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Impacts of Professional Development on Elementary Mathematics Teachers' Implementation of Cognitively Demanding Tasks

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IMPACTS OF PROFESSIONAL DEVELOPMENT ON ELEMENTARY MATHEMATICS TEACHERS' IMPLEMENTATION OF COGNITIVELY DEMANDING TASKS

by

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ABSTRACT

This study provided insight into the impact a professional development series on cognitively demanding tasks had on teachers' identification and implementation of tasks, as well as, determined which aspects of the professional development were beneficial to participants' understanding of cognitively demanding tasks. The professional development included five sessions and was centered on the Instructional Quality Assessment (IQA) Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019). As part of the study, participants submitted tasks and student artifacts pre and post professional development. The investigation included an analysis of tasks, student artifacts, and a thematic analysis of collaborative conversations and interviews. A single case study was conducted, with the case being the professional development series. Additionally, case participants provided insights on their experiences and learning on cognitively demanding tasks. Findings suggested that there was an impact on participants' implementation of cognitively demanding tasks after they participated in the professional development series. Throughout the thematic analysis, aspects of the professional development were identified as beneficial to participants' learning and understanding of cognitively demanding tasks. Discussion of the findings in relation to the current literature and their implications were provided. Additional research was suggested to continue the professional development series with the IQA Teachers' Questions, Teacher's Linking, and Teacher's Press Rubrics (Boston et al., 2019) which follow the IQA progression. Further research into the complexity of schools under heightened state or county supervision should be investigated in regard to professional development and teacher autonomy. These findings add to the literature and research in the field of mathematics education, cognitively demanding tasks, and professional development.

This dissertation is dedicated to my dad, who would have loved to see me walk across the stage.

Your memory and infamous ways encouraged me to conquer my own dreams.

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CHAPTER 1: INTRODUCTION AND OVERVIEW

Background

In effort to address the quality of instruction and learning opportunities for mathematics in the United States, the Common Core State Standards for Mathematics was published and was initially either adapted or adopted by 47 states (Akkus, 2016). Florida was one of the states that first implemented the Common Core in 2010. Florida made a slight revision to the Common Core that included renaming them the Mathematics Florida Standards (MAFS) in 2014 (Florida Department of Education [FLDOE], 2020). These standards which focused on providing multiple strategies on how to problem solve through mathematical tasks (Farfan et al., 2019). Six years later, Florida shifted to Florida's Benchmarks for Excellent Student Thinking (B.E.S.T.) Standards for Mathematics (FLDOE, 2020).

As Florida worked to implement the Florida's B.E.S.T. Standards for Mathematics, there was more focus on having students explore in mathematics, ensuring that students have opportunities to deepen their conceptual understanding of mathematics topics (FLDOE, 2020). In addition to this shift toward mathematical exploration, Florida's B.E.S.T. Standards included mathematical thinking and reasoning standards which, using teacher actions, promote students' mathematical thinking and reasoning (FLDOE, 2020). If we expect teachers to provide students with these learning opportunities, we also need to ensure that teachers have the content knowledge for teaching mathematics and pedagogical content knowledge to do so.

To increase mathematical knowledge, teachers need to be provided opportunities for professional growth. Professional development opportunities have been incorporated in school districts throughout the nation to assist in helping teachers develop students' learning and thinking (Garet et al., 2001; Kennedy, 2016). These professional development opportunities

should be focused on being a collaborative space for teachers to develop their expertise in teaching mathematics (NCTM, 2020).

Although understanding mathematics concepts is an integral part of teaching, it is not the only knowledge needed to successfully build students' mathematics understanding. Teachers also must have content knowledge for teaching, which allows teachers to make sense of student thinking and explanations in mathematics (Ball et al., 2005; Ball et al., 2008; Shulman, 1986; 1987). In addition, pedagogical content knowledge is needed to effectively guide students through questioning, multiple representations, and academic discourse (Ball et al., 2005; Ball et al., 2008; Shulman, 1986; 1987). Intertwining both types of knowledge allows teachers an opportunity to provide optimal learning environments that promote student thinking and learning.

Even with the implementation of new standards nationwide and the push for professional development for teachers (Holden, 2000), recent data showed grade 4 and grade 8 mathematics achievement scores have declined (The Nation's Report Card, 2022).

Statement of Problem

In 2019, NCES published the Trends in International Mathematics and Science Study (TIMSS), which shows how grade 4 and grade 8 students in the United States compare on a standardized measure to other countries in mathematics achievement every four years. Of the 64 countries that participated, the United States ranked 15th (National Center for Educational Statistics [NCES], 2019). What is most notable from the data from NCES (2019) is the "gap" in mathematics achievement between the highest percentile and lowest percentile, which is a 219-point score gap. This shows students in the United States have not yet met proficiency as measured by the assessment. Most recently, according to The Nation's Report Card (2022),

fourth grade mathematics scores in the United States dropped by five points from 2019 to 2022. While this data showed a five-point decrease, it is important to note this assessment was given right after the pandemic when many students had disruptions to their schooling.

Research has shown that long term learning occurs when students are exposed to critical thinking and problem-solving experiences (Ball et al., 2005; Barber, 2018; Liljedahl et al., 2007). One way to accomplish this lifelong learning is to ensure that mathematical tasks are cognitively demanding (Ball et al., 2005; Barber, 2018; Liljedahl et al., 2007). Pedagogical content knowledge and content knowledge for teaching are important factors when teachers are planning and considering tasks to use to promote student learning (Ball et al., 2005; Barber, 2018; Liljedahl et al., 2007). If teachers have this understanding, they can make just-in-time adjustments to raise the cognitive demand of tasks in their lessons, which can promote higher levels of students thinking. However, if teachers have limited pedagogical content knowledge or content knowledge for teaching then teachers are unable to provide meaning to mathematics concepts and procedures (Barber, 2018). This lack of pedagogical content knowledge and content knowledge for teaching inhibits teachers' abilities to attend to the mathematical processing of students (NCTM, 2020).

Organizational Context

Tide County Public Schools (TCPS) (pseudonym) is an urban school district located in Florida. TCPS's mission is to create enriching and diverse pathways to lead students to success. To meet this goal, TCPS created a strategic plan, which provides goals and expectations for the district to meet by 2025 (citation withheld to preserve the confidentiality of the research site). One of the goals is to close the achievement gap with regards to the percent of students who are proficient in the mathematics state standards.

The overall mathematics achievement on the Florida Standardized Assessment (FSA) in TCPS for the 2021-2022 school year was 53% proficiency and for the 2022 – 2023 school year was 52% proficiency (Florida Department of Education, n.d.). In the state of Florida, schools are graded based upon students meeting proficiency levels on statewide assessments. Pinnacle Elementary School (pseudonym) earned an F rating for the 2021-2022 school year. In mathematics, the school scored 30% proficiency, which is the percentage of students who reached mastery based on the results of the FSA. The schools' overall student mathematics learning gains were 39%, and our students who were considered in the lowest 25% had learning gains of 25% (Florida Department of Education, 2022).

To promote and assist in student growth, Pinnacle Elementary became part of the School Transformation Office (STO) learning community. STO was originally created in 2013, as part of a statewide initiative, to provide support to schools based on the academic needs of the students (FLDOE, 2020). STO is part of the Bureau of School Improvement (BSI), which provides continuous support to assist schools in improving academic outcomes (FLDOE, 2020). The BSI's goal is to show that 70% of schools in the program show an increase in their school grade in 2024 (FLDOE, 2020). As part of the STO learning community, this goal is accomplished through data driven standards-based instruction, training on rigor, and qualified site team members to aid in schools that were determined to be high needs based on previous statewide assessment data (citation withheld to preserve the confidentiality of the research site). At Pinnacle Elementary, STO provided mathematics plans for whole group, small group, centers work, and intervention to testing grade levels, which are third through fifth grades. STO also conducted Professional Learning Community (PLC) meetings, in which they discussed and led conversations on how to implement the lessons with fidelity but also provided time for teachers

to engage in the prescribed lessons, ask questions, and look through grade level unit data. These PLC meetings occurred three times per week and were led by the school's administration and STO personnel.

Conceptual Framework

The conceptual framework for this study centered on ideas from *Catalyzing Change in Early Childhood and Elementary Mathematics: Initiating Critical Conversations* (NCTM, 2020), professional development, pedagogical content knowledge, content knowledge for teaching mathematics, and the Instructional Quality Assessment (IQA) rubrics (Boston, 2019). *Catalyzing Change* (NCTM, 2020) calls for all students to have the opportunity to experience quality mathematics teaching. To meet this equitable goal, teachers' knowledge, specifically their content knowledge for teaching mathematics and pedagogical content knowledge, must be addressed because they impact the quality of instruction students experience in mathematics (Ball et al., 2008). Teacher knowledge along with professional development focused on the IQA rubrics (Boston, 2019) may impact teachers' instructional decision-making process when implementing quality tasks in the mathematics classroom. Additionally, encouraging teachers to make instructional decisions that prompt student learning and thinking in all students has the power to create a more equitable classroom environment (NCTM, 2020). These ideas and concepts were used to create the conceptual framework for my study.

Catalyzing Change (NCTM, 2020) was published to encourage stakeholders to make informed decisions on creating equitable instructional practices and deepening mathematical understanding. To create an equitable environment for student learning, teachers need to ensure that the students are at the forefront of learning, by doing and thinking about the mathematics (NCTM, 2020). Teachers can create this environment by using their content knowledge for

teaching mathematics and pedagogical content knowledge which could be developed by participating in professional development. Aligned with these goals, elementary mathematics instruction should build a foundation of conceptual understanding and reasoning that is aligned with research informed practices to build positive student mathematics identities (NCTM, 2020). The goal is that through professional development, teachers can develop their understanding of equitable teaching practices, with which they can create equitable learning environments in mathematics.

Professional development is used to provide opportunities that help teachers enhance their teaching knowledge, which includes subject matter or teaching practices (Borko, 2004). When developing and participating in professional development, students' conceptual understanding of mathematics should not only be embedded throughout the professional development but should be the overall goal (Loucks-Horsley et al., 2009). Teachers' experience and learning through professional development can enhance the unique knowledge that teachers use to help develop student thinking, such as pedagogical content knowledge and content knowledge for teaching mathematics (Loucks-Horsley et al., 2009).

Pedagogical content knowledge is the professional knowledge of the learners, strategies, and teaching practices that teachers use to help students understand and maintain the mathematics content taught (Ball et al., 2005; Ball et al., 2008; Shulman, 1986; 1987; Van Driel & Berry, 2012). Content knowledge for teaching mathematics is the specific knowledge educators use to present their subject matter with students in the classroom (Ball et al., 2005; Ball et al., 2008; Shulman, 1986; 1987). Teachers use both pedagogical content knowledge and content knowledge for teaching mathematics to develop and instruct mathematics lessons in the classroom (Ball et al., 2005; Ball et al., 2008; Shulman, 1986; 1987; Van Driel & Berry, 2012).

Teachers must consider many contributing factors within the classroom to ensure that the content is being properly received by those who are learning. Some of the factors are subject matter, pedagogy, curriculum, learners, and educational contexts (Ayebale et al., 2020; Berry et al., 2016; Shulman, 1986; 1987). Being able to understand these factors can help teachers better recognize some of the difficulties within teaching and how to ensure students are being provided opportunities for success. Therefore, I used pedagogical content knowledge and content knowledge for teaching mathematics as part of the conceptual framework for this study.

Another concept that framed my study is the instruction of cognitively demanding tasks assessed through the use of the Instructional Quality Assessment (IQA) rubrics from the IQA Toolkit (Boston et al., 2019). This concept relates to the recommendation of implementing equitable mathematics instruction found in *Catalyzing Change* (NCTM, 2020). The purpose of the IQA Toolkit is to provide statistical data to analyze mathematics instruction and the learning opportunities provided by the teacher during instruction of cognitively demanding tasks (Boston et al., 2012). The IQA toolkit can be used as a framework through the use of rubrics, to help the planning, implementation, and reflection of mathematics instruction (Boston et.al, 2019). The rubrics provided in the IQA Toolkit are Potential of the Task, Implementation of the Task, Teacher Questioning, Teacher Linking, Teacher Press, Student Linking, and Student Providing. As part of the IQA toolkit, there is also an observation tool, and a framework for the different types of questions teachers can ask (Boston et al., 2019). For my study, I used the IQA Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019). Through the use of these IQA rubrics, teachers can select tasks with a higher cognitive demand as well as maintain or raise that demand throughout the implementation phase. Understanding task selection and

implementation can help teachers in providing more learning opportunities for students during mathematics lessons.

The professional development framework from Loucks-Horsley et al. (2010) framed the overall study. The professional development encompassed the use of aspects of the IQA Toolkit (Boston, 2019), content knowledge for teaching mathematics, and pedagogical content knowledge to build on teacher practices that could have a positive impact on students' mathematics understanding (NCTM, 2020). The IQA rubrics were selected for this study because they tie in with content knowledge for teaching mathematics and pedagogical content knowledge, as well as fit within the time allotted for this study. Furthermore, having content knowledge for teaching impacts how teachers can understand the mathematical concepts related to understanding the task potential to be cognitively demanding. Similarly, having pedagogical content knowledge impacts how teachers implement mathematical tasks. A figure of the conceptual framework is below (Figure 1). The arrows within the framework are bidirectional between content knowledge for teaching mathematics and instruction of cognitively demanding tasks because teachers need content knowledge to correctly identify the cognitive potential of the tasks; moreover, teachers can increase the potential of the tasks through their content knowledge. Similarly, pedagogical content knowledge and instruction of cognitively demanding tasks are bidirectional because teachers need pedagogical content knowledge to implement tasks at their intended cognitive demand meanwhile understanding instruction of cognitively demanding tasks can impact teachers' pedagogy. Both content knowledge for teaching and pedagogical content knowledge can be expanded through the use of the IQA Rubrics (Boston et al., 2019).

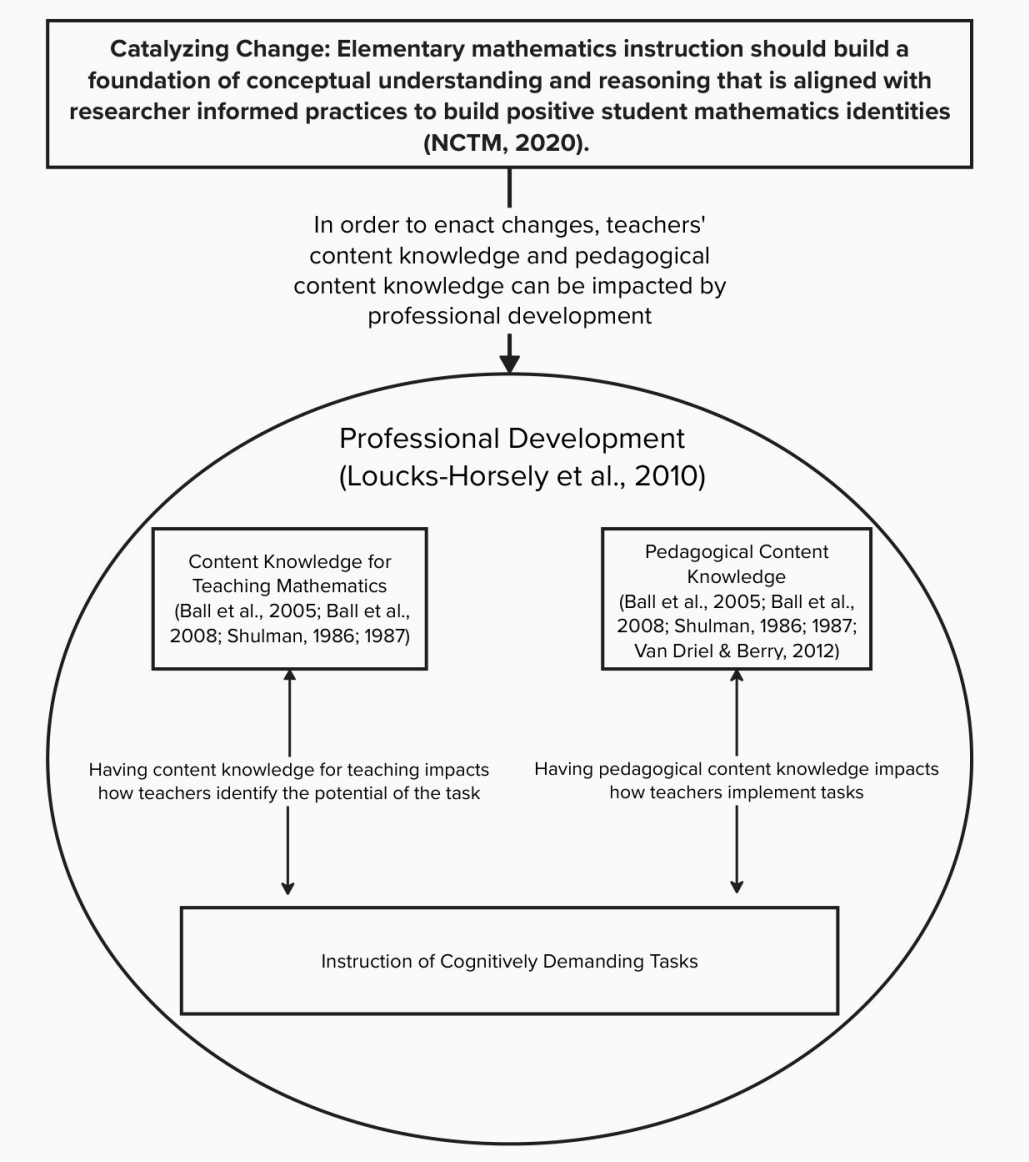


Figure 1: Conceptual Framework

The conceptual framework of my study helped me develop my professional development on cognitively demanding tasks. I analyzed the impact of the professional development using the IQA Implementation of the task rubric (Boston et al., 2019). This analysis was further developed by analyzing teachers' collaborative conversations and interviews, examining changes in teachers' implementation of cognitively demanding tasks.

Significance of the Study

This study was significant to my organization because it addressed the actions administration can take to support teachers to implement cognitively demanding tasks, which has the potential to change the instructional practices with teachers who work in schools with heightened supervision. This study also aimed to find aspects of the professional development that teachers felt assisted them in understanding how to implement cognitively demanding tasks. These ideas contribute to the current literature on pedagogical content knowledge, content knowledge for teaching mathematics, cognitively demanding tasks, and mathematics professional development. Due to a historical lack of proficiency at Pinnacle Elementary, providing teachers with learning opportunities through professional development may not only close the achievement gaps, but it could close the opportunity gap created by teachers' lack of pedagogical content knowledge.

Purpose of the Study

The purpose of this study was to examine the impacts professional development had on mathematics teachers' identification and implementation of cognitively demanding tasks in their classrooms, while determining the aspects of the professional development that aided in their learning.

Research Questions

1. How does professional development on cognitively demanding tasks impact mathematics teachers' identification and implementation of cognitively demanding tasks?

2. What aspects of the professional development (PD) helped mathematics teachers deepen their understanding regarding the implementation of cognitively demanding tasks?

Definition of Terms

Cognitively Demanding Tasks: Mathematical tasks that engage students in making sense of mathematics (Boston & Candela, 2018; Stein et al., 1996).

Task Implementation: The process in which the teacher releases the task and students perform the task they are given (Stein et al. 1996).

Teacher Autonomy: When teachers have the freedom to make professional decisions and have the ability to execute their decisions (Usma & Wilches, 2007).

Content Knowledge for Teaching Mathematics: Knowledge of the subject area that is needed to effectively teach, which allows teachers to understand students' thinking and explanations in mathematics (Shulman, 1986).

Pedagogical Content Knowledge: Knowledge needed in the classroom such as classroom management, knowledge of learners, knowledge of instructional strategies to effectively guide students through questioning, multiple representations, and academic discourse (Shulman, 1986).

Curricular Knowledge: The knowledge and understanding of curriculum programs (Shulman, 1986).

CHAPTER 2: REVIEW OF RESEARCH

Introduction/Review

In this literature review, I review and critique the research and scholarship on task selection and implementation in mathematics in elementary schools. Although studies in task selection and implementation have focused on teachers' mathematical content knowledge for teaching through professional development, these studies have not examined teachers in schools that are under heightened county or state supervision. As such, the literature review for this study provides additional insight into the procedures in place to ensure successful task implementation in schools while under heightened scrutiny. This study analyzes how professional development can impact implementation of cognitively demanding tasks. I address this issue by arguing that teachers should have mathematical content knowledge for teaching to be able to have autonomy in task implementation to meet the needs of their students.

Literature Search Methods

To obtain understanding of the current literature on my research topic, I completed a search in the ERIC (EBSCOhost) database through the UCF library and through Google Scholar. I began by using the search terms "Pedagogical Content Knowledge for Teaching," "Content Knowledge for Teaching," and "Professional Development" which are the concepts that are guiding my conceptual framework. After reading and understanding the concepts for my framework I began a second search using ERIC (EBSCOhost) and Google Scholar. The search terms used during the second round were "cognitively demanding tasks," "task implementation," "teacher autonomy," and "Instructional Quality Assessment." I excluded any articles that had subjects other than mathematics as its content focus and the remaining articles were examined

for relevance. The following synthesis of literature informed the decisions made for this dissertation and is organized conceptually, examining the different components within the framework.

Elementary Mathematics Education

Reform in Mathematics

Mathematics education has undergone many changes within the last hundred years. Most notably was during World War II, where it was decided that as a country, we needed to start making changes to the mathematics curriculum to start planning for the technical age (Herrera & Owens, 2001). Concerns about the inadequacies of education began to arise and there was a demand for change (The National Commission on Excellence in Education, 1983). The shift in mathematics curriculum affected elementary level mathematics as well, albeit slowly. Assessments in mathematics began to focus more on comprehension instead of computation (Herrera & Owens, 2001).

In 1989, standards-based reform began with the publication of the Curriculum and Evaluation Standards for School Mathematics by the National Council of Teachers of Mathematics (NCTM) (Herrera & Owens, 2001; NCTM, 1989). The changes that NCTM was hoping to elicit were not only in content but how teachers taught the content, with pedagogical content knowledge (Herrera & Owens, 2001). This standards-based reform change continues in schools throughout the nation today. With the publication of *Catalyzing Change in Early Childhood and Elementary Mathematics: Initiating Critical Conversations* (NCTM, 2020), the push for involving all stakeholders in ensuring that all students experience mathematics in a manner that promotes success while also being equitable, just, and inclusive. Similarities from

both publications show that mathematics should be integrated with real world context, multiple representations of abstract content, and have students be active participants in their learning while teachers facilitate the learning (Herrera & Owens, 2001; NCTM, 2020). With the continuous changes in education, teachers are faced with different obstacles when trying to meet the needs of their students.

Teacher Constraints

Due to the ongoing reform efforts, state and district policymakers have made revisions to curriculum policies to help with consistency in mathematics instruction (Spillane, 2000). An example of this is when districts create pacing calendars. These calendars provide a schedule teachers must follow which identifies when to teach each standard, the allotted time for each standard, and sometimes includes which resources to use (Bauml, 2015). The push for pacing calendars is to ensure that content from the tested subject areas is covered before district wide assessments are administered (Bauml, 2015). Stressing the importance of showing growth on these assessments, administrators expect teachers to follow pacing guides without it affecting other aspects of the classroom (Bauml, 2015). The pressures administrators put on teachers to follow the pacing calendars results in teacher centered, lecture style classrooms, as inquiry based cognitively demanding tasks require more instructional time (NCTM, 2020). In addition, this administrative pressure to follow pacing calendars makes teachers feel constrained, limiting their autonomy (NCTM, 2020).

Teacher Practices

Teacher Autonomy

Teacher autonomy has had different definitions based on different researchers but for the purpose of this study, it is when teachers have the freedom to make professional decisions and have the ability execute their decisions (Usma & Wilches, 2007). Having this professional freedom allows teachers to modify lessons to meet the needs and interest of their learners (Ramatlapana & Makonye, 2012). Though there are arguments about the positive or negative aspects of teacher autonomy, there seems to be a consensus about teaching in a too restrictive or too independent environment. Bolman and Deal (2021) stated that working in an environment where there is little freedom can cause people to act inflexibly and encourage system work arounds. In contrast, when there is too much freedom, people do what they want with no regard or awareness of what others are doing (Bolman & Deal, 2021). In this case, when teachers have too much autonomy, there is a lack of consistency within the school system, where some teachers may follow the curriculum and others may not (Ramatlapana & Makonye, 2012). This could lead to opportunity gaps within the school, due to the varying levels of teacher pedagogical content knowledge and content knowledge for teaching. However, the benefits from allowing teachers to have autonomy can outweigh the negative, because of the impacts that can happen within working in a more restrictive educational environment. Teachers who experience a lack of autonomy due to a restrictive environment may experience an effect on the creativity of their lessons and this impacts student learning (Anderson, 1987; Paradis et al., 2019; Ramatlapana & Makonye, 2012). Teachers' exercising creativity within lessons leads to classroom environments where students experience the wonder, joy, and beauty of mathematics (NCTM, 2020).

Though many educators see the benefits of having some autonomy in the classroom, there are many factors within the education system that are affecting teacher autonomy. In many cases, the legislation from the state or school district impacts the instructional decisions that teachers can make in their classrooms (Anderson, 1987; Paradis et al., 2019; Ramatlapana & Makonye, 2012). Some of these legislations include curriculum requirements and policies that encourage teachers to adhere only to the curriculum and methods prescribed by the state or school district (Paradis et al., 2019; Ramatlapana & Makonye, 2012). Another factor related to teacher autonomy is trust among the stakeholders, the trust that teachers will make the best instructional decisions for their students (Paradis et al. 2019). When teachers feel like they are not able to make and implement instructional decisions, there is a lack of trust, which makes teachers feel controlled and therefore leaves them with a sense of distrust (Paradis et al. 2019). Understanding the importance of teacher autonomy, regarding teaching practices and on the spot instructional decisions, can help foster trust and growth among administrators and teachers.

Teacher Knowledge

Teaching mathematics is viewed through a dual lens of pedagogical content knowledge and content knowledge for teaching, which the literature shows work together when teachers implement mathematics lessons (Ball et al., 2005; Ball et al., 2008; Berry et al., 2016; Liljedahl et al., 2007; Shulman, 1986; 1987; Thanheiser et al., 2010; Thanheiser et al., 2013; Van Driel & Berry, 2012). Understanding the content that is being taught is the minimum type of the knowledge teachers need to provide mathematics instruction. Researchers have posited that multiple domains of knowledge are needed to provide effective instruction and learning environments for students to learn (Ball et al., 2005; Ball et al., 2008; Liljedahl et al., 2007; Shulman, 1986; 1987; Thanheiser et al., 2010; 2013). Originally, Shulman (1986) created three

categories describing the types of content knowledge that teachers acquire. These three categories were: content knowledge, which is the knowledge of the subject area; pedagogical content knowledge, which is the knowledge needed in the classroom such as creating classroom culture or knowledge of learners; and curricular knowledge, which is the knowledge and understanding of curriculum programs (Shulman, 1986). Thinking through a lesson or task requires these different types of knowledge to be effective in the classroom. If you only understand the mathematics content but not how to cultivate students to be learners or how the curriculum works, learning may not be at the forefront of the lesson. The opposite can also be true, if you only know how to create a positive culture but do not have a deep understanding of the mathematics content, quality instruction may not occur.

As education and teaching has shifted and changed, other researchers have developed Shulman's (1986) categories into more specific domains. The five categories that Ball et al. (2008) created based on Shulmans (1986) original categories are: common content knowledge, specialized content knowledge, knowledge of content and students, knowledge of content and teaching, and knowledge of curriculum. Though some of the categories go hand in hand, others provide a more in-depth description of the thinking that teachers encounter when providing instruction. For example, Shulman's content knowledge can be compared to common content knowledge and specialized content knowledge which provides a different lens into the mathematics needed for teaching (Ball et al., 2008; Miller et al. 2022). Common content knowledge is the knowledge needed to complete mathematical tasks and specialized content knowledge is the mental resources needed to assist in completing mathematical tasks, however not including knowledge of students or teaching (Ball et al. 2008).

Similarly, Liljedhal et al. (2007) established the idea of using pedagogy and mathematical knowledge to promote student thinking when asking students to complete mathematical tasks. Though the categories created by Liljedhal et al. (2007) focused on perspectives in mathematics, they also include pedagogy. These categories include use of mathematics to understand mathematics, use of pedagogy to understand mathematics, use of mathematics to understand pedagogy, and use of pedagogy to understand pedagogy (Liljedhal et al. 2007). Using the knowledge of mathematics and pedagogy assists teachers in implementing effective and cognitively demanding lessons and tasks.

Task Implementation

Task design is the process educators take when making decisions on which tasks to use and how to use them effectively in the mathematics classroom. Understanding mathematical tasks and how they can contribute to student thinking is vital, but just as important is the implementation of the mathematical task (Ader, 2020; Bayazit, 2006; Coles & Brown, 2015; Stein et al., 1996). Task implementation describes how the teacher can provide opportunities for students to engage in mathematical tasks and thinking (Boston, 2012). Several researchers may vary in their definition of what task implementation should look like in the classroom, but they all acknowledge student success in mathematical thinking ties to how well teachers implement tasks (Ader, 2020; Bayazit, 2006; Coles & Brown, 2015; Geiger et al., 2021; Stein et al., 1996). There can be many contributing factors impacting the implementation of mathematical tasks. The majority of these factors are under the control of the teacher, such as the knowledge of subject or students, task conditions, consistency or inconsistency of the presentation, and oversimplifying the task (Bayazit, 2006; Geiger et al. 2021; Stein et al, 1996). These factors can

shift the cognitive demand of tasks during instruction and thus influence student thinking and learning.

Cognitively Demanding Tasks

For implementation to be effective, tasks need to be cognitively demanding to elicit students' mathematical thinking (Boston, 2012; Boston & Candela, 2018; Boston et al., 2019; Stein et al., 1996). The level of cognitive demand determines the type of thinking with which students will be engaged. Stein et al. (1996) identified levels of thinking that can arise during task implementation, which were memorization, procedures without connections, procedures with connections, and doing mathematics. Doing mathematics is when students are engaging in complex reasoning and thinking to justify responses to the mathematical tasks (Stein et al. 1996). Boston (2012) continued to work on defining the cognitive demand of tasks and created in-depth explanations of each of the levels of cognitive demand. Understanding these levels assists teachers in providing an environment where students can engage in deeper mathematical thinking (Boston, 2012; Boston & Candela, 2018; Boston et al., 2019; Stein et al., 1996). These descriptors were then used to create the Instructional Quality Assessment Mathematics Toolkit, which is a set of rubrics, that not only determine the cognitive level of tasks, but also include measures related to implementation of tasks, teacher questioning, teacher and student linking, observation tools, and more (Boston, 2012; Boston et al., 2019).

Instructional Quality Assessment

The Instructional Quality Assessment (IQA) Mathematics Toolkit contains rubrics to provide a framework throughout the phases of planning and implementing a mathematics lesson, aiming to look at how teachers and students interact with each other and mathematical tasks

(Boston et al., 2019). The use of the IQA can also be a tool in providing evidence-based feedback to encourage teachers and promote personal growth (Boston & Candela, 2018). As a resource, educators can apply ideas from the IQA rubric to enhance their current mathematics lessons and raise the cognitive demand of tasks. What is important to note, is that the task alone will not promote student thinking, it is the implementation of the task that has the potential to enhance or detract from the rigor, or demand, of the task (Ader, 2020; Bayazit, 2006; Boston, 2012; Boston & Candela, 2018; Boston et al., 2019; Coles & Brown, 2015; Geiger et al., 2021; Stein et al., 1996). The importance of the implementation of the mathematical task is the reason why I chose to use the IQA rubrics. Additionally, Candela and Boston (2022) used the IQA Toolkit as a tool for learning through professional development. This solidified my decision to use the IQA toolkit as the focus of my professional development and to format the sessions around the rubrics. In my study I used the IQA Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019) to see how teaching practices changed after engaging in professional development geared toward the understanding and implementation of cognitively demanding tasks.

Professional Development

Professional development in education can provide teachers with learning opportunities to grow in their craft, including enhancing their knowledge on subject matter and learning or developing instructional practices (Borko, 2004). To raise the academic achievement of students, teachers must have the knowledge and understanding of what to teach and how to teach it (Birman et al., 2000). Professional development is seen as an integral part of teacher learning, and as such there are a variety of ways to implement effective professional development; however, they should include similar attributes (Kennedy, 2016).

Effective Professional Development

Professional development opportunities for teachers happen throughout the school year and in some parts of the United States and it has generally become a requirement as part of the teaching contract (Kennedy, 2016). Professional development should be ongoing and should focus on subject specific content (Darling-Hammond, 2010). Though as previously noted by Kennedy (2016), there is no set procedure for professional development implementation. However, researchers have shared aspects of professional development that foster learning opportunities for teachers. Loucks-Horsley et al. (1996) created seven principles for effective professional development in mathematics and science, see Table 1. Interestingly, in these principles, Loucks-Horsley et al. (1996) recommend that professional development should include instructional methods that would be used in the classroom with students. Birman et al. (2000) and Garet et al. (2001) identified and analyzed literature on high quality professional development and found the same characteristics or features that need to be considered when creating and implementing professional development. These characteristics or features are form, duration, collective participation, content focus, active learning, and coherence (Birman et al., 2000; Garet et al., 2001). The similarities between the principles from Loucks-Horsley et al. (1996) and the characteristics or features from Birman et al. (2000) and Garet et al. (2001) help to establish what makes professional development effective. However, how can we incorporate them all and what do they mean?

Table 1: Adapted from *Seven Principles for Effective Professional Development by Loucks-Horsley et al. (1996)*

1. They are driven by a clear, well-defined image of effective classroom learning and teaching
2. They provide teachers with opportunities to develop knowledge and skills and broaden their teaching approaches, so they can create better learning opportunities for students.
3. They use instructional methods to promote learning for adults which mirror the methods to be used with students.
4. They build or strengthen the learning community of science and mathematics teachers.
5. They prepare and support teachers to serve in leadership roles if they are inclined to do so.
6. They consciously provide links to other parts of the educational system.
7. They include continuous assessment.

When implementing a professional development program, the first aspect to consider is the structure of the professional development such as what types of activities, length of professional development (in session and over a span of time), and collective participation (Birman et al., 2000; Garet et al., 2001). Are the teachers watching a presentation or are they engaging in tasks? Are teachers participating in professional development outside contract hours, such as afterschool, weekends, and summertime or during their contract hours? Are teachers working on their own or collaborating with others? These are all questions to consider when making decisions on how the professional development should be implemented (Birman et al., 2000; Garet et al., 2001). The next aspect to consider is the core features of the professional development, which include the content focus, active learning, and coherence (Birman et al., 2000; Garet et al., 2001). The content within the professional development should not be vague or generic but targeted and teachers should be actively engaged in their own learning. Coherence relates to how the professional development connects with other information given to teachers, such as school or classroom goals, standards, or what is being communicated by district or

school personnel (Garet et al., 2001). Relating the structure and core features, with guiding principles, allows for the creation of an effective professional development program.

To design an effective professional development that follows the previously discussed principles, I aligned with Loucks-Horsley et al.'s (2010) Professional Development Design Framework. Those who engage in professional development design go through an extensive decision-making process, in which they consider all the different facets that can impact the implementation of professional development (Loucks-Horsley et al., 2010). This process begins with understanding the four inputs, which help the designer in their decision-making process when planning the professional development. The four inputs are: 1. Knowledge and Beliefs, 2. Context, 3. Critical Issues, and 4. Strategies. The first thing the designer needs to consider is knowledge and beliefs, which is when designers think about the knowledge that will inform the professional development (Loucks-Horsley et al., 2010). Next, designers must consider the context, which is understanding the school site, as well as critical issues including thinking about and planning around anything that may impact the success of the professional development (Loucks-Horsley et al., 2010). In my study, Pinnacle Elementary was under the School Transformations Office (STO) Learning Community, which provided teachers with lesson plans and pacing calendars which could impact the effectiveness of the professional development. The last input to consider is strategies, which allows participants, in this case teachers, to participate in the professional development and enhance their knowledge.

These inputs were taken into consideration prior to the design and implementation phase of the Professional Development Design Framework. Next, designers need to think of a vision for the professional development and the vision for my study was for teachers to effectively implement cognitively demanding tasks. The following step is to analyze student learning and

data. Student data should come from multiple sources to understand where the students currently are in their acquisition of knowledge and skills in mathematics (Loucks-Horsley et al., 2010). After analyzing student learning and data, designers need to set goals either for student learning, teacher learning, teacher practice, or for the organization. Success in schools is directly linked to student achievement, therefore all goals are centered around student learning (Loucks-Horsley et al., 2010). Once all of this is completed, the designer can plan and implement their professional development. Throughout the implementation phase, also called the doing phase, the designers monitor the professional development to make adjustments as needed (Loucks-Horsley et al., 2010). The last part of the Professional Development Design Framework is to assess and evaluate the results of the professional development to adjust for future implementation.

Assessing Effectiveness of Professional Development

There are various studies in which teachers participated in professional development to learn about instructional practices, incorporate technology, or enhance understanding of strategies to integrate into their core subjects (e.g. Ader, 2020; Boston & Smith, 2011; Gee & Whaley, 2016; Hartsell et al., 2009; Koellner et al., 2011). Each one of these studies had a different approach to professional development and how to assess the effectiveness of the professional development. Ader (2020) used a mixed method approach and used Classroom Observation Coding Instruments and interviews to assess the effectiveness of a year-long professional development program. Koellner et al. (2011) completed a longitudinal study following their Problem-Solving Cycle Method, gathering quantitative and qualitative data using video recordings of workshop sessions, interviews, and pre-post assessments. Both Ader (2020) and Koellner et al. (2011) used a mixed methods approach to determine the effectiveness of the professional development provided and found that changes did occur in teacher knowledge.

Though not explicitly stated, Boston and Smith (2011) also conducted a mixed method study; however, they approached the analysis of their professional development program a little differently. Boston and Smith (2011) focused on gathering quantitative data from instructional tasks, student work, and lesson observations using the Instructional Quality Assessment (IQA) Academic Rigor in Mathematics rubrics (Boston & Wolf, 2006). The results of the study indicated that there was an increase in the teachers' ability in selecting and implementing cognitively demanding tasks. Within the results, Boston and Smith (2011) highlighted the growth in teachers by writing case studies on four teachers who showed patterns of change. Candela and Boston (2022) conducted a case study, with the case being the set of school participants, to determine how the implementation of tasks changed throughout a year based on the IQA. This study also investigated the aspects of the IQA and professional development that participants found supportive. Different in their approach, Hartsell et al. (2009) solely focused on quantitative data collection to assess their professional development program. Before and after a 20-day summer institute on integrating technology in mathematics, participants were asked to complete four different surveys based on the content taught throughout the institute, to analyze any changes in teachers' understanding of mathematics implementation with technology (Hartsell et al., 2009). The results of the research indicated that teachers who participated in the 20-day summer institute were able to develop and deepen their understanding and skills to effectively integrate technology within mathematics (Hartsell et al., 2009).

A different approach to professional development is lesson study. Gee and Whaley (2016) wanted to investigate the effectiveness of a longitudinal lesson study, which started at an 11-day summer institute. To assess the two-year lesson study program, Gee and Whaley (2016) gathered data using semi-structured interviews, videotaped recordings of teacher self-selected

videos, and teachers journal reflections. Teachers who participated in the lesson study showed changes in their teaching practices and reported collaboration as an important aspect of their professional growth (Gee & Whaley, 2016).

The research indicates that there is a variety of different professional development approaches and that assessing the effectiveness of the professional development can occur in a multitude of ways. Though each professional development differed in the content and goals, most of the professional development occurred over a long period of time, whether multiple full day sessions during a shorter amount of time, such as summer, or shorter sessions over an extended period of time. My research aimed to determine the ways professional development consisting of five sessions over a six-week period, within the constraint of contract time, influenced teachers' implementation of tasks. My research also added to the current literature because I was working in a school environment that included an influx of mandates from the school district and state. There is limited literature on research taking place in schools with heightened county or state supervision.

Summary

The review of literature established the background of reform efforts, teacher practices, and professional development. These concepts provide evidence that teachers need to have pedagogical content knowledge and content knowledge for teaching to effectively implement tasks in a manner that elicits student thinking (Ball et al., 2005; Ball et al., 2008; Liljedahl et al., 2007; Shulman, 1986; 1987; Thanheiser et al., 2010; 2013). Through the use of professional development, leaders can impact teachers' understanding, in this case conceptual and pedagogical content knowledge, needed for student learning (Ader, 2020; Boston & Smith, 2011; Darling-Hammond, 2010; Gee & Whaley, 2016; Hartsell et al., 2009; Koellner et al.,

2011). I wanted to explore the impact professional development had on teacher practices, such as implementing cognitively demanding tasks. Through the analysis of the literature and the understanding of my research site, I chose to focus on the implementation of cognitively demanding tasks using the IQA Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019).

CHAPTER 3: METHOD/RESEARCH DESIGN

Research Design

Qualitative studies are useful when the researcher is looking for a deep understanding of a specific problem or issue (Hancock et al., 2021). This study used a case study design, which is appropriate for analyzing a singular unit, event, situation, program, or activity (Hancock et al., 2021). For this study, the case was the professional development series within which the participants engaged. Yin (2009) states that case studies are effective for gaining insights that can help an organization with policies and procedures. This is especially important to examine in schools with heightened county or school supervision, which is the context in which this case is set. Yin (2008) explained case study as an ongoing process that can be continuously improved or developed, as if going through a cycle. Figure 2 shows the case study process according to Yin (2009, p. 1).

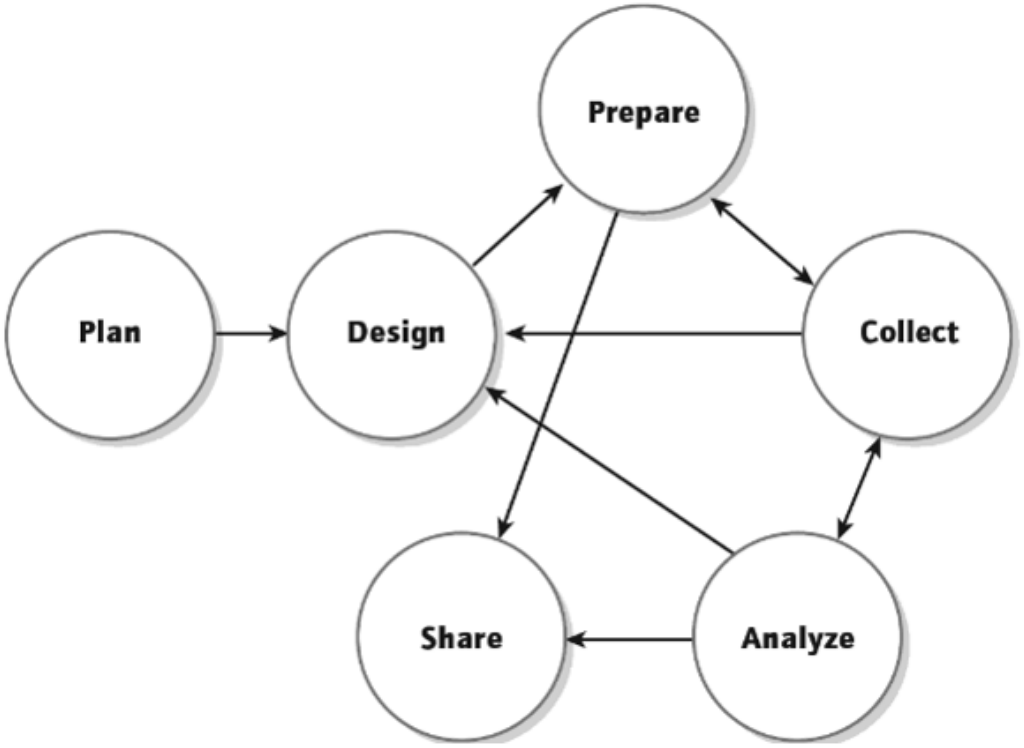


Figure 2: Organizational procedures for case study. Adopted from Yin, 2008

This case study gave insights to mathematics teachers' personal learning experiences as they engaged in a professional development series on the identification and implementation of cognitively demanding tasks. My case study examined the experiences of teachers to gain understanding of how professional development on cognitively demanding tasks impacted teachers' identification and implementation of cognitively demanding tasks in their classrooms.

Restatement of Research Question

1. How does professional development on cognitively demanding tasks impact mathematics teachers' identification and implementation of cognitively demanding tasks?

2. What aspects of the professional development (PD) helped mathematics teachers deepen their understanding regarding the implementation of cognitively demanding tasks?

Setting

School Demographics

Pinnacle Elementary is a Title 1 school in Tide County Public Schools (TCPS) (pseudonym), Florida, and part of the School Transformation Office (STO) learning community. The STO learning community was created to support schools based on prioritized needs, which includes providing training and support on standards-based instruction and rigor. Pinnacle Elementary is located in a low socioeconomic area, where students and their families are met with financial adversities. The poverty percentage at Pinnacle Elementary was 79%, which means that a majority of the students at Pinnacle Elementary were living in low income households. At the time of the study, there were approximately 750 students enrolled at Pinnacle Elementary. The approximation of student demographics were 45% Black, 30% Hispanic, 20% White, 2% Asian, and 3% Multiple (Florida Department of Education, n.d.). The demographics also indicated that 21% of the school population was English Language Learners (ELLs), and 12% were in Exceptional Student Education (ESE). Based on the School Improvement Plan (SIP), Pinnacle's learning goal was to have 61% proficiency in both reading and mathematics by the end of the 2023-2024 school year.

Pinnacle Elementary School has a staff of 94, which consisted of classroom teachers, instructional coaches, classified staff, custodial staff, a principal, and two assistant principals. There were 40 instructional classroom teachers, of which eight were kindergarten, seven were

first grade, six were second grade, six were third grade, six were fourth grade, four were fifth grade, and three were Exceptional Student Education (ESE) teachers. Additionally, there were 11 Tier 1 interventionists assisting teachers on all grade levels. There were also two instructional coaches, one mathematics coach, one science coach, and one Multi-Tiered Systems of Support (MTSS) coach. For the intermediate grades, third through fifth, the teams were departmentalized, which means that teachers were responsible for teaching assigned subjects (i.e. mathematics and science or English language arts and social studies). Due to departmentalization, there were a total of eight intermediate teachers who taught mathematics during normal school hours.

Ethical Considerations

Prior to beginning the study, I obtained permissions from school administrators followed by the university Institutional Review Board (Appendix A) and the district research review board. Once I gained permissions, I also determined interest from individuals to participate in my study. Afterword, any teachers who met the inclusion criteria were contacted via email (Appendix B) and were asked to consent to participate in the study (Appendix C). Pseudonyms were given to participants to maintain confidentiality. All written documentation and transcriptions were only available to the researcher. Confidentiality was kept throughout the study, with all student artifacts deidentified. Before turning in student artifacts, participants were asked to erase students' names from the work samples. Recordings of the collaborative conversations and interviews were saved to OneDrive to meet IRB and State requirements. Participants had the opportunity to opt out of the professional development at any time throughout the process.

Sampling Methods and Recruitment Methods

Convenience sampling was used for this study, which is when the participants are selected because of the accessibility the researcher has to the participants (Creswell, 2014). I chose convenience sampling because I wanted to glean insights from the colleagues I worked with, who shared similar experiences at Pinnacle Elementary. This sampling was appropriate for my study because case study research is bound to a specific context (Yin, 2008), for example schools that are under heightened supervision. Because I worked at a school in this context, convenience sampling allowed me access to gain teachers' perceptions and experiences about professional development and cognitively demanding tasks.

To recruit participants in this study, an email was sent out to all intermediate teachers who taught mathematics during regular school hours (Appendix B). Intermediate teachers were chosen due to my familiarity of the mathematics content of the intermediate grades as well as the time constraints that would arise to include all grade level teachers.

Participants

Inclusion Criteria:

- Teachers must teach mathematics.
- Teachers must teach in grades 3 – 5.
- Teachers must show interest in participating in the study.

Exclusion Criteria:

- Teachers whose time is limited due to engagement in an instructional practice development program with coaches.

I sent out emails to the six teachers who met the inclusions criteria and received three responses expressing interest from the recruitment email. Of those three teachers, two became

participants in the study because one teacher opted out of the study prior to the sessions beginning due to personal reasons. The two remaining participants were a third-grade teacher and a fifth-grade teacher, who are described in detail in the following paragraphs using pseudonyms to establish confidentiality.

Participant one, Theresa, was a Hispanic woman in her thirties who was beginning her ninth year of teaching. She had taught first grade for seven years, second grade for one year, and this year began teaching third grade. Theresa had been through one professional development that was geared towards mathematics.

Participant two, Francesca, was an African American woman in her forties who was starting her fifth year of teaching but also had several years of experience as a substitute teacher. This was her third-year teaching fifth grade at Pinnacle Elementary. During the 2022-2023 school year, Francesca participated in a county-wide mathematics training session. This session was an all-day session that was off campus, focusing on grade-specific mathematics content.

Based on the response rate, I prepared professional development activities with the grade level of the participants in mind. I initially prepared for all intermediate levels, third through fifth grade. Once my participants were solidified, I modified the professional development activities to use only third and fifth grade examples. This ensured participants had familiarized knowledge of the content within the tasks and that information was applicable to their instruction.

One of my goals for the two participants was that they both would fully participate in all aspects of the professional development, provide student artifacts, collaborate, and engage in interviews. Another goal was for the participants to find value in what they learned through the professional development and use this knowledge in their classrooms.

Procedures

To answer my research questions, I used case study design to investigate mathematics teachers who participated in a professional development series on cognitively demanding tasks at Pinnacle Elementary. The professional development series was intentionally created by me and was designed around the IQA Potential of the Task and Implementation of the Task Rubrics (Boston et al, 2019). The study aimed to examine the impact this professional development could have on teachers' implementation of cognitively demanding tasks. After receiving approval from the University's Institutional Review Board and the school district office of research, I began to recruit teachers via school email giving context of cognitively demanding tasks. Prior to the professional development, participants were asked to provide student artifacts on tasks that they deemed cognitively demanding in order for me to analyze the needs of the participants. Collaborative conversations were held immediately after each professional development session, to gain insight on the material learned during the session. At the end of the professional development series, participants turned in another set of student artifacts and participated in one-on-one interviews with the researcher. Table 2 shows the timeline to complete the research.

Table 2: Study Timeline

Date	Research Task
October 1st, 2023	Send out recruitment email (teachers had until the 13th to respond and begin looking for work samples within that time)
October 16th, 2023	Tasks and student artifacts turned in.
October 18th – November 29th, 2023	Professional Development Sessions on Wednesdays after school.
November 30 – December 15th, 2023	Interviews with the teachers. Teachers turned in tasks and student artifacts
January – February, 2024	Analyze and code data.

Data Collection Methods

Professional Development Sessions

Observations and notes of the professional development were completed for each individual session to analyze the impact the activities had on the participants (Appendix D). These notes were completed by the researcher in lieu of video or audio recording. This was done in hopes to capture more authentic interactions and conversations between the participants as well as with the researcher. These notes were used in data collection in conjunction with student artifacts, collaborative conversations, and interviews.

Instrumentation for Student Artifacts

Participants submitted three tasks that they identified as high cognitive demand tasks from their lesson plans or small group instruction. Participants were given the definition of cognitively demanding tasks as a guide to aide in their task selection. In conjunction with identifying high cognitive demand tasks, participants were asked to implement these chosen tasks and submit student artifacts as evidence of implementation. Student artifacts for the purpose of this study were defined as student work samples of these selected tasks. To collect the student artifacts, I obtained parental consent for each student; however, I received seven forms from Theresa and five from Francesca, for a total of 12 participating students. The student artifacts had to include three different tasks that were implemented in the participants' classrooms prior to attending the professional development. The purpose of having participants turn in three different tasks allowed me, as the researcher, to have a more well-rounded understanding of what tasks participants identified as high cognitive demand tasks, as well as the participants' implementation process of the selected tasks. Requesting one task would not have given me enough information on how tasks were being identified and implemented in the classroom (Boston et al., 2019; Boston & Smith, 2011). Therefore, having three task samples would allow me the opportunity to gain a better and more valid insight into participants' implementation process. Student artifacts can be used to help determine the effectiveness of a lesson or task implementation (Boston et al., 2019; Boston & Smith, 2011) and therefore can be used to assess the impact professional development could have on the implementation of cognitively demanding tasks. The tasks and student artifacts were important to collect before the professional development began in order to adequately prepare. After I analyzed and rated the tasks and the student artifacts, I determined what adjustments were needed within the professional development on identifying and implementing high cognitive demand tasks. They

were also used as a baseline to compare if there was a difference in identification and implementation by the end of the professional development.

The instrumentation used to evaluate the cognitive demand of the tasks and implementation was the Instructional Quality Assessment (IQA) Potential of the Task and Implementation of the Task Rubrics by Boston et al. (2019). The purpose of the Potential of the Task Rubric is to see the level of thinking a task can elicit from students (Boston et al., 2019). The Potential of the Task Rubric ranges from level 1 to level 4, where one is when the tasks is about memorizing and regurgitating facts or information and four is when the task promotes complex thinking and explicitly asks for students to justifying their thinking (Boston et al., 2019). The purpose of the Implementation of the Task Rubric is to rate the opportunities and levels of thinking the students had while engaging in the task (Boston et al., 2019). The Implementation of the Task rubric ranges from level 0 to level 4, where zero indicates that the students did not participate in any mathematical activity and a level four is when students were able to engage in complex thinking and showed evidence of their understanding (Boston et al., 2019). For both the potential of the task and implementation of the task, tasks at a level 1 and 2 are considered as having a low cognitive demand and tasks at a level 3 and 4 are considered as having high cognitive demand. The difference between a level 3 and a level 4 is that the tasks specifically calls for students to share their thinking and reasoning (Boston et al., 2019). I adopted these rubrics because they came from reputable and well-established researchers. Additionally, the rubrics aligned with what I was looking for when identifying and implementing cognitively demanding tasks in the mathematics classroom. The IQA Implementation of the Task Rubric can be used to rate the implementation of a task through observations, recordings, or student artifacts of their work (Boston et al., 2019). The use of the rubric assisted me in

identifying differences in the participants' implementation that was categorized and explained narratively in chapter 4.

After engaging in five professional development sessions, participants used their gained knowledge to select and submit three tasks that they either identified as high cognitive demand or modified to increase the level to high cognitive demand, which is a level 3 or 4 on the Potential of the Task Rubric (Boston et al., 2019). They also submitted the corresponding student artifacts. These tasks and artifacts were collected two weeks after session five to examine if there were any changes in way participants identified and implemented high cognitive demand tasks. The collection of artifacts gathered before and after the professional development were used to consider the overall impact the professional development had on teachers' ability to identify and implement cognitively demanding tasks.

Instrumentation for Collaborative Conversations

At the end of each professional development session, the researcher facilitated debriefing conversations, that were collaborative in nature, on teachers' experiences and learning that happened during each of the professional development sessions. These collaborative conversations were conducted in the same location as the professional development sessions since these conversations occurred immediately after. Debriefing conversation starters were established (Appendix E) and were used to guide the recorded conversations.

Instrumentation for Interviews

As part of the data collection process, after the professional development series on understanding and implementing cognitively demanding tasks, an interview protocol was used (Appendix F). The semi-structured interview was conducted at a mutually agreed upon time and

location. The interview protocol focused on the experience and learning participants had while engaging in the professional development. The interview specifically looked at the aspects of the professional development that they found most useful to their understanding of how to implement cognitively demanding tasks.

Professional Development

Planning the Professional Development

I created the professional development series based on the Loucks-Horsley et al. (2010) framework for designing professional development. Within that framework, I also used the IQA Toolkit (Boston et al., 2019) to design the sessions in the professional development. I framed the individual sessions around the Potential of the Task and Implementation of the Task Rubrics (Boston et al, 2019). I adjusted the Loucks-Horsley et al. (2010) Professional Development Design Framework to meet my needs and the needs of my school, as seen in Figure 3.

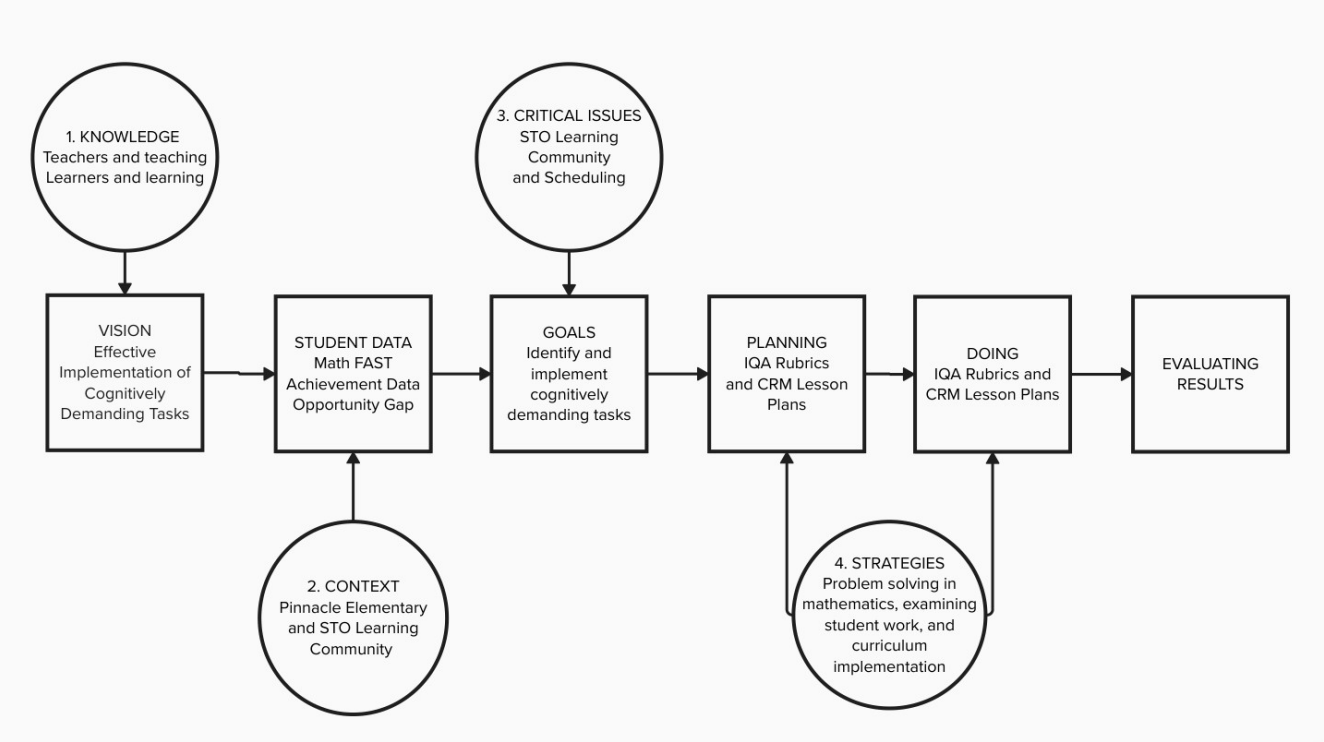


Figure 3 Professional Development Design Framework for Cognitively Demanding Tasks adapted from Loucks-Horsley et al., 2010

This figure aided in the creation of the professional development on identifying and implementing cognitively demanding tasks. What follows are detailed descriptions of the inputs, as well as the design and implementation process based on Loucks-Horsley et al. (2010) that guided in the preparation of the professional development in this study.

Four Important Inputs

To create an effective professional development, designers can be influenced by different inputs that can affect how the information shared during the professional development may be received (Loucks-Horsley et al., 2010). For the beginning of my design process, I made informed decisions when considering the 1. knowledge and beliefs, 2. context, 3. critical issues, and 4. strategies, which led to how the professional development was designed and implemented.

Knowledge and Beliefs

Knowledge and beliefs are what we know and what we think we know, which can influence how people engage in professional development (Loucks-Horsley et al., 2010). There are various domains in knowledge and beliefs which are: learners and learning, teachers and teaching, the nature of science and mathematics, adult learning and professional development, and the change process. For this study, I considered the domains of learners and learning, as well as teachers and teaching. I combined these two domains because teachers are part of the professional development, however, considering students and the goals we have for students should also be prioritized. Activities were centered on both teacher learning and student learning; this way teachers were able to find relevance to their professional learning and bring it back to the classroom. This helped me to also think about the strategies I wanted to use during the professional development. I wanted teachers to examine their own teaching and learning, while using student evidence.

Context

Context describes the features within an environment that can impact how professional developments are designed. The first factor to consider was that Pinnacle Elementary was part of the STO Learning Community, which helps bring support to schools that have low proficiency scores by providing resources and trainings. Understanding the students and the community they live in, as well as the needs of the teachers, are also part of context. These features helped inform how I designed the professional development.

Critical Issues

Critical Issues are any influences that can impact the success of the professional development. A critical issue for Pinnacle Elementary was that they were part of the STO

learning community. This can be seen as a critical issue because there was less teacher autonomy and limited planning time due to more PLC meetings. Decisions and changes related to lesson plans, student data, and interventions come from the STO personnel. Another issue that arose was scheduling. Due to added meetings as part of STO, many trainings or school wide meetings took place at the times when teachers were available.

Strategies

Strategies can be a combination of methods that make a professional development successful. Because I was planning a professional development series, which means it would have multiple sessions, I chose multiple strategies to make the professional development more effective. The strategies I selected were problem solving in mathematics, examining student work and thinking, and curriculum implementation. I selected these three strategies because they aligned with my vision of how I wanted to design my professional development.

These four important inputs were all considered before and during the planning of the professional development series.

Design and Implementation Process

The next part in planning the professional development based on Loucks-Horsley et al. (2010) is the design and implementation process, which starts with three considerations. These considerations are visions and standards, student data, and goals, which are needed prior to the planning and implementation.

Based on the Loucks-Horsley et al. (2010) framework, the first considerations were vision and standards. The vision I had for the professional development series was to help teachers effectively implement cognitively demanding tasks, either at the tasks' intended level or

higher. The reason I chose this as my vision was because I wanted teachers to elicit more thinking from students through the use of high cognitive demand tasks. To make this vision a reality, teachers need to understand what a cognitively demanding task is and how to effectively implement the task.

The next consideration was student data. For student data, I referred back to the FAST mathematics Progress Monitoring (PM) 3 assessment from the 2022-2023 school year and FAST mathematics PM 1 from the 2023-2024 school year. This synthesis of data allowed me to see a pattern in assessment when students solved complex tasks. These data, in conjunction with unit assessment data, were considered during the planning of the professional development while also considering the opportunity gaps that students may experience in instruction.

The last consideration for the first phase was goals. I used the knowledge I gained from the student data and the vision that I had and created a goal for the professional development. The goal was for teachers to effectively identify and implement higher cognitively demanding tasks.

Phase two, which is the final section of the framework, consisted of planning, doing, and evaluating the results of the professional development. During the planning phase, I thought about what to incorporate into the professional development, how long each session would be, and the number of sessions needed to meet the goal. I planned for the professional development to consist of five sessions and designed it around two rubrics from the IQA toolkit (Boston et al., 2019). These sessions were also planned with teacher contract time in mind. Research on professional development has shown that many professional development programs are longitudinal, usually multiple work sessions throughout a school year or years, or workshops, that have multiple full day sessions (Boston & Smith, 2011; Gee & Whaley, 2016; Koellner et

al., 2011). Knowing and understanding the staff at Pinnacle Elementary, I set out to examine a professional development that could be implemented during teachers' contract hours. I planned these sessions to be conducted in person on Wednesdays after school, which have less student contact time to allow an hour for teacher development. The professional development sessions were given throughout the months of October and November, and accounted for the monthly school-wide meetings conducted by administrators. The schedule and agenda for the professional development is outlined in Table 3.

Table 3: Professional Development Agenda and Design

Week 1: What are cognitively demanding tasks?	40 minutes - Introduction to professional development - Overview of IQA Potential of the Task Rubric - Collaborative work: engage in rating tasks in grade level CRM's - Share out ratings and noticing 10 - 15 minutes - Collaborative Conversation
Week 2: How can we raise the potential of the tasks?	40 minutes - Overview of what was accomplished in week 1 - Collaborative work: same tasks as week 1, how can we raise the demand of the tasks, i.e. A level 2 to a 3 or a 3 to a 4. - Share out revised tasks 10 - 15 minutes - Collaborative Conversation
Week 3: How does task implementation affect cognitive demand? Part 1	40 minutes - Overview of what was accomplished in week 2 - Introduce implementation of the task rubric - Teachers will use the Implementation of the Task Rubric to rate a video showing a teacher implementing a task that is being over scaffolded. - What did we notice in the video? 10 - 15 minutes - Collaborative Conversation - **HW**: hand out grade level tasks for teachers to implement in their classrooms to turn in and analyze in week 5
Week 4: How does task implementation affect cognitive demand? Part 2	40 minutes - Overview of what was accomplished in week 3 - Use the Implementation of the Task Rubric to rate student work samples from IQA (pgs. 40 – 43) - Teachers will collaboratively analyze samples and rate the implementations of the task based on student samples. 10 - 15 minutes - Collaborative Conversation
Week 5: How does task implementation affect cognitive demand? Part 3	40 minutes - Overview of what was accomplished in week 4 - Using the tasks from the homework assigned in week 3, teachers will rate their own implementation of the task - Share our noticing and wondering based on collaborative work 10 - 15 minutes - Collaborative Conversation

After the planning stage is the doing stage, when the professional developer implements their professional development while monitoring how it is progressing. During the doing stage, I monitored and reflected on each session, thinking about the needs of my participants and if any adjustments needed to be made to my initial professional development plan. The final two steps of the design framework is to evaluate the results of the professional development, followed by reflect and revise as seen in Figure 3. Though reflect and revise is part of the framework, it is not part of Figure 3 due to the fact that it was beyond the scope of this study.

Implementation of the Professional Development

The purpose of the professional development was to have the participating teachers work collaboratively while analyzing, rating, and modifying tasks from the lesson plans, also known as Curriculum Resource Materials (CRM's), that were provided by the district. Each participant was expected to attend all sessions, as each one built on the previous session. To account for any loss of knowledge, the beginning of each session, after session one, had an overview of what was accomplished the previous week. All materials from the sessions were available to both teachers after each of the professional development sessions.

Session One

The initial session began with an introduction of the research and researcher, followed by an overview of the IQA Potential of the Task Rubric (Boston et al., 2019). Because I wanted collaboration to start from the first session, I provided the participants with grade level tasks from their CRM's to collaboratively rate according to cognitive demand. Participants were given the opportunity review tasks from an upcoming unit that they had not yet taught. The collaborative structure I used during this part of the professional development was think-pair-

share, where participants had time to engage in their CRM's, then afterwards paired together to share out what they noticed about each of the task's rating. The session ended with a collaborative conversation, which focused on wonderings and what was learned. At the end of the professional development session, participants were given their own copy of the IQA Potential of the Task Rubric to have for their classrooms and were encouraged to begin using the rubric when planning for mathematical tasks.

Session Two

The second professional development session was built upon what was accomplished and observed in session one. Before starting the next activity, participants were encouraged to share if they attempted to look at CRM tasks using the Potential of the Task Rubric, highlighting any successes or challenges that came with using the rubric. Following the short discussion, we prepared for week two's activity. Participants were given the same CRM's and tasks from the previous session and were asked to modify the tasks that they had already rated. Teachers collaborated to modify tasks to raise the cognitive demand by using the IQA Potential of the Task Rubric. Participants shared the newly revised tasks, highlighting what made the task more cognitively demanding, based on the rubric. Once all share outs were completed, teachers then examined what they learned to take back to the classroom. The professional development ended with collaborative conversations focused on any wonderings the teachers had, as well as what they had learned about revising tasks. Teachers were once again encouraged to take what they learned about rating and adjusting the potential of the tasks by using the rubric to practice in their classrooms.

Session Three

Session three of the professional development focused on the implementation of cognitively demanding tasks. Teachers were asked to share what they remembered about the Potential of the Task Rubric and if any of them had used it in the class that week. After sharing out, participants were given an overview of the IQA Implementation of the Task Rubric prior to the session's activities. I explained to the participants that this session was slightly different because they were using the implementation of the task rubric while watching a video of a teacher implementing a task on multiplicative reasoning found on a public domain site used by our county. I encouraged participants to take notes on what was being observed during the lesson, taking into account student thinking, student engagement, and teacher actions. I showed a clip of the video which focused on a task that was being implemented during whole group. I expected the participants to take note of the scaffolding used by the teacher, which impacted how students engaged in the task. After the video, participants worked collaboratively to discuss student thinking and teacher actions seen in the video and to rate the implementation by using the IQA implementation of the task rubric. Afterwards, I had the participants share what they noticed during the video and discuss what we learned from this example. Additionally, participants engaged in collaborative conversations about how cognitive demand can change during the implementation of a task. At the end of the professional development session, I asked the participants to bring student samples of tasks implemented in their classroom which were submitted during session five, which would allow participants two weeks to identify and implement a task. These tasks had to be implemented between session three and five and be cognitively demanding, based on the Potential of the Task Rubric. The expectation was that each participant would bring at least one class sample of one task they implemented to use to analyze their implementation of the task. I only asked for one task sample to allow time for analysis and

discussion during session five. Participants also received their own copy of the IQA implementation of the task rubric to use in the classroom.

Session Four

At the beginning of session four, I provided a quick overview of the IQA implementation of the task rubric, to ensure that participants focused on student work as evidence of the implementation of the task rating. Participants were provided completed student tasks from *Making Sense of Mathematics for Teaching to Inform Instructional Quality* (2019), from pages 40 – 43, to rate on the implementation of the tasks. The participants were given three tasks, without the student work, and were asked to first rate each task using the IQA Potential of the Task Rubric. I structured this part of the professional development similar to session one, where I had participants do a think-pair-share. They rated the tasks individually before pairing up and sharing their ratings and comparing them to each other. After reviewing each of the tasks, I asked participants to focus on the implementation of the task by examining student responses and using the IQA Implementation of the Task Rubrics. After each task, we discussed as a group why the potential of the task ratings were the same as or different from the implementation of the task, and the factors that may have influenced the implementation process. After all three tasks were completed, participants shared during collaborative conversations what they noticed about the tasks and what they learned about using student work samples to relate to their teacher practices. Participants were encouraged to start examining their own implementation of practices in the classroom and to start using the IQA Potential of the Task and Implementation of the Task Rubrics as part of their planning and reflection process.

Session Five

The last session, on week five, was a continuation of the implementation of cognitively demanding tasks. Because this session directly correlated with the previous session, teachers were asked to discuss what was learned the previous week and how it impacted any implementation decisions they made in the classroom. Afterwards, the session focused on the class samples that the teachers brought for this session. The work samples were for the teachers to analyze while working collaboratively with each other to determine the level of implementation, while the researcher facilitated. In conjunction with the IQA implementation of the task rubric, teachers reviewed the IQA Potential of the Task Rubric as well. This way, participants were able to see if they were implementing the task at the level intended, or if they raised or lowered the cognitive demand based on how they implemented the task. Participants were given a set time to share what they noticed about their own implementation. This focused on the potential level of the task and the level in which they implemented the task. The final collaborative discussion was geared toward what teachers gained during the professional development series. The questions centered on what they learned about cognitively demanding tasks, their wonderings, and their biggest take aways.

Data Analysis

The data collection for this research study consisted of student artifacts, collaborative conversations, and semi structured interviews. Student artifacts were collected before and after the professional development series to evaluate the teachers' identification and implementation of high cognitive demand tasks over time. The collaborative conversations were conducted immediately after each of the professional development sessions and were used to gain insight on teachers' learning and wonderings during the specific sessions. Semi structured interviews were

conducted after the professional development series was completed, with a focus on teachers' understanding of cognitively demanding tasks and the identification and implementation of those tasks. Additionally, teachers were asked about the aspects of the professional development they found most useful in their understanding of cognitively demanding tasks.

Following Each Professional Development Session

After each professional development session, I documented my observations by writing what activities were accomplished, as well as the participant actions and words while engaging in the activities. This allowed for a different perspective which enhanced data analysis. Participants appeared to speak more freely during the professional development knowing that there was no audio or video recording. The observations were written as session notes and were used to deepen the analysis of the collaborative conversations and interviews.

Student Artifacts

To collect and analyze data on the impact the professional development had on the identification and implementation of cognitively demanding tasks, teachers submitted three separate tasks and the corresponding student artifacts before and after the professional development series. The three tasks were initially rated using the Potential of the Task Rubric (Boston et al., 2019). Additionally, I then rated the three sets of student artifacts that related to the selected tasks using the Implementation of the Task Rubric (Boston et al., 2019). Based on the IQA rubrics, I gave a numerical value to each individual task and each set of student artifacts. I took the three tasks and gave them an average score and did the same with the student artifacts. This procedure was replicated with the post professional development tasks and student artifacts. Afterwards, each of the tasks were coded to find similarities or differences between the pre and

post artifacts in regard to student responses and work. These ratings and themes were then used to describe changes seen in how teachers implemented cognitively demanding tasks, and are described narratively in chapter 4.

Collaborative Conversations

Data were gathered through collaborative conversations after each professional development session. Each of the collaborative conversations was a debrief of the teachers' experiences and their learning throughout the session and was styled similarly to a focus group. These conversations were recorded for the purpose of obtaining qualitative data and then stored in an approved password protected site. After each session, I reviewed the teachers' responses to see if there was anything I needed to adjust during the professional development. I reviewed the recordings and transcribed them using a voice to text software. The transcripts were reviewed for accuracy before downloading and coding for thematic content (Green et al., 2007) related to understanding, identifying, and implementing high cognitive demanding tasks, along with the aspects of the professional development teachers found helpful in their learning.

To analyze the collaborative conversations for codes and identify themes, I used the four steps to data analysis (Green et al., 2008), which includes data immersion, coding, creating categories, and identifying themes. For each of the collaborative conversations, I listened to the audio and read the transcripts in detail to immerse myself in the data and familiarize myself. From there, I analyzed the transcripts to find codes that were prevalent in each session. Once these codes were discovered, I searched for connections between them to identify themes for each session. After completing this process for each session, I then compared the codes across all five sessions to identify any themes that spanned across the sessions.

Interviews

I conducted face-to-face interviews with each participant the week after session five of the professional development series. I planned the interview protocol questions (Appendix F) that prompted participants about their previous experiences with mathematics professional development and the aspects of this professional development that aided in their understanding of cognitively demanding tasks. Each interview was recorded and transcribed prior to the coding process.

The analysis of the interviews followed the same process as the collaborative conversations. To identify codes and themes, I used the four steps to data analysis from Green et al. (2008). The first step is data immersion, which was when I listened to the interviews and read the interview transcripts multiple times to familiarize myself with the data. Step two is coding, which was when I discovered codes that were prevalent to each participant and relevant to the research questions. Step three is using these codes to find connections between the codes to create categories, which led me to step four, identifying the themes. I completed these steps for both interviews, then compared the codes and themes between both participants' interviews.

Trustworthiness, Reliability, and Validity

Multiple steps were used to ensure the validity and trustworthiness of this study. Rubrics were adopted from valid studies, increasing the study's dependability. To ensure validity, I used member checking as it related to collaborative conversations and interviews. For example, after my thematic analysis I shared a summary of my findings with participants to ensure that their experiences and impressions were correct and were not misinterpreted by me as the researcher. Additionally, I reached out to a member of my committee who had expertise in the use of the

IQA Rubrics to ensure ratings of tasks and student artifacts were accurate. This strengthened the validity of the study.

An issue with trustworthiness, as the researcher, is the positionality or bias towards the topic of cognitively demanding tasks. Since becoming aware of cognitively demanding tasks and the IQA process, I have seen a shift of teaching and learning in my classroom. This has made me a passionate advocate for this type of teaching. I am also part of the mathematics community at the site I researched at, and I am viewed as a mathematics leader on campus. As a mathematics leader, I provide assistance to my grade level, as well as one-on-one trainings as needed to anyone on campus. I was aware of this potential bias as I was collecting and analyzing the data.

Summary

This study analyzed the effectiveness of a professional development series on the rating and implementation of cognitively demanding tasks. Data collection through selected tasks, student artifacts, collaborative conversations, and semi-structured interviews provided ample information of the experiences of the participants who engaged in professional development throughout this case study. Qualitative research allows for insights on participants' experiences throughout the research process (Creswell, 2014). In the next chapter, I describe in detail the findings of my research that led to the answers to my research questions.

CHAPTER 4: DATA ANALYSIS

The purpose of this dissertation was to determine the effectiveness of a professional development series that I created, as well as the aspects of the professional development that were beneficial to participants. The professional development focused on mathematics tasks and employed the Instructional Quality Assessment Rubrics, specifically the Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019) and was designed using the professional development framework from Loucks-Horsley et al. (2010). Using the framework, I intentionally included recommendations from Loucks-Horsley et al. (2010) while designing the experiences within the professional development. I obtained data through selected tasks, student artifacts, collaborative conversations, and interviews to gain insights from participants on the professional development. My research questions are as follows:

1. How does professional development on cognitively demanding tasks impact mathematics teachers' identification and implementation of cognitively demanding tasks?
2. What aspects of the professional development (PD) helped mathematics teachers deepen their understanding regarding the implementation of cognitively demanding tasks?

I used my conceptual framework as the lens to view and analyze my data. My conceptual framework encompassed professional development, pedagogical content knowledge, content knowledge for teaching mathematics, and the Instructional Quality Assessment (IQA) Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2009). The overarching idea of the conceptual framework is to lay a foundation of conceptual understanding and reasoning to build students' mathematic identities (NCTM, 2020). Through this lens I analyzed the data to

answer the research questions, I provide a brief overview of the research to follow and a comprehensive analysis at the end of the chapter before the discussion in chapter five.

To answer the first research question, I describe the impact the professional development had on the identification and implementation of high cognitive demand tasks, through analysis of student artifacts. In this analysis, observations from the researcher and quotes were also provided from the collaborative conversations, which occurred after each of the professional development sessions, as well as the final one-on-one interviews. During the analysis, tasks and student artifacts were rated based on the Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019). Both participants showed an increase in their average scores when implementing cognitively demanding tasks; however, only one participant showed growth on selecting higher cognitive demand tasks. Based on the data analysis, the professional development on cognitively demanding tasks had an impact on how teachers implemented high cognitive demand tasks, which provided opportunities for students to engage in making connections and complex thinking. Though the participants developed in implementing high cognitive demand tasks, only one participant showed an increase in identifying cognitively demanding tasks.

Additionally, to answer the second research question, I describe the different aspects, activities, and structures from the professional development that the participants found most useful in their understanding of cognitively demanding tasks. This description resulted from an examination of the transcripts, which were coded for themes related to the professional development. Based on the data analysis, the following themes were identified based on participants' responses during collaborative conversations and interviews. The first theme, beneficial resources, related to the use of the IQA toolkit, curriculum tasks, and video lesson.

The next theme, beneficial experiences, related to pacing, debriefing together, and engaging with different grade level participants. These resources and experiences allowed for deeper connections and understanding of cognitively demanding tasks. An additional theme was found within the data, which was feedback related to implementation. This theme related to external factors that may have impacted the professional development and the implementation of what was learned.

What follows first is an introduction of the case participants and the data analysis from student artifacts. The analysis includes ratings and explanations for each participants' identification and implementation of cognitively demanding tasks. Next, I discuss the thematic coding of the collaborative conversations and interviews, which provides insights on the tools and experiences participants found beneficial to their learning. Additionally, themes on factors that were beyond my control as the professional development designer are shared. Participant quotes from the collaborative conversations and interviews are provided throughout the analysis to enhance the thematic descriptions. Through the data analysis I answer the research questions.

The Case Participants

The study analyzed the case of a professional development series bounded within five sessions, at a school with heightened state and county mandates. The two case participants involved in the study were given the pseudonyms Theresa and Francesca. Both participants shared details about their experiences in teaching as well as professional development through collaborative conversations and one-on-one semi structured interviews. Below are descriptions of the participants based on these conversations and interviews.

Theresa

Theresa was a veteran teacher with nine years of experience in her county. She began her teaching career at another school in the county and transferred over to Pinnacle Elementary due to lower student numbers during her first-year teaching. Since the transfer, Theresa has only been at Pinnacle Elementary. Her grade level experience included first grade, second grade, and third grade with this year being her first-year teaching third grade.

Francesca

Francesca was a fifth-grade teacher, with five years of varied teaching experience. This was her second year at Pinnacle Elementary, teaching fifth grade for both years. Her background in teaching includes intermediate Exceptional Student Education (ESE), Emotional or Behavioral Disability (EBD) unit, and 4th grade general education before transitioning to 5th grade. As part of her teaching background, Francesca added that she also had about 15 years' experience as a substitute teacher. These teaching experiences helped impact Francesca's instructional decisions.

Task and Student Artifact Analysis

An important aspect in determining how the professional development impacted the participants' identification and implementation of cognitively demanding tasks was to see what tasks they thought were cognitively demanding and how they implemented these tasks before and after the professional development series. These tasks were then rated using the Potential of the Task Rubric and the student artifacts were rated using the Implementation of the Task Rubric (Boston, et al., 2019). Student artifacts were necessary in analyzing the level of thinking and reasoning the students engaged in during task implementation.

Prior to the professional development series, both participants were asked to identify and

submit high cognitive demand tasks from their lessons. Using these same tasks, participants implemented them in their classrooms and provided student artifacts for each task as evidence. This allowed me to see what tasks the participants deemed as cognitively demanding and to determine if the cognitive demand was maintained during implementation. After the professional development, the submitted tasks could be identified or modified tasks. The option to modify the tasks was added for the post task because through participation in the professional development, participants would have the knowledge necessary to be able to adapt tasks. To find the potential of the task ratings for the teachers' pre and post student artifacts, each task was rated and then an average of the tasks was identified, see Table 4. Similarly, the implementation of the tasks was rated separately and then averaged. This resulted in each participant having one score for the pre and one score for the post in potential and implementation of the task.

Table 4: Pre and Post Student Artifact Ratings

	Instructional Quality Rubrics			
	Pre Potential of the Task	Post Potential of the Task	Pre Implementation of the Task	Post Implementation of the Task
Theresa	2	4	2	3
Francesca	4	3	2	3

Theresa

Theresa showed growth in both identifying higher cognitive demand tasks and implementing the tasks at a higher cognitive demand. At the beginning of the professional development series, Theresa selected tasks from the third grade Curriculum Resource Materials (CRM's) with an average cognitive demand of 2. The tasks themselves varied in their cognitive

demand ratings, with tasks that were at levels 2 and 3 which resulted in the aforementioned average. The tasks and their ratings are in Table 5.

Table 5: Theresa's Pre Task Examples

Pre Tasks	IQA Potential of the Task Rating
There are 8 markers in one package. How many markers are in 10 packages?	2
Seven friends get together to play a card game. Sixty cards are needed to play this game. Each friend brings ten cards. Are there enough cards to play the game?	3
What is 10 x 7? Explain how you know.	2

Each task that was submitted was rated using the IQA Potential of the Task Rubric (Boston et at., 2019). For the first task, I rated it a level 2 because there is little ambiguity on what needs to be done to complete it and the focus is on producing the correct answer. The second task was rated a level 3, due to the task asking students to engage in problem solving but it was not cognitively challenging, nor did it ask students to provide reasoning in their work. The final task was rated at a level 2. This task focused on students providing a correct answer and then explaining how they knew the response was correct. Though the task asked for an explanation, it is more about explaining the procedure and not about making connections or determining different methods or strategies, which would impact students' levels of thinking.

Throughout the professional development, Theresa was engaged and asked questions on how to better identify higher cognitive demand tasks. During the one-on-one interviews, after the professional development, Theresa mentioned that she has "a better understanding of what it means for a task to be cognitively demanding" and that she did not think she understood what that meant when the professional development started. This understanding was evident in her

task selection. By the end of the professional development series, Theresa submitted three tasks at a level 4 cognitive demand, which brought her average up to a level 4 post professional development. Two of the tasks were from the curriculum materials and the third task was created by Theresa.

Table 6: Theresa's Pre and Post Task Examples

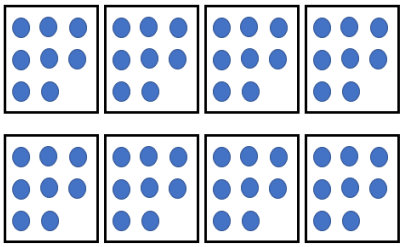
Pre Tasks	IQA Potential Rating	Post Tasks	IQA Potential Rating
There are 8 markers in one package. How many markers are in 10 packages?	2	Jeremy buys 7 packages of postage stamps. Each sheet has 20 stamps. How many stamps does she buy in all? Explain how you solved the problem. Tell why you chose that method.	4
Seven friends get together to play a card game. Sixty cards are needed to play this game. Each friend brings ten cards. Are there enough cards to play the game?	3	Sam said he used partial products to write 9 x 46 = 36 + 54 = 90. Explain Sawyer's error and use math to justify your explanation.	4
What is 10×7? Explain how you know.	2	Ms. Johnson has 30 skittles. She wants to share them equally with her friends. How many friends can have skittles. Write and solve an equation and explain how you solved and why you solved it that way.	4

The first post task sample was rated a level 4 because it asks students to solve a genuine task by choosing a method and explaining why they chose that method. Students would have to understand the connections between the strategies and procedures needed to solve the task to be able to explain why they chose that specific method. For task two, students had to find an error in someone else's thinking, explain that error, and justify their responses with mathematical thinking. This led me to rate the task a level 4 because students were asked to explain why the

procedure they looked at did not work and make connections to their solutions or justifications. The final task, which was created by Theresa, was an open-ended question that allowed for multiple solutions. The task asked students to create an equation based on the situation, explain how they solved it, and explain why they solved it in that manner. Students would have to engage in problem solving to identify patterns within solving for a solution of 30. As seen in Table 6, Theresa showed growth in her identification of high cognitive demand tasks from pre to post professional development. This showed that Theresa's participation in the professional development positively impacted her identification of high cognitive demand tasks.

After the professional development series, Theresa also showed growth in implementing cognitively demanding tasks. Prior to the professional development series, Theresa had an average implementation score of a 2, as shown in Table 4. An implementation level of 2 indicated that her current instruction focused on the procedural process of solving mathematics problems (Boston et al., 2019). When looking at the pre student artifacts, there were responses for the tasks; however, the justifications of the solutions were not as evident in the students' work. When comparing the implementation of the tasks to the potential of the tasks, Theresa either maintained or lowered the cognitive demand of the tasks throughout the implementation process pre professional development.

Table 7: Theresa's Pre Implementation Description and Ratings

Task	Work Sample Descriptions	Implementation of the Task Rating
There are 8 markers in one package. How many markers are in 10 packages?	All students had a numerical response to the task. Four out of five students only had a response with no work indicating how to solve it, however, had the correct response. One out of the five students showed work by attempting to model the mathematical situation, however they modeled it as eight boxes with eight markers inside each box, with a response of 52. Below is a recreation of what was modeled in the student work. 	2
Seven friends get together to play a card game. Sixty cards are needed to play this game. Each friend brings ten cards. Are there enough cards to play the game?	Three of the five students responded that there would be enough cards to play the game. The first student wrote: yes, because ten plus ten seven times is enough. They related the task to repeated addition. The second student wrote: yes with $10 \times 7 = 70$ and the third student put yes 70. The other two students said no to having enough cards. One student wrote no because they don't need sixty and the other student said no because $7 \times 10 = 70$.	3
What is 10×7? Explain how you know.	Four out of five students only responded with the numerical response of 70, without any explanation. One student explained how they knew their answer. They responded with: Because they switched it $7 \times 10 = 70$ so 10×7 is also 70.	2

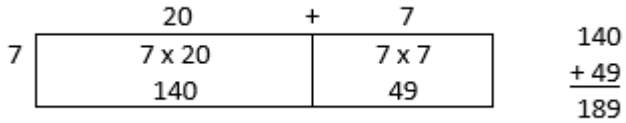
As shown in Table 7, student work samples were used to rate the implementation of the tasks. For the first task, a majority of the students gave numerical responses without explanation

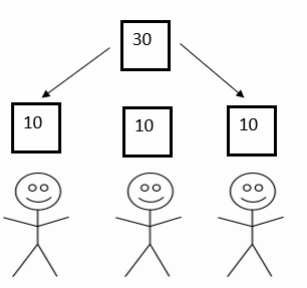
or justification of their work or thinking. This led to an implementation rating of 2. The second task required students to make connections to factors of multiplication and included multiple solution strategies; however, students explained their process and not the deeper thinking behind it. For this reason, this task was implemented at a level 3. For the final task, it was not a high cognitive demand task though it did ask for an explanation. Students again responded with the numerical response which led to the implementation rating of a 2. These pre implementation of task ratings averaged out to a 2 for Theresa. Additionally, when reviewing the tasks, I noted that there were little to no eraser marks. It looked like students just answered the question and moved on with limited evidence of thinking.

Throughout the professional development series, Theresa shared the realization that she impacted the cognitive demand, especially during sessions three and four. Based on my observation of session four, when comparing potential of the tasks to implementation of the task, she shared her epiphany about the importance of teacher actions during implementation. During the collaborative conversation, Theresa stated, “The teacher or educator has the option to maintain the demand, increase the demand, or decrease the demand of the tasks.” Prior to the professional development session which focused on how to implement cognitively demanding tasks, participants were asked to bring one task implementation sample from their classrooms so they could reflect on their own teaching during the session. Theresa was very eager to learn from the sessions and when asked to bring one task sample she brought four samples to reflect on. During the refection process she asked questions about how to analyze the student artifacts to improve her teaching practices. This enthusiasm seemed to translate into how she implemented cognitively demanding tasks. Post student artifacts showed student thinking through explanations of their work; however, the implementation of the tasks did not reach the rigor of a level 4

because students did not justify their reasoning or compare solution methods. Therefore, by the end of the professional development series, Theresa's implementation rating was an average of a 3 (see Table 8).

Table 8: Theresa's Post Implementation Description and Ratings

Task	Work Sample Descriptions	Implementation of the Task Rating
Jeremy buys 7 packages of postage stamps. Each sheet has 20 stamps. How many stamps does she buy in all? Explain how you solved the problem. Tell why you chose that method.	Two of the five students responded with 140 stamps, which is the correct response. One of the two students solved it by relating the task to two strategies: patterns and basic multiplication facts. For patterns, they skip counted from 20 to 140 and then also explained that 7 × 2 = 14 which helped them solve 7 × 20. The second student used repeated addition and wrote repeated addition is just like solving 7 × 20. The other three students used multiplication strategies; however, there was evidence of unfinished learning with place value and/or incorrect use of the are model. Two students used repeated addition with errors in regrouping. One student used the area model and repeated the number 7 twice, changing the value of her numbers. A recreation is provided below. 	3
Sam said he used partial products to write 9 × 46 = 36 + 54 = 90. Explain Sawyer's error and use math to justify your explanation.	Three of the four students were able to explain and show their thinking to justify their response. Two of the three students used the distributive property of multiplication over addition to show the mistake. Both of those students wrote that Sawyer forgot to add the zero to 36. The other student used the area model and repeated addition. They wrote that Sawyer was wrong because it is 360 + 54 = 414. The final student created and area model and used repeated addition but there was evidence of unfinished learning with place value, specifically with regrouping. The student wrote that she put a plus sign and then the numbers 50 and 320.	4
Ms. Johnson has 30 skittles. She wants to share them equally with her friends. How many friends can have skittles.	Three of the four students responded with six friends would get five skittles. The first student explained that they skip counted by 5's to get to 30, because that was the easy way. They used the skip counting to see how many numbers there were to show there were six friends. The other student completed it	3

Task	Work Sample Descriptions	Implementation of the Task Rating
Write and solve an equation and explain how you solved and why you solved it that way.	similarly, they skip counted by 5's and created an equation to related to the situation, $5 \times 6 = 30$. The third student explained that each friend would get five because they knew the equation $5 \times 6 = 30$. The last student modeled three friends receiving ten skittles. This student explained that thirty was made up of three groups of ten or ten groups of three. A recreation of the model is below. 	

Post implementation ratings were identified from student artifacts. For the first task, it asked students to solve for how many stamps while explaining how they solved it and why they solved it in that manner. Though there were different strategies in use for the task, students did not explain their rationale behind their strategy, therefore the implementation did not reach a level 4 and was rated at a level 3. The second task asked students to explain the error in someone's mathematical thinking when solving for 9×46. Students explained the error and solved it in various ways, such as using the distributive property of multiplication over addition and repeated addition to find the correct solution. This task was rated an implementation level 4. The final task was an open-ended multiplication task created by Theresa. She intended for there to be multiple solutions to the task. Students used different strategies such as skip counting and modeling to find the solution. Though students attempted to justify their solution methods, they explained the procedure they used. This put the implementation rating at a level 3. The average

post implementation rating for Theresa was a level 3, which was an increase to her pre implementation rating. In addition, observation of the tasks showed that students used more workspace to solve these tasks by using additional papers. On the workspace there were eraser marks and evidence of checking strategies, such as with the repeated addition. For example, one student attempted the task twice, probably to ensure the answer was correct.

After the professional development series was completed, Theresa wanted to continue her learning about cognitively demanding tasks. She asked about ways to enhance student understanding throughout mathematics lessons that will help students reach and answer level 4 tasks. Simply put, how can she get students to reach a level 4 when they are not there yet. This question led to an informal conversation outside of the professional development on the questioning, linking, and press rubrics from the Instructional Quality Assessment toolkit (Boston et al., 2019).

Francesca

Francesca also showed growth in her learning throughout the professional development series; however, it was not evident in her task selection. What was interesting about Francesca's results was her pre and post student artifacts ratings. Francesca began the professional development submitting tasks that she identified as cognitively demanding. Even though I asked participants to submit three tasks, Francesca submitted two. She did not indicate why she only submitted two tasks; however, she was reminded that the goal was to submit three tasks before the professional development. I rated these tasks and corroborated that her tasks were already at a cognitive demand level 4 (see Table 9).

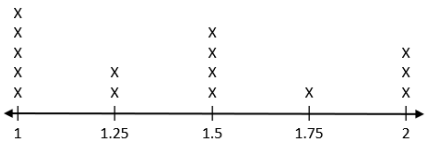
Table 9: Francesca's Pre Task Samples

Pre Tasks	IQA Potential of the Task Rating
Artemis has two strips of fabric. One is $\frac{2}{6}$ foot long and the other is $\frac{7}{12}$ foot. When she sews the strips together, will it be closer to $\frac{1}{2}$ foot or 1 foot long? Explain.	4
Sandra is making breakfast. The recipes call for $\frac{7}{8}$ cup of milk for grits and $\frac{3}{4}$ cup for biscuits. He only has two cups of milk. Does he have enough to make his breakfast? Explain.	4
N/A	N/A

Francesca submitted two tasks from the fifth grade CRM's prior to the professional development series. Both tasks were rated at a level 4. These tasks asked the students to make sense of fractions through the use of conjectures and to support their reasoning with mathematics. The second task also asked students to problem solve a genuine problem.

At the end of the professional development, Francesca submitted three tasks from the approved curriculum that had an average rating of a 3. The tasks that Francesca submitted ranged from a level 2 through a level 4. This means that her identification of high cognitive demand tasks lowered from the beginning of the professional development to the end (see Table 10).

Table 10: Francesca's Pre and Post Task Examples

Pre Tasks	IQA Potential Rating	Post Tasks	IQA Potential Rating
Artemis has two strips of fabric. One is $\frac{2}{6}$ foot long and the other is $\frac{7}{12}$ foot. When she sews the strips together, will it be closer to $\frac{1}{2}$ foot or 1 foot long? Explain.	4	Marcy records the distance she walks each day. She wants to show which distance she walks most frequently. Should she draw a line plot or line graph? Explain.	4
Sandra is making breakfast. The recipes call for $\frac{7}{8}$ cup of milk for grits and $\frac{3}{4}$ cup for biscuits. He only has two cups of milk. Does he have enough to make his breakfast? Explain.	4	What situation could be represented by this line plot? Write a label for the line plot. 	3
N/A	N/A	Which ordered pair would be plotted on a line graph of the data shown in the table? <table><tr><td colspan="7">Student Absences</td></tr><tr><td>Day</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>Absent</td><td>2</td><td>0</td><td>1</td><td>3</td><td>1</td><td>0</td></tr></table> A. (0,2) C. (1,2) B. (1,1) D. (1,3)	2

The first task Francesca submitted, I rated at a level 4 because it asked for students to understand the mathematics of the situation, determine how to share the data, and explain. Students would have to engage in sense making and understand the connection between the mathematics situation and the representation. For the second task, I rated it as a level 3 because students had to make sense of the line plot to create a situation that could correctly represent it. This task was open ended because the task allowed for various responses. The third task I rated as a level 2 because the task required procedures to answer the question: however, there was

little ambiguity on how to answer the task. The third task focused on producing the correct response.

After engaging in the professional development series, Francesca showed growth in the implementation of tasks. Prior to the professional development, the implementation rating was a 2, which means the cognitive demand of the tasks was lowered. This means that prior to the professional development, Francesca did not maintain the cognitive demand on any of the tasks that were implemented (see Table 11).

Table 11: Francesca's Pre Implementation Description and Ratings

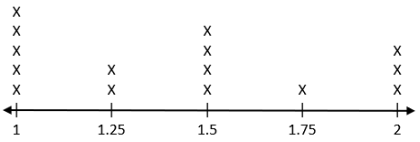
Task	Work Sample Description	Implementation of Task Rating
Artemis has two strips of fabric. One is $\frac{2}{6}$ foot long and the other is $\frac{7}{12}$ foot. When she sews the strips together, will it be closer to $\frac{1}{2}$ foot or 1 foot long? Explain.	All four students wrote a sentence to respond to the task. All students said that 1 foot was the answer because $\frac{1}{2}+\frac{1}{2}$ is 1. In the students' work they changed $\frac{2}{6}$ foot and $\frac{7}{12}$ foot to $\frac{1}{2}$ foot. From there, three of the four students put $\frac{1}{2}+\frac{1}{2}=1$. One student wrote $\frac{1}{12}+\frac{1}{12}=1$, however their sentence said that they were adding halves.	2
Sandra is making breakfast. The recipes call for $\frac{7}{8}$ cup of milk for grits and $\frac{3}{4}$ cup for biscuits. He only has two cups of milk. Does he have enough to make his breakfast? Explain.	Two of the three students responded with computational work and one of them answered with a single word yes. Both students' work showed $\frac{7}{8}=1$ and $\frac{3}{4}=1$, so $1+1=2$. The third student wrote: yes because $\frac{3}{4}$ is close to 1 and $\frac{7}{8}$ is closer to 1. The student then showed $\frac{7}{8}+\frac{6}{8}=1\frac{5}{8}$ and he will have $\frac{3}{8}$ left. Though the final student showed that they were making sense of the mathematics and justifying their reasoning, they were an outlier compared to the other students.	2
N/A	N/A	N/A

Francesca's pre implementation average came from the two tasks submitted prior to the professional development. For the first task, students had to explain if adding two fractions would be closer to $\frac{1}{2}$ or 1 whole. All the students showed a similar way to solve the task and they wrote the same sentence to respond to the task. For this reason, this task was rated a level 2 implementation. The second task asked the students if there would be enough milk to make two recipes for breakfast. There were only three students whose work was included for this task and two of the students did not try to explain their solutions with words, just equations. The third student solved the task in multiple ways and explained their reasoning behind their work.

Because only one student tried to meet the cognitive demand of the task, I rated the second task implementation a level 2. This brings Francesca's pre implementation average to a level 2. Additional noticings of the tasks was that three students annotated by circling numbers and two students used additional paper to write out their work and response.

After the professional development, Francesca showed growth in the implementation of the tasks, which was an average rating of a 3 from her initial level 2. Though the potential of the tasks of the post student artifacts were lower than the pre student artifacts, during implementation, Francesca was able to maintain or raise the cognitive demand of two tasks and lowered the cognitive demand of one task. This showed a positive change in the way that she implemented tasks in the classroom, since prior to the professional development she was implementing at a lower cognitive demand than the potential (see Table 12).

Table 12: Francesca's Post Implementation Description and Ratings

Task	Work Sample Descriptions	Implementation of Task Rating
Marcy records the distance she walks each day. She wants to show which distance she walks most frequently. Should she draw a line plot or line graph? Explain	All students responded by creating a line plot or line graph to show which one should be used in Marcy's situation. Two students drew line graphs, one student drew a line plot, and the last student drew a graph that was a combination of both line graph and line plot. That student did not explain the data they chose to graph/plot. The first two students, with the line graph, gave examples of how to read the data and how far Marcy ran with those data points. The third student shared her line plot and wrote: Yes, she should make a graph to know which one she walked the most.	3
What situation could be represented by this line plot? Write a label for the line plot. 	All four students created their own line plots and created their own situation. The first two students chose to interpret the line plot as the weight of fruits, the first one choosing apples and the second one choosing bananas, however the students did not specify the unit of measurement (i.e. ounces or pounds). The third student chose to interpret the amount of money people have and put the amount in the thousands. The last student created a line plot for how many students brought lunch from home, relating it to the days of the week, Monday being 1, Tuesday being 1.25, and so on. Students attempted to make sense of the line plot and connect it to what they had learned, however, none of the students justified why they created the line plots the way that they did.	3
Which ordered pair would be plotted on a line graph of the data shown in the table?	Each of the four students responded with c and then wrote a sentence to describe why they chose their answer. All four students had similar sentences stating that c was the answer because the other numbers were not on the line plot and then gave examples of all the numbers	2

Task	Work Sample Descriptions	Implementation of Task Rating
<table><tr><td colspan="7">Student Absences</td></tr><tr><td>Day</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>Absent</td><td>2</td><td>0</td><td>1</td><td>3</td><td>1</td><td>0</td></tr></table> A. (0,2) C. (1,2) B. (1,1) D. (1,3)	that would be on the line plot. The examples that were given were (2,0), (3,1), (4,3) and (5,1).	

Francesca submitted three tasks for the post student artifacts. The first task asked students if a line plot or line graph would be appropriate for a specific situation. Students gave examples of how they would share the data and how to read the data from their line plot or line graph. Students did not write justifications of their reasoning, which is why I rated the implementation of the task as a level 3. The second task asked students to create a situation that could be used for the data in a line plot. All students created a situation in which the line plot could be used, with one student not understanding how to interpret the data. None of the students justified their versions of the line plot, which led me to the implementation rating of a 3. The last task was identifying which ordered pair would be plotted on a line graph based on the data provided. Students wrote their responses as sentences and explained the process of how they were able to come up with the solution. Again, the students explained the process and not their reasoning which kept the cognitive demand at a level 2. Francesca's average for her post implementation was an average of a level 3. For these tasks, all student used additional paper to create line plots or tables. There was evidence of trial and error by students, with eraser marks or crossing out work and trying again.

After the professional development series, as well as after the one-on-one interviews, Francesca approached me with questions regarding tasks even though the professional

development was over. These questions were geared toward the final portion of the professional development, which was implementation of tasks and using student samples to reflect on implementation. This was further evidence of the impact the professional development had on current and future implementation of cognitively demanding tasks.

Review of Analysis

I analyzed and rated pre and post tasks for the potential of the task and pre and post student artifacts for the implementation of the task. Pre and post tasks and student artifacts were used to examine the impact the professional development had on the participants' identification and implementation of cognitively demanding tasks. To analyze these tasks and student artifacts, the IQA Potential of the Task and Implementation of the Task Rubrics (Boston, et al., 2019) were used. This analysis was further supported by formal and informal conversations and observations that indicated the impact the professional development had on the participants. Theresa increased in the identification of high cognitive demand tasks, increasing from a level 2 to a level 4. Francesca decreased in her identification of cognitively demanding tasks, decreasing from a level 4 to a level 3. Though Francesca decreased in her average score, level 3 tasks are cognitively demanding tasks, with the only difference between a level 3 and level 4 being that the task explicitly asks students to justify their thinking or reasoning (Boston et al., 2019). Both participants increased from a level 2 to a level 3 in the implementation of cognitively demanding tasks. Though it was important to analyze the ways that participants identified and implemented mathematics tasks, it was also helpful to consider how the professional development impacted participants and what aspects they found useful.

Thematic Coding of Collaborative Conversations and Interviews

Thematic coding and analysis were used for observation notes, the collaborative conversations, and interviews. Each collaborative conversation was conducted immediately after each professional development session and the interviews were conducted after the professional development series. The collaborative conversations and interviews were recorded and transcribed prior to the analysis process. This process of thematic coding was completed in multiple phases, the phases were immersion in the data, process of coding, creation of categories, and identification of themes (Green et al., 2007). Below, I begin by describing the analysis of codes and categories which led me to identify the themes within the data. Afterwards, I describe each of the themes and the codes within the themes with data from observation notes, collaborative conversations, and one-on-one interviews.

Emerging Codes within the Data

For the data immersion phase of my data analysis, I listened to the audio and read the transcripts multiple times for each individual collaborative conversation session and interview. Following this step, I began to find codes that related to the aspects of the professional development that participants found useful in deepening their understanding of cognitively demanding tasks. This led me to see the relationship between codes, which helped me create categories, see Table 13. The first set of codes that were combined was the Instructional Quality Assessment Tool Kit (Boston et al., 2019), Curriculum Tasks, and Video Lesson. These codes were combined because these codes all related to the tools and activities that I used during the professional development series. The second set of codes were debriefing together, the pacing of activities, and different grade level representations. These codes were combined because they related to the intentional planning and implementation of the professional development. They

were part of the structure of the professional development that was strategically planned by me, based on the Loucks-Horsley (2010) recommendations. The final set of codes were enthusiasm, willingness to learn, time constraints, STO influence, and CRM mandates. I combined these codes because these were all factors that related to the participants' ability to implement cognitively demanding tasks in their classroom. Each of these factors were outside the realm of the professional development.

Table 13: Thematic Coding Process

Combined Codes:	Categories:	Themes:
Rationale: Codes related to items selected and shared during the professional development - IQA Toolkit - Curriculum Tasks - Video Lesson	- Tools - Activities	Beneficial resources
Rationale: Codes related to the intentionally planned structure of the professional development - Pacing of activities - Debriefing together - Different grade levels (vertical alignment)	- Structure	Beneficial experiences
Rationale: Codes related to the factors outside of the professional development that impact implementation - Enthusiasm - Willingness to learn - Time constraints - STO influence - CRM mandates	- Participants Disposition - Participants Concerns	Feedback related to implementation

These codes and categories were used to identify themes within the collaborative conversations and interviews. The themes are beneficial resources, beneficial experiences, and feedback related to implementation. These themes and codes were corroborated through member

checking, which was an informal conversation with the participants that was used to verify the interpreted data. Analyzing in this manner helped make sense of the impact the professional development had on the implementation of cognitively demanding tasks as well as the aspects of the professional development that participants found useful. These themes are discussed thoroughly next.

Beneficial Resources

While analyzing the codes and categories within the collaborative conversations and interviews, participants described what aided in their learning throughout the professional development. The descriptions were analyzed to find common words or phrases the participants shared about the professional development and what helped them understand the idea of cognitively demanding tasks. These descriptions helped me identify main codes across the sessions and interviews. These descriptions were coded, put into categories, and used to identify the theme of effective or beneficial resources. The main codes were the IQA Toolkit, curriculum tasks, and video lesson, which I linked together into the categories of tools and activities. This led me to the theme of beneficial resources. Included next are participant descriptions to further the support of the three main codes that make up this theme.

During the professional development, both participants engaged with the IQA toolkit through the use the Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019). Participants' understanding of the IQA developed through the multiple sessions included in the professional development. Throughout the first two sessions, both participants shared that having the time to use the Potential of the Task Rubric helped them understand the rubric and how to use it to analyze tasks in their lesson plans. For example, during the second session

Theresa stated “I feel like I understand the rubric more now too. Like just going over it again, I'm like, oh, OK. I really do understand more of the differences between like a level 1 and level 2.” Francesca chimed in agreement saying “Yeah, definitely very helpful” and later on in the conversation added “I have a clearer understanding of how to go from a level 2 to a level 3. So definitely, it was definitely informative.” This was corroborated during the one-on-one interviews as well. When discussing about what the participants found useful, Theresa said:

> The rating of the tasks was fun. That was fun because I like looking at the rubric and really being like, oh, is this [task] this or this? Oh, but no because of this part…. I like a good rubric, and these are fantastic rubrics.

Both teachers showed similar interest in the Implementation of the Task Rubric. This was evident during conversations that were held after sessions four and five. Francesca mentioned, “It’s interesting to look at like the potential [of the task rubric] versus the implementation of [the task rubric].” During the same session, Theresa stated, “I’ve learned is that the implementation of a task could actually be rated higher than the potential of task. The teacher or educator has the option to maintain the demand, increase the demand, or decrease the demand of the tasks.” Francesca agreed and added “I learned the power that the teacher has when it comes down to the implementation, how that can affect the task … what the students are able to produce.” This conversation showed that the participants found that engaging with the IQA Rubrics was beneficial to their understanding of cognitively demanding tasks and how they could be applicable in the classroom. Not only could they use the rubrics to understand the tasks they were implementing more deeply, but participants also shared the importance of the teacher during the implementation process.

The second main code that arose from the data was the use of curriculum tasks. The tasks chosen for the professional development came from the lessons that the participants were going to be using in their classrooms. Theresa stated:

> I thought this was a really valuable use of my time. To look at the tasks that we are teaching and actually talk about the tasks that we are teaching and talk about it umm in terms of their cognitive demand. I wish that this is what I did in PLC.

Francesca continued the conversation by saying "Right. I agree. Just going through like, just being able to go through like the CRM's and identify what task is a level 1 or level 2 that helped a lot." Being able to use tasks from the participants' lesson plans helped participants relate the activities back to their classrooms. This was evident with the informal conversation I had with Theresa when she stopped me in the hallway to let me know that she had already made changes to some of the questions in her lessons based on session two of the professional development. She had mentioned that just with the slight changes she's made, she can already see the benefit of seeing the students thinking on higher cognitive demand tasks.

Another aspect of using curriculum tasks was the ability for participants to reflect on their teaching practices using student work samples of the tasks while engaging in the professional development. This is evident with Francesca's response to the interview question about what was beneficial from the professional development. Francesca stated:

> Looking at well looking myself, looking at the student samples. They all, they have all had their own way of solving. Um. A lot of them were procedural to be honest with you some did models ... It tells me that. We need to teach our kids how to think more. This is what this tells me because actually they can easily solve multiplying a fraction by fraction

but how like dive in deeper, how did you get that answer. I know what $\frac{1}{3} \times \frac{1}{2}$ is $\frac{1}{6}$ but being able to explain it and draw a model is where they struggle.

Theresa shared similar sentiments about using the curriculum tasks and student samples to reflect on her teaching practices while implementing tasks. She said:

> It reminded me that the tasks themselves are not just cognitively demanding because it says explain. And it also was a fun reminder that failure is also a learning opportunity because the kids had a really hard time with some of them [tasks]. And so I had to think, what part of it was so difficult for them? Like, what part of it made them unsuccessful. Like what do I need to teach again?... It made me realize that you can't just do the thing. Umm, you have to really think about implementing cognitively demanding tasks.

These data show that both participants found using curriculum tasks beneficial to their understanding of cognitively demanding tasks, as well as a method of self-reflection. This is shown through the participants' data because there was evidence of the participants reframing their focus during task implementation in their classroom instruction. These quotes demonstrate an awareness and responsiveness to the learning that occurred throughout the professional development.

The final main code that was identified was related to the video lesson. During session three, participants were asked to watch a video lesson and keep the implementation of the task rubric (Boston et al., 2019) in mind to determine the level of implementation. The video lesson helped the participants to see how teacher actions impacted the cognitive demand of the task. When asked what stuck to them from the video, Francesca mentioned "Over scaffolding. It is not just on the students. I am now taking a look at how I influence [tasks] and how I'm going to

implement my lessons in the future and make sure I'm not over scaffolding." Later in the conversations Theresa stated:

> The video made me, it made me open my eyes… Like breaking it down. Like ohh were the students actually thinking? Oh no. One of them was talking about planting seeds. Yeah, so that is not related to what happened … She was trying to get the students to realize the vocabulary but you didn't get them to realize the vocabulary. It was like, almost like trying to get them there without [being successful].

The conversation ended with the participants debating on whether the video lesson implementation was a zero or a one, since the teacher did a majority of the thinking and work. Theresa mentioned "Because you could say yes, some students were able to just reproduce facts. Students did not make connections." Francesca added "They most certainly did not … and so we can argue like the students [who] were called to the board received more. But whereas those who were just [sitting] didn't even have the task in front of them." The video engaged the participants in deeper conversation and self-reflection, which was also highlighted during their one-on-one interviews. Francesca stated "I liked the video because I saw myself in the video, over scaffolding. So that caused me to you know self-reflect and so I don't need to over scaffold so much." Theresa mentioned similar sentiments, stating:

> When we did the video observation and then we looked at the implementation of the tasks. The video was really good. I think the video is really helpful because when you watch videos of teachers teaching like the expectation is look at this teacher and look at everything she's doing, it's perfect … Then we watched this video and we really thought about it critically and we were like, oh wait. Is she doing what she should be doing? Like would I do it like that? And it made me think more about how I teach and how I do hold

the kids' hands too much sometimes and being better about like releasing. And that was a good video for that.

Based on the participants' discussions during the collaborative conversations and the one-on-one interviews, the resources and activities that impacted their understanding of cognitively demanding tasks were the IQA Toolkit, using curriculum tasks, and watching the video lesson.

Beneficial Experiences

During the collaborative conversations and one-on-one interviews, participants described structures that were intentionally planned for, which contributed to participants' experiences. The main codes to arise from the participants' descriptions were pacing of the activities, debriefing together, and having different grade levels present. These were linked together to create the category of structure, which related to how I planned and formatted the professional development experience. Though these codes were present in the collaborative conversations, they were truly highlighted during the one-on-one interviews with the participants. Below are the descriptions from the participants that led to the main codes.

The first code within beneficial experiences is pacing of the activities. During the professional development sessions, I gave the participants time to look at the rubrics, tasks that were part of their lesson plans, and time to analyze their own tasks from the classroom with the rubrics. During session one, when discussions began about the IQA Potential of the Task Rubric, Theresa stated how important it was for her to have her own pacing. Both participants discussed looking at tasks they were going to implement, and Theresa added "At our own pace too. Not everyone is looking [at] one day right now and we are only looking at this one question right

now. At our own pace, looking at what's coming and really thinking about these tasks." Francesca joined in by saying "right" multiple times while Theresa was talking.

The second and third main codes related to beneficial experiences were debriefing together and having different grade levels present during the sessions. I combined these codes because participants continuously mentioned one with the other. Though the participants did not explicitly state that debriefing together was beneficial throughout all the collaborative conversations, it was highlighted during the final collaborative conversation session and through member checking. Below is the conversation from session five that related to debriefing and having different grade level participants in the professional development. The conversation was between both participants and me as the researcher.

> **Theresa:** You're fourth and you're fifth, so I thought it was interesting seeing like the kinds of tasks and how we could talk about them.
>
> **Francesca:** Mmm Hmm
>
> **Theresa:** And. What's it called? Vertical alignment. The vertical alignment of some of the different things [tasks]. I just thought it was interesting, like, I'm glad we weren't all on the same grade level because I feel like it's interesting to see the different things that they [students] can do.
>
> **Francesca:** Yes, and you don't realize, like how it goes from third to fourth to fifth.
>
> **Researcher:** How you guide them to me, and I guide them to her.

Theresa: Being new to third grade and third grade seems so high right now and I'm like fifth grade must be super hard. Like everything they do must be totally cognitively demanding now I'm like, oh, I guess not.

Francesca: No, no. Some of those lessons are easy, but some of them are really hard. But not cognitively demanding.

This back and forth during the last session highlighted participants' feelings about having the time to debrief together and having different grade level perspectives. Based on my observations and notes from the sessions, these topics were ongoing conversations I observed on multiple occasions. Theresa found it interesting that what was being discussed about third grade tasks was still happening in fourth and fifth grades.

Feedback Related to Implementation

Throughout the professional development sessions, collaborative conversations, and interviews, participants shared feedback related to external factors that may have affected their implementation of high cognitive demand tasks. Five main codes were identified within the data that were associated with participant feedback regarding task implementation. These main codes were enthusiasm, willingness to learn, time constraints, School Transformation Office (STO) influences, and Curriculum Resource Material (CRM) mandates. These codes were then linked together to create categories. Enthusiasm and willingness to learn were combined to create the category of participant dispositions while time constraints, STO, and CRM mandates were used to create the category, participant concerns. These codes and categories helped to identify the theme of feedback related to implementation. Below are the descriptions related to the codes identified in the data.

During the professional development series, collaborative conversations, and interviews participants shared their insights about their engagement in the series, which included their enthusiasm and willingness to learn about cognitively demanding tasks. This was first evident in between the sessions, when participants would ask when the next session would be or if there could be more than five sessions to the professional development. These questions and informal conversations indicated that the participants were enthusiastic about their learning. This enthusiasm and eagerness to learn was also apparent in my observation notes and during the collaborative conversations. During each of the sessions, participants would ask questions about how to bring the information being learned into their lesson planning and ultimately into their classrooms. For example, during session one on rating the potential of the tasks, Theresa asked how to integrate what was being learned and translate it to students' independent work. Theresa stated:

> I was just wondering about like looking through and seeing if there is any questions that I can make more cognitively demanding for their independent work cause a lot of their collaborative work is more demanding but their independent work isn't. So, I wanted to see if there was anything I can change.

This type of questioning was a natural progression of what the professional development was trying to accomplish and indicated that Theresa wanted to continue her leaning about cognitively demanding tasks. Another example happened during session two, where participants began to ask questions regarding grade level standards and how each standards' expectations related to the IQA Potential of the Task Rubric (Boston et al, 2019). This discussion continued into the collaborative conversation where Theresa pondered and stated, "So for me I'm still thinking about like, which standards and which skills are um benefit from having more cognitively

demanding tasks." Francesca added "For me, just making sure that they are aligned with the assessments. So, having to go back and look at the assessment and make sure that it calls for umm higher thinking." These discussions and the act of asking questions to gain knowledge and understanding continued throughout the entire series. For instance, during session four Francesca stated, "I'm wondering how to go from that, the potential being a [level] 1 to a level 4?" and during session five she asked, "How to manage the implementation of it [cognitively demanding tasks]?" Even though participants were eager to implement what they had learned during the professional development series, there were obstacles or factors outside of the professional development that impacted their implementation.

Concerns about implementation began to arise during session two of the professional development series and were evident throughout the remaining sessions, collaborative conversations, and interviews. At the beginning of each session, I encouraged the participants to share if they were able to use the IQA rubrics between sessions in their classrooms or discuss any barriers that they experienced. Embedded within each conversation with the participants, Theresa and Francesca brought up time concerns. These time concerns included both time to plan and time within the classroom. For example, Francesca shared during the professional development session that she did not have a lot of time throughout the week, therefore she did not have a chance to use the IQA Potential of the Task rubric before joining session two. Francesca also mentioned during her interview that when adjusting tasks, time within the classroom was a factor. She stated:

> Of course, you know time is always a problem. But it did cause me to ask the kids to think a little deeper. Like, how did you get this answer? And have them demonstrate, you

know using models, or providing an explanation, versus you know just solving the problem.

This was also evident in my observation notes. When working together during the professional development during session two, participants shared that modifying the task to be more cognitively demanding was not as difficult as they originally thought but that they wish they had more time to be able to review and adjust the tasks during their regular planning time. Theresa mentioned that having the time to modify tasks during planning time would be beneficial but that majority of the time it is being taken away by Professional Learning Community (PLC) or other meetings. During session four she stated:

> Planning is a factor when it comes to really looking at these tasks. Hmm. It would be lovely if we could actually look at the task and be like, do we want to keep it like this? Especially towards the end of the unit because we need those procedural days, we do, we do and but then after those procedural days. How can we improve those questions?

In this quote, it supports her comments during the professional development where she indicates that there is no time to look at the tasks individually. During session five, Theresa stated:

> I'm just trying to find the time, hmm, to allow the children, our students, to justify their answers and to show different ways on how to solve the problem. That's yeah, so the main thing is like how to make it more time effective in the classroom.

Both participants indicated that having limited time, whether for planning or in the classroom, could impact the implementation of cognitively demanding tasks.

The next concern that participants had was the STO influence and CRM mandates. I combined these two codes because they go hand in hand at Pinnacle Elementary. STO is a learning community within Tide county (pseudonym) that assists schools with academic needs

and are present daily on campus. Discussion about STO and CRM's mainly occurred during the professional development sessions, which were not recorded, as well as informal conversations between sessions. The comments focused around whether participants were allowed to make adjustments to tasks based on the professional development, with regards to maintaining STO's pacing and materials. This concern was made clear during session four when Theresa stated:

> Well, it's also hard too sometimes cause because we're at an STO school and the STO people have certain expectations of what we should be teaching and how they want us to teach it, even if in my opinion, it's not always what's best for the students in my classroom.

During that same session, there was also discussion about the CRM tasks and the students' academic needs. The CRM lessons provided were from the STO learning community. Francesca mentioned:

> I mean for me I would rather have like a combination of maybe level two, three, and four tasks versus just all level ones and all level two tasks and I think when we looked back most of our [lesson plans] were level 2. But we rarely reached that level three and four, and if we did, we didn't teach a three or four in any way, shape or form. It was just like a right, here, go.

The participants also alluded to the fact that if students encountered high cognitive demand tasks, it often occurred during independent work time, which limits the teacher's ability to implement the tasks at the intended level. During informal conversations, participants indicated hesitation to make changes to the CRM's, even though they knew the tasks were not high cognitive demanding tasks. Participants shared their insights about STO and CRM mandates, for example during session two of the professional development, participants asked if they had permission to

make changes to tasks. I observed they were more critical of the mandates when recording was not in progress.

Summary

This case study aimed to determine the effectiveness of a professional development series on cognitively demanding tasks created by me. In this chapter, the data analysis provided rich descriptions of each of the data collection methods. The IQA Toolkit (Boston et al., 2019) was used to rate pre and post tasks and student artifacts, with the rating being described narratively. This narrative description paired with direct quotes from participants from collaborative conversations and interviews, were also analyzed using thematic coding. These codes were used to create themes to answer the research questions. Researcher observations and member checking were used to verify themes found in thematic coding. A full analysis of the data was used to answer the two research questions: *1) How does professional development on cognitively demanding tasks impact mathematics teachers' identification and implementation of cognitively demanding task?* and *2) What aspects of the professional development (PD) helped mathematics teachers deepen their understanding regarding the implementation of cognitively demanding tasks?* In the next chapter, I share my conclusions and limitations based on these findings as well as suggestions for future research.

CHAPTER 5: DISCUSSION

Introduction

This study provided insight into the impact a professional development series on cognitively demanding tasks had on teachers' identification and implementation of tasks, as well as determined which aspects of the professional development were beneficial to participants' understanding of cognitively demanding tasks. The professional development was created by me and was based on the framework for designing professional development from Loucks-Horsley et al. (2010). Participants engaged in a five-session professional development, which centered around the Instructional Quality Assessment (IQA) Toolkit, specifically the Potential of the Task and Implementation of the Tasks Rubrics (Boston et al., 2019). Both participants, Theresa and Francesca, participated in all sessions, submitted tasks and student artifacts, and shared insights on their experience through collaborative conversations and interviews about the professional development. The tasks and student artifacts were analyzed using the IQA Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019) while a thematic analysis was used on the collaborative conversations and interviews to determine themes and codes.

In this chapter, I discuss the findings of this study and their relationship to the research questions. I share how the data from task and thematic analysis supports, challenges, or extends literature. I also share practical implications for stakeholders, as well as implications for future research on professional development on cognitively demanding tasks.

Research Questions

1. How does professional development on cognitively demanding tasks impact mathematics teachers' identification and implementation of cognitively demanding tasks?

2. What aspects of the professional development (PD) helped mathematics teachers deepen their understanding regarding the implementation of cognitively demanding tasks?

Discussion

Findings and Implications

I organized the findings by research questions, interpreting and connecting the data from the tasks, student artifacts, collaborative conversations, and interviews with the current literature on the IQA toolkit, professional development, and teacher knowledge. These finding also include implications for school stakeholders when addressing professional development and teacher learning.

Identification and Implementation of Cognitively Demanding Tasks

This study aimed to determine the impact the professional development had on participants' identification and implementation of cognitively demanding tasks, which relates to research question one. Evidence and data to answer this question were provided from the task and student artifact analysis and observations from the researcher. Themes were also found in the collaborative conversations and interviews that related to the implementation of cognitively demanding tasks.

Changes to Instructional Decisions

In the initial results for identifying potential of the tasks, Theresa began the professional development at a level 2 while Francesca started at a level 4. Theresa submitted three tasks while Francesca submitted two tasks. This is important because according to Boston et al. (2019) and Boston and Smith (2011), three tasks are needed to obtain the average rating. Theresa's average

may be a more accurate representation of her identification level whereas Francesca's may not be. The result of submitting tasks already at a cognitive demand of 4 might be attributed to the fact she only submitted two tasks. If she had submitted another task, her average ratings may have resulted in a different score. At the end of the professional development series, Theresa was at a level 4 and Francesca was at a level 3. This time Francesca submitted three tasks, which was a more accurate representation of her identification of tasks. This data showed Theresa increased in her identification of cognitively demanding tasks, while Francesca decreased. This could also be associated with the engagement each participant had during the professional development.

Additionally, participants' choices in selecting tasks for instruction could be attributed to a multitude of factors such as standards, the school being a part of the STO Learning Community, and the inferred mandated use of the CRM's. When examining the task selection before the professional development, both participants identified and submitted tasks from the CRM lesson plans and curriculum. The CRMs covered a variety of standards including multiplication for Theresa and fractions and data for Francesca. There are times within the progression of mathematics that would not include high cognitive demand tasks, due to the focus being on procedural knowledge and memorization (Boston et al., 2019). Similarly, for the post task selection, Francesca identified and submitted three tasks which came from the CRM lesson plans. Theresa submitted two tasks, which came from the CRM's and created one task on her own. Her creation of a task used in her classroom could be an indicator of her enthusiasm to apply what she learned from the professional development. Theresa's creation of a task used in her classroom supports the research from Linda Darling-Hammond (2010) which indicates teachers will implement practices they engage in during professional development, as my professional development engaged participants in identifying, adapting, and implementing

cognitively demanding tasks. Although we did not create tasks in the professional development, Theresa extended her learning on adapting tasks to create a task on her own. Using knowledge from the professional development, Theresa was able to adjust her lessons and engage students in cognitively demanding tasks. Though Theresa showed an increase in her task selection and Francesca showed a decline, it is difficult to establish the impact the professional development had on their task selection. The increase or decrease in scores may have been influenced by the lessons or standards participants were teaching, as well as which tasks were available on the given CRM's. Although other factors may have impacted participants' task selections, the literature is clear that teachers' selection of tasks is important to student opportunities (Boston et al., 2019; Candela & Boston, 2022; NCTM, 2020). Furthermore, professional development can improve teachers' instructional practice which impacts the way in which teachers maintain the cognitive demand (Candela & Boston, 2022; Loucks-Horsley et al., 2010).

The analysis of the student artifacts gave insight to the participants' implementation of tasks. Both Theresa and Francesca began at a level 2 prior to the professional development and ended at a level 3. Though it is a one-point average growth, implementing tasks at a level 3 allows for students to make meaning of the mathematics with which they are engaged (Boston et al., 2019). Based on the analysis of the student artifacts, students showed more of their thinking process when completing tasks after the participants engaged in the professional development. For example, the student thinking noticed on the samples included items such as different strategies, evidence of mathematical errors with work scratched out or eraser marks, and use of multiple papers to show work. This showed a shift in Theresa and Francesca's instructional practice, which relates to teachers' pedagogical content knowledge, knowledge of the learners, strategies, and teaching practices (Ball et al., 2005; Ball et al., 2008; Shulman, 1986; 1987). The

student thinking on the artifacts was evidence of teachers' use of strategies and instructional practices that allowed for students to engage in cognitively demanding tasks in ways that were not evident prior to the professional development. This shift aligns with the findings of Candela and Boston (2022), who also identified shifts in their participants' practices after a professional development on the entire IQA toolkit. This growth in the implementation of cognitively demanding tasks can lead to better student opportunities and outcomes in learning mathematics (Darling-Hammond, 2010; NCTM, 2020).

Participants' Engagement

The task analysis alone is not the only indicator of the impact the professional development had on participants' identification and implementation of cognitively demanding tasks. My observations during the professional development series supported change as well. For example, during session five, participants were asked to bring one task and student work samples to help them reflect on their own task implementation. Theresa brought multiple tasks with student samples while Francesca brought one task. Theresa wanted to use the professional development as a time to reflect on more than one task and have a more solid understanding of how to use student work samples to reflect on how cognitively demanding tasks were implemented. This indicated that Theresa was not only engaging in the professional development, but she found value in the learning she was experiencing. This engagement in the professional development could have impacted the increase in her average in identifying and implementing cognitively demanding tasks. Francesca also brought a task with student samples, as required by the professional development, however she did not bring extra tasks and student samples to analyze and rate. This difference could be because both participants are in different grade levels and their daily schedule, structures, and time spent on mathematics differs. Theresa,

who teaches third grade, utilizes a 45 minute longer mathematics block in comparison to Francesca, who teaches fifth grade.

Barriers to Implementation

Participants shared, during the collaborative conversations and interviews, external factors they viewed as obstacles while trying to implement cognitively demanding tasks. External factors were shared in depth in chapter 4. An example is when Francesca shared that time in the classroom was a concern, that having the time for the students to engage deeply in the task might not be feasible. Based on conversations with the participants, time constraints were due to Pinnacle Elementary being part of the School Transformation Office (STO) Learning Community, which means that PLC meetings were held three times a week. STO personnel participated in these meetings, in which they set expectations and pacing of the CRM lessons. To better align with recommendations from *Catalyzing Change* (NCTM, 2020), schools and districts need to provide time for teachers to engage in extended mathematical inquiry and discussions. During the professional development sessions, when the participants were not being recorded, the topic of STO and CRMs arose. I noticed participants were more comfortable sharing their thoughts during that setting and minimal concerns were shared while the microphone was on. The one quote that was captured came from Theresa, who shared:

> Well, it's also hard to sometimes cause because we're at an STO school and the STO people have certain expectations of what we should be teaching and how they want us to teach it even if, in my opinion, it's not always what's best for the students in my classroom.

This indicated the impact STO had on the teachers' instructional decisions. Theresa shared that she knew that the methods or tasks were not best for her students' learning but based on her

comments, did not feel like she was able to adjust for the needs of her students. This further supports the literature on the distrust that develops between stakeholders and teachers, when teachers feel like their instruction is controlled (Paradis et al. 2019). This control was limiting her autonomy and may have impacted her pedagogy during her lessons. This supports the literature on teacher autonomy, which states that teacher autonomy is needed to enhance student learning opportunities through teacher creativity and ownership (Anderson, 1987; Paradis et al., 2019; Ramatlapana & Makonye, 2012). This highlights the impact STO had on the instruction during mathematics at this school site.

Additionally, concerns about the CRM mandates were mentioned by Francesca. She shared that she felt the CRM tasks were not always high cognitive demand tasks and seemed to be more focused on procedural thinking. Francesca stated, "I think when we looked back most of our [lesson plans they] were level 2." This statement highlighted the connection between content knowledge for teaching and identification of cognitively demanding tasks. She noted the difference between procedural and conceptual thinking. Though these were their comments about the CRMs, participants seemed hesitant to make the adjustments they felt were needed, even though they deemed a majority of the tasks as level 2 tasks, which have lower cognitive demand. Though having level 1 or 2 tasks should be part of the progression when learning mathematics, students also need to be engaged with tasks that reach a level 3 or 4, which allows students to problem solve, think about tasks critically, and make connections (Boston et al., 2019). Although administration and STO personnel were aware and approved of the professional development series, that did not seem to make a difference in the participants' decision to make the adjustments. This could be due to expectations and weekly walk throughs, which was shared during an informal conversation during session four of the professional development. Though

there were limited statements captured while recording related to the impact of STO and CRM mandates on the implementation of cognitively demanding tasks, the statements that were captured, along with the informal conversations, gave insight to the strength of the impact. The lack of recorded conversations indicated the perceived wariness participants had in the relationship with STO. This insight pointed to teachers feeling controlled when it came to implementing instructional decisions. Therefore, arming teachers with pedagogical content knowledge and content knowledge for teaching through professional development could boost confidence and teacher autonomy.

Professional Development Implications

The ability to share and discuss knowledge gained from the professional development would help other teachers with their instructional practices and impact the students' opportunities to engage with tasks that are at a higher cognitive demand. The aim of this professional development was to develop teachers' knowledge of and implementation of cognitively demanding tasks, while providing opportunities for teachers to evaluate and discuss student thinking (Boston et al., 2019; Darling-Hammond, 2010; Loucks-Horsley et al., 2010; NCTM, 2020). This growth in teachers' pedagogical content knowledge and content knowledge for teaching mathematics can create better opportunities for student learning (Darling-Hammond, 2010). This meets the goal from *Catalyzing Change* (NCTM, 2020) which states that students should have the opportunity to experience mathematics with higher cognitive demand, with teachers facilitating conceptual understanding and reasoning. This is best evidenced by the students' varied use of strategies on the post student artifacts.

Teachers should feel comfortable to share their thoughts and insights with colleagues during PLC's when making instructional decisions that can impact their classroom, even in an

STO setting. To help make teachers more comfortable, teachers should have opportunities to develop their pedagogical content knowledge and content knowledge for teaching mathematics. *Catalyzing Change* (NCTM, 2020) highlights the importance of elementary teachers developing deep mathematical thinking, as they often lack confidence and personal learning experiences with high cognitive demand tasks. This can be achieved through the use of the IQA and engagement in professional development, as seen in the conceptual framework in this study. Based on the analysis in this study and recommendations from *Catalyzing Change* (NCTM, 2020) and Loucks-Horsley et al. (2010), opportunities should be given to teachers to learn about student thinking and reflect on their instructional decision making and teaching. Participating in professional development on cognitively demanding tasks can empower participants to look more critically at the tasks in their curriculum materials. Armed with new knowledge, teachers would be prepared to adjust tasks to make the lessons more cognitively demanding.

The observations, discussions, and quotes discussed in chapter four and this section on themes regarding implementation relate to research question one. For example, research question one asked how the professional development impacted the identification and implementation of cognitively demanding tasks. Even though during the professional development participants shared their enthusiasm to learn and implement the concepts in the classroom, the influence of time, STO, and the CRM mandates may have impacted the participants' ability to effectively implement what was taught on high cognitive demand tasks. The statements and observations pointed to participants' hesitations to change given CRM tasks to raise the potential due to the time constraints and STO presence at Pinnacle Elementary.

Aspects of the Professional Development that Deepened Understanding

The purpose of the professional development was to enhance teachers' knowledge about cognitively demanding tasks and to impact their ability to use high cognitive demand tasks during mathematics instruction (Loucks-Horsley, 2010). I determined the aspects of the professional development that the participants found helpful to their understanding, which were beneficial resources and beneficial experiences. During the planning of the professional development, resources and experiences were designed with the context, in this case, the school site and learners in mind (Loucks-Horsley et al., 2010).

Resources for Building Teacher Practices

Participants indicated the resources they found beneficial during the professional development were the IQA Toolkit, curriculum tasks, and the use of a video lesson. Specifically, the use of the IQA Toolkit in conjunction with curriculum tasks and the video lesson, which aided in participants' understanding of cognitively demanding tasks. For example, participants used the IQA Rubrics as a guide to understand the cognitive demand of tasks, which were part of the planned curriculum or reflection while watching a video lesson. This supports the research from Candela and Boston (2022) that stated their participants found value in the use of videos during professional development. Using the video and IQA rubrics (Boston et al., 2019) paired with discussions, participants realized that doing mathematics was more about the process students engaged in while searching for the response, instead of just the accuracy of the answer (NCTM, 2020). This supports the *Catalyzing Change* (NCTM, 2020) statement "Implementing tasks well involves intentional planning to ensure the mathematical focus is on the sense-making process, and not just on finding solutions" (p. 66). Based on the conversations during the professional development sessions, the use of classroom curriculum tasks was also seen as

beneficial to participants, since they were able to bring back modified tasks and knowledge from the sessions to their classrooms. I intentionally planned for the tasks used in the professional development to be from the CRMs so participants would be familiar with the mathematics unit and content. Because participants found that a majority of the CRMs tasks were lower-level , specifically level 2 tasks, equipping teachers with the knowledge on how to adapt tasks to be more cognitively demanding helped them make adjustments that can build problem solving and reasoning in students (Boston et al., 2019; NCTM, 2020).

Immediate Professional Development Impacts

The literature suggests professional development should be ongoing (Darling-Hammond, 2010; Loucks-Horsley et al., 2010), and this study's professional development allowed for teachers to immediately enact learned practices in their classrooms. For example, Theresa noticed changes in student thinking after making changes to her own instructional practice throughout the professional development. These instructional changes were evident from the student artifacts provided by the participants. Students were given opportunities to engage in higher cognitive demand tasks. For example, the tasks from Theresa began as level 2 or 3 tasks at the beginning and at the end were level 4 tasks. Her students had the chance to engage in tasks that were at a higher cognitive demand. This could be seen with the differences in the student artifacts before and after the professional development. The tasks before the professional development had the answers with minimal work being shown. Whereas after the professional development, students used the paper to show their work and strategies, such as modeling, repeated addition, and using the distributive property of multiplication over addition. With these tasks, it became evident that students had a different experience because numbers were crossed out or erased as if the students were engaged in mathematical reasoning. These changes are

promising because the professional development was able to make an impact in a relatively short amount of time. This demonstrates that it is possible to see evidence of teachers implementing higher cognitive demand tasks as a result of participating in a five-session professional development, thus honoring the scheduling needs of teachers. These findings differ from the current literature on ongoing professional development (Darling-Hammond, 2010; Loucks-Horsley et al., 2010) by indicating a positive change in teacher practices after just five sessions.

Experiences that Deepen Understanding

Participants also shared the experiences that were beneficial, which were pacing of the activities, debriefing together, and having different grade levels represented in the PD sessions. Participants shared that having collaboration and viewpoints from different grade levels helped them to see the vertical alignment in mathematics instruction at Pinnacle Elementary. Professional development that allows participants opportunities to develop knowledge and skills, use methods similar to the classroom, and build the learning community are characteristics that can foster success (Birman et al., 2000; Garet et al., 2001; Loucks-Horsley et al., 2010; Loucks-Horsley et al., 1996). Participants' statements about debriefing together supports the literature that collaboration among teachers during a professional development, especially from the same department, can support each other's learning and teaching practices (Birman et al., 2000; Boston & Smith, 2011). Being from the same school and having the same student clientele, participants of a professional development can discuss the needs of the students among different classes and grade levels (Garet et al., 2001).

Based on the professional development literature, I chose strategies on how and what to implement to meet the intended goals of increasing participants' understanding of cognitively demanding tasks for my professional development. This supports the call to action from

Catalyzing Change (NCTM, 2020) on educators having professional development opportunities that focus on reflecting and enhancing teachers' pedagogical content knowledge and content knowledge for teaching. One intentional choice that I made was to allow time for participants to process the content taught and engage with their curriculum at their own pace. I planned for the participants to have the time to look through the tasks in their lessons at their pace, without telling them what day or what task to focus on, which is what regularly would happen in PLC's. The data from chapter 4 indicated how planning for the pacing of activities during the professional development benefited participants' understanding of cognitively demanding tasks. Another choice that I made was the decision to use the Potential of the Task and Implementation of the Task Rubrics from the IQA Toolkit (Boston et al., 2019) to provide opportunities for participants to develop and reflect on knowledge and skills related to cognitively demanding tasks.

Based on the two themes mentioned above, the intentional planning of the professional development aided in the participants' learning. This included using structures such as think-pair-share where participants were engaged in what I was sharing with them, and it allowed time for their voices to be heard. This allowed participants to experience the strategy and learning as a student would and they could take that strategy back to the classroom. Structuring the professional development where participants gained the perspective of a student learner encourages participants to mimic these instructional methods in their classrooms (Loucks-Horsley et al., 2010). Participants shared that the structure of the professional development allowed them to engage in the sessions and relate their learning back into their classrooms, which could strengthen their pedagogical content knowledge and content knowledge for teaching mathematics.

Practical Implications for Stakeholders

This dissertation revealed practical implications that should be considered for school stakeholders, such as teacher leaders, instructional coaches, and administrators. They have the opportunity to provide professional development to the instructional staff at their school sites. This supports the work of *Catalyzing Change* (NCTM, 2020), which advocates for ongoing professional development and support on children's mathematical thinking and content specific pedagogical practices. Based on the data analysis and discussion, it is important to allow time for teachers to reflect on and learn about their instructional practices. The IQA toolkit is a resource that can be used to impact teachers' pedagogy but also can be used as a reflection tool, especially reflecting on the implementation of high cognitive demand tasks. The Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019) allow for teachers to discuss and reflect on a tasks' cognitive potential and student reasoning while engaged in tasks. Designing professional development that focuses on the IQA Toolkit, with structures that foster learning, can help shift teachers' instructional practices (Boston et al.,2019; Loucks-Horsley et al., 2010).

As part of the implications of this study, I recommend that my school site participate in school wide professional development on cognitively demanding tasks. This study centered around two teachers, who were in third and fifth grades. It would be beneficial for more grade levels to experience and learn about cognitively demanding tasks through professional development. This would allow for further vertical alignment across grade levels and allow for more collaboration among teachers. This would be beneficial as more teachers would be aware of the cognitive demand of tasks and also be aware of how to adjust tasks to make them more cognitively demanding. This would provide more students opportunities to engage in thinking and reasoning about mathematics (Boston et al., 2019; Darling-Hammond, 2010; NCTM, 2020). Having more teachers engage in the same professional development would help the school

sustain teaching practices over a longer period of time (Darling-Hammond, 2010; Garet et al., 2001; Loucks-Horsley et al., 2010).

Limitations and Strengths

A limitation of my study is the focus on rating the implementation of the task based on student artifacts. This provided a limited view of the implementation of mathematical tasks in the classroom. To strengthen the research and provide a more well-rounded view of the implementation of the tasks, observations and video recordings can be used in conjunction with student artifacts to rate the implementation of the tasks. Another limitation of the study would be the number of participants. Having more participants could allow for more robust data as well as provide more collaborative opportunities for participants during the professional development sessions.

A strength of my study was obtaining more truthful responses from participants, due to the fact that I have a working relationship with the participants. Having this knowledge of the school setting and its teachers allowed me to cater the professional development to the needs of the teachers and students at my school. Being a teacher at Pinnacle Elementary gave me a personal relationship with the participants which allowed them to speak freely about the external factors that impacted their implementation of tasks. These conversations allowed me to find additional codes within the data that might not have been found without the relationship. Another strength was gaining the perspective of teachers who work in a Bureau of School Improvement (BSI) school. This perspective allows for a better understanding of the issues that may arise at Pinnacle Elementary, that may not arise in other school settings.

Additional strengths of this study included member checking the data, the design of the professional development, and using authentic classroom materials with the participants. Member checking allowed for the participants to be part of the data confirmation to ensure that there was no misinterpretation of what they intended to say. Member checking is an effective way to assess and ensure accuracy of the findings (Creswell, 2014). Additionally, I designed this professional development around the needs of our students and teachers at Pinnacle Elementary. This tailored approached ensured participants found value in the sessions. Part of the design process was the inclusion of authentic classroom materials. This followed the recommendations from Loucks-Horsley et al. (2010) and was valuable to the participants because they were able to reflect on the tasks being used in their lessons, as well as the implementation of the tasks. Participants were able to enhance their reflection because they could relate their learning to their teaching practices.

Recommendations for Future Research

This study provided insights and experiences of participants as they engaged in a professional development series on cognitively demanding tasks. Throughout this study, the IQA Toolkit was determined by the participants to be a beneficial tool to use for discussion and reflection. In this study, the focus was on the Potential of the Task and the Implementation of the Task Rubrics, which are the first two rubrics in the IQA Toolkit (Boston et al., 2019). I would suggest continuing research on the use of the IQA Toolkit in professional developments, extending into the other rubrics in the toolkit. The data from this study suggest that professional development centered around the Potential of the Task and Implementation of the Task Rubrics had a positive impact on teachers' identification and implementation of cognitively demanding tasks. Based on my findings, the use of the entire IQA Toolkit could also have a positive impact

on teachers' pedagogical content knowledge and content knowledge for teaching mathematics. This finding is also corroborated by research from Boston and Smith (2011), Boston and Candela (2019) and Candela and Boston (2022). Extending to the other rubrics is important because the Teacher's Questioning, Teacher's Linking, and Teacher's Press Rubrics (Boston et al., 2019) can help teachers further their understanding on the implementation of cognitively demanding tasks, which could impact teachers' pedagogical content knowledge and content knowledge for teaching. This increase in teachers' knowledge allows for opportunities for students to engage in problem solving through complex tasks (NCTM, 2020).

As part of the planned structure of the professional development, five sessions were created. The five sessions were centered around the Potential of the Task and Implementation of the Task Rubrics (Boston et al., 2019). While the participants showed positive increases in their implementation of cognitively demanding tasks, more time with the rubrics might have benefited the participants. Also, if integrating the entire IQA toolkit, which has five rubrics related to assessing teacher practices during instruction with cognitively demanding tasks, I suggest that the professional development series be longer, due to the multiple components included within the toolkit. This aligns with the recommendations of Darling-Hammond (2010) and Loucks-Horsley et al. (2019), which state that teachers benefit from professional development that is ongoing, and content focused.

The structure of the professional development was designed with the needs of Pinnacle Elementary students and teachers in mind. When replicating the professional development or study, it is suggested by Loucks-Horsley et al. (2019) that the four inputs are considered when designing a professional development. These inputs are 1. knowledge and beliefs, 2. context, 3. critical issues, and 4. strategies. When using these inputs, it is also suggested that modifications

be made to meet the needs for a specific school site. The culture and climate of the school can impact participants' learning, such as in this study. Since participants felt constricted on the use of curriculum, it would be interesting to see if findings would be different at other schools with less oversight.

Additionally, this study highlighted barriers participants encountered that may have impacted the outcome of the professional development and the implementation of cognitively demanding tasks. The barriers that potentially impacted the implementation of cognitively demanding tasks that were identified in this study, based on participants insights, were time constraints, STO presence, and CRM mandates. These barriers could be different for each school site. Therefore, further research is suggested to explore overcoming potential barriers to teachers' efforts in implementing high cognitive demand tasks.

Conclusion

Enhancing teachers' knowledge on mathematics content and instructional practices provides opportunities for students to engage in mathematical reasoning (Boston & Candela, 2018; Boston et al., 2019; Candela & Boston, 2022; NCTM, 2020). My study focused on the impact professional development had on participants' identification and implementation of cognitively demanding tasks. I also wanted to determine which aspects of the professional development were beneficial to participants' learning on cognitively demanding tasks. Instructional Quality Assessment (IQA) Rubrics (Boston et al., 2019) and thematic analysis were used to analyze the impact the professional development had on participants' identification and implementation of cognitively demanding tasks. The findings suggest that engaging in the professional development had a positive impact on participants' implementation of high cognitive demand tasks. The findings of the thematic analysis indicated that the design included

in this study benefited participants' learning. As a result, they changed their instructional practices and provided opportunities for students to engage in cognitively demanding tasks. Professional development focused on building teachers' pedagogical content knowledge and content knowledge for teaching enhances teachers' knowledge, and therefore impacts student opportunities. This aligns to the call to action in *Catalyzing Change* (2020), which aims to create equitable learning environments and mathematical opportunities for students.

APPENDIX A: IRB

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138, IRB00012110
Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

August 17, 2023

Dear Maria Porras:

On 8/17/2023, the IRB determined the following submission to be human subjects research that is exempt from regulation:

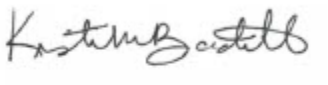
Type of Review:	Initial Study
Title:	The impacts of professional development on elementary mathematics teachers' implementation of cognitively demanding tasks
Investigator:	Maria Porras
IRB ID:	STUDY00005764
Funding:	None
Documents Reviewed:	• Faculty Advisor Review , Category: Faculty Research Approval; • 5. Principal_Letter_Porras.pdf, Category: HIPAA; • Consent Form , Category: Consent Form; • Debriefing Conversation Starters , Category: Interview / Focus Questions; • HRP 255 FORM Request for Exemption Porras, Category: IRB Protocol; • HRP-254 Explanation of Research , Category: Consent Form; • Instructional Quality Assessment (IQA) Implementation of the Task Rubric, Category: Test Instruments; • Instructional Quality Assessment (IQA) Potential of the Task Rubric, Category: Test Instruments; • Interview Protocol , Category: Interview / Focus Questions; • Recruitment Email, Category: Recruitment Materials; • Sample of Cognitively Demanding Tasks, Category: Other;

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please submit a modification request to the IRB. Guidance on submitting Modifications and Administrative Check-in is detailed in the

Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,



Kristin Badillo
Designated Reviewer

APPENDIX B: RECRUITMENT EMAIL

Dear Teacher,

I am writing to ask your help in a case study examining the effects professional development has on elementary mathematics teachers' task implementation.

You are being invited to participate in my research study because you are 18 and older and an intermediate teacher who teaches mathematics at [redacted] Elementary School during the 2023 to 2024 school year in which you will engage in a professional development geared towards cognitively demanding tasks, as well as collaborative conversations and interviews. The study has been approved by the [redacted] Office of Research & Evaluation, and by our principal, [redacted]. Results from the study will be used to understand the impact professional development can have in teachers' task implementation.

This process will have multiple parts. First, teachers will provide deidentified student artifacts prior to the professional development. Next, teachers will participate in 5 professional development sessions on cognitively demanding tasks. Teachers who participate in the professional development sessions will be expected to participate in collaborative conversations, following each session. Additionally, teachers will be asked to participate in a follow up interview about the experiences within the professional development. Lastly, teachers will be asked to supply new deidentified student artifacts that were implemented after the professional development series.

After I analyze the collaborative conversations and interview data, the data will only be reported as summaries in which no individual's answer can be identified. This is voluntary. No one will require you to participate. However, by participating in this study, you can help to shape professional developments and procedures affecting 3 to 5 mathematics instruction at [redacted] Elementary School.

If you have any questions or comments about this study, I would be happy to talk with you. My phone number is [redacted] or you can email me at [redacted].
Thank you very much for helping with this important study.

Sincerely,
Maria Porras, M.Ed.

APPENDIX C: INFORMED CONSENT

UNIVERSITY OF CENTRAL FLORIDA

EXPLANATION OF RESEARCH

Title of Project: The Impacts of Professional Development on Elementary Mathematics Teachers' Implementation of Cognitively Demanding Tasks

Principal Investigator: Maria Porras Monroy

Faculty Supervisors: Dr. Lisa Brooks

You are being invited to take part in a research study. Whether you take part is up to you. The purpose of this study is to understand the impact professional development could have on the implementation of cognitively demanding tasks during mathematics instruction in [redacted].

You are being asked to participate in a professional development series on cognitively demanding tasks, which is an additional professional development series and is part of the research. As part of the professional development you are being asked to provide deidentified student artifacts before and after the professional development. Deidentified student artifacts are task samples, mathematics problems from classroom assignments during whole group or small group, without student names. You will choose three different tasks that highlight student thinking to submit before and after the professional development series.

The professional development series will consist of five 45 – 60-minute sessions. During the professional development sessions, the researcher will present on cognitively demanding tasks and have teachers collaboratively work with tasks from the grade level lesson plans. This collaboration includes rating tasks, adjusting tasks, and rating the overall implementation of tasks. As part of the professional development session, you are being asked to participate in collaborative conversations, facilitated by the researcher, about the experience and learning in each session. Each of these collaborative conversations will be recorded through a digital voice recorder, transcribed through Otter.ai, and have all identifiers removed and stored separately.

Last, you are being asked to participate in a follow up interview that is expected to last 30-60 minutes. You may do so at a time and place that is mutually convenient for you and the interviewer, in person or via Zoom. The interview will be audio recorded and transcribed by Zoom.

The research study involves NO more than minimal risk. Your participation is voluntary and you free to withdraw consent at any time with no penalty.

Any individually identifiable information will be removed and your name will be replaced with a pseudonym. Nobody outside of the research team will know your identity and every effort will be made to protect your confidentiality. The student artifact, collaborative conversations, and interview data, with individual identifiers removed, will be stored for 5 years after study closure. All data will be stored on UCF OneDrive that is password protected for 5 years after study closure.

This study is being conducted as a dissertation requirement for the EdD Curriculum & Instruction program at UCF during the Fall of 2023 and Spring of 2024. Results from this study could be presented at a conference or turned into manuscripts submitted for publication. If publication occurs, I will use pseudonyms for the school and participants.

You must be 18 years of age or older and a third through fifth grade mathematics teacher at [redacted] located in [redacted] to take part in this research study.

If you have questions, concerns, or complaints please contact:

Maria Porras Monroy, [redacted], or by email at [redacted] or

Dr. Lisa Brooks, Dissertation Chair, [redacted], [redacted] or by email at [redacted]

IRB contact about your rights in this study or to report a complaint: If you have questions about your rights as a research participant, or have concerns about the conduct of this study, please contact Institutional Review Board (IRB), University of Central Florida, Office of Research, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901, or email irb@ucf.edu.

APPENDIX D: SESSION NOTES FORM

Session: _____ Topic: _____ Date: _____ Participants: _____

Activity	Description	Participant Actions	Participants Words

APPENDIX E: COLLABORATIVE CONVERSATION STARTERS

Professional Development Agenda with debriefing conversation starters

Week 1: What are cognitively demanding tasks?	Debriefing Collaborative Conversation - What have we learned about? - What are you still wondering? What else would you like to share about today's session?
Week 2: How can we raise the demand of tasks?	Debriefing Collaborative Conversation - What have we learned about revising tasks? - What are you still wondering? - What else would you like to share about today's session?
Week 3: How does task implementation affect cognitive demand? Part 1	Debriefing Collaborative Conversation - What have we learned about implementing tasks? - What are you still wondering? - What else would you like to share about today's session?
Week 4: How does task implementation affect cognitive demand? Part 2	Debriefing Collaborative Conversation - What have we learned about student evidences related to teacher practices during implementation? - What are you still wondering? - What else would you like to share about today's session?
Week 5: How does task implementation affect cognitive demand? Part 3	Debriefing Collaborative Conversation - What have we learned about cognitively demanding tasks? - What are you still wondering about when it comes to implementing cognitively demanding tasks in your classroom? - What is your biggest take away from the professional development series? - What else would you like to share?

APPENDIX F: INTERVIEW PROTOCOL

Interview Protocol

Main Questions	Additional Prompts	Data	Research Question
Please tell me about your teaching experiences at [redacted] Elementary.	- Years of teaching - Grade level or subject - Student population	- Ice Breaker - General Experience	N/A
Please tell me about your professional development experiences prior to these sessions.	- School wide PD's - District PD's - Quality of experience - Topics learned - Effectiveness	- Gauge personal experience on PD'S	N/A
What aspects of the professional development did you find most useful in understanding cognitively demanding tasks? Can you tell me your understanding of cognitively demanding tasks?	- Rating of the tasks - Adjusting of the tasks - Observation - Implementation of the task - Rubrics	- Experiences during the professional development - Parts of the PD that were effective for their understanding.	2
How did adjusting tasks from the [redacted] impact your implementation of mathematics instruction? How did practice raising the cognitive demand of tasks impact your learning? How did rating your own student sample impact your learning on the implementation of cognitively demanding tasks?	- Adjusting of the tasks - Implementation of the task	- Impacts of analyzing tasks - Adjusting tasks - Interacting with tasks	3
Is there anything else related to your experiences of the professional development that you would like to share with me?			N/A

Generally useful prompts and elicitations:

Silence: Pauses suggest to the interviewee that you want them to continue talking.

Seeking elaboration: 'What did you mean...?' or 'Can you give more detail...?'

Probing for details: 'Do you have any examples?' or 'Could you say more about...?'

Specifying questions: 'What happened when you said that?' or 'What did he say next?'

Reflecting meaning: 'Do you mean that...?' or 'Is it correct that...?

Reflecting emotion: 'You sound [emotion] when you say that?' or 'Is it correct that you feel [emotion]...?

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