70.
8. Create a number that rounds to 70.
9. Create a number that rounds to 4.
10. Create a number that is closest to 30.
11. Which questions had only one possible answer? Which had multiple? Why?

<table>
<thead>
<tr>
<th>Ticket To Leave</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Which number was hardest for you to create? Why?</td>
</tr>
<tr>
<td>2. Using the digits and decimal below, create a number with an 8 in the tens place.</td>
</tr>
<tr>
<td>. 5 7 8</td>
</tr>
<tr>
<td>3. Using the digits and decimal below, create a number that rounds to 9.</td>
</tr>
<tr>
<td>. 5 7 8</td>
</tr>
<tr>
<td>4. Challenge: Create your own &quot;create a number&quot; question to answer using digits and decimal below and answer it.</td>
</tr>
<tr>
<td>. 4 6 8</td>
</tr>
</tbody>
</table>
Appendix I: HCD vs LCD Actions from Observation Data by Tutor

Participant: Richard; observed Tuesday, November 15, 2022, 6th period, 12:35pm-1:26pm

<table>
<thead>
<tr>
<th>Item</th>
<th>Tally</th>
<th>Item</th>
<th>Tally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaffolding</td>
<td>5</td>
<td>Routinization</td>
<td>2</td>
</tr>
<tr>
<td>Modeling of high-quality exemplars</td>
<td>4</td>
<td>Reduction in complexity or ambiguity</td>
<td>1</td>
</tr>
<tr>
<td>Conceptual understanding with connections</td>
<td>1</td>
<td>Too much instructor intervention</td>
<td>1</td>
</tr>
<tr>
<td>Building on prior knowledge</td>
<td>2</td>
<td>Lack of student interest</td>
<td>1</td>
</tr>
<tr>
<td>Sufficient time</td>
<td>4</td>
<td>Lack of student background skills</td>
<td>1</td>
</tr>
<tr>
<td>Student self-monitoring</td>
<td>3</td>
<td>Focus on answer over process</td>
<td>2</td>
</tr>
<tr>
<td>Push for explanations, justifications, and demonstrated understanding</td>
<td>1</td>
<td>Not adequate time for students to think deeply</td>
<td>0</td>
</tr>
</tbody>
</table>

Participant: Emily; observed Wednesday, November 16, 2022, 4th period, 10:30am-11:20am

<table>
<thead>
<tr>
<th>Item</th>
<th>Tally</th>
<th>Item</th>
<th>Tally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaffolding</td>
<td>5</td>
<td>Routinization</td>
<td>0</td>
</tr>
<tr>
<td>Modeling of high-quality exemplars</td>
<td>5</td>
<td>Reduction in complexity or ambiguity</td>
<td>0</td>
</tr>
<tr>
<td>Conceptual understanding with connections</td>
<td>9</td>
<td>Too much instructor intervention</td>
<td>1</td>
</tr>
<tr>
<td>Building on prior knowledge</td>
<td>5</td>
<td>Lack of student interest</td>
<td>0</td>
</tr>
<tr>
<td>Sufficient time</td>
<td>5</td>
<td>Lack of student background skills</td>
<td>1</td>
</tr>
<tr>
<td>Student self-monitoring</td>
<td>3</td>
<td>Focus on answer over process</td>
<td>0</td>
</tr>
<tr>
<td>Push for explanations, justifications, and demonstrated understanding</td>
<td>10</td>
<td>Not adequate time for students to think deeply</td>
<td>0</td>
</tr>
</tbody>
</table>

Participant: Sammy; observed Wednesday, November 16, 2022, 5<sup>th</sup> period, 11:24am-12:14pm

<table>
<thead>
<tr>
<th>Actions that keep cognitive demand high (Stein et al., 1996)</th>
<th>Actions that lower cognitive demand (Stein et al., 1996)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Tally</td>
</tr>
<tr>
<td>Scaffold</td>
<td>11</td>
</tr>
<tr>
<td>Modeling of high-quality exemplars</td>
<td>5</td>
</tr>
<tr>
<td>Conceptual understanding with connections</td>
<td>9</td>
</tr>
<tr>
<td>Building on prior knowledge</td>
<td>4</td>
</tr>
<tr>
<td>Sufficient time</td>
<td>5</td>
</tr>
<tr>
<td>Student self-monitoring</td>
<td>3</td>
</tr>
<tr>
<td>Push for explanations, justifications, and demonstrated understanding</td>
<td>11</td>
</tr>
</tbody>
</table>