AN INVESTIGATION OF RELATIONSHIPS BETWEEN ELEMENTARY TEACHERS' SKILLS FOR ANALYZING VIDEOS OF TEACHING AND SKILLS FOR LESSON PLANNING

by

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ABSTRACT

Designing a professional development program that supports teachers to improve multiple teaching skills is a complex endeavor. In this dissertation study, I outline an exploration of possible relationships between two teaching skills: analyzing videos of teaching and lesson planning. I used teacher noticing (van Es & Sherin, 2002; Sherin, 2017) as a framework to explain why these relationships might exist. To investigate this relationship, I used a subset of data from a research project that I was a part of for four years. The data included open-ended responses from participants to prompts that asked them to analyze video clips of teaching (other teachers' teaching) and to plan a lesson by interpreting written curriculum materials. Both quantitative and qualitative findings supported the use of teacher noticing as a broader construct that can be applied to multiple teaching skills. Correlation analyses revealed that there was a relationship between teachers' analysis of teaching video and lesson planning skills. Specifically, teachers' ability to describe the key mathematics in the video aligned with their lesson planning skills. I qualitatively described two cases that were around the trend line for these skills, and these cases tended to demonstrate the same teacher noticing dimension for both skills. I chose two additional cases as extreme cases to describe qualitatively, because they provided counterexamples to the trends in the sample; their open-ended answers showed an understanding of what the trend did not

look like. This study has implications for professional development designers and facilitators. When engaging teachers in professional learning, teachers would benefit from opportunities to make connections between multiple teaching skills to simultaneously support the improvement of multiple teaching skills. Finally, this study demonstrates how educational researchers can recognize interconnections between multiple teaching skills by using teacher noticing dimensions as a framework to interpret teaching skills, if relevant.

Chapter 1

INTRODUCTION

Teaching is a complex profession that requires enacting many skills all at once (Hirst, 1971). There are many professional development (PD) programs that aim to improve teaching practices and, ultimately, students' learning and thinking. However, given the complexity of the work of teaching, it is challenging to support teachers to improve their teaching skills in a single PD. Even though there is a large body of literature identifying ways to make PD programs more effective (Borko, 2004; Desimone, 2009; Garet et al., 2001; Kennedy, 2016), this study aims to contribute the current literature by investigating the connections between different teaching skills. If there are connections between skills for teaching, it might be possible to embed and improve multiple teaching skills in a single PD design by leveraging the connections between them. In other words, it might be possible to connect different teaching practices during PD, building upon one skill to improve another, instead of considering them to be separate tasks. Furthermore, as elementary school teachers have the challenge of becoming excellent at teaching multiple subjects, it is even more important for elementary school teachers to develop interconnected teaching skills.

The purpose of this study was to investigate whether and how skills for analyzing videos of teaching and skills for planning lessons relate, if at all. Then, it aimed to illustrate what these relationships looked like in certain cases of teachers' open-ended answers. This study focused on two important teaching skills: (1) analyzing videos of teaching, and (2) planning lessons. I focused on these two teaching skills because I interpreted that both skills could be situated in the teacher noticing framework (Choy et al., 2017; Sherin, 2017). If the processes of teacher noticing involve both skills, there might be ways in which these skills can relate to each other. Furthermore, both teaching skills (analyzing videos of teaching and planning lessons) have been found to be important for teachers to develop, as they have been identified as two indicators of quality of teaching and higher student achievement (Blömeke et al., 2015; Hiebert et al., 2017; Kersting 2008; Morris & Hiebert, 2017).

The construct of teacher noticing is based on focusing on student thinking and learning by using artifacts from the classroom such as video recordings, curriculum materials, and students' work, etc. (van Es, 2011). This focus on student thinking and learning promotes teaching and learning mathematics for conceptual understanding and subsequently, student achievement (Franke et al., 2007; Jacobs et al., 2010). Some may argue that teacher noticing is restricted to taking place in the moment, during teachers' interactions with their students (Sherin, 2017; Sherin et al., 2011; Weyers et al., 2023), and this might be the reason why most studies focus on teachers' analysis of classroom videos about teaching to capture teachers' noticing skills. Practicing noticing while watching a video of a lesson could have the potential to support teachers' noticing while teaching their own lessons. However, teacher noticing is not limited to the moments when teachers interact with students. Noticing also occurs when teachers prepare for and reflect on their teaching experiences (Sherin, 2017). In this study, teacher noticing is used as a broad construct that entails multiple types of teaching knowledge and skills to capture key mathematical ideas in the lesson and teaching moves that can promote or limit possible learning opportunities and interactions for students (including facilitating multiple strategies and representations as well as promoting questions and discussions).

Recent reviews of research have shown that most studies about teacher noticing focus mainly on pre-service teachers (Santagata et al., 2021; König et al., 2022; Weston & Amador, 2023), which suggests a need to examine in-service teachers' noticing further. Researchers who investigated pre-service teachers' noticing mostly incorporated artifacts from the classroom to focus their noticing as an intervention to improve pre-service teachers' ability to attend to noteworthy features of instruction and analyzed the relationships between teaching and student learning (König et al., 2022; Stockero et al., 2017; Stockero, 2021; Sun & van Es, 2015). On the other hand, in-service teachers' contexts, using artifacts from classrooms, such as video clips of teaching, and making an analysis for the purpose of improving teaching is a relatively rare practice, even though it can have multiple implications for in-service teachers' teaching practices (Sherin & Han, 2004; Kersting et al., 2008; Kersting et al., 2012). Developing analysis of teaching skills, such as using teaching videos as artifacts, might result in teachers to be more attentive in their lesson planning. This also might reflect on teacher' noticing skills in-the-moment of teaching (Sherin, 2002; van Es & Sherin, 2008), as teachers will anticipate and improve their lessons beforehand. In my study, I value the importance of teacher noticing in in-service teachers' contexts and try to investigate the transferability of teacher noticing skills into different teaching skills.

To investigate these ideas, I address the following research questions: (1) How do elementary teachers' analysis of teaching video skills relate to their lesson planning skills?, (1.a.) What relationships, if any, exist between teachers' ability to describe key mathematical ideas in a teaching video clip, (1.b.) teachers' ability to describe pedagogical teaching moves while analyzing a teaching video clip and teachers' lesson planning skills?, (1.c.) Among the relationships that were found between analysis of teaching video skills and lesson planning skills, what do teachers' responses to open-ended questions reveal about the nature of these relationships, in terms of what they look and sound like? I also explore the following research question that emerged, and caught my attention, after I conducted analyses for the initial research questions: (2) To what extent do teachers' lesson planning skills relate to their a) ability to describe key mathematical ideas in a teaching video clip, b) years of teaching experience?

By answering the first research question and its sub-questions, I sought to explore how elementary teachers' skills for analyzing videos of teaching and its sub-factors (mathematical description, and pedagogical description) related to their skills for lesson planning. I designed this analysis to focus on data from participants who had been minimally affected by professional learning. Additionally, I focused on data from participants that aligned with the same mathematical content (fractions) to minimize possible mathematical knowledge for teaching-related effects. Then, I seek to understand what these relationships looked like in certain cases of teachers' open-ended answers on the tasks the research team designed to assess these two teaching skills.

The analyses for the first research question and its sub-questions led me to a new investigation and a second, new research question. I identified two factors that I conjectured could have significant correlations with teachers' lesson planning scores: teachers' years of experience and ability to describe key mathematical ideas in the teaching video clip. With a second research question, I sought to understand to what extent these factors could predict teachers' lesson planning skills.

In the following chapter, I will explain how I define and interpret teacher noticing as a construct and skill. I will also elaborate upon dimensions of teacher noticing, as well as the factors that researchers take into account about teacher noticing when they assess and help teachers improve their noticing. I will define these dimensions and factors and explain how they were incorporated into rubrics, assessment tools, and/or the intervention designs that researchers used. Finally, I will review the literature for the two teaching skills I examined and how I incorporated the teacher noticing construct as a conceptual framework for this study.

Chapter 2

LITERATURE REVIEW

The goal of this chapter is to set the stage for framing the study and provide rationales for designing and conducting this study. This chapter also describes what the current literature says about two teaching skills that I use: (a) analysis of teaching videos and (b) lesson planning. Additionally, I describe findings from studies that investigate links between these two skills, although there are only a limited number of these studies, to reveal what is currently known and to situate my study's findings in the current literature.

Conceptual Framework

In this section, first, I will elaborate on the teacher noticing construct, including how it is defined by scholars and how it is interpreted and defined by me. This will set the stage for the conceptual framework for my dissertation study. Second, I will present the dimensions of teacher noticing that have been identified in this research literature and used by scholars, which also informed the analytical framework for my qualitative analysis. Then, I will present the factors that have been incorporated into rubrics, assessment tools, and/or intervention design by teacher noticing researchers, which also establishes the rationales for the task and rubric design of my study.

Teacher Noticing

Teacher noticing is considered to be a critical set of skills for teachers to have (Santagata et al., 2021; Sherin, 2017; van Es & Sherin, 2021; Weyers et al., 2023) because "it is at the crux of developing responsive interactions focused on students' ideas—capturing the invisible, moment by moment attention and sensemaking teachers engage in as they develop classrooms organized around student thinking" (p. 17, van Es & Sherin, 2021). However, authors of recent reviews of research have argued that what is meant by *teacher noticing* differs (Amador & Weston, 2024; Weyers at al. 2023; Weston & Amador, 2023), as there are many studies of teacher noticing (Scheiner, 2016). van Es and Sherin (2021). The researchers who created the Learning to Notice Framework (van Es & Sherin, 2002) upon which many scholars have built their teacher noticing studies, have also revised their initial thinking about teachers' noticing and acknowledged the value of extending the boundaries of the construct of teacher noticing.

Teacher noticing is broadly defined as "specialized ways in which teachers observe and make sense of classroom events and instructional details" (Choy & Dindyal, 2020). Some may argue that teacher noticing research primarily refers to what teachers notice during teaching (Sherin, 2017; Sherin et al., 2011; Weyers et al., 2023). However, the teacher noticing construct can apply to more than what teachers notice during the act of teaching or while examining teaching artifacts such as teaching video clips. Sherin (2017) explains the scope of teacher noticing as "we should not restrict our study of teacher noticing to moments in which teachers interact with students and that, instead, we should think of noticing as something that occurs when teachers prepare for and reflect on their teaching experiences" (p. 405). Choy et al. (2017) support this approach by stating:

> If teachers want to teach in a way that enhances students' reasoning, they may need to attend to relevant aspects of student thinking evidenced in classroom artifacts and students' explanations, and interpret them using a mathematical perspective before, during and after a lesson. (p.446)

The main claim behind these approaches is that teacher noticing is not restricted to in-the-moment (during teaching) noticing. It is also a skill that teachers can be prepared for using classroom artifacts such as classroom videos, curriculum materials, and student work.

Synthesizing these approaches and definitions of teacher noticing, I define *teacher noticing* as the ability to adapt instruction and guide instruction based on what teachers are able to notice and interpret about the noteworthy events of the classroom. I then situate teacher noticing in two mutually important contexts: analysis of artifacts from before teaching (lesson planning) and during teaching (analyzing videos of teaching). I use teacher noticing as a broader construct that includes both teachers' lesson planning skills that they use when they interpret written curriculum materials, and elementary teachers' analysis of teaching skills using mathematics teaching video clips.

Over the years, scholars created several constructs for core dimensions of noticing and analytic frameworks to either reinforce or examine teachers' noticing. These different conceptualizations lead to various terms for dimensions of teacher noticing: "perceiving/attending, interpreting/elaborating, proposing improvements/decision-making" (Scheiner, 2016, p. 229). There are also scholars who use these pairs of terms interchangeably (Santagata & Yeh, 2016).

There are many studies that unpack dimensions of teacher noticing somewhat differently but in parallel to one another (Santagata & Yeh, 2016; Scheiner, 2016). For example, van Es and Sherin (2002) propose three key aspects of noticing as "(a) identifying what is important or noteworthy about a classroom situation; (b) making connections between the specifics of classroom interactions and the broader principles of teaching and learning they represent; and (c) using what one knows about the context to reason about classroom interactions" (p. 573). Kaiser et al. (2015) proposed that teacher noticing consists of (a) perceiving particular events in an instructional setting, (b) interpreting the perceived activities in the classroom, and (c) decision-making, either as anticipating a response to students' activities or as proposing alternative instructional strategies (p. 374). Santagata and Yeh (2016) focused on (a) attend to the details of the teaching-learning process (such as student thinking, teacher questions, and math content); (b) elaborate on these details to examine the impact of teacher decisions on student progress towards lesson learning goals; and, (c) propose improvements in the form of alternative strategies teachers might adopt to enhance students' learning opportunities (p. 155). Finally, Amador and her colleagues (2017) framed curricular noticing as a group of interrelated skills: attending, interpreting, and deciding how to respond to curriculum materials.

When we consider these different terms and definitions for dimensions of teacher noticing, this study brings video noticing of enacted teaching and curricular noticing for lesson planning together and classifies teacher noticing under three dimensions: (1) attending, (2) interpreting, and (3) responding. For this study, *attending* refers to describing the details of the teaching-learning process such as identifying key mathematical ideas, identifying teaching moves that might affect students' learning opportunities, and conjecturing the possible key learning moments of the lesson. *Interpreting* refers to examining the impact of teacher decisions on student progress towards lesson learning goals, why the presented key mathematical idea is important for students to learn, and how students might respond to the mathematical tasks. Finally, *responding* refers to making suggestions for improvement to provide a more complete development of the key mathematical idea and more opportunities for students to learn. *Responding* also includes anticipating a response to students' activities and deciding how to respond based on students' understandings.

Even though there are different terms for dimensions of teacher noticing, there are common factors among how scholars approached and classified dimensions of teachers' noticing skills. The core common factor to classifying dimensions of teacher noticing is to look for what teachers attend to while noticing (van Es, 2011) which mainly can be listed as (1) Mathematics Content and (2) Pedagogical Teaching Moves. For example, Kaiser et al., (2015) specifically distinguished their TEDS-FU (follow up study of Teacher Education and Development Study in Mathematics [TEDS-M]) video assessment test items between mathematics and pedagogy.

First of all, the *mathematics content* factor of the content of teachers' noticing can be defined as participating teachers' ability to describe the mathematical content of the clip in their analysis (Kersting, 2008; Santagata et al., 2007). Examining teachers' ability to identify the big mathematical idea and student thinking was a common factor in many studies (Kersting et al., 2010; Kersting et al., 2012; Santagata et al., 2007; Santagata & Yeh, 2016). The level of description behind the conceptual aspect of the mathematics that is in the lesson and its importance to the students' learning and thinking is an important indicator of teachers' noticing skills. For example, Santagata et al., (2007) and Kersting (2008) used rubrics to specifically examine teachers' descriptions of mathematics content and student learning. According to Santagata et al., (2007), the full credit criteria for their mathematics content rubric were if teachers "included the discussion of strategies used by the teacher to teach specific mathematics content or of students' learning of specific mathematical ideas" (p. 135). From the lesson planning perspective, Choy et al., (2017) also used noticing as an analytic framework with the focus of identifying the key mathematical concepts of the lesson and anticipating students' thinking. In their model, the criteria for noticing skills during lesson planning were: being able to "identify specifics of the mathematical concept(s) for the lesson, recognise what students find difficult or confusing about the mathematical concept, analyse why students find the concept difficult or confusing, and analyse possible ways to address students' confusion when learning the concept" (p. 453). Therefore, being able to identify mathematics content and describe its importance for student thinking and learning is an important skill for teachers to have in both teaching video clip analysis and lesson planning contexts as this study applies.

Second, the *pedagogical teaching moves* factor of the content of teachers' noticing can be defined as participating teachers' ability to describe pedagogical teaching moves that might have an impact on student learning towards the learning goals of the lesson (Santagata & Yeh, 2016). Examining the level of ability to identify the pedagogical teaching moves and how these moves might have positive or limitational effect on students' learning opportunities is a common factor in many studies (Kersting, 2008; Santagata et al., 2007; Santagata & Yeh, 2016). According to van Es' (2011) framework for learning to notice student mathematical thinking, at the highest level (Level four - extended) of what teachers notice, teachers notice particular students' mathematical thinking, teachers' pedagogy, and the connection between teachers' pedagogies and student mathematical thinking. Similarly, Santagata & Yeh (2016) listed "elaborating on details to examine the impact of teacher decisions on student progress towards lesson learning goals" (p. 155) as one ability for the analysis of teaching. The importance of identifying pedagogical teaching moves and description of the possible relationships between these teaching moves and students' learning opportunities were also apparent in Santagata et al.'s (2007) critical approach rubric and Kersting's (2008) level of interpretation rubric, both of which were used to examine teachers' analysis of teaching video skills. This shows that being able to identify critical pedagogical teaching moves and discuss their possible impacts on student thinking and learning while analyzing a teaching video clip is an important skill for teachers to obtain. For this reason, this study includes *pedagogical teaching moves and their impacts on student thinking* in its rubric for understanding teachers' analysis of teaching video skills.

In addition to factors that focus on what to notice, providing *suggestions for improvement* was another common factor to classify dimensions of noticing among many studies. Providing suggestions for improvement is an indicator of building cause-effect relationships between teaching and learning that leads to making decisions regarding content and pedagogy in the teaching video clip (Amador et al., 2017; Santagata & Angelici, 2010). Providing suggestions for improvement usually refers to the *responding* dimension of noticing (Kaiser et al., 2015; Santagata & Yeh, 2016). Therefore, providing suggestions for improvement is considered to be the most extended level of noticing (van Es, 2011; van Es & Sherin, 2002). Furthermore, many studies included a rubric on providing suggestions or alternatives for improvement in their analysis of teaching measures (Kersting et al., 2010; Kersting et al., 2012; Santagata et al., 2007; Santagata & Yeh, 2016). Hence, this study also uses providing suggestions for improvement into its rubric for understanding teachers' analysis of teaching video skills.

There are different contexts in which teachers might use their noticing skills, such as before or during teaching. Therefore, this study investigates the relationships between two teaching skills—analysis of teaching in videos and lesson planning—using the teacher noticing construct. In the following paragraphs, I will present what existing research suggests about why these skills are important for teachers to have, the ways in which to examine these two teaching skills, and what they found in their analysis.

Background Literature

In this section, I will present the significance of the two teaching skills that I used: (a) analysis of teaching videos, and (b) lesson planning. After, I will elaborate on how previous studies assessed these skills, what they suggested to improve them, and what they found. Then, I will also describe findings from two studies that linked these two teaching skills in the pre-service teachers' context to later discuss later in conversation with the findings of this study. Finally, I will provide the background literature for an emergent factor identified during the analyses of the initial research question of this study: teachers' years of teaching experience. I found that this factor was also related to teachers' lesson planning skills.

Analysis of Teaching Video

One common form of understanding and supporting teachers' noticing skills is by engaging teachers in analysis of teaching through viewing video clips from real classrooms (Choy et al., 2017; van Es 2011). Analysis of teaching video refers to viewing a video clip of classroom teaching and describing how the teacher and the students interact around the mathematical content. Classroom videos can play a role in supporting teacher learning and influencing teachers' understanding of classroom interactions (Sherin & Han, 2004). This assessment measures teachers' abilities to notice certain aspects of classroom teaching and has been indicated to predict the quality of teaching and, consequently, student learning (Kersting, 2008; Kersting et al., 2010; Kersting et al., 2012). Theoretical arguments supporting the importance of teacher noticing, as well as empirical data that connect teachers' open-ended responses to classroom teaching video clips to both the quality of teaching and student thinking around mathematics, suggest that analyzing video clips of teaching evaluates significant teaching-related skills (Hiebert et al., 2017).

It is especially common to engage pre-service teachers in analyzing video clips in the context of pre-service teacher education to prepare pre-service teachers to work in real classrooms (e.g., Santagata et al., 2007; Hiebert et al., 2017). Many pre-service teacher studies use mathematics teaching video clips and frameworks for analyzing them as an intervention to support pre-service teachers' analysis of teaching video skills (e.g., van Es, 2011; Hiebert et al., 2007). Additionally, using video clips to understand in-service teachers' analysis of teaching video skills has been valuable and found to have important implications for teachers' classroom practices and students' learning (Kersting et al., 2010; Kersting et al., 2012).

Considering Kersting et al.'s (2010) approach on analysis of teaching video as teachers' usable content knowledge which contains teachers' abilities to analyze mathematical content, and pedagogical teaching moves that have impact on students' thinking and understanding in the context of a teaching situation, this study uses a similar approach for how to conceptualize teachers' analysis of teaching video skills. Therefore, instead of limiting the scope of analysis of teaching video skill as a proxy for during teaching practices this study defines analysis of teaching as a skill that teachers need to develop to attend, interpret, and respond to effective mathematics teaching practices even before getting into the classroom. This can prepare teachers for similar situations that they have noticed, analyzed, or discussed before. This is also one of the rationales for why this study conjectures that analysis of teaching video skill and lesson planning can be connected skills as they both aim to prepare teachers to be more efficient during teaching practices, and to promote student learning in the classroom.

Defining and specifying key constructs that will inform analysis for this study is important. To analyze participating teachers' analysis of teaching video skills, this study used teachers' abilities to *describe key mathematical ideas in the teaching video clip*, *describe pedagogical teaching moves*, and *provide suggestions for improvement* (Kersting et al., 2010; Santagata et al., 2007; Santagata & Yeh, 2016). All three factors have been previously used and analyzed in many studies to understand teachers' abilities to analyze teaching video (van Es & Sherin, 2002; Kaiser et al., 2015; Kersting et al., 2010; Santagata et al., 2007; Santagata & Angelici, 2010; Santagata & Yeh, 2016).

First, in this study, I focused on how teachers *describe key mathematical ideas in the teaching video clip* because this has been a process aligned with was one of the main factors in rubrics that were designed to measure teachers' analysis of teaching video skills (Kersting, 2008; Santagata et al., 2007; Santagata & Yeh, 2016). Scholars have typically used the term '*mathematics content'* for this factor, referring to the level to which teachers attend to the mathematical content of the clip in their analysis (Kersting, 2008; Santagata et al., 2007). Looking across these studies, I define *describing key mathematical ideas in a teaching video clip as* participating teachers' ability to articulate the important mathematics ideas in the lesson and explains why it is important in this lesson. Teachers are expected to describe the key mathematical idea in ways that go beyond the literal description of what happened in the video.

Second, I examined how teachers *describe pedagogical teaching moves*. This factor has been handled differently by many scholars. For example, Santagata et al., (2007) used the term '*critical approach*' and analyzed participating teachers' level of positive and negative judgment of teachers' moves in the clips and provision of rationales for these judgments. They leveraged describing limitational teaching moves and providing rationales for their evaluations over stating only positive judgements in their rubric, and this study used the same approach. Furthermore, van Es (2011) listed teachers' pedagogy as a feature of *what teachers attend to notice* and highlighted its importance. Kersting (2008) embedded attending to teachers' pedagogical moves into her *level of interpretation* rubric. Taking all these different adaptations of analyzing teachers' pedagogical moves together, it is clear that examining teachers' pedagogical moves and their impact on student learning towards the learning goals of the lesson is an important analysis skill for teachers (Santagata & Yeh, 2016). Looking across these studies, my definition for *describing pedagogical teaching moves* is participating teachers' ability to describe pedagogy in their own words with some positive or limitational teaching moves in terms of students' learning and/or participation opportunities.

Some studies use a separate rubric called *student thinking/learning* to analyze participating teachers' level of analysis of what students were thinking and understanding during the instruction (Kersting, 2008; Santagata et al., 2007). However, this study uses two factors: *describing key mathematical ideas in the teaching video clip* (mathematics content) and *describing pedagogical teaching moves* (pedagogical teaching moves), and embeds *student thinking/learning* into these rubrics as the highest level of analysis for both rubrics. For example, to reach the highest score for *describing key mathematical ideas in the teaching video clip,* it is expected that teachers will explain why this mathematical idea is important for students to learn, and how its lack of development might have generated students' confusion. Similarly, to reach the highest score for *describing pedagogical teaching moves* it is expected that teachers will describe how pedagogy shown in the video was limited in terms of students' opportunities to think carefully about the mathematics and/or participate in the discussion.

Finally, I investigated teachers' efforts to *provide suggestions for improvement,* which I define as participating teachers' ability to provide suggestions for how to improve the pedagogy and/or development of mathematics, which includes providing a rationale for why these suggestions would be helpful. This factor was considered as the most extended level of teacher noticing (van Es & Sherin, 2002; van Es, 2011) as it incorporates making connections between teaching and learning and proposing an alternative strategies to extend the learning opportunities for students (Santagata et al., 2007; Santagata & Angelici, 2010). Kersting (2010) leveraged providing suggestions that were connected to mathematics content over providing suggestions that were of a general pedagogical nature, and this study used the same approach.

Studies that considered the aforementioned three common factors—mathematics content, pedagogical teaching moves, and suggestions for improvement—in their rubrics found, using measures that they created, a potential to examine teachers' competence in noticing and analyzing teaching video clips. For example, Kersting's (2008) Classroom Video Analysis (CVA) assessment included four categories: (1) Mathematical Content, (2) Student Thinking/Understanding, (3) Alternative Teaching Strategies, and (4) Level of Interpretation. The third factor, proposing alternative teaching strategies, was found to be most highly associated with students' learning as mediated by the quality of participating teachers' instruction. Santagata and Yeh (2016) used Kersting's (2008) CVA to examine teachers' competence and found that this CVA measure had the potential for examining competence over time or changes in competence as a result of PD experiences. Their findings supported the importance of including teacher noticing dimensions in the conceptualization of teacher competence.

Similarly, Santagata et al., (2007) used five dimensions to assess pre-service teachers' lesson analyses: (1) Elaboration, (2) Mathematics Content, (3) Student Learning, (4) Critical Approach, and (5) Alternative Strategies. They aimed at measuring participants' ability to analyze teaching in a cause-effect manner by reflecting on both the student learning process and the mathematics content being taught with dimensions one to three. Dimensions four and five were intended as measures of participants' ability to critique, provide rationales for their opinions, and explain the effects of the proposed suggestions. They used this rubric to assess pre-service teachers' analysis of teaching video skills, and they found that after engaging with *A Lesson Analysis Course* intervention, pre-service teachers improved their analyses of teaching by moving from simple descriptions of what they observed to analyses focused on making connections between teacher actions and student learning as observed in the video. Van Es and Sherin (2002), using a similar framework—characterized in four levels—to identify a trajectory of development in learning to notice. They found that teachers could engage in analyzing videos of classroom lessons and, over time, move from descriptive responses to analytic responses.

Finally, Hiebert et al., (2007) proposed a framework for analyzing teaching under four skills: (1) Specify the Learning Goal(s) for the Instructional Episode, (2) Conduct Empirical Observations of Teaching and Learning, (3) Construct Hypotheses About the Effects of Teaching on Students' Learning, and (4) Use Analysis to Propose Improvements in Teaching. They connected these skills (except for the first one) with teacher noticing dimensions. They argued that when teachers engaged in attending, interpreting, and responding with specific student learning goals in mind, they learn from their teaching and thus improve their practices over time.

These studies provide rationales for the decisions made to create rubrics and define constructs for this study to examine teachers' analysis of teaching video clips. In this way, it could be possible to rigorously investigate teachers' abilities to analyze enacted teaching from video clips. The following sections will incorporate the current literature about lesson planning, and how teacher noticing could be used to integrate these two lines of teaching skills.

Lesson Planning

Most researchers study and support mathematics teachers' noticing by analyzing what teachers report that they observed from video clips of lessons. However, teacher noticing is not limited to teaching artifacts from enacted teaching in the classroom. It is critical for researchers to examine the role of noticing during lesson planning (Choy et al., 2017). Amador et al. (2017) described a *curricular noticing* construct and defined it as "how teachers make sense of the complexity of content and pedagogical opportunities in written or digital curricular materials" (p. 427). I used a similar approach and investigated teachers' abilities to describe the learning goal of the lesson, to describe the learning goal of the identified key learning moment of the lesson, and to anticipate students' thinking before and after the identified key learning moment of the lesson.

Stigler and Hiebert (1999) defined planning as the "premier teaching skill" (p.156) and it has long been considered a crucial skill for teachers (Blömeke et al., 2015; Cevikbas et al., 2023; Morris & Hiebert, 2017). Researchers have identified many important factors to consider in lesson planning (Cevikbas et al., 2023; Chen & Zhang, 2019; Little, 2003) because effective planning of teaching requires attention to "what to teach, how to represent it, how to question students about it and how to deal with problems or misunderstanding" (Shulman, 1986, p. 8). This study focused on teachers' abilities to describe the learning goal of the lesson, learning goal of the key learning moment of the lesson (that participating teachers identified), and anticipate students' thinking before and after the key learning moment of the lesson.

First, it is important to clarify what is meant by the learning goals of the lesson. Goals should be a detailed description of what mathematical concepts, ideas, or strategies students will understand as a result of teaching practices as well as the mathematical practices that students will use more proficiently (NCTM, 2014). Posing one of the Common Core Standards for Mathematics (CCSSM, 2010) as a learning goal is usually too general to guide planning or make teaching-related decisions. The grain size of the learning goal needs to be specific enough to be achieved in one lesson. Furthermore, learning goals should go beyond a performance goal, or "students will be able to" (SWBAT) format, and provide insight into the mathematical understanding that students will develop during the lesson (Smith & Stein, 2018). Spitzer and Phelps-Gregory (2017) made an important distinction between mathematical learning goals and objectives or standards:

> Mathematical learning goals are statements of the mathematical content that students should learn in a lesson. They are similar to objectives in that they describe the outcomes of a lesson but different in that they do not need to be directly measurable and describe particular mathematical thinking rather than behavioral or observable student outcomes. (p. 306)

I used a similar approach as Spitzer and Phelps-Gregory's (2017) definition for mathematical learning goals to define *describing learning goal of the lesson.* I define *describing learning goal of the lesson* as providing detailed description of the conceptual aspect of the lesson, such as the conceptual advance or breakthrough students might achieve or the understanding they will take away at the end of the lesson.

Setting clear learning goals for what is expected from students to learn at the end of the lesson is the foundational element of intentional and effective mathematics teaching practices (NCTM, 2014; Smith & Stein, 2018). Explicit identification of learning goals for students is the premier step to plan effective conditions for students' learning because it sets the stage to identify what students should know and be able to do at the end of a lesson (Hiebert & Grouws, 2007). Hiebert and his colleagues (2007) explained the importance of learning goals of the lesson as:

> Without explicit learning goals, it is difficult to know what counts as evidence of students' learning, how students' learning can be linked to particular instructional activities, and how to revise instruction to facilitate students' learning more effectively. Formulating clear, explicit learning goals sets the stage for everything else. (p.51)

Specifying precise mathematical learning goals has importance for many aspects of teaching, including selecting appropriate tasks, representations, and questions to elaborate students' thinking (Smith & Stein, 2018) and improving the effectiveness of teaching over time (Hiebert et al., 2007). Therefore, explicitly identified learning goals can guide teachers to provide a clear target for discussion, helping the teacher decide which solutions to highlight and what questions to ask about the solutions (Smith & Stein, 2018, p. 19).

Second, both (a) identifying key learning moments of the lesson and (b) identifying the learning goal aligned with that key moment have potential to contribute in important ways to mathematics teaching and learning (Hiebert & Stigler, 2023; Leatham et al., 2015; Stockero & van Zoest, 2013; Yang & Ricks, 2012). There are a variety of terms and definitions to define these moments (Leatham et al., 2015). For example, Stockero and van Zoest (2013) used the term '*pivotal teaching moment*' and defined it as "an instance in a classroom lesson in which an interruption in the flow of the lesson provides the teacher an opportunity to modify instruction in order to extend or change the nature of students' mathematical understanding" (p. 127). According to Leatham et al.'s (2015) MOST (Mathematically Significant Pedagogical Opportunities to Build on Student Thinking) framework, these moments are defined as "instances of student thinking that have considerable potential at a given moment to become the object of rich discussion about important mathematical ideas" (p.90). Looking across different conceptualizations of these moments, my definition of a key learning moment is a cornerstone experience that supports the students to reach the learning goal of the lesson. In the context of professional learning, key learning moments are described as those in which students engage with a critical task that can be challenging for them. However, teachers may identify other moments as key as well. Then, I define *describing learning goal of the identified key learning moment of the lesson* as participating teachers' ability to provide detailed description of the conceptual aspect of the key learning moment that they identify as well as the conceptual advance or breakthrough students might achieve, or the understanding they will take away after this moment. This learning goal aligns with a key moment in a lesson is more specific than the learning goal of a lesson.

Even though there are multiple terms and definitions available for these moments (Leatham et al.,2015; Stockero & Van Zoest, 2013), literature suggests that these moments have a potential to contribute in important ways to mathematics teaching and learning (Leatham et al., 2015). Expert teachers and teacher educators often recognize when important mathematical moments occur during a lesson (Leatham et al.,2015; Stockero & van Zoest, 2013). However, it may be possible to conjecture these moments before they even occur. This calls attention to analyzing teachers' ability to anticipate the key learning moments of the lesson and the learning goal of these moments while they engage in lesson planning.

Choy (2014) suggested that most researchers study mathematics teacher noticing by examining what teachers observe from mathematics teaching video clips. However, he extended the noticing construct by investigating what mathematics teachers notice during the planning of mathematics lessons. He used Yang and Ricks' (2013) three-point framework—key point; difficult point; and critical point—to analyze teachers' lesson plans. According to Yang and Ricks' (2013) three-point framework, "the *key point* refers to the central objective of the lesson for which the lesson is constructed"; "the *difficult point* refers to cognitive difficulty that the students might encounter as they try to learn the mathematical key point"; the *critical point* refers to "teacher's consideration of how to help students navigate the mathematical terrain, to eventually reach the instructional objectives while avoiding or overcoming the pitfalls that might arise (the difficult point)" (p.43). Similarly, Choy and his colleagues (2017) based their FOCUS framework for planning the lesson on Yang and Ricks' (2013) framework. They used five elements in their FOCUS framework for planning the lesson:

> 1. Identifies specifics of the mathematical concept(s) for the lesson;
> 2. Recognises what students may find difficult or confusing about the concept;
> 3. Analyses why students might find the concept difficult or confusing;
> 4. Analyses possible ways to address students' confusion about the concept;
> 5. Develops and implements a high-level cognitive demand task to target students' potential confusion about a concept. (p. 452)

These elements incorporates (a) the importance of identifying the key mathematical concept of the lesson to be able narrow down the focus of the lesson, (b) the key learning moments for students that might be challenging and confusing but potentially lead to learning opportunities for students to understand key concept, and (c) anticipating students' thinking about the possible confusions, and coming up with a plan to address these misunderstanding. These elements were also embedded in this study's lesson planning task and the rubric.

Looking across these frameworks, it is possible to argue that although Yang and Rick's (2013) definition of *key point* implies the importance of identifying learning goals of the lesson, his *difficult point* implies key learning moments of the lesson for students. Besides, Yang and Rick's (2013) proposed that being able to clearly identify and anticipate this *difficult point* helps Chinese teachers to plan lessons to go beyond transferring the content knowledge to students but helps to elaborate students' thinking.

Finally, anticipating students' thinking is an important factor to analyze teachers' lesson planning skills (NCTM, 2014; Smith et al., 2008; Smith & Stein, 2018). Hiebert and Stigler (2023) proposed that "thoughtful planning of a lesson necessarily involves anticipating how students will respond to particular instructional tasks" (p.40). According to Smith and Stein (2018), anticipating includes "what strategies students are likely to use to approach or solve a challenging mathematical task (e.g., a high-level task), and how to respond to the work that students are likely to produce" (p.41). I applied Smith and Stein's (2018) steps for anticipating in my definition of *anticipating students' thinking before and after the identified key learning moment of the lesson.* Therefore, the process of anticipating students' thinking refers to teachers' ability to describe student thinking completely and precisely before the key learning moment and after the key learning moment. By completely and precisely, I mean that the description of student thinking is descriptive enough to suggest (to another teacher) what might be done instructionally to help correct a lack of understanding or misconception. In other words, the description needs to be detailed enough to suggest implications for what could have been done instructionally to move students from a lack of understanding before the key learning moment to a stronger understanding after the moment.

Anticipating what students might think before and after the key learning moment helps teachers be more prepared to overcome possible lack of understanding or misconceptions (Smith et al., 2008; Smith & Stein, 2018). This refers back to Choy et al.'s (2017) third and fourth elements in their FOCUS framework. Anticipating student thinking in the planning process guides teachers to bring up what kind of solutions they want to share in front of the whole class to accomplish their learning goals for the lesson (Smith & Stein, 2018).

Noticing students' mathematical thinking is a key element of effective mathematics teaching (Jacobs et al., 2010; Stockero et al., 2017). However, one could argue that anticipating students' thinking during lesson planning can be a catalyst for noticing students' mathematical thinking during teaching. In their review article, Cevikbas et al., (2023) found anticipating students' thinking to be one of teachers' biggest difficulties in lesson planning. Anticipating student thinking is a skill that is important in the planning phase, and it is also a step to come up with questions that teachers will ask students to uncover what students understand and direct them toward the goal of the lesson. Even if it is not possible to anticipate everything that might occur in the classroom, whatever the teacher can predict in advance of the lesson can be helpful in recognizing and understanding students' thinking during the lesson (Smith & Stein, 2018).

Integrating Two Lines of Teaching Skills

This study aligns with research on teacher noticing in two ways: (a) what teachers notice in video clips of mathematics teaching and (b) what teachers notice in their curriculum materials when planning lessons. As it was discussed earlier, teacher noticing is not limited to analysis of enacted teaching video. Teacher noticing is also applicable to lesson planning (Choy et al., 2017). Amador et al., (2017) framed curricular noticing as “a set of interrelated skills including attending, interpreting, and deciding how to respond to curriculum materials” (p. 428). *Attending, interpreting, and responding* skills are the dimensions of teacher noticing that are also used in analysis of teaching video context. This implies that the same teacher noticing dimensions can be transferable in different contexts. Therefore, this study is situated around the transferability of the noticing construct from the analysis of teaching video to the analysis of curriculum materials for planning a lesson.

Some studies have examined analysis of teaching video and lesson planning skills with pre-service teachers’ context and found relationships between them. For example, Taylan (2018) investigated the relationships between pre-service teachers’ lesson analysis and lesson planning skills. She found that pre-service teachers’ lesson analysis scores were significantly and positively correlated with scores on a lesson planning task focused on student thinking. Taylan’s (2018) study indicated that pre-service teachers who had intermediate and advanced lesson analysis skills for focusing on student thinking performed better in preparing a lesson plan protocol with a focus on student thinking. In another context, Santagata et al., (2007) used a lesson planning task to measure the impact of analysis of teaching video intervention. They found that preservice teachers’ planning tasks revealed an overall understanding of the advantages of reflection and lesson analysis. More specifically, participating pre-service teachers' lesson plans showed an effort to make student learning goals explicit, included prediction of students' behavior and mistakes, and planned for alternative strategies for addressing students' difficulties. These studies set a baseline for the possible transferability between these two teaching skills for pre-service teachers' context. In my study, I investigated this relationship for in-service teachers' context.

Teachers' Years of Teaching Experience

Teachers' years of teaching experience is demographic information that interests educational researchers (Podolsky et al., 2019). In case studies, teachers' previous experiences are taken into consideration in findings (i.e. van Es & Sherin, 2008; van Es & Sherin, 2010). For a quantitative study, teachers' years of teaching experience are sometimes used as grouping criteria (ie., Jacobs et al., 2010). However, evidence on the extent to which teachers' years of teaching experience are associated with their level of expertise is controversial. For example, there are studies that investigate relationships between teachers' years of experience and quality of teaching (Graham et al., 2020), and studies that investigate relationships between teacher effectiveness and/or student achievement (Podolsky et al., 2019). In a review of 30 studies that examined the effects of teaching experience on student achievement, Podolsky et al. (2019) found that 28 of these studies concluded that teaching experience is positively and significantly associated with teacher effectiveness (measured by standardized test scores of students). On the other hand, Graham et al., (2020) found no evidence of lower teaching quality for beginning teachers in their study. This is why it is important to break apart concepts such as quality of teaching and teacher effectiveness into more specific teaching practices. Decomposition of the construct of effective teaching could help to identify relationships between specific teaching practices and teachers' years of teaching experience.

In teacher noticing research, there are studies that make distinctions between novice versus expert teachers regarding their abilities to notice noteworthy events of the classroom (i.e. Konig et al., 2022; Santagata & Angelici, 2010; Santagata et al., 2021; Stockero and van Zoest, 2013). Teachers may engage in noticing differently because teachers can see classrooms through different lenses depending on their teaching knowledge, beliefs (Kersting, 2008; Santagata & Yeh, 2016), experiences, cultural backgrounds, and so on (Jacobs et al., 2010). For example, expert teachers utilize evidence of student learning or difficulties to guide their decisions on which instructional strategies to implement moving forward. They can better perceive and interpret key moments of the lesson that they think affect achieving the key learning goals of the lesson (van Es, 2011; Kersting, 2008; Santagata & Angelici, 2010).

Many of these studies do not use "expert" as a synonym for teacher with many years of teaching experience. Rather, they define expertise as being better at using evidence of student learning or students' struggles to make instructional decisions (Santagata & Angelici, 2010). However, there are also studies that included having at least a certain amount of teaching experience in their definition for teachers' expertise (Konig et al., 2022). For this study, I aim to explore to what extent teachers' years of teaching experience could be related to their lesson planning skills. I make an underlying assumption that teachers with more years of teaching experience would already be better at the analysis of teaching videos. Consequently, having learned to analyze their teaching over time would then explain why it is possible that more experienced teachers might have higher scores on the lesson planning task.

As part of my assumption, there are studies that have suggested, with more experience in the classroom, teachers' noticing of students' mathematical thinking can improve (Stockero et al., 2021). For example, in their study of comparing between the noticing of teachers with different levels of experience, Huang and Li (2012) found that experienced teachers were more skilled at paying attention to develop mathematical thinking and ability in the classroom. Similarly, Jacobs et al. (2010) grouped teachers according to four different levels of experience of teachers and found that teaching experience by itself can support the development of *attending* and *interpreting* skills to some degree. In line with this finding, Konig et al. (2015) found teachers' skills at interpreting videos of teaching could be predicted by their amount of time they spent on teaching relative to their overall working time.

On the other hand, Leatham et al. (2015) observed many teachers and discovered that novice teachers, especially those who had less experience and knowledge to draw on as they make their decisions. Specifically, novice teachers tended to approach all student thinking as worth pursuing further during instruction. However, they claimed that even though teachers need to carefully listen to all students' ideas, among all the students' ideas, teachers need to identify the ones that might create more learning opportunities for students to pursue in the limited amount of instruction time. This means that teacher experience makes a difference in identifying these moments or student ideas as what they call *MOST*. Similarly, Stockero and van Zoest (2013) argues that novice teachers often fail to notice or act upon such moments. Considering that the learning goal aligned with the (identified) key learning moment of the lesson and anticipating students' thinking before and after these moments are two of three factors that forms my lesson planning task, it is reasonable to conjecture that teachers with more years of teaching experience would be more likely to score higher on the lesson planning task.

The Current Study

The purpose of this study was to explore the possible relationships between two teaching skills: analysis of teaching video and lesson planning. I proposed a teacher noticing framework to examine teachers' analysis of teaching and lesson planning skills and reveal how these skills might mutually be the indicators for the other (Kurutas, 2025). I also used teachers' open-ended answers to tasks designed to measure these two teaching skills to illustrate what these relationships look like in a qualitative analysis. Based on my findings from these analyses, I examined to what extent the factors which found to be associated with teachers' lesson planning—teachers' mathematical description of the teaching video clip, and teachers' years of teaching experience—predict teachers' lesson planning skills.

Figure 1 situates this study's factors for examining teachers' analysis of teaching video and lesson planning skills in prior research on teacher noticing. Even though teacher noticing dimensions are not the primary focus of this research, it is important to remember that the *providing suggestions for improvement* factor corresponds with the *responding* level of teacher noticing dimensions, which is considered to be the highest level of noticing (Kaiser et al., 2015). Additionally, there might be relationships between teacher noticing dimensions in two teaching skills contexts: analysis of teaching video and lesson planning. Figure 1 shows how skills for analyzing teaching in videos and skills for lesson planning align with teacher noticing dimensions. It also categorizes each factor according to whether teachers are attending to either: (a) mathematics or (b) pedagogy. For lesson planning, factors that are used in this study are specific to teachers' abilities to (a) attend to the conceptual aspects of mathematics in the lesson rather than solely the procedural aspects and (b) anticipate student thinking rather than attending to pedagogical aspects of the lesson.

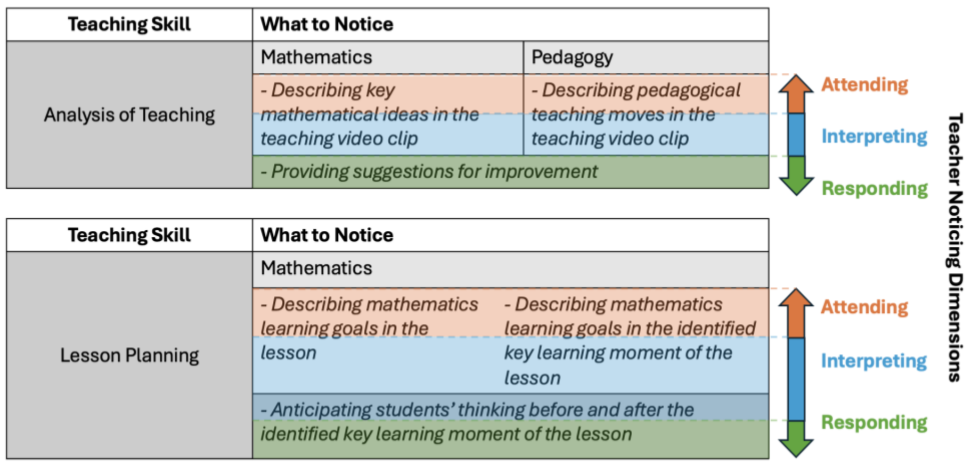

Figure 1 Situating Factors to Examine Teachers' Analysis of Teaching Video and Lesson Planning Skills in Teacher Noticing Framework

Figure 2 summarizes possible correlations between this study's factors to examine teachers' analysis of teaching video and lesson planning skills, as well as how they align with the teachers' noticing construct. My first and overall conjecture was that there might be an overall relationship between teachers' analysis of teaching video and lesson planning using written curriculum materials because factors from both skills can fall under the same teacher noticing dimension (see Figure 1).

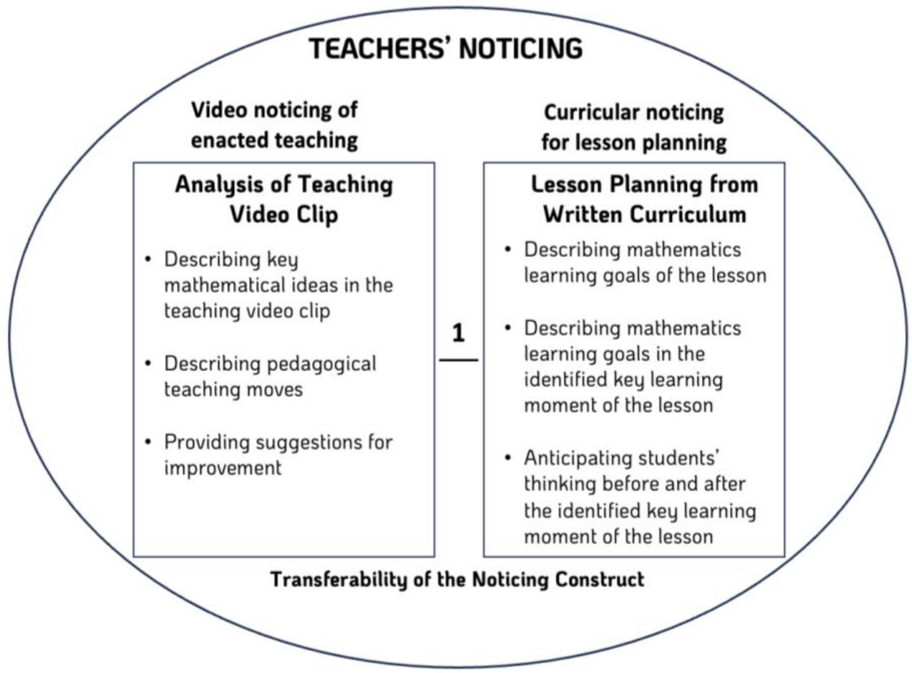

Figure 2 Conjecture 1: Conceptual Framework Linking Teachers' Analysis of Teaching Video Skills and Lesson Planning Skills

Note. The "1" in the figure refers to the ideas in the figure as representing my first conjecture.

Making an attentive analysis of video of teaching gives teachers a chance to realize, take a critical stance, and develop ways to improve classroom interactions and address missed learning opportunities for students and mathematics during the lesson. In my study, I used three factors—describing key mathematical ideas in the teaching video clip, describing pedagogical teaching moves, and providing suggestions for improvement—to examine teachers' analysis of teaching video skills. All three factors have previously been used and found to be important aspects of teaching and making a thorough analysis of these aspects can be an indicator of high-quality teaching. For example, Kersting et al., (2012) used the Classroom Video Analysis (CVA) assessment, which includes four categories: (1) Mathematical Content, (2) Student Thinking/Understanding, (3) Alternative Teaching Strategies, and (4) Level of Interpretation and found that teachers' performance on the CVA was positively related to their students' learning as mediated by the quality of their instruction. Simultaneously, lesson planning requires similar skills, such as identifying the key mathematics learning goals of the lesson to maintain the focus of the lesson on the learning goal. It also requires predicting possible key learning moments for students in the lesson to come up with a plan to manage these moments, including anticipating students' thinking and responses, creating discussion groups, developing probing questions to unearth students' thinking, or being prepared to enable students to use multiple strategies or representations to show their thinking. Besides, planning is one of the key steps in high-quality teaching (Stigler & Hiebert, 1999). This suggests that, if stronger skills for analyzing a video of teaching can predict high-quality instruction and if planning is an important part of the instruction, there might be relationships between teachers' analysis of teaching video and lesson planning skills. Therefore, my first hypothesis was that there would be a relationship between teachers' scores on the analysis of teaching video and lesson planning tasks. In other words, teachers who had higher scores on analysis of teaching video tasks would also have higher scores on lesson planning tasks because they would be more attentive to classroom interactions and mathematics in the lesson.

Further, Figure 3 represents the other two conjectures that arose related to sub-factors of analysis of teaching video. So, my second hypothesis was that there might be an even stronger relationship between teachers' ability to describe key mathematical ideas in the teaching video clip and lesson planning using written curriculum, because all four factors—describing the key mathematical ideas in the teaching video clip (analysis of teaching), describing the learning goal of the lesson (lesson planning), describing the learning goal of the identified key learning moment of the lesson (lesson planning), and anticipating students' thinking before and after this key learning moment (lesson planning)—are about the *mathematics content* and *student thinking/learning* factors, which were previously used in the literature to analyze teachers' noticing skills.

The first factor that this study used to analyze teachers' analysis of teaching videos is their level of description of key mathematical ideas in the teaching video clip. Analysis of teaching by using video recordings from classrooms has been a medium for especially pre-service teachers to gain experience in noticing noteworthy events in the classroom (Hiebert et al., 2007; Santagata et al., 2007; Santagata & Angelici, 2010). These researchers have developed different frameworks to analyze teaching (e.g., Lesson Analysis Framework, Video Analysis Support Tool), and one of the key elements in all these frameworks is identifying the learning goals in the teaching video. Identifying and setting clear learning goals for what is expected from students at the end of the lesson is the foundational element of intentional and effective mathematics teaching practices (NCTM, 2014). This skill is highly connected to the concept of teachers' description of the mathematics learning goal of the lesson they teach (in the lesson planning task of this study). This is because even in a short video clip, if teachers can identify the key mathematical idea in the clip, then they can better identify the key mathematical idea and key learning moment in their lessons while they are planning. This will allow them to keep their classroom discussions and learning centered around the key mathematical idea that teachers expect all students to learn at the end of the lesson. Furthermore, if teachers are more skilled at explaining why the key mathematical idea they identified in the teaching video clip is important for students to learn (or how its lack of development can cause misconceptions or lower student learning), then they would also be better at anticipating their students' thinking before and after these moments in their lesson planning.

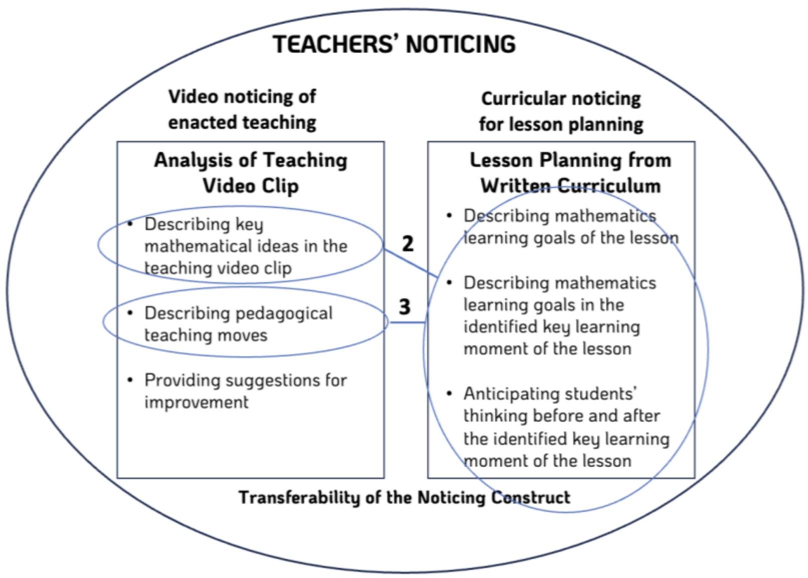

Figure 3 Conjecture 2 and 3: Linking Specific Factors of Teachers' Analysis of Teaching Video Skills and Lesson Planning Skills

Note. The "2" and "3" in the figure refer to the ideas in the figure as representing my second and third conjectures, respectively.

Second, I conjectured that there might be possible correlations between (a) teachers' ability to describe pedagogical teaching moves in the teaching video clip and (b) plan a lesson using written curriculum materials. But I also thought that this correlation might not be as strong as the correlation with teachers' ability to describe key mathematical ideas in the teaching video clip, because the lesson planning task did not account for the factors that were aligned with the pedagogical aspects of the lesson. However, I still conjectured that there might be transferability between the different domains of what to notice—mathematics and pedagogy—across the teaching skills. The second factor that this study used to analyze teachers' analysis of teaching videos is their level of description of pedagogical moves that teachers use in the teaching video clip, including both positive and limitational pedagogy that might probe or limit students' learning and/or participation opportunities. Researchers who developed frameworks to analyze teaching also elicited teachers' interpretations of the influence of teacher moves and decisions on students' thinking (van Es & Sherin, 2002; Hiebert et al., 2007; Santagata et al., 2007; Santagata & Angelici, 2010). These are opportunities for teachers to think about their and other teachers' taken-for-granted ways of using teaching practices, and to observe how different teachers' practices reflect on students' learning opportunities in the teaching video clip. Therefore, I conjectured that developing the skill of describing pedagogical moves in the teaching video clip can enable teachers to anticipate their students' thinking and responses better, and consequently, they may be more attentive in their lesson planning to providing pedagogically rich learning opportunities for their students even though this was not the focus of the lesson planning task.

Initially, this study was also intended to look at the correlations between teachers' ability to provide suggestions for improvement for the teaching video clip and their lesson planning skills, but because there was only one instance of one teacher providing a brief suggestion for improvement, this sub-research question is removed from the study. Instead, I qualitatively examined how that participant provided suggestions for improvement. Finally, a new investigation was added to this dissertation study after conducting analyses to test the first three hypotheses and after examining these relationships qualitatively. Through my qualitative analysis, I began to wonder whether teachers' lesson planning skills were associated with teachers' years of teaching experience and teachers' mathematical descriptions of teaching in a video. Therefore, I conjectured that these factors might be the factors that can highly predict teachers' lesson planning scores and decided to investigate them through another research question.

Research Questions

By conducting this dissertation, I hope to better understand whether and how in-service elementary teachers' analysis of teaching video skills relates to their lesson planning skills. Findings from this study may shed light on whether and how different teaching skills might mutually support the improvement of the other, which can inform PD designers to be more attentive to connecting teachers' noticing skills for before and during teaching artifacts and supporting their development. In this study, I investigated the following research questions:

1. How do elementary teachers' analysis of teaching video skills relate to their lesson planning skills?
    a. What relationships, if any, exist between teachers' ability to describe key mathematical ideas in a teaching video clip and teachers' lesson planning skills?
    b. What relationships, if any, exist between teachers' ability to describe pedagogical teaching moves while analyzing a teaching video clip and teachers' lesson planning skills?

c. Among the relationships that were found between analysis of teaching video skills and lesson planning skills, what do teachers' responses to open-ended questions reveal about the nature of these relationships, in terms of what they look and sound like?

2. To what extent do teachers' lesson planning skills relate to their a) ability to describe key mathematical ideas in a teaching video clip and b) years of teaching experience?

Chapter 3

METHODS

The purpose of this study is to explore and describe relationships between elementary teachers' analysis of teaching video (describing key mathematical ideas in the teaching video clip, describing pedagogical teaching moves, and providing suggestions for improvement) and lesson planning skills (describing learning goal of the lesson, describing learning goal of the identified key learning moment of the lesson, and anticipating students' thinking before and after the identified key learning moment of the lesson). Mixed methods research design is well suited for this study because both qualitative and quantitative analysis can help better understand the relationships between these two teaching skills (Creswell & Clark, 2017). Furthermore, most empirical studies on teacher noticing use qualitative approaches to explain the nature and development of teachers' noticing (Konig et al., 2022; Weyers et al., 2023). However, quantitative analyses can also reveal relationships between processes and the degree to which they are prevalent in a group. My study aimed to use the advantages of embedding both analyses (Creswell, 2012) on the same data to understand the relationships between teachers' analysis of teaching video and lesson planning skills. Quantitative analysis helped to explore the existence and significance of the relationships between teachers' analysis of teaching videos and lesson planning skills. Then, qualitative analysis helped to illustrate the nature of these relationships. My quantitative analyses were aimed to be exploratory, and my qualitative analysis was aimed to be descriptive in nature.

Figure 4 summarizes this study's mixed-methods design, analyses plans and corresponding research questions. First, this study examined for possible correlations between mean scores of teachers' analysis of teaching video skills—describing key mathematical ideas in the teaching video clip, describing pedagogical teaching moves, and providing suggestions for improvement—and mean scores of teachers' lesson planning skills—describing mathematics learning goal of the lesson, describing mathematics learning goals in the identified key learning moment of the lesson, and anticipating students' thinking before and after the identified key learning moment of the lesson. In this way, it was possible to explore whether there are any relationships between teachers' analysis of teaching video and lesson planning skills in the scope of the teacher noticing framework. Then, I conducted correlation analyses for each of the sub-research questions of RQ 1 (RQ 1.a.-b.) to further specify the relationships between factors of the analysis of teaching video and lesson planning.

In the qualitative strand of this study, I aimed to seek a deeper understanding of the relationships between two teaching skills: teachers' analysis of teaching video and lesson planning (RQ 1.c.). The scatter plot for the correlation analysis of RQ 1 informed me to intentionally choose cases of teachers whose qualitative analysis helped to understand these relationships closely by using the teacher noticing framework—teacher noticing dimensions. Qualitative analysis of teachers' open-ended answers to the prompts sheds light on the nature of the relationship between these two teaching skills. In other words, qualitative analysis helped to illustrate the ways in which teacher noticing dimensions in one teaching skill correspond to the other.

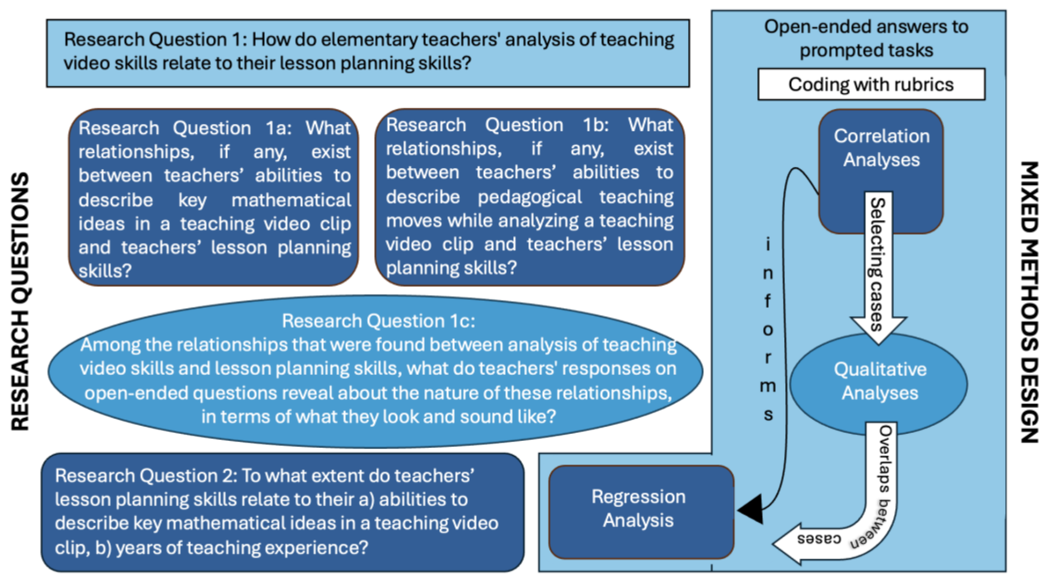

Figure 4 Mixed Methods Design, Analyses, and Corresponding Research Questions

Finally, findings of both qualitative and quantitative analyses informed and led to a new research question (RQ 2) as teachers' mathematical description of teaching video was correlated with their lesson planning, but not their pedagogical description. Additionally, two of the cases of teachers who scored high in lesson planning task (compared to other teachers) were the teachers who had the highest years of teaching experience, and I wanted to account for this findings by searching for how much of the teachers' lesson planning scores were predicted by these two factors.

Setting and Participants

This study is part of a larger project called Transforming & Understanding Professional Learning (TUPL, PIs James Hiebert, Erica Litke, Lynsey Gibbons, Valerie Maxwell and Jamila Riser), which was funded by the National Science Foundation, that aimed to understand how teacher learning translates into student learning and to understand how professional learning (PL) works (Gibbons et al., 2023; Kurutas et al., 2023; McKie et al., 2025). In this PL intervention, there were two main parts. In the first part, teachers participated in multiple day-long professional learning sessions, which included video analysis, doing math together, and unpacking lessons from their curriculum (two days during summer and five days during the academic year).

The second part of the intervention was a set of coaching cycles that involved lesson planning, enactment, and debriefing of a selected lesson with a coach and three to five same grade-level teachers. Coaches worked with their group to develop a lesson plan for the focus lesson from the group's curriculum. The coach videotaped each teacher's focus lesson in their classroom and chose two to three segments from the video-taped lesson to share with the teacher during an individual conversation about the nature of the mathematical learning opportunities and how the lesson could be enriched. As a small group, the teachers met again to collaboratively debrief one or two video segments selected by the coach and to share additional insights about the lesson. For this dissertation study, I analyzed data from a subset of the teachers who participated in the larger TUPL project.

The number of participants in this study was 23 teachers who taught mathematics in grades four and five. Participating teachers who were teaching using the *Bridges* curriculum materials (The Math Learning Center, 2017) volunteered to be a part of the larger project from approximately eight school districts in Delaware. During the recruitment process for the larger project in its year one, the number of participants was less than expected. Therefore, PIs decided to recruit more teachers in year two. Among the 23 teachers who participated in this study, 11 (eight as grade four and three as grade five) teachers joined the project in year one and 12 (five as grade four and seven as grade five) teachers joined the project in year two.

This project focused on teachers from the project who teach grades four and five. Elementary school teachers teach more than one subject, which can be challenging, so it is important to find ways to support their mathematics teaching. One possible way to do this is by improving and connecting multiple teaching skills in the design of professional learning opportunities. Also, grade four and five teachers lay the foundation for developing meaning for rational number operations, which is a focal topic of the Common Core (CCSSM, 2010) as well as the principles and standards for school mathematics (NCTM, 2000). Because this study involves all elementary teachers, I refer to elementary teachers only as *teachers* throughout the study.

As part of the TUPL project, the research team asked teachers to provide some demographic information about themselves: number of years taught, number of years taught at the grade level, number of years taught mathematics, number of years taught using *Bridges* curriculum, grades to which they have ever taught mathematics, if their grade level was departmentalized (if yes, courses they currently teach), education degrees, race/ethnicity and gender. Based on the data received, all the participants of this study identified themselves as *female*. The overall teaching experience and teaching mathematics experience of participants ranged from half a year to 31 years.

The majority of the participants identified themselves as white and not of Hispanic origin, two participants identified as black and not of Hispanic origin, and one as Hispanic, regardless of race. The average years of teaching using the *Bridges* curriculum materials were about four years among participants. Among all the participants, only two had experience teaching mathematics at the high school level in addition to elementary and middle school level. Finally, 65% of participants indicated that they earned a graduate-level degree in education.

Table 1 Data Collection Timeline

Year 1 Teachers (11 teachers)			**Year 2 Teachers (12 teachers)**		
September 2022	September 21, 2022	Fall of 2022-2023	September 2023	September 20, 2023	Fall of 2023-2024
Analysis of Teaching Video	First day of PD for Year 1 teachers Intervention started	Lesson Planning	Analysis of Teaching Video	First day of PD for Year 2 Teachers Intervention started	Lesson Planning
Grade 4: 8 teachers Grade 5: 3 teachers		Grade 4: 8 teachers Grade 5: 3 teachers	Grade 4: 5 teachers Grade 5: 7 teachers		Grade 4: 5 teachers Grade 5: 7 teachers

Table 1 represents the timeline of the data collection for year one and year two teachers. As this study investigates relationships between two teaching skills rather than understanding the effect of PD program on these teaching skills, the data that was used in this study was intentionally chosen to have the minimum effect of the PD. For example, for both years, only the teachers who had just started the project were included in this study to align participants' PD experiences with when they completed the teaching analysis task. Similarly, fractions was the first lesson planning task topic for both grade four and five teachers so that when all participating teachers completed this task, they had less than a semester-long PD experience for lesson planning, and no PD experience for analysis of teaching.

Researcher Positionality

As I have been actively part of the TUPL project as a research assistant since 2021, it is important to present some features of my positionality entering this work and the roles I have taken in the project. My research interest in professional development and teacher learning studies started to develop during my master's program. After conducting a study for my master's thesis about effective PD characteristics, I was fortunate enough to be part of a research project here at the University of Delaware that aligned with my research interests, which is understanding how teachers' professional learning transforms from PD programs to their teaching practices. Thanks to this project, I was able to narrow my teacher learning research into two areas: analysis of teaching video and lesson planning skills.

Throughout the TUPL project, I took an active role in various sources of data collection including the teaching video analysis task and teacher interviews. I attended professional learning sessions for grade four and five teachers and also coaches. I get to know the teachers as well as their backgrounds and contexts. In the project's first year, the research team, including myself, intentionally chose video teaching clips from a teaching video clips database. At the end of the first year, the research team piloted these clips with three teachers per grade level to see if videos were representative of deficiencies in teaching that could limit students' learning opportunities and if the instructions and process were clear for the participants. In the second year of the project, I was part of creating rubrics for both the teaching video analysis and lesson planning tasks. After reaching the inter-coder reliability, I have coded all the responses. In year three, I continued to code the year two data for both data sets. I also suggested a revision of the rubric for teaching the video analysis task to increase the three-point scale to four-point scale to be more representative of the variability among years. Therefore, I was part of every decision that was made to create these rubrics and code the data. My background in the project's context and the data guided me to bring insights from my qualitative analysis about what the relationships between these two teaching skills can look and sound like.

Finally, it is valuable to distinguish between the TUPL project's goals and my dissertation study's goals. The overall goal of TUPL is to understand how teacher learning translates into student learning, including identifying features from the professional development that helped them to adapt their instruction, that leads to impacts on students' learning. The rationale for designing tasks to assess participants' analysis of teaching and lesson planning tasks changed over time, considering that this was a longitudinal PD intervention study, which involved coaching cycles, using classroom videos as an artifact, etc. Furthermore, the lesson planning task was intended to be analyzed specifically for translations of teachers' lesson planning skills between different focal topics. Consequently, the overall project did not situate these two teaching skills under the same framework (e.g., teacher noticing), and other members of the project had not intended to analyze relationships between these skills.

Data Collection

To answer my research questions, I analyzed two sets of data: teachers' analysis of classroom video and teachers' lesson planning using written curriculum (teachers' guide and student textbook pages). There are scholars who conduct research to investigate both how teachers analyze videos of teaching (Kersting et al., 2012), and teachers' lesson planning (Morris & Hiebert, 2017) are specific to mathematical knowledge for teaching. In other words, they suggest that developing these skills might be content specific. I value this approach to investigating teachers' analysis of videos of teaching and lesson planning skills for the specific mathematics content. For this study, I chose fractions as focal content, as developing meaning for rational number operations is part of the Common Core (CCSSM, 2010) as well as the Principles and Standards for School Mathematics (NCTM, 2000). Moreover, fractions are one of the most important mathematics topics in elementary and middle schools because fractions create a foundation for learning algebra and beyond (Empson et al., 2011) which affects their success in many professions and daily life functions (Lortie-Forgues et al., 2015).

Therefore, to be consistent between the assessment of two teaching skills and prevent potential variance between mathematics topics, both data sets focus on the topic of fractions. Both data sets were collected in open-ended response forms with no length requirement. Table 2 summarizes the data collection and analysis plan for answering the overarching research question and each sub-question.

Table 2 Research Questions, Data Sources, and Data Analysis Plan

	1	1a	1b	1c	2
Research Questions	How do elementary teachers' analysis of teaching video skills relate to their lesson pla49 nning skills?	What relationships, if any, exist between teachers’ ability to describe key mathematical ideas in a teaching video clip and teachers’ lesson planning skills?	What relationships, if any, exist between teachers’ ability to describe pedagogical teaching moves while analyzing a teaching video clip and teachers’ lesson planning skills?	Among the relationships that were found between analysis of teaching video skills and lesson planning skills, what do teachers' responses to open-ended questions reveal about the nature of these relationships, in terms of what they look and sound like?	To what extent do teachers’ lesson planning skills relate to their a) ability to describe key mathematical ideas in a teaching video clip, b) years of teaching experience?
Data Sources	Mean scores of all three factors of analysis of the teaching task for all three video clips and mean scores of all three factors of the lesson planning task	Mean scores of the describing key mathematical ideas factor of analysis of teaching for all three video clips and mean scores of all three factors of the lesson planning task	Mean scores of the describing pedagogical teaching moves factor of analysis of teaching for all three video clips and mean scores of all three factors of the lesson planning task	Open ended responses for three factors of analysis of teaching and the lesson planning tasks	Mean scores of the describing key mathematical ideas factor of analysis of teaching for all three video clips, teachers’ years of teaching experience, and mean scores of all three factors of the lesson planning task
Analysis Plan	Assumptions of correlation analysis and correlation analysis between teachers' analysis of teaching video and lesson planning scores	Correlation analysis between teachers' ability to describe key mathematical ideas in the teaching video clip and lesson planning skills.	Correlation analysis between teachers' ability to describe key mathematical ideas in the teaching video clip and lesson planning skills	Content analysis through the teacher noticing dimensions	Regression analysis of teachers' ability to describe key mathematical ideas in the teaching video clip and their years of teaching experience as predictors for their lesson planning skills

Teachers’ Analysis of Teaching Video Task

First, to understand teachers' analysis of teaching video skills, I analyzed data from a field-tested teaching analysis task, similar to one used in prior studies (Hiebert et al., 2017; Kersting, 2008). The task asks participants to view three video clips of classroom teaching. Each video clip (two to four minutes) from a classroom lesson shows a teacher interacting with students around a mathematics on a particular topic. The clips are from a non-participating teacher’s classroom. Using other teachers’ classroom videos limits isolation of practice, in which the only learning material is the teachers’ own practice with little external contribution. It may also prevent teachers’ taken-for-granted ways of observing and interpreting teaching and learning (Ball & Cohen, 1999; Putnam & Borko, 2000).

Each video showed some deficiencies in the teaching video clip that could limit students’ opportunities to think carefully about the mathematics and participate in this part of the lesson. For example, in one of the videos, a teacher asked the students what one-sixth means, rather than clarifying the referent for one-sixth, such as “one-sixth of” in a context of one out of the six equal boxes. Similarly, she did not connect the idea of dividing [a whole] into 6 equal boxes to “one-sixth of” the cupcakes. Also, she could have asked another student to restate what the previous student said to assess understanding. Therefore, the clips were intentionally chosen so participants could identify the limited opportunities provided in the teaching video clip and suggest alternative instructional moves. The rationale for choosing a video with a deficiency was to give the teachers an opportunity to notice it and potentially offer a suggestion for improvement (without a direct prompt to do so). After watching each video, participants were asked to respond to the simple prompt: “View the clip and discuss how the teacher and the students interact around the mathematical content." No length requirements for the responses were provided or required. This task was given to teachers before their PL experience started. They had a week to complete this task. They were allowed to respond to the video clips in any order they wanted. They could also write a draft response to a clip and save it to edit later. Once they submitted a final response, they could not edit it.

Teachers' Lesson Planning Task

Second, I analyzed data from a lesson planning task using a modified version of a task from Morris and Hiebert (2017). As part of the TUPL project, each participant was asked to answer lesson planning questions and pay special attention to the learning goal of the lesson, key learning moment of the lesson, learning goal of this key moment, and students' thinking before and after this key moment. The plans were collected three days before the lesson was taught by participating teachers. The data was collected through Google Forms.

It is important to note that even though this task is called *lesson planning*, it does not account for all the important aspects of the skills for planning a lesson. For lesson planning, factors that are used in this study are specific to teachers' abilities to (a) attend to the conceptual aspects of mathematics in the lesson and (b) anticipate student thinking about the mathematics rather than attending to pedagogical aspects of the lesson. One of the reasons for this decision was the time considerations of data collection from in-service teachers, as the TUPL project required multiple data sources from these teachers. Another reason was that the aforementioned three factors were unpacked in great detail during professional learning, meaning that change over time of these aspects of lesson planning would be expected from teachers throughout the TUPL project.

Data Analysis

To answer my overarching RQ 1, its three sub-questions, and later emerged RQ 2, I used teachers' open-ended responses to the prompts that aimed to capture teachers' analysis of teaching video and lesson planning skills were used. For quantitative analysis, open-ended responses were coded by using specialized rubrics. Both rubrics were developed by the research project team (three researchers, including the PI of the project) in which this study is situated. The detailed descriptions of the rubrics are in the following section.

Rubric Development

Analysis of Teaching Video

The *Analysis of Teaching Video* rubric consists of three categories of codes: (1) pedagogical description, (2) mathematical description, and (3) providing suggestions. Within the description categories responses are coded based on participants' description of the interactions in the video clip. Each category is coded on a zero to three scale. This rubric was created by the TUPL research team including myself.

Pedagogical description entails teachers describing pedagogy in their own words with some positive or appropriately limiting terms regarding students' learning and/or participation opportunities. The mathematical description category is designed to capture participating teachers' ability to articulate the important mathematics ideas in the lesson and explains why it is important in the lesson. For the providing suggestions category, the responses are coded based on the participants' offering of suggestions for improvement related to either pedagogy, mathematics, or both, including an explanation of suggested changes and explain why these suggestions would be helpful. In light of these category descriptions, the definitions of each scale are presented in Appendix A.

While developing the rubric for the *pedagogical description*, the research team watched all three teaching videos and came up with a list of positive and limitational pedagogical teaching moves that the teaching video captures. The research team leveraged the description of limitational pedagogical teaching moves over the positive ones so that even when participants named more than one pedagogical teaching moves, if none of them were limitational, that was still coded as a one, not a two. Also, participants were scored when they provided a limitational pedagogical teaching move that was not listed by the research team whereas participants were only credited when the positive teaching moves they mentioned were on the list that the research team developed.

While developing the rubric for the *mathematical description*, the research team listed the key mathematical ideas for each teaching video. Participants' data were scored as one when they partially mentioned the key mathematical idea(s) of the lesson. Whereas they were scored as two when they named all the key mathematical idea(s) of the lesson. The key ideas participants mentioned had to be in the *Key Ideas* list that the research team developed for each teaching video. The explanation for its importance in this lesson (including a description of how its lack of development might have contributed to students' [or teacher's] confusion) was necessary for a full three points.

For the *providing suggestions* rubric, participants had the freedom to provide any suggestion for improvement related to either pedagogy or mathematics of the lesson. This rubric assessed participants' unprompted responses for how the teacher might have improved the opportunities for students to think about the mathematics and participate in class discussions. When coding the data, the research team leveraged the mathematical suggestions over the pedagogical ones so that even when participants provided more than one suggestion, if none of them were mathematical, that was still coded as one, not two. A rationale for why *the suggestion* would have been better than what happened in the video was necessary for the full three points.

Table 3 represents a sample response that one participant gave for one teaching video, as well as the assigned codes for that participant's response. The pedagogical description was marked as a two because there was a criticism about the teacher giving the answer right away. Additionally, the description gives details about positive teaching moves such as allowing students to talk and work collaboratively. It was not rated at a level of three points because there was no explanation about how and why these teaching moves were helpful/not helpful for students' learning opportunities. Mathematical description for this response was rated at one point because the key mathematical idea of the video was only partially presented—mentioning the whole broken into 10 equal pieces (meaning 10 as the denominator), but not specifying what the whole was. Finally, the suggestion for this response was rated at 0 because there was no description about what could have been done differently or what could have made the lesson better regarding students' learning.

Table 3 Analysis of Teaching Video Coding Example for Teaching Video

Response	Pedagogical Description	Mathematical Description	Suggestion
The teacher circled the denominator and then asked how many pieces that the whole needs to be broken into. She basically gave them the answer when she asked how many pieces the whole needed to be broken into. She even circled it twice and had them repeat it twice. She used the picture models and allowed student collaboration to talk about how to break their whole into 10 equal pieces.	2	1	0

Lesson Planning

The *lesson planning* rubric applied the general principle of specificity to responses for three prompts: (1) learning goal of the lesson, (2) learning goal of the identified key learning moment, and (3) students' thinking before and after the identified key learning moment of the lesson. There was another prompt that was specific to identifying the key learning moment, but this prompt was not coded. Instead, it was used to analyze the second and third prompts that are about the key learning moment. Each prompt is coded using a scale from zero to two scale.

The *learning goal of the lesson* prompt entailed a detailed description of the conceptual aspect of the lesson, which means the conceptual advance or breakthrough students might achieve or the understanding they would take away at the end of the lesson. The *learning goal of the identified key learning moment* prompt captured participating teachers' ability to provide detailed description of the conceptual aspect of the key learning moment that they chose and the conceptual advance or breakthrough students might achieve, or the understanding they will take away after that moment. The *students' thinking before and after the identified key learning moment of the lesson* prompt assesses teachers' ability to describe student thinking completely and precisely before the key learning moment and after the key learning moment. In light of these category descriptions, the definitions of each scale are presented in Appendix B.

While developing the rubrics for all three prompts, the research team reviewed a lesson from the *Bridges Teachers' Guide* and developed an ideal response for the learning goal of the lesson, (possible) key learning moment, and learning goal of the key learning moment. However, participants who copied and pasted the learning goal of the lesson from the *Teachers' Guide* were not credited. In some cases, more than one key learning moment was possible, but the conceptual content was similar. Therefore, participants were equally scored for different yet listed key learning moments as long as they described the learning goal of the key learning moment and possible student thinking before and after the identified key learning moment of the lesson. The ideal responses for the learning goals were used to calibrate what kinds of responses count as a two, one, and zero for these prompts.

For the *learning goal of the lesson* prompt, participants were only credited if their descriptions could clearly apply to this specific lesson. Similarly, for the *learning goal of the identified key learning moment* prompt, participants' answers were only credited if their descriptions clearly apply to the moment, they described in another (but not coded) prompt. For both prompts, the detailed description of the conceptual aspect of the lesson or the moment—the conceptual advance or breakthrough students might achieve, or the understanding they will take away—was necessary for full two points. Finally, participants were only credited for the third prompt—students' thinking before and after the identified key learning moment of the lesson—if they mentioned students' possible thinking both before and after the moment. Yet, either before or after the moment had to be precisely described, and only one could be vague for one point, and both of them had to be precise for the full two points. Students' thinking before the moment had to be about some struggle/misconception/incomplete thinking or something in need of changing.

Table 4 is an example of one participant's responses for the lesson planning prompts and its assigned codes. The first prompt was coded as full two points because the participant fully presented the learning goal of the lesson. The second prompt was coded as full two points because the description of the learning goal of the moment that was identified by the participant, and it fully captured the conceptual aspect of the identified and described moment. Finally, the third prompt about anticipating students' thinking was coded as one because there was a description for both before and after the identified moment, and neither description was vague. The only precise description was after the moment description where she said, "I am hoping that they recognizing that is not correct as they are developing an understanding that decimals are base-ten, and as such need to be expressed as tenths, hundredths, thousandths when written as fractions". The teacher precisely referred back to the point that decimals need to be in the form of base-ten, and this is why after the moment where students grapple with expressing ⅖ in a decimal form, she hopes her students to understand that they need to notate the fractions as tenths, hundredths, and thousandths.

Table 4 Lesson Planning Coding Example

(1) Learning goal of the lesson	
With the support of base-ten pieces, show and express fractions with denominators of 2, 4, 5, and 20 as an equivalent fractions with denominators of 10 and/or 100, and in decimal notation.	**2**
(2) Learning goal of the identified key learning moment	
Identified key learning moment: Students need to represent 2/5 using base-ten pieces. I expect this to be the moment where I see grappling. I may need to ask students to think about how we show 1/10, the relationship between tenth and fifths, and how we can use that knowledge to figure out how to show 2/5 on the mat. Once they realize that 2/5 is equivalent to 4/10, I am expecting them to be able to easily determine how to express 2/5 as a decimal.	
Students use base-ten pieces to find and identify fractions with a denominator of five as equivalent fractions with the denominators of 10 and 100. They then use the information to express the fractions as decimals.	**2**
(3) Students' thinking before and after the identified key learning moment of the lesson	
I am expecting some students to automatically think that the numerator of the fraction becomes the digits used when writing the equivalent decimal (ex - 2/5 = 0.2). I am hoping that they recognizing that is not correct as they are developing an understanding that decimals are base-ten, and as such need to be expressed as tenths, hundredths, thousandths when written as fractions.	**1**

Intercoder Reliability

While developing the rubrics, the research team practiced by applying the rubrics to a number of teachers' responses at each grade level. Sometimes, some aspects of the rubric applied well, but additional important features of the responses were not captured. The team continued elaborating and refining the rubrics by reading responses of different participants until they believed the definitions were sufficiently clear to code reliably. To calculate intercoder reliability, the research team randomly chose 10% of the data for both rubrics and two researchers coded each response independently and compared scores. Teacher responses that were used while developing the rubrics were not used in the reliability process. Intercoder reliability for analysis of the teaching video rubric between two coders was 100% for pedagogical description and 91.7 % for mathematical description and suggestions for improvement. All the disagreements were discussed and settled by the coders. Intercoder reliability for the lesson planning rubric was also calculated between two coders and reached 100% reliability for the learning goal of the lesson, the learning goal of the key learning moment, and the anticipating students' thinking factors. After reaching the intercoder reliability, I coded all responses for both data sets. I also flagged responses that were not clear. These were coded by consensus among the coding group.

Quantitative Analysis

First, I ran a correlation analysis between the mean scores of all three factors of teachers' analysis of teaching video skills and the mean scores of all three factors (sub-skills) of lesson planning skills to explore the overall correlation between two skills (RQ 1). Then, for the first two sub-research questions (RQ 1a.,1b.), I tested the correlation between each factor of teaching video analysis skills and mean scores of lesson planning skills. The reason I did not take apart teachers' lesson planning skills as part of the analysis is that lesson planning data was coded with a zero to two scale for only one lesson. This meant that breaking apart each factor (prompt) of lesson planning would reduce the variability of the data. Additionally, prompts for the lesson planning task referred to similar teacher noticing dimensions. On the other hand, the teaching video analysis data consisted of a zero to three scale for three different lessons, so I was curious to learn whether and how each sub-skill of teaching video analysis skills correlated with teachers' lesson planning skills.

Data Screening

First, I confirmed that my variables were normally distributed before conducting any quantitative analyses. I did so by checking for skewness (i.e., the extent of symmetry in a distribution) and kurtosis (i.e., whether data is over- or under-represented in the "tails" of the distribution) by checking the descriptive statistics of each variable used in the study (Gravetter & Wallnau, 2016). All the variables' skewness was less than |2.0|, and kurtosis less than |4.0 (see Table 5),| which do not violate the assumption of normality.

Table 5 Normality Tests for Each Variable

Variables	**Skewness**	**Kurtosis**
Analysis of Teaching Video (overall)	0.64	-0.89
Mathematical Description	0.85	-0.71
Pedagogical Description	0.76	1.15
Lesson Planning	1.15	1.06
Years of Teaching Experience	0.41	-0.94

To assess the assumption of linearity, I compared the goodness-of-fit (R^2) of linear, quadratic, and cubic models. Table 6 presents the *coefficient of determination* (R^2) for each model. The linearity model fit better for each analysis except for one relationship: teachers' years of experience as the dependent variable and lesson planning as the independent variable (RQ 2). I decided to use a *centered* quadratic model for the *years of teaching experience* predictor variable.

Table 6 R^2 Scores of Linear, Quadratic, and Cubic Models for Each Analysis

	Linear Model	**Quadratic Model**	**Cubic Model**
Analysis of Teaching Video (overall) (DV) Lesson Planning (IV)	**0.1881**	0.1541	0.1239
Mathematical Description (DV) Lesson Planning (IV)	**0.2136**	0.1752	0.1511
Pedagogical Description (DV) Lesson Planning (IV)	**0.03164**	0.01241	0.001977
Years of Teaching Experience (DV) Lesson Planning (IV)	0.2276	0.392	**0.5082**
Years of Teaching Experience (centered) (DV) Lesson Planning (IV)	0.2276	**0.5435**	0.5223

Note. **Bolded** results indicate which model best suits for each analysis.

I used the following process to determine the appropriateness of the *centered* quadratic model. First, I tried to transform the data for this relationship (teachers' years of experience and lesson planning) to be linear by taking the square and cube root of all years of teaching experience scores, but the data still did not meet the linearity assumption. Then, I decided to write a curvilinear model for the teachers' years of teaching experience predictor variable. Iacobucci et al. (2016) suggest centering (i.e., subtracting the mean of a predictor variable from each of its values to create a new variable with a mean of zero) dependent non-linear variables before creating quadratic and cubic terms because including the product of the main effect and the squared or cubed terms will increase multicollinearity. Centering assists in reducing multicollinearity because it often reduces the correlation between the individual variables (here, years of teaching experience) and the product term. When I checked the different models for the centered variable, the quadratic model fit better (see Table 6).

For the regression model, I tested whether all residuals from variables in my analyses were normally distributed. A Shapiro-Wilk test was conducted to assess the normality of residuals (Keith, 2019). The results indicated that the assumption of normality of residuals was met, $W(22) = 0.97$, $p = .63$, suggesting that the data were not significantly different from a normal distribution. Then, I tested variables for multicollinearity, or whether variables in my sample are too highly correlated (collinear). To test this, I calculated the variance inflation factor (VIF) for all variables, considering a VIF above 6 to be problematic. VIF scores for all variables were close to 1, which indicates that the variance was not highly overestimated because of the correlation between the two predictors in the model. I also tested for homoscedasticity, or whether the distribution of errors was fairly consistent across data for normality. A Breusch-Pagan test was conducted to assess homoscedasticity in the regression model. The results indicated no significant evidence of heteroscedasticity, $\chi^2(3) = 0.65$, $p = .89$, suggesting that the assumption of constant variance was met.

For correlation analysis purposes, I checked each variable to see if any of them were three standard deviations above or below the mean to detect outliers. No outliers were identified. For regression analysis purposes, I screened the quantitative data for outliers, examining distance, influence (df betas), and leverage of estimates (Keith, 2019). Distance refers to how far each data point is from the regression line, whereas leverage refers to how far each data point is from the mean. Both are a measure of how much effect a data point has on the slope of the regression line. I examined these by computing Cook's distance, leverage of estimates, and df betas, respectively, for each data point. I took a conservative approach to removing outliers, considering the sample size. I considered them outliers if they demonstrated multiple indicators of being an outlier. None of the data was problematic in terms of distance. Two cases (T1405, T1418) fell into the outlier category because of their leverage and influence. Instead of removing them from the data set, I further examined them as my qualitative analysis cases.

This exploratory study focuses on individual-level teacher skills rather than school or district-level effects. Considering the majority of participants came from different schools—reducing the likelihood of clustering effects—the intraclass correlation coefficient (ICC) was not calculated, and observations were treated as independent. Cronbach's Alpha was calculated to assess internal consistency among rubric items, resulting in $\alpha = 0.66$ for the analysis of teaching video and $\alpha = 0.2$ for lesson planning. These results suggest that the analysis of the teaching rubric demonstrates moderate reliability, indicating that it partially maintains reliability across raters. Intercoder reliability for the analysis of teaching video rubric between two coders was 100% for pedagogical description, 91.7 % for mathematical description and suggestions for improvement. All the disagreements were discussed and settled by the coders.

For lesson planning, Cronbach's Alpha value was poor, meaning that the rubric needs improvement to maintain reliability across raters. Intercoder reliability for the lesson planning rubric was also calculated between two coders and reached 100% reliability for the learning goal of the lesson, the learning goal of the key learning moment, and the anticipating students' thinking factors. Therefore, the reason why Cronbach's Alpha score was low might be because there were only three items to assess teachers' lesson planning skills, and data for only one lesson was included in the study, meaning there were not enough items to capture the concept. Because Cronbach's Alpha was low for lesson planning, the maximum observable correlation estimate between analysis of teaching video and lesson planning was also low—lower than the calculated correlation. Ideally, maximum observable correlation would set an upper bound on expectations for observed correlations.

A power analysis was conducted to assess the statistical power of the study given the obtained sample size ($N = 23$). Using R, the power to detect an effect size of Pearson's Correlation (r) for analysis of teaching video and lesson planning at $\alpha = 0.1$ was 0.68. This means that with $N = 23$, a correlation of $r = 0.43$, and $\alpha = 0.1$, the study has 68% power, indicating a higher risk of Type II error (failing to detect a true effect). The power for mathematical description and lesson planning (RQ1a) was 0.74, which was close to but still lower than the recommended 80%.

This study had a small sample size and was exploratory. Given the low real-world consequence of making a Type I error, I used (alpha level) $\alpha = .10$ as the threshold for statistical significance for all quantitative analyses. I also discuss the possible implications of having a small sample size in my limitations section. I then returned to the qualitative data to triangulate and clarify the findings.

Case Selection

After running the correlation analyses, I engaged in qualitative analysis to investigate what these possible relationships looked like in teachers' open-ended responses. Whether there is a weak or strong correlation, qualitative analysis can help us understand teachers' thinking through teachers' open-ended responses. I used the previously described teacher noticing dimensions as my analytical framework to interpret the qualitative data (see Figure 1). I was curious to learn what the two teaching skills looked like regarding the teacher noticing dimensions, including how and when the skills appeared to be similar or different from the teacher noticing dimensions. I was also curious to learn if there was a pattern of language that teachers used when they described their answers for these two tasks. This study's findings can provide conjectures for the future research that investigates the explanation for why these two teaching skills may or may not be related.

After running the correlation analysis for RQ1 and finding a statistically significant correlation between teachers' analysis of teaching video and lesson planning skills, I created a scatterplot to compare each teacher's performance to the trend line out in the analysis. Based on the scatter plot, I selected two extreme cases for a lack of correspondence between the two teaching skills: Teacher 1517 for being the higher on analysis of teaching video but still poor on lesson planning, and Teacher 1405 for being the higher on lesson planning even though she performed lower (than expected based on the trend line) in analysis of teaching video. These extreme cases provided counter-examples, or an understanding of what the trend did not look like. Then, I selected two cases who were in line with correlation analysis findings: Teacher 1409 was in the middle of the trend line between analysis of teaching video and lesson planning, and Teacher 1418 scored high (compared to other teachers) in both teaching skills. The teacher in the middle of the trend like (Teacher 1409) illustrated the trend of what a moderate score on both skills would look like. The teacher who scored high in both skills (Teacher 1418) was more of an ideal case of someone who exhibited strengths in both skills. In this way, I aimed to explore how the open-ended responses of teachers who showed different results in which they scored high or low in both teaching skills contradicted or supported the quantitative results. The following table (Table 7) summarizes all of the demographic information that was collected for these selected cases of teachers.

Table 7 Demographic Information of Selected Cases

Teacher ID	**Teacher 1517**	**Teacher 1405**	**Teacher 1409**	**Teacher 1418**
Years of teaching experience	7	31	15	31
Years of teaching mathematics	7	31	10	17
Years of teaching curriculum	6	6	1	5
Grade levels previously taught	Grades 3 through 6	Grades Kindergarden through 6	Grades 3 through 12	Grades 3 through 6
Degree of education	An undergraduate education major, Graduate-level degree in education	An undergraduate education major, Graduate-level degree in education	An undergraduate education major	An undergraduate education major, Graduate-level degree in education
Race	White	White	White	White
Gender	Female	Female	Female	Female

Qualitative Analysis

After intentional case selection, I used the teacher noticing dimensions—*attending*, *interpreting*, and *responding*—to identify how the teacher noticing dimensions in one teaching skill might correspond to the other. In this way, it was possible to understand when there is an overlap between two teaching skills and in what ways these overlaps appear. See the detailed definitions of teacher noticing dimensions below (see Table 8).

Table 8 Teacher Noticing Dimensions' Definitions

Teacher Noticing Dimensions	Definitions
Attending	Describing the details of the teaching-learning process such as identifying a key mathematical idea, teaching moves that might affect students' learning opportunities, and conjecturing the possible key learning moments of the lesson.
Interpreting	Examining the impact of teacher decisions on student progress towards lesson learning goals, why the presented key mathematical idea is important for students to learn, and how students might respond to the mathematical tasks.
Responding	Making suggestions for improvement that the participating teacher suggests to provide a more complete development of the key mathematical idea and more opportunities for students to learn. Anticipating a response to students' activities and deciding how to respond based on students' understandings.

For example, one teacher's response for lesson planning task/prompt one and lesson planning task/prompt two was presented in Table 4. This teacher got full two points for his/her responses for both prompts according to the lesson planning rubric because both answers fully captured the conceptual aspect of the mathematical idea of the lesson and the identified moment. Yet, these answers were in between *attending* and *interpreting* according to teacher noticing dimensions because there was only a brief interpretation of how these conceptual goals could be achieved in the specific lesson and moment. This teacher's response to lesson planning task/prompt 3 (see Table 4) was given one point from the lesson planning rubric. This answer was between *attending* and *interpreting* because the interpretation of the student progress towards the learning goal of the key moment was incomplete. For example, the teacher fully described how students might respond to the key moment task by saying, "I am hoping that they recognizing that is not correct as they are developing an understanding that decimals are base-ten, and as such need to be expressed as tenths, hundredths, thousandths when written as fractions." However, the teacher did not identify why students might automatically think the numerator of the fraction became the digits used. This answer was not at the *responding* level because the teacher did not describe how she/he would respond based on the students' possible thinking and reactions.

The same teacher got 0 for her/his responses for providing suggestions for all teaching videos (see Table 9) which was the main indicator for *responding* level of teacher noticing dimensions. This means that this teachers' analysis of teaching video skill was also in the level of *attending* or *interpreting*. Another proof for this is that his/her response for lesson video one, received 2 points for mathematical description (see Table 9) which means that describing the response fully captured key mathematical idea(s) of the lesson but provided no explanation for why these ideas were important in this lesson. This corresponded to the *attending* level of teacher noticing dimensions, because there was no interpretation of why these mathematical ideas were important for students to learn.

Table 9 One Teacher's Teaching Video Analysis Task Responses for All Three Teaching Videos

Lesson	Response	Pedagogical Desc.	Mathematical Desc.	Providing Suggestions
Video 1	When she calls on the student who suggests asking 132/6, and the others are still unclear, she backs up the level of questioning to the basic level - what does 1/6 mean. She has a student come up and show her work. The teachers asks the students questions to come back to the idea that to 1/6 of the cupcakes is 132 divided into 6 equal parts, and that one of the equally sized parts is 1/6. After the student finishes her explanation, the teacher ask the class if they agree and if anyone has a question for the student.	1	2	0
Video 2	The teacher guides the students through the use of a physical model to perform subtraction of fractions. When students are asked to answer, they give number of pieces and then the fraction represented. After that, the teacher goes back through the steps and writes the equation that represents the problem they modeled. As needed, the teacher goes back to the models with individuals who are confused. The teacher has confused students go back through the steps and connects back to the equation.	1	0	0
Video 3	The teacher poses a problem. She gives students some support as a class and then she tells students that she wants to see and hear them thinking. As she is walking around and watches groups completing the task and talking she asks questions to help guide their understanding.	0	0	0

Finally, this teacher's response for video one received one point for pedagogical description (see Table 9) which means the teacher partially captured teaching moves that might have had impacts on students' learning opportunities. This also corresponded to the *attending* level of teacher noticing dimensions, because there was no interpretation of how these teaching moves impact students' learning opportunities. Therefore, in this specific teacher's case, her responses for analysis of teaching video and lesson planning were mostly at the level of *attending* and her lesson planning response was partially at the *interpreting* level, which shows that these two teaching skills can be interrelated and improvement in one of them might reflect on the other.

This chapter informed the reader about the context and the participants of the study, as well as my background and position in the TUPL project that could have shaped my interpretations of the findings for this study. Then, in the data collection and analysis sections, I explained how the tasks, and rubrics were designed, descriptions of decisions that I made regarding data analysis and rationales for these decisions, and also examples of how the data were coded and analyzed. I also clarified how the cases were selected for qualitative analysis, and I explained how they were analyzed by describing the definitions I used, along with examples to demonstrate how they were analyzed.

Chapter 4

RESULTS

In this section, I present my results in relation to my research questions. I describe quantitative analysis results related to overall RQ1 and its sub-questions RQ1a and RQ1b. I begin by presenting the results of the correlation analyses between teachers' analysis of teaching video skills and its sub-factors (mathematical description and pedagogical description), and lesson planning skills. Then, I share my qualitative analysis results related to RQ1c, which explored how these relationships appeared or did not appear in different cases of teachers' open-ended answers for these tasks. Finally, I share my exploratory multiple regression results (teachers' years of teaching experience and their mathematical description scores for the analysis of teaching video task predicting teachers' lesson planning scores).

My first research question aimed to explore whether there were statistically significant relationships between teachers' analysis of teaching videos and lesson planning skills. My overall hypothesis was that teachers who are more skilled at describing mathematical and pedagogical aspects of other teachers' teaching video clips and providing suggestions for improvement of the lesson would be better at identifying their lessons' learning goal, learning goal of the key learning moment, and anticipating students' thinking before and after this moment while they plan their own lessons. The rationale of this hypothesis was: analysis of teaching is an opportunity for teachers to notice critical concepts and events of the classroom and taking a critical stance to figure out ways in which to address missed learning opportunities for students for better mathematics learning so that when they actually plan their own lessons, they could transfer these skills to identify conceptual ideas, moments, and student thinking.

For the first two sub-questions (1.a. and 1.b.), I looked at these relationships specifically in relation to each factor of analyzing videos of teaching (mathematical description and pedagogical description, respectively). The hypothesis for the first sub-research question was (1.a.) teachers who are more skilled at describing key mathematical ideas in the teaching video clip would be better at identifying their lessons' learning goal, learning goal of the key learning moment, and anticipating students' thinking before and after this moment while they plan their own lessons. The rationale behind this hypothesis was: all these skills are about the *mathematics content* and *student thinking/learning* factors of teacher noticing, so that they could be transferred between different contexts of teaching skills. The hypothesis for the second sub-research question was (1.b.) teachers who are more skilled at describing pedagogical teaching moves in the teaching video clip would be also better at identifying their lessons' learning goal, learning goal of the key learning moment, and anticipating students' thinking before and after this moment while they plan their own lessons. However, I also hypothesized that this correlation would not be as strong as the correlation with teachers' ability to describe key mathematical ideas in the teaching video clip, because the lesson planning task did not account for the factors that were aligned with the pedagogical aspects of the lesson. The rationale of the possibility of this correlation was the transferability between the different domains of what to notice—mathematics and pedagogy—across the teaching skills.

It is also important to highlight that even though initially teachers' suggestions for improvement for the teaching video clip was included as one of the factors of teachers' analysis of teaching video skills, only one teacher provided a brief (not detailed) suggestion for pedagogical teaching moves in the teaching video clip. Therefore, I did not add a factor for suggestions for improvement as a separate sub-RQ1. Another important point to recall while reading this chapter is that the lesson planning task incorporated three factors: (a) describing learning goal of the lesson, (b) describing learning goal of the identified key learning moment of the lesson, and (c) anticipating students' thinking before and after this moment. Teachers' lesson planning scores were calculated by taking the means of scores for these three factors. Furthermore, the main difference between the learning goal of the lesson and the learning goal of the identified key learning moment of the lesson is that the learning goal of the identified key learning moment is specific to the moment teachers identified (in non-coded prompt) and serves rich learning opportunities for students to reach the learning of the lesson.

The third sub-RQ 1 (1.c.) aimed to investigate these relationships closely by taking a look at four cases: two extreme cases of a lack of correspondence between two teaching skills and two cases around the trend line that could illustrate stronger correspondence between the two teaching skills. I added a second research question after conducting analyses for RQ 1 and its sub-questions. The goal of RQ 2 was to explore the extent to which teachers' years of teaching experience and their mathematical description scores for analysis of teaching video task predicted their lesson planning scores.

Research Question 1: Overall Relationships Between Teachers' Analysis of Teaching Video and Lesson Planning Skills

To examine the relationship between teachers' analysis of teaching video and lesson planning skills, I conducted a Pearson correlation. The results showed a significant positive correlation (see Table 10), r(21)=.43, p=0.04, indicating that teachers' analysis of teaching video scores were associated with their lesson planning scores. Furthermore, the confidence interval gives the range around the sample correlation that is likely to contain the true population correlation (Cumming, 2014).

Table 10 Means, Standard Deviations, and Correlation Coefficients with Confidence Intervals for Analysis of Teaching Video and Lesson Planning Variables

Variable	*M*	*SD*	ρ
Analysis of Teaching Video	0.76	0.39	
Lesson Planning	0.49	0.41	.43** [.03, .72]

Note. M and SD are used to represent the mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates $p < 0.10$. ** indicates $p < .05$.

For this case, it means that with 95% confidence, the true correlation in the entire population lies between 0.03 and 0.72. Considering the wide span of the bounds, there is uncertainty about how strong this positive relationship actually is. However, since the entire interval sits above zero, there is enough evidence that suggests a positive correlation in the population. Figure 5 presents the scatter plot that shows the relationship between teachers' analysis of teaching video and lesson planning skills in this sample, indicating a consistent upward pattern.

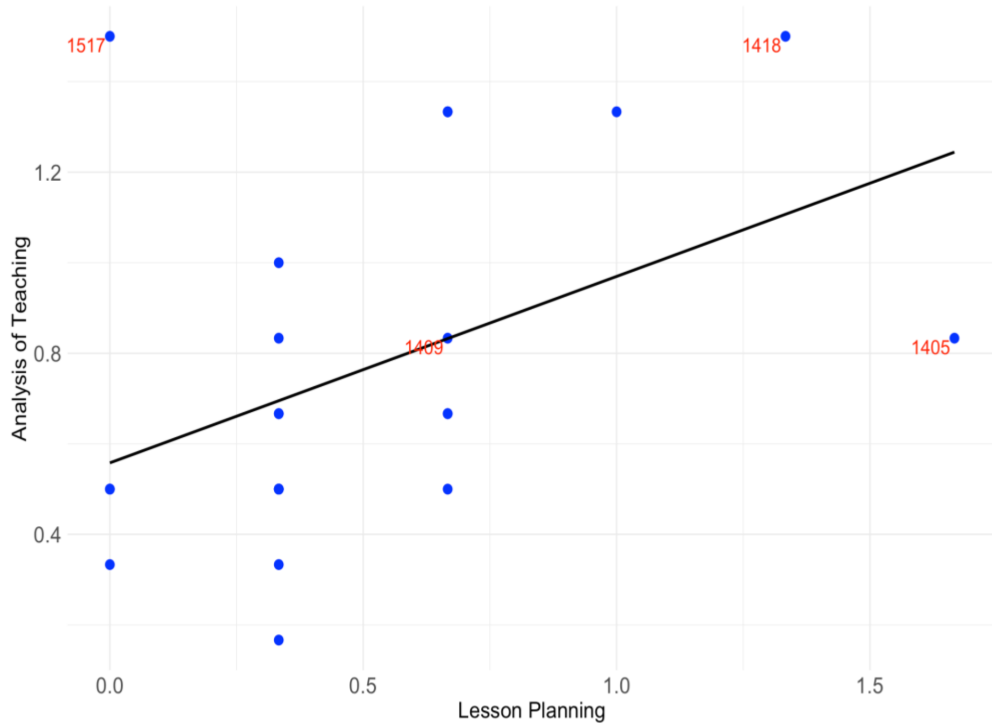

Figure 5 The Scatter Plot Showing the Relationship Between Teachers' Analysis of Teaching Video and Lesson Planning Scores

To illustrate cases of teachers regarding their different tendencies in scoring analysis of teaching video and lesson planning task scores, I selected teachers for qualitative analysis so that their open-ended answers could provide insights into the correlation between teachers' analysis of teaching video and lesson planning skills. For example, Teacher 1517 scored high on the analysis of teaching video whilst getting zero points on the lesson planning task. I conjectured that this result would have been unlikely; eliminating this teacher's data from the sample would have made the trend line (shown in Figure 5) steeper.

In contrast, Teacher 1405 scored high on lesson planning whilst getting a relatively lower score on analysis of teaching video task, which is an inverse result compared to Teacher 1517. Similar to Teacher 1517, cutting Teacher 1405 from the sample would make the trend line steeper. Therefore, examining these two cases of teachers can illustrate the ways in which the teacher noticing dimensions in one teaching skill correspond to/differ from the other, as they represent extreme cases of a lack of correspondence which means the least correlated scores.

Two other teachers were selected because they were closer to the trend line. Teacher 1409 was selected as the third case as she is on the trend line, meaning that her scores on the analysis of teaching video and lesson planning tasks aligned with the general pattern or trend in this sample. Her responses could illustrate possible relationships between these two teaching skills. Finally, Teacher 1418 was selected as a case because she was above the trend line and had high scores (compared to other teachers) for both skills. This teacher was closer to an ideal case: strong at both skills. I will describe these teachers' results in greater detail, qualitatively, later in this results chapter in response to research question 1c.

Research Question 1a: Relationship Between Teachers' Ability to Describe Key Mathematical Ideas in a Teaching Video Clip and Teachers' Lesson Planning Skills

To examine whether there is a relationship between teachers' ability to describe key mathematical ideas in a teaching video clip and teachers' lesson planning skills, I conducted a Pearson correlation. The results showed a significant positive correlation (see Table 11), $r(21)=.46$, $p=0.03$, indicating that teachers' mathematical description scores were associated with their lesson planning scores. Besides, with 95% confidence, the true correlation in the entire population lies between 0.06 and 0.73. This means that there is enough evidence that suggests a positive correlation in the population as entire interval is above zero. However, there is uncertainty about how strong this positive relationship actually is, considering the wide span of the bounds.

Table 11 Means, Standard Deviations, and Correlation Coefficients with Confidence Intervals for Mathematical Description and Lesson Planning Variables

Variable	*M*	*SD*	ρ
Mathematical Description	0.49	0.60	
Lesson Planning	0.49	0.41	0.46** [.06, .73]

Note. M and SD are used to represent the mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates p < 0.10. ** indicates p < 0.05.

Figure 6 presents the scatter plot that shows the relationship between teachers' mathematical description scores when they analyze videos of teaching and their lesson planning scores in this sample, indicating a consistent upward pattern. My interpretation is that this result aligns with my initial conjectures for this study. I conjectured that the mathematical description of the analysis of teaching video and lesson planning task of this study would likely correspond because they both focused on similar processes: *identifying key mathematical idea in the teaching video clip* and *identifying the learning goal of the lesson, (identified) key learning moment of the lesson,* and *anticipating students' thinking before and after this moment.* My interpretation is that the processes were similar because of the focus on key mathematics.

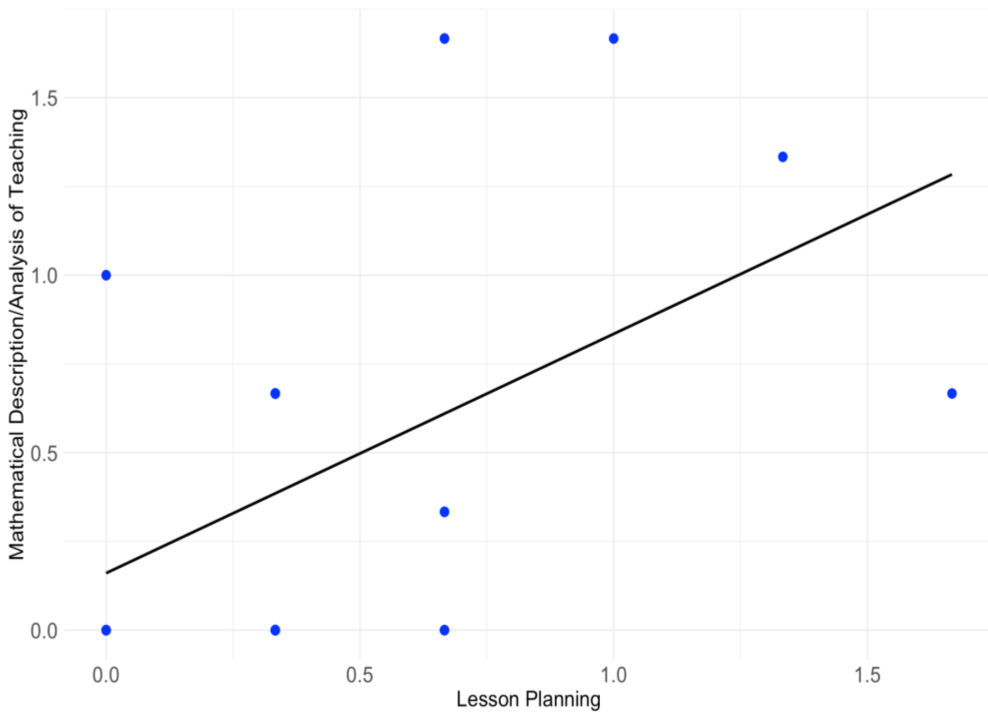

Figure 6 The Scatter Plot Showing the Relationship Between Teachers' Mathematical Description and Lesson Planning Scores

Research Question 1b: Relationship Between Teachers' Ability to Describe Pedagogical Teaching Moves While Analyzing a Teaching Video Clip and Teachers' Lesson Planning Skills

To examine the relationship between teachers' ability to describe pedagogical teaching moves while analyzing a teaching video clip and lesson planning skills, I conducted a Pearson correlation. The results showed no significant correlation (see Table 12), $r(21)=.18$, $p=0.42$.

Table 12 Means, Standard Deviations, and Correlation Coefficients with Confidence Intervals for Pedagogical Description and Lesson Planning Variables

Variable	*M*	*SD*	ρ
Pedagogical description	1.03	0.35	
Lesson Planning	0.49	0.41	0.18 [-.25, .55]

Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates $p < .1$. ** indicates $p < .05$.

However, it is important to remember that the lesson planning task in this study is more mathematics-oriented than the pedagogically-oriented. In contrast, the pedagogical description factor of analysis of teaching video was mainly focused on the pedagogical aspect of teaching. Therefore, it might be possible that these two skills would be associated if the lesson planning task were designed to be more comprehensive in a way that not only covers mathematics but also the pedagogical aspects of the lesson. Another reason for this result might be that many teachers received credit for their open-ended answers on pedagogical description because they provided descriptions for positive teaching moves in the clip, but, in the rubric, we leveraged describing limitational pedagogical teaching moves over the positive ones.

Research Question 1c: The Nature of These Relationships That are Revealed by Different Cases of Teachers' Open-ended Responses

As it was stated earlier, I intentionally selected four different cases of teachers based on the scatter plot that shows the relationship between teachers' analysis of teaching video and lesson planning skills (see Figure 3). First, I will present the two cases which were on the trend line. One teacher (Teacher 1409) represented a case whose scores were around the trend line between the analysis of teaching video and lesson planning. This teacher was around the middle of the trend line, not at higher or lower end. Teacher 1418 was a case who scored high (compared to other teachers) in both tasks to see if the expected relationship between these two teaching skills is also reflected in qualitative analysis. Two other cases were selected as extreme cases of a lack of correspondence between two teaching skills: one was stronger at analysis of teaching video whilst scoring zero for the lesson planning task (Teacher 1517), and the other was stronger at lesson planning whilst getting lower (than expected based on the trend line) scores at the analysis of teaching video task (Teacher 1405). The following section presents findings of qualitative analyses for each case of teachers.

Teacher 1409: On the Trend Line Between Analysis of Teaching Video and Lesson Planning

This teacher was a case of a teacher who was on the trend line between analysis of teaching video and lesson planning, in the middle. As expected, based on the correlation analysis for RQ1, her open-ended answers revealed a similar trend on the teacher noticing dimension for both skills: *attending* level. This was expected because my initial hypothesis was that teacher noticing skills are transferrable between multiple teaching skills. More specifically, I expected that a teacher who is in the *attending* level in analysis of teaching would also be in the *attending* level for lesson planning.

For the lesson planning task, teacher 1409 received partial credits (did not receive the highest score) for the learning goal of the lesson and the (identified) key learning moment. For the learning goal of the lesson, the teacher named the conceptual aspect of the lesson: using equivalent fractions in a model and converting fractions to their decimal form. The description for the learning goal given by the teacher was also specific to this lesson, but the lesson was beyond the teacher's description. The teacher only stated, "Students will be able to express a fraction with a denominator 10 as an equivalent fraction with denominator 100, and represent the decimal equivalent to the hundredths place," but the lesson was applied to factors of 10 and 100, and students were using base ten area pieces, which indicates that the teacher could have described more.

Similarly, the teacher's description of the learning goal for the (identified) key learning moment was specified to the moment she described, yet her description was not detailed enough to understand what she meant by 'new numbers.' Her open-ended response for the learning goal of the key learning moment prompt was "2/5 is equivalent to 4/10 or 40 /100. They should see how factors play a role in finding equivalent fractions and how they can apply that concept to new numbers." She might have been referring to decimals, but it was not clear. However, she still mentioned 10 or 100 as the denominator and finding equivalent fractions of 2/5. She did not receive any credit for anticipating students' thinking before and after this moment as the description the teacher provided was vague and not enough to be applied for either before or after the moment. This teacher was at the *attending* level of the teacher dimension for lesson planning, because there was no interpretation or description regarding students' thinking, and the descriptions for the learning goals of the lesson and key learning moment were not fully captured.

Contrary to what I found in the quantitative analysis (teachers' lesson planning skills were associated with their mathematical description rather than pedagogical), teacher 1409 received most of her analysis of teaching video score from the pedagogical description rather than the mathematical description even though she was on the trend line of teachers' analysis of teaching video and lesson planning skills. This teacher was attending more to the pedagogical description than the mathematical description of what happened in the teaching video clip. Therefore, this teacher may have been more attentive to mathematics than pedagogy when she was thinking about and planning her own lesson. But when she was analyzing other teachers' teaching, she was focusing more on the pedagogical teaching moves. Overall, as expected from a teacher who was in the middle on the trend line, she showed a similar teacher noticing dimension for both skills, which was *attending.* This is because her answers could not go beyond the content-related descriptions and did not involve interpretations regarding students' thinking and learning. Besides, as this teacher was almost in the middle of the trend line between analysis of teaching video, and lesson planning, this finding is even more likely considering she was not at the top of the line which may have corresponded to *interpreting* or *responding*. The following case represents a *responding* level of this scenario with a trend of scoring slightly higher on the analysis of teaching video than expected (based on the trend line).

Teacher 1418: Scored High (Compared to Other Teachers) in Both Teaching Skills

This teacher was a case that helps us understand what strong skills in lesson planning and analyzing videos look like at high levels of teacher noticing, such as *responding*. Because her open-ended answers for both tasks revealed the same level of teacher noticing dimension (*responding*), my interpretation is that this case aligns well with the correlation analysis results of RQ1. Table 13 presents this teacher's open-ended answers for the two factors of lesson planning as well as one prompt that was not coded in the scope of this study: (identified) key learning moment. I will explain why I also included a non-coded prompt in this table in the following paragraph.

For the lesson planning task, teacher 1418 provided a full description of the conceptual aspect of the lesson, which was the conceptual advance or breakthrough students might achieve or the understanding they will take away. When her responses were coded, she did not receive any points for identifying the learning goal of the key learning moment, because she answered this question when she was identifying the key learning moment of the lesson (rather than the learning goal of the key learning moment) (see Table 13). It may be a limitation of the study that she answered this question under another prompt; the prompts might need revisions so that participants respond as the researchers intended. In the coded answer, she gave a different example that was not part of the moment she described (see Table 13). More specifically, she proposed step four as the key learning moment of the lesson when she was answering the identifying key learning moment prompt. Later, for the same prompt, she explains the learning goal of this moment is to use base-ten pieces to find and identify fractions with a denominator of five (because of working with 2/5) to generate equivalent fractions, with the denominators of 10 and 100, so that students can understand the relationships between fractions and decimals. However, this part should have been answered in the next prompt provided because that was the prompt the research team and I specifically asked for the learning goal of the (identified) key learning moment.

Finally, the teacher presented a rare response by describing student thinking completely and precisely before the key learning moment and after the key learning moment (see Table 13). After describing anticipated students' thinking and responses, she provided a plan to support students' learning further by writing, "I plan to keep relating it back to money and use the money pieces in a small group to help them visualize the relationship." This corresponds to the *responding* teacher dimension for lesson planning, because the description incorporates a potential plan to promote higher student thinking related to the concept.

Table 13 Teacher 1418's Open-ended Responses for Lesson Planning Task

(Identified) key learning moment	"I see step 4 which is asking students to represent 2/5 as a decimal number is the key learning moment in the lesson. Students will have previously shown how 2/5 is represented on the base 10 mat. They should then be able to use that knowledge to identify 2/5 as a decimal and see the relationships between fractions and decimals. Once students see the 2/5 is the same as 4/10 on the base 10 mat, they should be able to identify it as a decimal number. I will also relate the base 10 mat to a dollar, asking what coin is 1/10 of a dollar. Then I would point out that 4/10 is 4 dimes out of 10 times to make a dollar. Just like we can use different coins to represent the same amount of money, there are different fractions/decimals that represent the same amount. I will then ask what coin do I need 100 of to make a dollar. How many pennies would I need to represent the same value as 4 dimes? This way they can see that 4/10 is the same as 40/100 and 0.4 is the same as 0.40. All are equivalent to 2/5. Relating the fractions and decimals to money will help them when they get to the partner assignment looking at other fraction/decimal relationships."
Learning goal of the (identified) key learning moment	"The learning goal for this moment is understanding that a fraction with a denominator of 10 such as 3/10 can be represented as an equivalent fraction with denominator 100. Also the decimal numbers for each of those fractions are also equivalent. (3/10=30/100 and 0.3=0.30...all of these represent the same amount.)"

Students' thinking before and after the identified key learning moment of the lesson	"Some of my students have already built this understanding that 3/10=30/100 and understand the decimal equivalencies also. Some are still struggling with this concept. I expect that if I asked students what decimal number would represent 2/5, some would say 2.5. They would not see that it needs to be represented as an equivalent fraction in 10ths or 100ths first. After this moment, I would expect students to think about the base 10 mat and how that fraction is represented in the mat. For example, in the independent assignment for students, they need to think of decimal numbers for 1/2, 1/4, 3/4 and others. They have a model of the base 10 mat that they need to divide into fractional amounts to help them see the equivalent fraction in 10ths or 100ths to help them write a decimal number. I expect that some of my students who are still struggling to represent 3/10 as a decimal number will continue to struggle with this next step. I plan to keep relating it back to money and use the money pieces in small group to help them visualize the relationship."

In her analysis of teaching, teacher 1418 was the only teacher who provided any suggestions for improvement (without prompting) for the teaching in the video, which is also the *responding* level of teacher noticing. She provided an "I wonder…" as a "what if?" scenario to improve the teaching in the video clip, which corresponds to partial credit when coding, as it was not an explicit suggestion. She wrote:

> I wonder how many other kids were able to get to that idea on their own if given time to productively struggle with the concept for a while. In the beginning, the teacher asked if there was someone who knew 1/6 of 132 that could give us a clue...Do the students understand how to figure out 1/6 of 132? Do they really understand that that is dividing 132 into 6 equal groups and then it is one of those groups? Without hearing from other students, the teacher does not have a strong grasp of what students are capable of.

She wondered about lingering more on the concept, as well as about posing questions to students to foster additional opportunities for students to learn. In general, she was very attentive to both the pedagogical and mathematical indicators of the lesson, but she did not provide detailed explanations about why these indicators are important for students. This teacher might be a unique case, but it may not be a coincidence that the teacher who exhibited strong skills also provided rich and long (compared to other teachers) descriptions for the prompts of both tasks. Longer open-ended answers seem to be more likely to earn higher scores in the coding scheme because there would be more description and/or interpretation for a coder to score.

Teachers 1517 and 1405: Extreme Cases of a Lack of Correspondence Between Two Teaching Skills

Both teachers 1517 and 1405 were extreme cases, which made the trend line between teachers' analysis of teaching video and lesson planning skills less steep. Teacher 1517 is the case of a teacher who scored relatively high on the analysis of teaching video task but scored zero for the lesson planning task. In contrast, teacher 1405 is the case of the teacher who scored high in lesson planning (almost full score) but low scores in the analysis of teaching video (under the trend line).

Teacher 1517

This teacher was a case that illustrated that being at the *attending* level for the analysis of teaching video did not translate into higher lesson planning scores at all. Teacher 1517 received no credit, according to the rubric, for her lesson planning answers due to lack of specificity. For the learning goal of the lesson and key learning moment she chose, her answers were too general; in other words, they could be applied to many fraction lessons or moments in the lesson. For example, the teacher wrote, "Describe relationships between equivalent fractions," but the answer does not specify which relationship, such as the same fractional quantity can be represented by fractions with different numerators and denominators for fractions with denominators that are factors of 12. The teacher was not precise about what she meant by the relationships between fractions. The teacher mentioned multiplication and division relationships between numerators and denominators when she was responding to students' thinking before and after the (identified) key learning moment of the lesson (see table 14). But yet again, she was not conceptually specific about how students' thinking would change after the moment she specified. Neither descriptions of students' thinking before nor after the moment were precise.

Table 14 Teacher 1517's Open-ended Answers for Lesson Planning Task

	Open-ended answer
Learning goal of the lesson	"Students will record and generate equivalent fractions by using visual models if needed."
Learning goal of the (identified) key learning moment	"The learning goal is that students will be able to utilize a ratio table as a tool to help them see/describe relationships between equivalent fractions."
Students' thinking before and after the identified key learning moment of the lesson	"I think students will have a greater comfort with the fraction 1/2 and from that they will build on that knowledge in discussing the relationships between fractions that they might not be as comfortable with. I hope that they will utilize ratio tables more in the future and really understand the multiplication/division relationships between numerators and denominators."

On the other hand, teacher 1517 was very attentive in describing teachers' pedagogical teaching moves. She provided more than one teaching move (both positive and negative) that might have an effect on students' learning for each video clip. Below is her answer for one of the teaching video clips.

> The teacher asks students who know the answer of 1/6 of 132 to give a clue or ask a question in order to assist other students in thinking of the way to solve the problem. Without giving the answer and some students giving input, the teacher again asks another rephrased question in order to have the students think about the problem. She then allows student discussion and collaboration before allowing another student to come up to the board and show her strategy without telling the answer. However, she does end up sharing the answer.

In this instance, she mentioned that the teacher asked probing questions, and allowed student discussion, yet shared the answer at the end. She even explained that giving a clue and asking a probing question assisted students to think further about the problem, which was beyond *attending* and closer to the *interpreting* teacher noticing dimension. However, overall, there was not much explanation about how these teaching moves might affect students' learning opportunities. This teacher's thinking helps illustrate the quantitative results that teachers' pedagogical description is not associated with their lesson planning skills.

Teacher 1517 showed different tendencies for describing the key mathematical idea for each teaching video clip. For one video clip, she captured all the key mathematical ideas, whereas for the other two, she either partially described the mathematics in the video clip or did not do so at all. For example, the open-ended answer above for one of the teaching video clips did not capture the key mathematical idea in the video clip. However, none of her mathematical descriptions offered explanations about why this mathematical idea is important for students to learn or what conceptual breakthrough students might achieve. She also did not provide any pedagogical or mathematical suggestions for improvement.

Consequently, teacher 1517 was at an *attending* level because she sometimes captured the key mathematical idea that the teaching in the video tried to achieve. This finding is challenging to explain in the context of this study because, according to quantitative results, getting some credit for the open-ended answers for the lesson planning task would be expected from this teacher, as she provided evidence for the *attending* level in mathematical description. On the other hand, as she was at the *attending* level, maybe this skill was not strong enough to be translated into lesson planning skills yet. It is possible that teacher 1517 needs to be at the *interpreting* level when analyzing video to translate this skill into lesson planning. Overall, the length of her lesson planning task responses was much shorter than the analysis of the teaching video task.

Teacher 1405

This teacher was a case that illustrated that being more skilled at lesson planning tasks does not always align with higher scores in the analysis of teaching video task, meaning that there might be other factors that play a role in developing lesson planning skills over extended years of teaching experience. In the lesson planning task, for both the learning goal of the lesson and the key learning moment the teacher specified, she provided a detailed description of the conceptual aspect of the lesson and the moment. Her descriptions were short, yet clear and detailed enough that it was specific to this lesson and the moment she selected (see Table 15). There was also a brief interpretation of how these conceptual goals could be achieved in the specific lesson or moment. Moreover, she precisely described the after-the-moment student thinking, and she explained conceptually how after-the-moment students would develop an understanding that decimals are base-ten and, as such, need to be expressed as tenths, hundredths, and thousandths when written as fractions (see Table 15). These skills demonstrate the *interpreting* teacher noticing dimension for lesson planning. However, her before-the-moment description of students' thinking was vague as she did not specify why students would think that way before the moment.

Table 15 Teacher 1405's Open-ended Answers for Lesson Planning Task

	Open-ended answer	**Corresponding teacher noticing dimension interpretation**
Learning goal of the lesson	"With the support of base-ten pieces, show and express fractions with denominators of 2, 4, 5, and 20 as an equivalent fractions with denominators of 10 and/or 100, and in decimal notation."	*Attending & Interpreting*: The teacher was able to precisely identify and describe the learning goal of the lesson. She also interpreted this goal would be achieved with the support of base-ten pieces.
Learning goal of the (identified) key learning moment	"Students use base-ten pieces to find and identify fractions with a denominator of five as equivalent fractions with the denominators of 10 and 100. They then use the information to express the fractions as decimals."	*Attending & Interpreting*: The teacher was able to precisely describe the learning goal for the moment she picked. She also interpreted this goal would be achieved with the support of base-ten pieces.
Students' thinking before and after the identified key learning moment of the lesson	"I am expecting some students to automatically think that the numerator of the fraction becomes the digits used when writing the equivalent decimal (ex - 2/5 = 0.2). I am hoping that they recognizing that is not correct as they are developing an understanding that decimals are base-ten, and as such need to be expressed as tenths, hundredths, thousandths when written as fractions."	*Interpreting*: She identified a possible misconception about $\frac{2}{5}$ might be understood and notated as 0.2 by students. She also clearly interpreted that this moment would lead students to understand decimals are base-ten and fractions need to be in the form of tenths, hundredths, thousandths to be expressed as decimals.

This teacher appeared to be reluctant to provide a critique for teaching moves because she did not write any. Instead, she only wrote instances that have affordances on students' learning. For example, she mentioned that teachers let students come and show their work, asked clarifying questions, and made students work on models with their partners. However, these videos were intentionally chosen so participants could legitimately identify the limited opportunities provided by the instructional interaction, so it was an opportunity for participants to provide a critique for certain teaching moves, although they were not explicitly asked to do so. She did not identify key mathematical concepts in the teaching video clip, either. For only one video, she captured all the key mathematical ideas by writing, "The teacher asks the students questions to come back to the idea that to 1/6 of the cupcakes is 132 divided into 6 equal parts and that one of the equally sized parts is ⅙." Yet, she did not explain why this concept is important for students to understand. Finally, even though her open-ended answers for analysis of teaching video task prompts were longer than 1-2 sentences, which could imply a possibility for *interpreting*, her descriptions were mostly literal. Therefore, teacher 1405 was still at the *attending* level where she sometimes captured the key mathematical ideas and pedagogical teaching moves in the teaching video clip.

It is possible that this teacher was new at analyzing teaching videos, yet she had a lot of experience (31 years) to potentially improve at planning her lessons. Lesson planning is a task that teachers most likely engage in through their profession, meaning that in this teacher's case, she might have improved other skills (not analysis of teaching video) that could have had an impact on lesson planning skills. Just like teacher 1418, who scored high (compared to other teachers) in both teaching skills, teacher 1405 was the only other teacher who had 31 years of teaching experience. These were the two teachers with the most years of teaching experience in a sample where the average years of teaching experience was around 13 years (M = 13.3, SD = 8.9), and they also had high scores in lesson planning. Therefore, it might be possible that teachers' years of teaching experience is an indicator of their lesson planning skills. Based on the qualitative analysis of these teachers' data, I added the second research question to examine whether teachers' years of teaching experience could be related to the skills investigated in this study.

Research Question 2: To What Extent Do Teachers' Lesson Planning Skills Relate to Their a) Ability to Describe Key Mathematical Ideas in a Teaching Video Clip, b) Years of Teaching Experience?

This research question arose after conducting quantitative and qualitative analyses for the previous research questions. The purpose of this research question is to explore how much of the variance in teachers' lesson planning scores was predicted by their mathematical description scores (as it was found statistically significantly associated with lesson planning as part of RQ 1a), and their years of teaching experience (two teachers who both scored high in lesson planning [teachers 1405 and 1418, see research question 1.c.] also had a high number of years of teaching experience). Table 16 presents significant positive correlations; teachers' mathematical description scores were associated with their lesson planning scores [$r(21)=.46$, $p=0.03$]. Teachers' years of teaching experience were also associated with their lesson planning scores [$r(21)=.48$, $p=0.02$]. Both factors had confidence internals that are above zero, which means that there is enough evidence to suggest the correlations are statistically significant. However, there is uncertainty about how strong these positive relationships actually are considering the wide span of the bounds.

Table 16 Means, Standard Deviations, and Correlation Matrix for Variables of Multiple Regression

Variable	*M*	*SD*	1	2
1. Mathematical description	0.49	0.60		
2. Lesson Planning	0.49	0.41	.46** [.06, .73]	
3. Teachers' years of experience	13.35	8.86	.17 [-.26, .54]	.48** [.08, .74]

Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates $p < 0.1$. ** indicates $p < .05$.

A multiple regression analysis was performed to investigate the degree to which teachers' lesson mathematical description scores and years of teaching experience could predicted teachers' lesson planning scores. The overall regression model was significant, $F(3,19)=12.5$, $p=0.01$, with an R^2 of .66, indicating that 66% of the variance in teachers' lesson planning scores was explained by the predictors.

The model coefficients revealed that the teachers' mathematical description scores ($\beta=0.20$, $t(19)=2.1$, $p=.005$) and quadratic term of years of teaching experience ($\beta=0.03$, $t(19)=4$, $p=0.01$), but not linear term of years of teaching experience ($\beta=0.09$, $t(19)=1.4$, $p=0.19$) were significant predictors of lesson planning scores (see Table 17).

Table 17 Multiple Regression Parameter Estimates

Predictor	Beta	Std. Error	t	p
(Intercept)	0.182	0.083	2.188	0.041
Mathematical Description	0.197	0.094	2.092	0.050**
Years of Teaching Experience (centered)	0.009	0.007	1.365	0.188
Years of Teaching Experience_sq (centered)	0.003	0.001	4.015	0.001**

Note. * indicates $p < 0.1$. ** indicates $p \leq 0.05$.

This means that teachers' mathematical description scores positively predicted their lesson planning scores (see Figure 8), whereas teachers' years of teaching experience had a curvilinear relationship with their lesson planning scores (see Figure 7) and did not have a simple linear relationship.

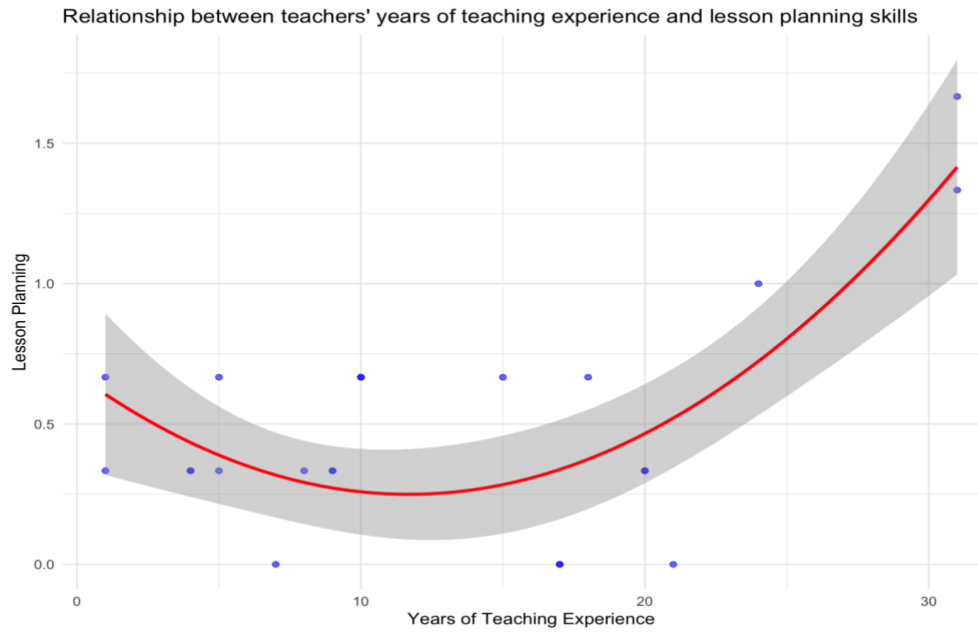

Figure 7 The Relationship between Teachers' Years of Teaching Experience and Lesson Planning Skills

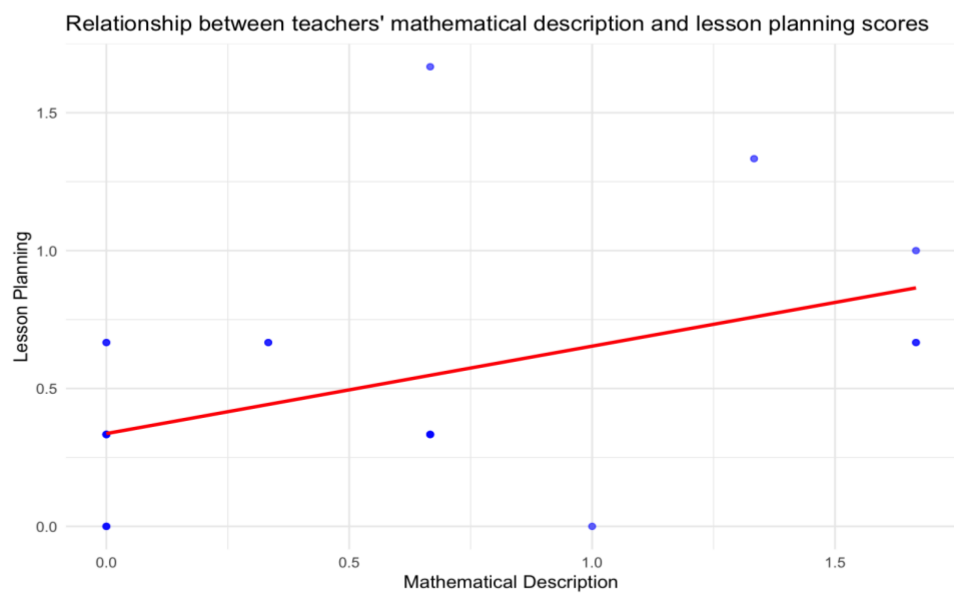

Figure 8 The Relationship between Teachers' Mathematical Description and Lesson Planning Scores

Mainly, in this exploratory study, I found a statistically significant correlation between teachers' analysis of teaching video and lesson planning skills. More specifically, this relationship was mostly associated with teachers' mathematical description of the analysis of teaching video rather than pedagogical description (based on RQ1a and RQ1b results). Because of my qualitative analyses, I started to wonder whether there might be other factors that might reflect on lesson planning, such as teachers' years of teaching experience. These salient factors might be the focus of future research that can also explain this study's extreme cases of a lack of correspondence between the two teaching skills. However, the cases that were closer to the trend line tended to be in the same teacher noticing dimension for both skills, which confirmed my initial claim, which was that teacher noticing skills can be transferrable and reflected in multiple teaching skills. Finally, although I recall that this study was underpowered, multiple regression analysis also showed that teachers' years of teaching experience and mathematical description of analysis of teaching video significantly predicted teachers' lesson planning scores.

Chapter 5

DISCUSSION

In this chapter, first, I present a summary of my findings and how these findings validate and/or are different from the previous literature's findings. Second, I share limitations of the study and my insights and suggestions for future research, considering the strengths and limitations of this study. Third, I discuss the implications of the findings for professional development designers and facilitators, and teacher noticing scholars. I end the chapter with final statements about the study in the conclusions section.

This study explored relationships between teachers' analysis of other teachers' teaching in video clips and lesson planning tasks for lessons they will teach. Because this was an explorative study that investigated a relationship that has not been investigated previously, most of the findings extend the literature. Figure 9 represents a summary of the findings of this study and possible directions for future research. I will explain what each pointed line (→) means throughout the discussion section.

Finally, not having a more comprehensive lesson planning task strongly impacted the interpretations of this study's findings. I discussed this issue later in this chapter. As the lesson planning task of this study mostly accounted for noticing the mathematical concepts and students' mathematical thinking skills of lesson planning, I prefer to call this set of sub-skills “conceptual planning” throughout the discussion section. This also means that all the initial hypotheses of this study are reflected in teachers’ *conceptual planning skills* rather than comprehensive *lesson planning skills* (but I still called it a lesson planning task when I refer to the data collection tool). In this way, I aim implications of this study could be interpreted more thoroughly.

Summary of the Findings and Review of Contributions to the Literature

My study’s overall hypothesis was: if teachers have stronger skills at analyzing teaching videos (identifying the key mathematical idea, identifying teaching moves that have the potential to impact students’ learning opportunities, and providing suggestions to improve teaching in the video clip), they will be better at conceptually planning their lessons. More specifically, teachers will more effectively attend to mathematics and the possible key learning moments of the lesson, as well as anticipate students’ thinking in these moments while planning a lesson if they have stronger skills for analyzing teaching in videos. This hypothesis was supported by prior research on pre-service teachers’ analysis of videos of teaching (i.e., van Es, 2011; Hiebert et al., 2007). These studies argued that learning from teaching helps pre-service teachers have opportunities to develop effective mathematics teaching skills (NCTM, 2014). Analysis of videos of teaching is a skill that teachers can develop to *attend*, *interpret*, and *respond* to effective mathematics teaching practices even before getting into the classroom, then teachers can prepare themselves for similar situations that they have noticed, analyzed, or discussed previously. This is also why this study investigated the analysis of videos of teaching as a teaching skill by itself, even though it may only be a proxy for what teachers do during the act of teaching in the moment.

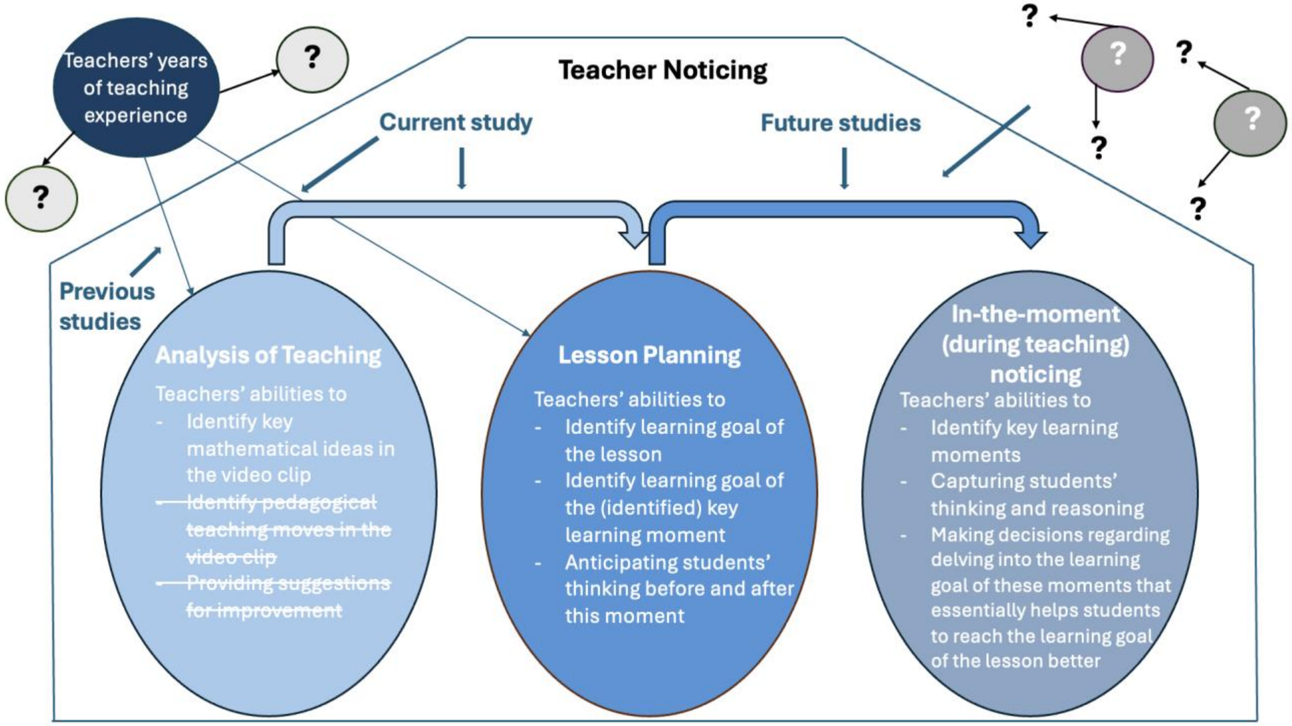

Figure 9 Summary of the Findings and Direction for Future Research

Note. The reason why teachers' ability to identify pedagogical teaching moves in the teaching video clip and providing suggestions for improvement were crossed out from the Figure 7 was because this study did not detect a relationship between teachers' ability to describe pedagogical teaching moves in teaching video and lesson planning, and there was not enough data to test any kind of relationship—considering that only one teacher provided a brief suggestion—between the teachers' abilities to provide suggestions for improvement and lesson planning skills.

With my first overarching research question, I aimed to explore whether there was any correlation between these two skills among the participants in this sample. If there were, I aimed to explore qualitatively what these relationships looked like in teachers' open-ended answers on these tasks; this qualitative examination would help me understand more about my overall hypothesis. The correlation analysis between teachers' overall analysis of videos of teaching and conceptual planning skills indicated that teachers' analysis of teaching video scores was positively associated with their conceptual planning scores. This means that teachers who were more skilled at analyzing videos of teaching were also better at identifying the learning goal, key learning moment of the lesson, as well as anticipating students' thinking before and after these moments. This finding corresponded to the pointed line from the analysis of teaching video to lesson planning in Figure 9 (one of the lines where it says *current study*). This finding was in line with Taylan's (2018) study with pre-service teachers, which found that pre-service teachers who had stronger skills in the analysis of videos of teaching focusing on student thinking also performed better in preparing lesson plan protocol with a focus on student thinking. As Santagata et al. (2007) also discovered in their study, my study also supported that analysis of videos of teaching can be an indicator and/or practice that supports better lesson planning skills, including *conceptual planning*.

The scatter plot of this analysis helped me to select cases to qualitatively illustrate how these relationships appeared in teachers' open-ended answers to tasks. Before the qualitative analysis, I also ran a correlation analysis between each specific element of analysis of teaching video—mathematical description and pedagogical description as research questions 1a and 1b, respectively—and conceptual planning.

Even though the analysis of the teaching task incorporated both pedagogical and mathematical aspects of teaching, the lesson planning task of this study was more focused on mathematics than pedagogy. This is why I conjectured that there would be a higher correlation between the mathematics aspect of the analysis of teaching and conceptual planning than the pedagogical aspect of the analysis of teaching. This is also the reason I now prefer to call it *conceptual planning* rather than lesson planning.

The results of the quantitative analysis for research question 1a supported the hypothesis that teachers' conceptual planning skills were statistically significantly associated with teachers' ability to describe key mathematical ideas in a teaching video clip. Therefore, the hypothesis for the first sub-research question was supported by the findings of this study. It means that teachers who are better at describing the key mathematical ideas in other teachers' teaching video clips are likely to identify their own lesson's learning goal, the learning goal of the key learning moment, and anticipate their students' thinking before and after this moment. In other words, teachers were able to transfer their skills for identifying the important mathematical idea from the teaching video into their skills for conceptual planning. On the other hand, the quantitative analysis for research question 1b did not show relationships between conceptual planning skills and teachers' ability to describe pedagogical teaching moves while analyzing a teaching video clip. This also means that I could not find transferability between the different domains of what to notice—mathematics and pedagogy—as part of my third hypothesis of this study.

That said, one should not draw the too far-reaching a conclusion that teachers' pedagogical descriptions of teaching in video clips could not relate to teachers' conceptual planning. For example, teacher 1409—the teacher who was on the trend line— received most of her analysis of teaching scores from pedagogical description, and she was still able to transfer her skills for analysis of teaching to her conceptual planning. Instead, this finding suggests that it is possible that a lesson planning task that is more comprehensive, including pedagogical aspects of teaching mathematics, may be more likely to show a stronger overall correlation between these two teaching skills. Similarly, a sub-analysis of the specific elements of these skills that focuses on similar domains of what to notice or teaching, such as pedagogy, could lead to similar results as this study. Considering this is a limitation of the lesson planning task of this study, future research should account for different domains of what to notice when developing lesson planning tasks. Therefore, the revised hypothesis for the relationship between teachers' abilities to describe pedagogical aspects of the lesson while analyzing videos of teaching and lesson planning is that, with a more comprehensive lesson planning task and prompts, this relationship is still likely to exist, which this study was unable to capture.

Each qualitative case was intentionally chosen to represent different trends regarding getting higher/lower scores from both tasks. Some cases aligned with the quantitative results, while some cases contradicted them. The contradicting cases were extreme cases of a lack of correspondence between two teaching skills or outliers. Regarding a case that aligned with the quantitative results, teacher 1418 was the teacher who scored highly (compared to other teachers) on both tasks, which meant that her open-ended responses showed a similar tendency to the correlation analysis of RQ1. As I expected, her open-ended answers for both tasks revealed a similar level of teacher noticing dimension: *responding*. This was the only teacher who provided any kind of suggestion for improvement (without prompting) for the video clip of teaching. She also shared a possible strategy to respond to a possible student, thinking she described in her conceptual plan. This case suggested that teachers' data may align with the same teacher noticing dimension for both the analysis of videos of teaching and conceptual planning skills. In other words, a teacher whose data reflects the *responding* level for analysis of teaching video would be also likely reflect the *responding* level for conceptual planning. Taken together, the findings of this study and previous research, the first overarching hypothesis of this study still stands. Teachers who are better at describing key mathematical ideas, pedagogical teaching moves in the lesson, and providing suggestions for improving the lesson are likely to be better at identifying their own lesson's learning goal, the learning goal of the key learning moment, and anticipating their students' thinking before and after this moment.

Similarly, teacher 1409, who was on the trend line between analysis of teaching video and lesson planning, indicating a consistent upward pattern, was in the same teacher noticing dimension for both tasks: *attending*. However, as opposed to what I found for RQ1a-b, teacher 1409 received most of her analysis of video of teaching scores from the pedagogical description, which I did not expect. It is possible that this teacher was more attentive to mathematics than pedagogy when she was thinking and planning her own lesson. But when she analyzed other teachers' teaching, she focused more on the pedagogical teaching moves.

Furthermore, as opposed to what I found from my correlation analysis for RQ1, teacher 1517 did not appear to translate her *attending* level of teacher noticing for describing mathematical and pedagogical aspects of the teaching video clip to her conceptual planning skills. As this was one of the cases that was selected as an extreme case of a lack of correspondence between the two teaching skills, this finding was naturally outside the trend. It is possible that this teacher needed to be at the *interpreting* level when analyzing video to translate this skill into conceptual planning. Considering this was not the case for teacher 1409 (being at the *attending* level for analysis of teaching video skill was enough for her to somehow translate these skills into conceptual planning), there is room for future research to investigate the reasons for differences between these cases.

One similarity between the teachers who received high scores (almost full scores for teachers 1405 and 1418) on the lesson planning task was that these teachers had the most years of teaching experience among all the participants: 31 years. Interestingly, a teacher who was on the trend line between analysis of teaching video and lesson planning (teacher 1409) had 15 years of teaching experience, which was very close to the mean of years of teaching experience among all the participants ($M=13.3$, $SD=8.9$). One possible substantive explanation would be that there is a relationship between teachers' years of teaching experience and conceptual planning skills. In other words, teachers with more experience in the classroom were likely to better identify the learning goal of the lesson and specific key learning moments, and anticipate their students' thinking. This finding corresponds to the pointed line from teachers' years of teaching experience to lesson planning in Figure 9 (one of the lines where it says *current study*). My exploration of the qualitative cases led me to investigate further by accounting for both teachers' years of teaching experience and their mathematical description scores to predict their lesson planning, which was my RQ2.

Even though teachers' years of teaching experience served teachers as an opportunity for teachers to foster their teaching skills, specific studies that investigate which teaching skills are impacted by years of teaching experience (and why) are lacking (Podolsky et al., 2019). I presented this ambiguity in Figure 9 with question marks that come out of teachers' years of experience. There have been teacher noticing studies that examined the novice versus expert teachers with the occasional assumption that expert teachers are also the teachers who have longer years of teaching experience (ie. Konig et al., 2022). These studies proposed that teachers who are better at the analysis of teaching videos are more likely to be teachers who already have experience in the classroom (Jacobs et al., 2010; Konig et al., 2015; Stockero et al., 2021). This argument corresponds in Figure 9 to the pointed line from teachers' years of experience to the analysis of teaching video (the line where it says *previous studies*). This study is based on this assumption. In this dissertation, I took one step further (after qualitative analysis) by investigating whether teachers' years of teaching experience related to their conceptual planning scores, because I suggested in this study that teachers who were better at analyzing videos of teaching were better at conceptually planning their lessons.

One unexpected aspect of teachers' years of teaching experience was its quadratic relationship with teachers' skills for lesson planning. One of the main reasons for the upward U shape was that the two teachers (teachers 1405 and 1418) who had the highest years of teaching experience also had the highest scores on the lesson planning task (see Figure 7). When we ignore those two cases, the trend is that there are higher lesson planning scores in the early career of teaching and remaining stable at a certain level. One possible explanation for this is that teacher preparation programs use lesson plans as both intervention and assessment tools (ie. Morris & Hiebert, 2017; Santagata et al., 2007). This means that in early in their careers, teachers might refer more back to their experiences with lesson planning, and later they might rely more on their classroom experiences. Another possible explanation is that this study's lesson planning task may not have accounted for all the necessary constructs that are needed for comprehensive lesson planning. For example, it is possible that some experienced teachers were new to the concept of *key learning moments of the lesson,* which was a construct that composed two out of the three items that the research team and I used to test teachers' skills for lesson planning in this study. However, they might be more successful at pedagogical considerations of the lesson, such as student engagement, which is another important factor of lesson planning (Cevikbas et al., 2023; Little, 2003) but not included in my lesson planning task. This concern will be further discussed in the limitations.

Even though this study was underpowered for a regression analysis due to its small sample size, the results for RQ 2 were surprisingly promising and will hopefully inspire future researchers. 66% of the variance in teachers' conceptual planning scores was explained by teachers' years of teaching experience and their mathematical description scores for the teaching video clip. Besides, both teachers' mathematical description scores and the quadratic term of years of teaching experience (but not linear terms) were significant predictors of teachers' conceptual planning scores. From that, I infer that teachers who learn from analyzing videos of teaching throughout their careers can develop better lesson planning skills, including conceptual planning. This might also be the reason why teachers' years of teaching experience did not have a linear relationship with their conceptual planning scores, meaning that teachers needed some teaching experience to start developing their analysis of teaching video skills and later translate it into their conceptual planning skills.

Limitations and Directions for Future Research

First of all, this study had a small sample size for a correlational and regression analysis. This is why the power of the study was under the preferred thresholds (e.g., 80%). Even though this study had inspiring findings for relating analysis of teaching video to conceptual planning skills, it is important to remember that this was an exploratory study, meaning that it did not assert causal claims or extremely generalizable arguments.

Because this study used Year 1 data of a project that offers longitudinal PD (for the purposes of exploring the sole relationship between these two teaching skills and to eliminate the PD effect), the scores teachers received for both tasks were not very high. Teachers' analysis of teaching scores (M=0.76, SD=0.39) was relatively higher than their conceptual planning scores (M=0.49, SD=0.41). The main reason for this was that most of the teachers' analysis of teaching scores was coming from their pedagogical description (M=1.03, SD=0.35) rather than mathematical description (M=0.49, SD=0.60). Considering all the factors of lesson planning task of this study were about the mathematical aspects of a lesson, it is possible to infer that making an analysis about the mathematical aspects of a lesson, either in the analysis of teaching video or the lesson planning context, is more challenging for teachers before professional learning experience.

Furthermore, for providing suggestions for improvement, there was only one teacher (teacher 1418) who provided any kind of suggestion. Even in that case, the suggestion was more of a *wondering what if* scenario rather than explaining how teaching differently would impact students' learning opportunities. One possible explanation is that these data did not address the effects of PD because the analysis of teaching video data was collected before PD started. In other words, teachers might need some time and practice to develop this skill. Furthermore, as part of the project, in the demographic questions, the research team did not ask for teachers' previous PD experiences, including analysis of teaching video exercises with their colleagues. This might be another factor that influenced teachers' scores, considering my claim for RQ2: teachers who develop skills for analyzing videos of teaching throughout their careers can develop better lesson planning skills.

Another explanation for teachers' low scores on the analysis of teaching video task was that the research team used open-ended prompts. This approach was similar to Kersting's (2008) study, which prompted teachers to "view the video and record what you notice." In other words, the research team did not ask the teachers to provide suggestions for improvement explicitly. Therefore, it is possible that teachers did not consider providing suggestions for improvement. However, even with an open-ended prompt, Kersting and her colleagues (2010; 2012) found that teachers with a higher tendency to offer suggestions about how the mathematical interactions in the video clips were more likely to exhibit higher-quality teaching and better student learning. This dissertation study seems to align somewhat with Kersting's findings, because the only teacher in this study who provided any suggestion was also the teacher who scored high (compared to other teachers) in both teaching skills. However, there was just one case in this study who provided suggestions to improve the teaching in the videos.

On the contrary, the prompts for the lesson planning task of this study were much more specific in a way that directly asked the participants about what the research team was coding. However, the scores for conceptual planning (M=0.49, SD=0.41) were still not higher than the analysis of the teaching video task (M=0.76, SD=0.39). There was even a case of a teacher (Teacher 1418) who responded to two prompts under one, whereas it should have been answered under two different prompts. This situation created an issue for her score of identifying the learning goal of the (identified) key learning moment. This means that there is room for future research to investigate what makes teachers write more and in greater detail to open-ended prompts. It is possible that teachers score lower for this type of tasks, not because they did not notice, but because they did not write for many reasons, such as time constraints, work overload, and other issues.

As I explained in the methods chapter, Cronbach's Alpha for the lesson planning task was low (α= 0.2). This could stem from multiple reasons: (1) the task included only three items for one lesson, (2) the items may not have been very consistent to each other, or (3) the teachers included in the study were inconsistent in their responses to the items on the lesson planning task. Within the current version of the assessment, dropping *describing mathematics learning goals of the lesson* item made the reliability even lower (α= 0.15), meaning that keeping this item contributes reliability of the assessment somewhat positively, but not strongly. Dropping *describing the learning goal of the (identified) key learning moment of the lesson* item improved the alpha (α= 0.34) the most out of the three factors, meaning that this item was the most poorly aligned item with the others. One possible explanation for this could be due to not having clear distinctions between prompts that unpacked similar constructs, which will be explained further in the implications. Finally, removing the *anticipating students' thinking before and after the (identified) key learning moment of the lesson* item hurt the scale the most, as the alpha score (α= -0.08) decreased drastically. In other words, this item appeared to support the scale most, because removing it reduced reliability dramatically (alpha became negative). However, the overall scale reliability was low no matter which item was dropped. All of these explanations suggest that this task may need to be revisited and tested with more lessons, more teachers, and even added prompts in future research. There is a possibility that the reliability scores of the task would be higher if there were more data to test. However, the items may need to be revised if the internal consistency among the items still remains low.

As this study met the requirements for intercoder reliability, I still used this task to assess teachers' lesson planning skills when they interpreted written curriculum. I intended to calculate the maximum observable correlation to eliminate the possible errors that affect the strength of a correlation between two variables. However, because of the low reliability of the lesson planning task, the maximum observable correlation estimate between two teaching skills was also low, even lower than the calculated correlation. It may be the case that, with the current data, I underestimated the reliability for the lesson planning task due to having a small sample size.

Another important limitation of the *lesson planning* task of this study was not accounting for all the important aspects of successful lesson planning. In this study, I only focused on aspects of lesson planning related to identifying mathematical concepts in the lesson and anticipating students' thinking. Even though these are key elements of lesson planning, it is hard to make generalizable claims by calling them *lesson planning*. Instead, future researchers should consider this study's lesson planning task as a set of sub-skills for planning a lesson that is mainly focused on mathematical concepts of a lesson, and students' conceptual understanding. As I suggested earlier, future researchers should also consider pedagogical aspects of mathematics lessons when designing *lesson planning* tasks.

One unexpected finding was that teacher 1405, who scored higher on conceptual planning than expected (considering the trendline and based on her analysis of teaching video scores), did not provide any critique for pedagogical teaching moves in the teaching video clip. There are many possible explanations for this finding. When members of a community engage in artifacts of practice, such as viewing classroom teaching video with colleagues, teachers should be able to learn from constructive criticism, develop and discuss ideas about what to look, how to describe what is noticed, provide enough evidence and rationales for given claim, and engage in productive disequilibrium through self-reflection and collegial dialogue (Ball & Cohen, 1999; van Es & Sherin, 2002; van Es, 2012). This requires a safe social environment. Such an environment requires intentional development of a learning community, such as creating professional discourse, establishing norms, and maintaining engagement in communities of practice (Ball & Cohen, 1999; Kazemi & Franke, 2004; van Es, 2012). Therefore, it is possible that before establishing such an environment, teachers can be reluctant to critique their colleagues' teaching, even when they are not with others and just analyzing teaching videos by themselves. Considering this dissertation used very early data of a longitudinal study to minimize PD effect, participants of this study might be less likely to critique their colleagues' teaching even when they notice something to critique. Future research should consider this factor (norms of a community, willingness to critique in that community) when they draw conclusions from this study.

Implications

This exploratory study had the purpose of investigating possible relationships between teachers' analysis of videos of teaching and conceptual planning skills. In this study, skills for analyzing videos of teaching were conceptualized as skills that can prepare teachers to plan more effectively and, later, enact more effective teaching. My hypothesis was that teachers who were more skilled at analyzing teaching video clips would be better at conceptually planning their lessons, because they would notice more of the moments or details that they think would lead to richer learning opportunities for their students. In other words, the analysis of teaching video skills they developed could transform into better conceptual planning. One of the implications of this study is that both learning from analysis of teaching video and conceptual planning may transform into more attentive and intentional teaching or in-the-moment (or during teaching) noticing. This direction corresponds to the pointed line from lesson planning to in-the-moment (during teaching) noticing in Figure 9 (the line where it says *future studies*). Because of the complexity of teaching, these two steps would not guarantee better teacher enactment, but future studies can still shed light on the rationales for teachers' decisions they make during teaching. This is why, in Figure 9, I added question marks to represent other factors that might have an impact on these relations for more intentional teaching practices that incorporate noticing what teachers are doing in the classroom and why.

This study has exploratory findings that might inspire PD designers to consider developing multiple teaching skills in a single PD design so that teachers would not have to approach each and every activity as a separate task. Instead, they can try to find ways in which to find relations among multiple teaching skills and translate teachers' learning from one to another. For example, teachers who examine teaching video clips in a collaborative PD setting can become better at *attending*, *interpreting*, and *responding* to these teaching video clips. Later, these teacher noticing dimensions might translate into their conceptual planning, and, similarly, they may become better at *attending*, *interpreting*, and *responding* to their conceptual plans.

Overall, there was a common trend among teachers' open-ended answers. Teachers' responses that were longer and written with more detail usually were coded with higher scores for both tasks, as there was more information for a coder to examine. One methodological implication of this study is that when collecting open-ended answer data from prompted tasks, requesting a minimum word count for the responses might help researchers collect more informative data. Furthermore, having clear distinctions between prompts might confuse participants less. In teacher 1418's case (a teacher who scored high [compared to other teachers] in both skills), she could not get credit for her response for the learning goal of the key learning moment she described because she answered this prompt under *identifying the key learning moment,* which was a prompt I did not code.

Conclusions

This study indicated that there was a relationship between teachers' analysis of teaching video, mathematical description in particular, and conceptual planning skills for teachers in this sample. The rationale for this conjecture, which was also a finding of this study, was that the same teacher noticing dimensions could be applied to multiple teaching skills. This argument was also supported by two of the cases, which were selected as teachers who were on or close to the trendline of teachers' analysis of videos of teaching and conceptual planning scores. This means that it is possible to (a) draw upon teacher noticing as a framework to connect multiple teaching skills and, later, (b) use the development of skills for analyzing videos of teaching to simultaneously improve teachers' conceptual planning skills. One of the implications of this study is that, within the teacher noticing framework, it might also be possible to transfer this learning one step further, which is teachers' classroom activities and teaching moves. In other words, future studies can build around the idea of translating these skills into teachers' in-the-moment noticing of their teaching and noticing of students' mathematical thinking and understanding.

Conceptualizing teacher noticing as a broader construct, with underlying sub-skills (such as those I investigated in this study), can help educational researchers unpack the complexity of teaching. Subconstructs of teacher noticing can be used to connect multiple teaching skills and promote them to mutually support the improvement of the other. By taking Sherin's (2017) and Choy et al.'s (2017) teacher noticing approach, as researchers, we can apply the teacher noticing framework to teachers' skills before, during, and after teaching practices, which almost represents a full cycle of teaching.

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Appendix A

ANALYSIS OF TEACHING VIDEO RUBRIC

	Pedagogical description	**Mathematical description**	**Providing suggestions**
0 points	Participant provides, at most, a **literal description** of what happened in the lesson.	Participant **does not identify the mathematics** in the video or identifies it with only a literal description of what happened. Participant provides no interpretation.	Participant **does not offer any suggestions** for how to improve the pedagogy or math shown in the video.
1 point	Participant describes pedagogy in their own words with a mention of **only one pedagogical move** (either positive or limitation).	Participant names some **parts of the key mathematical idea(s)**, but does not fully name the key idea(s). Participant implies that the teacher was focusing students' attention on this idea.	Participant names **one or more suggestions but they are all pedagogical and no mathematical** suggestions. Also there is no explanation for why the suggestion would be helpful.

2 points	Participant mentions **more than one pedagogical move and at least one of them is limitational** pedagogical teaching move.	Participant names **all key mathematical idea(s)** but provides **no explanation** for why these ideas are important in this lesson and/or how its lack of development might have contributed to students' (or teacher's) confusion.	Participant names **one or more suggestions** and **at least one suggestion relates to how mathematics** during the lesson should have been done differently and describes the suggestion.
3 points	Participant mentions **more than one pedagogical move** (at least one of them is limitational) and **describes in detail why pedagogy shown in the video was limited** in terms of students' opportunities to think about the mathematics and/or participate in the discussion.	Participant **describes all key mathematical idea(s) and explains why** it is important and/or how its lack of development might have contributed to students' (or teacher's) confusion. The participant describes key idea(s) in detail and explains why it is important in this lesson and describes how it is relevant in the discussion.	Participant **suggests changes** that would facilitate a **more complete development of the key mathematical idea** and **explains why the suggestion** would have been better than what happened in the video.

Appendix B

LESSON PLANNING RUBRIC

	(1) Learning goal of the lesson	**(2) Learning goal of the identified key learning moment**	**(3) Students' thinking before and after the identified key learning moment of the lesson**
0 points	- Participant **responds too general and vague** which means it leaves too much information implied. - Participant's response does not identify all the main conceptual aspects of the lesson. - Participant's response includes a description of something that is not part of the lesson or focuses on a minor aspect of the lesson.	- Participant **responds too general and vague** which means it leaves too much information implied (there are too many words to fill in to reach a complete response).	- Participant **does not describe student thinking** (e.g., describes what students might do or should be able to do, or what teachers could do to help students) or **describes student thinking** (or something that could be interpreted as student thinking) **but too imprecisely**. - Participant describes change in student thinking around a minor idea or an idea that is not explicitly connected to the key learning moment.

1 point	- Participant describes of what students will be able to do after the lesson **with at least some reference to the conceptual aspect**—what conceptual breakthrough might students achieve, or what understanding will they take away.	- Participant responds in a detailed description of what students will be able to do after the learning moment with **at least some reference to the conceptual aspect**—what conceptual breakthrough might students achieve, or what understanding will they take away.	- Participant **describes some thinking specifically** and **precisely**, **but only part of the question is answered precisely** (e.g., only thinking before the key learning moment is described; change in thinking is not described).
2 points	- Participant responds in a **detailed description of the conceptual aspect of the lesson**—the conceptual advance or breakthrough students might achieve, or the understanding they will take away.	- Participant responds in a **detailed description of the conceptual aspect of the moment**—the conceptual advance or breakthrough students might achieve, or the understanding they will take away.	- Participant **describes student thinking completely and precisely** before the key learning moment and after the key learning moment.

Appendix C

IRB/HUMAN SUBJECTS APPROVAL

UNIVERSITY OF DELAWARE

Institutional Review Board
210H Hullihen Hall
Newark, DE 19716
Phone: 302-831-2137
Fax: 302-831-2828

DATE:	March 10, 2022
TO:	Erica Litke
FROM:	University of Delaware IRB
STUDY TITLE:	[1456276-3] Improving Professional Development in Mathematics by Understanding the Mechanisms that Translate Teacher Learning into Student Learning
SUBMISSION TYPE:	Amendment/Modification
ACTION:	DETERMINATION OF EXEMPT STATUS
EFFECTIVE DATE:	March 10, 2022
REVIEW CATEGORY:	Exemption category # *(1)*

Thank you for your Amendment/Modification submission to the University of Delaware Institutional Review Board (UD IRB). According to the pertinent regulations, the UD IRB has determined this project is EXEMPT from most federal policy requirements for the protection of human subjects. The privacy of subjects and the confidentiality of participants must be safeguarded as prescribed in the reviewed protocol form.

This exempt determination is valid for the research study as described by the documents in this submission. Proposed revisions to previously approved procedures and documents that may affect this exempt determination must be reviewed and approved by this office prior to initiation. The UD amendment form must be used to request the review of changes that may substantially change the study design or data collected.

Unanticipated problems and serious adverse events involving risk to participants must be reported to this office in a timely fashion according with the UD requirements for reportable events.

A copy of this correspondence will be kept on file by our office. If you have any questions, please contact the UD IRB Office at (302) 831-2137 or via email at hsrb-research@udel.edu. Please include the study title and reference number in all correspondence with this office.

INSTITUTIONAL REVIEW BOARD

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