Supporting Pre-Service Mathematics Teachers to Notice and Understand the Practice of Positioning Students Competently

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Abstract

Positioning students as competent learners has been shown to be a crucial approach in fostering student learning in mathematics, and has been especially effective in supporting students who express mathematically incorrect understandings (Gresalfi, Martin, Hand, & Greeno, 2009; Kazemi & Hintz, 2014; Lampert, 2003). Few studies have aimed to support pre-service teachers (PSTs) in learning to notice interactions that can deepen their understanding of positioning students competently (PSC). During this qualitative design-based research study, four pre-service teachers from an eastern Canadian university participated in three one-on-one video analysis sessions where they were asked to watch videos and use a framework to support them in attending to and interpreting moments that relate to positioning students competently. Three research questions guided this study: 1) How do pre-service mathematics teachers' conceptualizations of PSC change through their engagement in video viewing sessions? 2) How do pre-service mathematics teachers' noticing of moments of positioning change through their engagement in video viewing sessions? 3) How do the design supports help to contribute to the development of PSTs' understanding and noticing? To answer these questions, audio- and video-footage were collected from pre- and post-interviews, while audio-footage, video-footage, written artifacts, and researcher observations were collected from video analysis sessions. Results showed that: 1) three of the four participants emerged from the study with a deeper understanding of PSC; 2) two participants emerged from the study more consistently attending to the teacher and students, whereas the majority of participants showed improvements in interpreting PSC; 3) most supports were beneficial in supporting PSTs' noticing and understanding of PSC. In addition, a fine-grained analysis of two contrasting episodes from one session showed how the facilitator's role in providing alternative teaching examples and the

PST's interactions with the framework (e.g., the definition of PSC) supported one participant in expanding her understanding of PSC. These results have implications for possible resources that can help PSTs cultivate deeper understandings and more focused noticing of interactions of PSC.

Résumé

Positionner des étudiants en tant qu'apprenants compétents a été démontré comme étant une approche essentielle favorisant l'apprentissage des étudiants en mathématique, et a été particulièrement efficace comme support pour des étudiants qui expriment une compréhension incorrecte des mathématiques (Gresalfi, Martin, Hand, & Greeno, 2009; Kazemi & Hintz, 2014; Lampert, 2003). Peu d'études ont eu pour but d'appuyer les enseignants en formation à apprendre comment remarquer des interactions qui peuvent approfondir leur compréhension sur comment positionner les étudiants en tant qu'apprenants compétents. Au long de cette étude qualitative, quatre enseignants en formation d'une université est-canadienne ont participé à trois sessions tête-à-tête d'analyse vidéo où on leur a demandé de regarder des vidéos et d'utiliser un cadre de référence comme appui pour se concentrer sur et pour interpréter les moments concernant le positionnement des étudiants en tant qu'apprenants compétents. Trois questions de recherche ont guidé cette étude : 1) Comment est-ce que la conceptualisation des enseignants en formation sur ce qui est du positionnement des étudiants en tant qu'apprenants compétents change par leur engagement dans les sessions d'analyse vidéo ? 2) Comment est-ce que l'habilité des étudiants en formation à se concentrer sur les moments relatifs au positionnement change par leur engagement dans les sessions d'analyse vidéo ? 3) Comment est-ce que les supports d'étude ont contribué au développement de la capacité des enseignants en formation à comprendre et à remarquer ? Pour répondre à ces questions, des enregistrements audio-visuels ont été recueillis lors des séances pré-entrevue et post-entrevue et des enregistrements audio-visuels ainsi que des écrits et observations du chercheur lors des sessions d'analyse vidéo. Les résultats ont démontré que : 1) trois des quatre participants sont ressortis de l'étude avec une meilleure compréhension du positionnement des étudiants en tant qu'apprenants compétents; 2) deux participants sont

ressortis de l'étude avec une meilleure capacité de concentration sur l'enseignant et sur les étudiants, et la majorité des participants ont aussi démontré des améliorations quant à l'interprétation du positionnement; 3) la majorité des supports d'étude ont été bénéfiques au développement de la capacité des enseignants en formation à comprendre et remarquer. De plus, une analyse approfondie de deux épisodes contrastants pendant l'une des sessions a démontré comment le rôle du facilitateur en fournissant des exemples d'apprentissage alternatif, ainsi que les interactions du participant avec le cadre d'étude (p. ex. : définition du positionnement) l'ont aidé à cultiver une compréhension plus étendue du positionnement des étudiants en tant qu'apprenants compétents. Ces résultats ont des implications pour des possibles ressources qui peuvent aider les enseignants en formation à cultiver une compréhension approfondie et une meilleure capacité à remarquer des interactions de positionnement d'élèves en tant qu'apprenants compétents.

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Preface: Contributions of Author

I undertook the task of conducting this study by myself, including the research, recruitment of participants, data collection, data analysis, and the writing of this thesis. Chapter one includes an introduction to my study, a discussion of salient research, and an overview of how my study attends to gaps in the literature. Chapter two includes a review of relevant literature and theoretical perspectives, as well as an exploration of the design principles and supports that guided my study. Chapter three includes my methodology and analysis procedures. The fourth chapter explores my results in relation to my research questions. The fifth chapter includes a discussion centered around my results in relation to relevant literature, with a focus on this study's contributions to knowledge. The fifth chapter also brings attention to my study's limitations, as well as possible further research. Although I am the sole author of this study, it is important to note that throughout each stage of my study I received guidance from my supervisor, Dr. Marta Kobiela. My supervisor not only guided me academically but also helped me when designing the study and analyzing data. More specifically, she took the time to help me select videos for video analysis sessions, revised and coded a sample of data from interview transcripts, as well as made suggestions for revisions to design supports (see Chapter 3).

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Chapter 1: Introduction

Recent reforms in mathematics education advocate for immersive and student-centered environments where students can cultivate rich learning opportunities (National Council of Teachers of Mathematics, 2000, 2014; Québec Ministère de L'Éducation, 2001; van Es, Cashen, Barnhart, & Auger, 2017). In these environments, students are encouraged to author their own mathematical understandings and feel competent in their ability to make sense of ideas (Gresalfi, Martin, Hand, & Greeno, 2009; Kazemi & Hintz, 2014; Johnson, 2017). They are also encouraged to take risks and justify their thinking (Stein, Grover, & Henningsen, 1996). Through the implementation of meaningful activities, students can foster deeper understandings and more positive associations with mathematics (Boaler & Greeno, 2000; Stein et al., 1996).

While student expectations advocated for in reform initiatives are complex and challenging, the methods needed by teachers to successfully foster them are equally so. Such instruction – often referred to as *ambitious* – discourages low cognitive demand tasks that passively engage students (e.g., rote memorization) (Boaler & Selling, 2017; van Es et al., 2017). Ambitious instruction refers to learning environments that center on student contributions as teachers take a less active role in directing students' thinking and instead encourage students to assume more responsibility in mathematical discussions (van Es et al., 2017). Activities yield more than one solution as they are designed to challenge but also provide students with the necessary supports needed to excel (Stein et al., 1996). Teachers are expected to teach complex mathematical ideas in ways that are meaningful to students (National Council of Teachers of Mathematics, 2000, 2014; Québec Ministère de L'Éducation, 2001; Stein et al., 1996). Although there is not one way to do so, emphasis has been placed on whole class discussions, debates and challenging but authentic tasks meant to provoke students to negotiate ideas and expand their

thinking (Boaler & Selling, 2017; National Council of Teachers of Mathematics, 2000, 2014; Québec Ministère de L'Éducation, 2001).

Within ambitious instruction and other reform-oriented approaches, positioning students competently (PSC) is a teacher practice that can foster positive dispositions towards mathematics. Through this practice, students' responses are valued and students are encouraged to author mathematical ideas (Kazemi & Hintz, 2014; Johnson, 2017). PSC does not frame competence as a set of "skills or abilities" held by individual students (Gresalfi et al., 2009, p. 50); nor is a student's ability to articulate correct answers an indicator of their competence. Rather, a student's efforts are valued and competence is considered "an interaction between the opportunities that a student has to participate competently and the ways that individual takes up those opportunities" (Gresalfi et al., 2009, p. 50). This mindset shifts the focus away from what students can do, and instead places the onus on the teacher to provide students with opportunities to author ideas and contribute to class discussions.

However, one challenge facing implementation of ambitious teaching practices, such as PSC, is the knowledge and experience needed. Many pre-service teachers (PSTs) have a limited understanding of how ambitious forms of teaching look in practice, making it more difficult for PSTs to align themselves with such a teaching approach (Santagata, Zannoni, & Stigler, 2007). When teaching, PSTs and teachers often use the traditional methods of teaching they were familiar with in school (Ball, 1988; Lortie, 2002). It is thus imperative that more research focus on supporting PSTs in valuing, understanding, and implementing current reform ideals.

Although it is important that PSTs align themselves with ambitious instruction, achieving this in teacher education programs can be challenging. Time constraints coupled with limited experiences and exposure to ambitious teaching during fieldwork continue to impact the

effectiveness of instruction (Santagata & Yeh, 2014; Santagata et al., 2007). Santagata and Yeh (2014) explain that "[t]eacher preparation programs often find it challenging to build strong connections between coursework content and the practice of teaching" (p. 492). There is no straightforward solution to such shortcomings; however, a possible solution is to support PSTs in developing practices that can be adapted and applied to a range of situations.

One practice that has gained increased attention as critical for teachers' development is noticing (Jacobs, Lamb, & Philipp, 2010; Mason, 1991; Sherin & van Es, 2009). Noticing entails honing in on important aspects of a classroom environment to direct focus towards more manageable units that can be considered in-depth (Jacobs et al., 2010). Noticing can significantly impact how teachers interact with a learning environment; Goleman states:

> [t]he range of what we think and do is limited by what we fail to notice. And because we fail to notice that we fail to notice, there is little we can do to change until we notice how failing to notice shapes our thoughts and deeds. (as cited in Jacobs et al., 2010, p. 24)

Noticing has clear implications for professional development and practice, as it has been shown to support teachers in focusing more on student's thinking and expanding their "knowledge-based reasoning" (Sherin & van Es, 2009, p.26). Thus, developing noticing skills is imperative for PSTs, as by noticing, they are given more opportunities to further their understanding of ambitious instruction and of students' thinking – a set of practices they have seldom had experience with (van Es et al., 2017).

However, noticing is difficult, and novices tend to focus on student behaviour and the classroom environment in a "simplistic and dichotomous way – as right or wrong; good or bad; teaching or learning" (Seago, 2003, p. 274). Such struggles with noticing have been attributed to a limited understanding of what to notice or to distractions present in the classroom environment

that divide attention (Walkoe, 2014), making it important to implement activities that can counter such mindsets.

To attend to this, many studies have focused on cultivating PSTs' noticing through video analysis (e.g., Barnhart & van Es, 2014; McDuffie et al., 2014; Santagata & Angelici, 2010; Santagata & Yeh, 2014; Santagata et al., 2007; Seago, 2003; Seidel, Blomberg, & Renkl, 2013; Star, Lynch, & Perova, 2011; Star & Strickland, 2008; van Es et al., 2017; van Es & Sherin, 2002), an approach that has been shown to significantly impact how PSTs are able to interpret, reflect, and enact current teaching approaches (Santagata & Yeh, 2014; Sherin & van Es, 2009; van Es & Sherin, 2002). Video analysis calls on PSTs not only to view video footage, but to notice what is of importance and interpret these significant interactions more broadly.

Researchers continue to expand video noticing to include tasks that support PSTs to elaborate on their reflections and consider teaching more deeply. For instance, scholars have researched the use of frameworks to support PSTs when video noticing (Barnhart & van Es, 2014; Hiebert, Morris, Berk, & Jansen, 2007; McDuffie et al., 2014; Santagata & Angelici, 2010; Santagata & Guarino, 2011; Santagata & Yeh, 2014; Santagata et al., 2007; Seago, 2003; Star, Lynch, & Perova, 2011; Star & Strickland, 2007; Walkoe, 2014; Yeh & Santagata, 2014; van Es & Sherin, 2002; van Es et al., 2017). These frameworks can include theoretical ideas and/or questions to focus PSTs' viewing and help them articulate more detailed responses. Theoretical ideas explain or decompose a teaching practice, whereas questions direct PST attention towards significant aspects of a lesson (e.g., "Which best describes the structure of the activities?" (Star, Lynch, & Perova, 2011, p. 25)).

The merit of this research is rich. However, limited attention has been placed on using video analysis and frameworks to direct PST's attention towards noticing and understanding a

specific practice to forge more in-depth understandings. Frameworks often include questions that are broad, and although attention can be directed towards specific aspects of a classroom environment, PSTs are often encouraged to consider a wider range of interactions. For example, Santagata and others (e.g., Santagata & Angelici, 2010; Santagata & Guarino, 2011; Santagata & Yeh, 2014; Santagata et al., 2007; Yeh & Santagata, 2014) developed frameworks that included questions meant to direct attention towards several key features of a classroom environment. Further, Santagata and Angelici (2010) explored PSTs' experience with a framework that highlighted: a lesson's learning goals, the practices teachers used to achieve these, how this in turn affected students' learning, and, possible alternative teaching practices that can be used to support students. Questions from their framework included, but were not limited to, asking PSTs to "[c]hoose the three most significant moments of the video clip," "[e]valuate the effectiveness of the activities" using a likert scale, and "[e]xplain which activities/ strategies you saw this teacher use" (p. 343). Other scholars have chosen to use frameworks to focus either on the teacher (Star & Strickland, 2008) or students (Barnhart & van Es, 2014; Walkoe, 2014). Star's and Strickland's (2008) framework included questions to focus video viewing. Questions directed PSTs attention towards: "[c]lassroom management," "[t]asks," "[m]athematical content," and "[c]ommunication" (p. 113). In contrast, Walkoe's (2014) framework did not include questions but was designed to support PSTs in noticing students' algebraic thinking. Their framework served as a springboard that PSTs could consider to "tag" video footage (p. 529).

The aforementioned frameworks have proven to be valuable resources that can support PSTs in developing more organized and detailed noticing. However, within the noticing literature, more research is needed in understanding how more focused frameworks can promote teacher noticing of particular teaching practices (Santagata et al., 2007). This holds especially

true for PSC, as studies have not yet focused on supporting PSTs in noticing and understanding the practice of PSC through video and noticing frameworks.

1.1 Study Overview

This study attends to this gap by using a framework, along with other supports to cultivate PSTs' ability to notice and reflect on interactions relating to PSC. To do this, I engaged in a design-based research study (Cobb, Jackson, & Dunlap, 2014) consisting of several supports designed to cultivate PSTs' understandings and noticing of PSC. Ultimately, this study aimed to answer three overarching research questions:

1. How do pre-service mathematics teachers' conceptualizations of PSC change through their engagement in video viewing sessions?
2. How do pre-service mathematics teachers' noticing of moments of positioning change through their engagement in video viewing sessions?
3. How do the design supports help to contribute to the development of PSTs' understanding and noticing?

The findings help build an understanding of how PSTs can be supported in conceptualizing a complex ambitious practice (PSC) and also attends to current gaps in knowledge by exploring how a focused framework (i.e., centered on one practice) can impact PSTs' learning to notice and understanding of PSC.

1.2 Chapter Summaries

My thesis is organized in five chapters. This first chapter briefly introduced my study, salient research in this field, and discussed the need for more empirical work to further current understandings. The second chapter contextualizes my work within various bodies of literature and explores the theoretical perspectives that underpin this study, including the design principles

that guided the design of the instructional supports. The third chapter discusses the methodology and methods guiding my study, including an overview of my analysis procedures. The fourth chapter explores my results in relation to my three overarching research questions. Finally, the fifth chapter grounds these findings in relevant literature, considers their contributions towards future knowledge, and highlights implications, limitations and next steps.

Chapter 2: Theory and Context

This design study was created to support PSTs in familiarizing themselves with PSC by noticing and understanding instances related to this practice. In what follows I will explore the various theories that have influenced my work and situate them in relation to my study. This chapter begins with a review of literature and key theoretical perspectives that are foundational for guiding and motiving my work and concludes with an exploration of the design principles guiding my work.

2.1 Positioning Theory

Before exploring PSC it is important to discuss positioning theory more broadly. Positioning occurs during discourse and shapes the way interlocutors (i.e., speakers participating in conversation) narrate their storylines (Davies & Harré, 1990). Storylines are forged when meanings are recurrently assigned to categories (e.g., teacher, student; good at math, bad at math; etc.). As in a story plot, various characters are located by others or by themselves in different storylines. When conversations unfold, positioning can happen in two ways: a person can position another person (*interactive positioning*) or can position themselves (*reflexive positioning*) (Davies & Harré, 1990). It is important to note that positioning is not always straightforward. An utterance can be uniquely taken up, or not, by interlocutors and often the ways interlocutors position is influenced by convergent or divergent socially constructed storylines (Herbel-Eisenmann, Wagner, Johnson, Suh, & Figueras, 2015).

When a person attempts to position another through interactive positioning, they are providing others with a limited range of positions to potentially assume. To make this clearer, Davies & Harré (1990) explain that,

> By giving people parts in a story, whether it be explicit or implicit, a speaker makes available a subject position which the other speaker in the normal course of events would take up. A person can be said thus to 'have been positioned' by another speaker. (p. 48)

However, it is important to note that speech acts (i.e., the way an utterance is interpreted and taken up socially) are rarely clearly defined, as multiple interlocutors can interpret the same utterance in different ways. These speech acts are thus experienced differently in ongoing storylines (Davies & Harré, 1990; Herbel-Eisenmann et al., 2015). In the context of a math class, the teacher may voluntarily or involuntarily position students as either competent in mathematics or not, and students can then either take up this position or refuse it. Still, discourse is fluid and dynamic, and following a negative statement, a student may or may not position themselves in alignment with it. However, not positioning students competently on one occasion may affect students adversely and be detrimental to their disposition towards mathematics and belief in their mathematical capabilities.

Worse still, if this position is taken up (*reflexive positioning*), then student(s) can position themselves as incompetent in mathematics. Considering the way a teacher positions students can "strip initiative from students" (Gresalfi & Cobb, 2006; Wagner & Herbel-Eisenmann, 2009, p. 5), if students are not positioned competently, they may be more reluctant to participate. This, in turn, may provide the teacher with fewer opportunities to position the student competently in the future. In line with this point, Davies & Harré, (1990) state that,

> [a] subject position incorporates both a conceptual repertoire and a location for persons within the structure of rights for those that use that repertoire. Once having taken up a particular position as one's own, a person inevitably sees the world from the vantage point of that position and in terms of the particular images, metaphors, story lines and

> concepts which are made relevant within the particular discursive practice in which they are positioned. (p. 46)

In a classroom, students who are not positioned competently can feel limited and confined to a specific label and if not rectified, may begin to reflexively position themselves as such. It is thus important that PSTs are encouraged to explore how students can be affected by the ways teachers position students.

2.2 Positioning Students Competently

Mathematics is highly engaging but can be daunting to students who express misunderstandings (Kazemi & Hintz, 2014). Considering current reforms advocate for classroom discussions, debates and activities that encourage students to cultivate their own understandings in mathematics (van Es et al., 2017), it is crucial that students feel comfortable and confident enough to participate (Kazemi & Hintz, 2014).

PSC calls on the teacher to acknowledge students' contributions regardless of the correctness of their responses and support students in seeing not only the value of their answers, but also their ability thereafter to author and make sense of mathematical ideas (Gresalfi et al., 2009; Kazemi & Hintz, 2014; Johnson, 2017). PSC, although alluded to in academic texts, is seldom discussed as a practice, in that the term "positioning students competently" has received less attention in research in teacher educator contexts. In what follows, I discuss research related to PSC and how, based on this research, I created a definition that was multifaceted while still straightforward enough for PSTs to readily learn during the study. This definition includes three components: (a) acknowledging all student contributions to highlight their value, (b) providing students with opportunities to make sense of and author mathematical ideas, and (c) using teacher moves to PSC. Each component of the definition will guide the following sections.

2.2.1 Acknowledging all student contributions to highlight their value. When students' ideas are acknowledged and valued, competence is re-conceptualized as how students participate and not necessarily as what is said; to do so, students need to be provided with opportunities to express their mathematical understandings (Gresalfi et al., 2009). Different activities thus vastly affect how students' contributions are acknowledged and valued. This comparison is more readily visible when comparing traditional and reform-based classrooms (Boaler & Greeno, 2000; Gresalfi et al., 2009). In traditional classrooms, students are required to reveal their competence by providing correct answers and solutions learnt through rote exercises (Boaler & Greeno, 2000). In this context, students cannot be positioned as competent learners as competence is a *trait* held by students that can reproduce memorized content knowledge (Gresalfi et al., 2009). Only correct responses are acknowledged, and when students contribute an incorrect response, whether their ideas are acknowledged or not, the teacher does not value it, as the goal is to find *the* right answer and move on (Gresalfi & Cobb, 2006).

On the other hand, reform classrooms emphasize whole-class discussions where all students are encouraged to negotiate ideas and author their understandings (Boaler & Greeno, 2000; Gresalfi & Cobb, 2006). Teachers support the use of different solutions, and discussions thus afford students opportunities to share both correct and incorrect ideas to cultivate and negotiate deeper understandings. Incorrect responses are not simply acknowledged as being wrong. Instead, efforts to contribute and share ideas (regardless of their correctness) are welcomed as a way to signal acknowledgement (Gresalfi et al., 2009).

Once students are provided with opportunities to express their understandings (to acknowledge them), it is then important to highlight the value of students' contributions. This calls on teachers to "recognize publically students' ideas, [and] mak[e] sure [not to] single out

just a few students as mathematically 'smart'" (Kazemi & Hintz, 2014, p. 5). In their research, O'Connor and Michaels (1996), Lampert (2003), and Ball (1993) illustrate how teachers do this, as they each focus on how teachers support all students in understanding mathematical ideas, regardless of the correctness of their claims. Through such support, students' contributions are acknowledged and valued, encouraging them to participate in the future. This approach combats initiation response evaluation (IRE) pedagogical methods (Mehan, 1979) because teachers no longer search for and call on only the students who express mathematically correct responses, but instead focus on all student contributions – not valuing one more than another (O'Connor & Michaels, 1993, 1996).

Acknowledging and valuing work in tandem, as all responses that are acknowledged are equally valued. O'Connor and Michaels (1993; 1996) give an example of a teacher acknowledging and valuing a student response by voicing what they had said (a move they term *revoicing*). Similarly, Lampert (2003) recounts how an incorrect response was brought attention to in a positive way. When one student, Richard, shared an incorrect answer, the teacher chose to write it on the board and seized the moment as an opportunity to share how manipulatives can be used to solve mathematical problems. Richard's response was not pegged as wrong nor did the teacher (Lampert) correct him with the right answer; instead she acknowledged and valued his response by revoicing and representing his ideas on the board. Lampert valued the student's answer, indicating to the class that all answers are relevant. Likewise, Ball (1993) discusses how a student named Sean believed that six could be both an even and odd number. Although incorrect, Ball used this as an opportunity to value the student's response by classifying his answer as a "mathematical invention" called "Sean numbers" (p. 387). Ball's choice did not seem to confuse students, as on their quizzes they were still able to correctly reason about even

and odd numbers. Although PSC is not mentioned explicitly, all three papers describe how acknowledging and valuing a students' response can support student learning at an individual (i.e., O'Connor and Michaels, 1993; 1996) and/or group (i.e., Ball, 1993 & Lampert, 2003) level. When positioning students as competent learners, it is crucial that students' responses are acknowledged and in turn valued.

2.2.2 Providing students with opportunities to make sense of and author mathematical ideas. Despite their importance, acknowledging and valuing are not enough to support mathematical understandings, as students also need to learn to make sense of and author content ideas. Authoring entails that students actively engage in classroom discussion and exercise agency by expressing their own mathematical understandings (Boaler & Greeno, 2000). The interaction Ball (1993) highlighted as an instance where Sean's incorrect answer was valued, also succeeded in encouraging him to continue to cultivate and author his mathematical understandings. Although the student had expressed a mathematically incorrect statement, Ball positioned the student as an author of ideas by inviting him to continue to negotiate his understandings about even and odd numbers. Supporting students as authors and sense makers in this context can be considered as an *opportunity* given to students as they are called on to continue to contribute and reconcile their ideas. Similarly, when considering O'Connor and Michaels (1996), the teaching move revoicing, in some cases can provide students with opportunities to author and make sense of mathematical ideas. For example, when revoicing, a teacher can ask a student to affirm their statement or adjust it. Doing so not only shows value for the student's contribution, but also shifts the authority from the teacher back to the student by provoking them to reflect on their thinking. Likewise, when Lampert (2003) described how

Richard's answer was valued, with the teacher's guidance and the class discussion, he was also given the opportunity to reconstruct his understanding and voice the correct answer.

In light of this, PSC attempts to sustain interest and engage students who express correct or incorrect understandings, while also encouraging students who are more reluctant in mathematics to contribute and author their ideas (Gresalfi et al., 2009; Kazemi & Hintz, 2014; Johnson, 2017).

2.2.3 Using teacher moves to position students competently. Various teacher moves have been found useful when positioning students as competent learners; but before describing these, a distinction must be made between a teacher move and a teaching practice. A practice can be considered a resource and a lens a teacher may use (Boerst, Sleep, Ball, & Bass, 2011). However, to enact a practice, a teacher can draw on other resources (Boerst et al., 2011; van Es, Tunney, Goldsmith, & Seago, 2014). Thus, I refer to PSC as a practice because a teacher can use various teacher moves to position students. These moves include but are not limited to: (a) representing student ideas (Aki & Chana, 2017; Ball, 1993), (b) revoicing (Kazemi & Hintz, 2014; O'Connor & Michaels, 1996), (c) pressing on student thinking (Ball, 1993; Ozgur, Reiten, & Ellisvan, 2015; Webb, Franke, Ing, Turrou, Johnson, & Zimmerman, 2017) and (d) highlighting student ideas (Goodwin, 1994; Stevens & Hall, 1998; van Es et al., 2014). I elaborate on each of these in what follows.

Representing students' thinking is an important teacher move that not only acknowledges and places value on a student's response, but can also provide other students with a new lens to use (Aki & Chana, 2017). Representations serve to illustrate a mathematical idea and can be especially useful in making thinking visible (Aki & Chana, 2017; Ball, 1993). Ball (1993) brings attention to how teachers must consider how a representation can highlight particular

mathematical ideas to support student learning (i.e., money or an illustration of a large multileveled house to support students' understandings of integers). She explains that, "[f]iguring out powerful and effective ways to represent particular ideas implies, in balanced measure, serious attention to both the mathematics and the children" (p. 378). Representations are not limited to one medium. For example, Aki and Chana (2017) bring attention to the possible ways students' work can be represented on the board. Still, despite their usefulness, representations must be deliberately used as they can otherwise be distracting to students (Aki & Chana, 2017).

Revoicing also allows a teacher to represent a student idea; however, a teacher does so only verbally (Kazemi & Hintz, 2014; O'Connor & Michaels, 1993, 1996). Often the teacher repeats what is said, which then positions the student as the author of the idea. The teacher may then ask the student to acknowledge that the restatement of their idea aligns with their original intent. Through this, students are supported in authoring their own mathematical understandings as the move gives them the opportunity to accept the teacher's conceptualization or rephrase it. The teacher does not seek the right response but places the onus on the students to further make sense of their thinking and of content ideas. This move can be especially useful for students who express misunderstandings, as they are given the opportunity to reconsider their ideas and realign their responses (O'Connor & Michaels, 1993, 1996).

Pressing on someone's thinking is a means to provoke them to further consider an idea (Ozgur et al., 2015; Webb et al., 2017). It is also an effective way to help students author and make sense of mathematical ideas. Ozgur et al. (2015) explains that pressing can serve multiple purposes as a student may be pressed to: elaborate on their expressed ideas, justify a statement, or formulate an alternate solution. Through such questioning, the teacher prompts a student to

reflect and elaborate on their ideas, which can prove helpful in supporting students who struggle with mathematical concepts. For instance, Ball (1993) used pressing by asking Sean to formulate a definition for "Sean numbers" (p. 387). By pressing, Ball was able to help the student reflect on his thinking and make it visible to others.

Finally, highlighting involves honing in on a noteworthy idea (Goodwin, 1994; van Es et al., 2014). Highlighting has commonly been discussed in professional practice (Goodwin, 1994; van Es et al., 2014) and although less focus has been placed on it in teaching, it has merits as a teaching move. For instance, Stevens and Hall (1998) describe a mathematics tutoring session in which the tutor highlighted aspects of mathematical representations for the student by asking the student to "look at it this way" (p. 141). When considering PSC, the teacher can use a similar strategy to equally highlight both correct and incorrect contributions (e.g., "Let us consider what Laura and Devin just said when reviewing this solution") or to emphasize students' participation over their answers (e.g., "I like your reasoning. Explain to me your . . ."). Ultimately, the aim of this approach is well aligned with those of PSC, as it can encourage all students to participate in mathematical discussions and can foster positive dispositions towards mathematics.

2.2.4 Conceptualizing a working definition for pre-service teachers. Based on the aforementioned literature, in an attempt to encompass the multifaceted nature of the practice in a way that is accessible to PSTs, I define PSC as: *a practice that calls on the teacher to value all contributions by acknowledging them and using teaching moves to provide students with opportunities to make sense of and author mathematical ideas*. Two aspects of the definition – providing students with opportunities to make sense of and author ideas and acknowledging all student contributions to highlight their value – can be considered as overlapping (see Figure 1), while using "teacher moves" can work with one or both components. The definition works

together because to PSC a teacher can use moves to simultaneously value, acknowledge, and support students as sense makers and authors. Yet, the definition can work independently since a teacher may still PSC using only one component of the definition. For example, in an attempt to value a students' contribution, the teacher may acknowledge and value it by using highlighting, and if the teacher does not follow up with another move, the student may not be explicitly supported in authoring and making sense of mathematical ideas. To further distinguish between each aspect of PSC, I outline the following thought experiment: When a teacher acknowledges a students' response, they may say, "No, 21 is not correct. The answer is 22." In this example, despite being acknowledged, the students' response was not valued and can be considered an example when the student was not positioned as competent. In contrast, if a teacher were to revoice and say, "Bobby said that he got 22 by adding 10 + 10 + 2," the teacher would be acknowledging and valuing the students' response. However, because the teacher did not follow up with additional moves, this interaction did not lead to opportunities for sense making and authorship. Thus, the definition of PSC can work together and independently depending on the interactions that are taking place and their purpose.

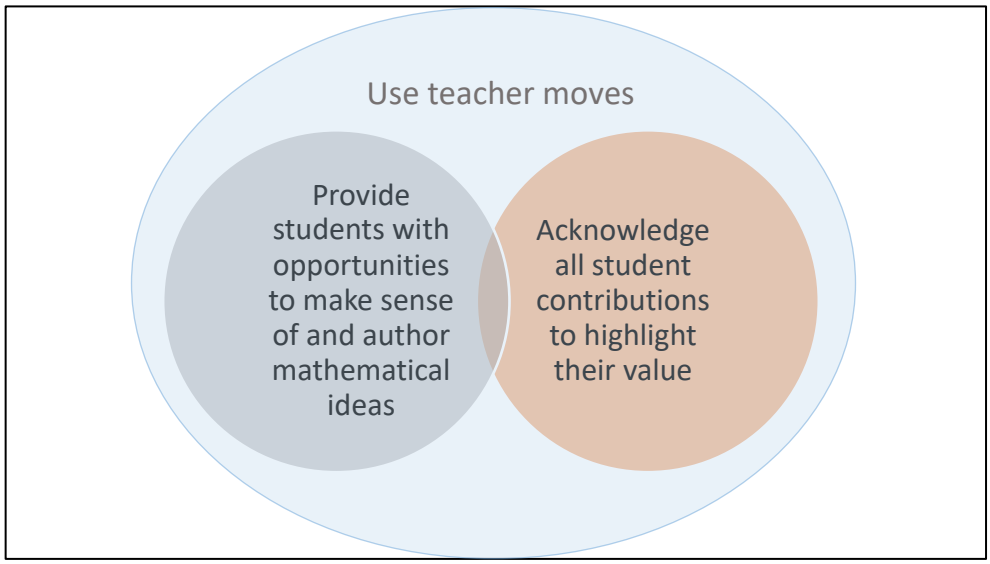

Figure 1. Defining Components for the Practice of Positioning Students Competently.

2.3 Noticing

Noticing entails honing in on significant aspects of an environment (Goodwin, 1994; Jacobs et al., 2010; Mason, 1991). When considered in professional contexts, maintaining a common lens allows people to *socially* construct a *professional vision* (Goodwin, 1994). Coding, highlighting, and using representations are considered practices that can cultivate a shared vision (Goodwin, 1994). Coding refers to categorizing and naming what is observed in order to create a shared discourse, while highlighting gives meaning to significant aspects of these observations. Representations then refer to mediums used to convey what is observed (e.g., video, diagrams, and transcripts). Goodwin (1994) explains that engaging with these practices can support an understanding of a specific aspect of analysis more deeply than otherwise possible. Using practices to notice salient moments in representations can "creat[e] a whole that is greater than the sum of its parts" (p. 627).

In the context of teaching, noticing entails viewing a teaching situation with a lens or focus. This involves actively trying to *attend* to and *interpret* ongoing interactions and their implications in practice and for learning (Jacobs et al., 2010). *Attending* involves honing in on what is salient (i.e., highlighting) in a teaching situation (e.g., "I think that Cassandra made 6 circles with the number 43 in each one."), to in turn *interpret* those moments (e.g., "The last boy has good number sense and understands different amounts.") (Jacobs et al., 2010, p. 183 – 185). Jacobs et al. (2010) refer specifically to attending and interpreting students' strategies and understandings, however, in this study PSTs were encouraged to attend to and interpret both teacher and student interactions. Ultimately, when considering PSC, PSTs were broadly supported in:

> (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 [they know] about the context to reason about classroom interactions. (van Es & Sherin, 2002, p. 573)

When noticing, understanding PSC would mean that PSTs attend equally to both how the teacher positions students, and how students in turn take up that position. If a teacher does not position a student competently, this is often visible through what the teacher and student say and/or do (verbal and non-verbal). For instance, if a student shrugs, shuffles their feet, or is reluctant to speak, these non-verbal cues are equally important aspects of PSC and can reveal how the student is taking up the position. Noticing is ultimately a complex endeavour that requires one to pay particular attention to significant aspects of interaction.

2.4 Situative perspective

Learning is always situated. When a teacher positions a student competently, learning often takes place in a mathematics classroom. Likewise, when PSTs develop their noticing, this endeavour too is situated in a specific context, mediated by and distributed across various resources and people (Putnam & Borko, 2000). Considering this, recent research has advocated for using situative perspectives when conceptualizing teacher learning (Putnam & Borko, 2000). A deep understanding of PSC is difficult to obtain by only reading a definition without seeing the practice enacted or watching a video. Using this lens, learning is not isolated, but is directly affected by one's social interactions, as well as their use of resources in a specific environment (Greeno, 2006; Putnam & Borko, 2000). To understand learning, it would be difficult to account for social interactions without considering the tools speakers draw upon and vice versa (Greeno,

1998). Thus, when creating this design study, I needed to consider where PST learning would be situated, what supports could be included to facilitate learning, and how these components could work together to form a productive learning ecology. Since learning is contextualized and mediated by tools, it was also important for me to maintain a situative perspective when analyzing data as I needed to understand how the study design and the supports implemented facilitated PSTs' learning of PSC.

2.5 Design Principles

Design principles can be considered the foundation of a design study (Cobb et al., 2014). Greeno (1998) explains that, "[t]he difference between learning in different arrangements is not whether learning is situated or not, but how it is situated" (p. 14). Creating opportunities for PSTs to understand PSC and see its value in practice would be difficult to achieve without considering PSTs' learning environment, just as the learning goals in a classroom would be difficult to meet if the teacher did not have a lesson plan. For this reason, design principles outline learning goals and allude to the resources (i.e., design supports) needed in achieving these aims. Design based research (DBR) requires both theoretical and pragmatic goals as the researcher aims to create an ecology to understand how the learning trajectories are cultivated and supported, while also considering how the design can be improved (Cobb et al., 2014). This study focuses on the first iteration of a design study in order to understand PSTs' learning of PSC.

In what follows I will explore the design principles that guided my design and analysis of the instructional supports for pre-service teachers' noticing and understanding of PSC: 1) Using video to support noticing; 2) Noticing with purpose; 3) Decomposition of practice to support noticing; 4) Envisioning new ways of proceeding to deepen understandings. Each principle

highlights the situated nature of learning, especially since in this study PST learning was considered in a specific context (e.g., video analysis sessions). Sections will also be discussed in relation to designed supports; however, a thorough overview of how the supports were used in my study will be explored in Chapter Three (see Figure 2). These principles were originally discussed in Iacono (2018). In the following sections, I draw from and expand on the ideas and relevant literature discussed.

2.5.1 Using video to support noticing. In a seminal study of different professions, Grossman, Compton, Igra, Ronfeldt, Shahan, & Williamson (2009) noted several pedagogies that are supportive of learning to engage in practice. One such pedagogy was *representations of practice*, which are mediums that reflect an authentic aspect of a profession. For instance, artifacts, transcripts, or videos from a classroom can be considered representations of authentic practice in a teacher education context. However, video is a representation of practice with unique affordances. Video footage of lessons allows pre-service teachers to gain understandings related to teaching without having to be present in the classroom. Unlike other resources (e.g., transcripts, artifacts), video affords teachers the opportunity to observe verbal and non-verbal interactions taking place in a lesson, as well as the classroom environment (Grossman et al., 2009). Learning is thus situated in the aforementioned activity as PSTs can further develop their teaching practice without needing to be physically present in a classroom. The viewed video clip can essentially be seen as a *tool* used to facilitate and direct learning (Putnam & Borko, 2000).

Accordingly, following from a situative perspective, it's not surprising that video has been explored extensively to support teacher noticing. When watching videos, PSTs have opportunities to hone in on significant interactions and/or aspects of the classroom environment (e.g., Barnhart & van Es, 2015; Borko, Jacobs, Eiteljorg, & Pittman, 2008; Rosaen, Lundeberg,

Cooper, Fritzen, & Terpstra, 2008; Santagata et al., 2007; van Es & Sherin, 2002). Video is one of the only representations that affords the opportunity to replay instances of practice in order to consider those interactions in more depth (Goodwin, 1994; Santagata et al., 2007) Reviewing video also creates opportunities to confirm or disconfirm initial understandings (van Es & Sherin, 2002). This is important since after watching a video, it is common not to remember the exact sequence/wording of interactions, and to instead fore-front our own assumptions. Thus, replaying the video can yield claims grounded in evidence (van Es & Sherin, 2002). By doing this, attention can be averted away from student behavior and instead towards the intricacies of teaching and student thinking (Barnhart & van Es, 2015; Rosaen et al., 2008).

Moreover, another affordance of video is that it allows an approximation to practice (Grossman et al., 2009) while still maintaining enough distance to allow teachers to purposefully attend to classroom interactions. Video is more proximal to classroom practice than other representations (e.g., classroom artifacts) that are easily used within a teacher education classroom (Grossman et al., 2009). Video can thus support pre-service teachers in linking theoretical concepts to authentic contexts represented in video clips (Santagata et al., 2007). Considering that in teacher education programs, PSTs mainly use fieldwork to gain such understandings, video can enable more frequent reflections that link theory and practice, allowing PSTs to create a 'shared language' (Santagata et al., 2007).

Regardless of these affordances, video still has its constraints, as does any representation. Primarily, video does not normally provide PSTs with a long-term view of classroom events nor the planning that took place prior to them (Grossman, 2009; Iacono, 2018). Further, video quality and what is visible to teachers in video clips (e.g., teacher, student, mathematical content, etc.) have been found to afford or restrict opportunities for learning (van Es & Sherin, 2006). For

example, tending to the placement of camera and quality of video is a crucial consideration of what PSTs will be able to notice. To attend to this, during this study, videos were included as a design support and were thus carefully selected to include high quality audio and a clear view of the entire class and teacher(s). However, as the videos were found on publically accessible websites, the quality between videos varied (e.g., student voices were at times low and the camera placed focus on some speakers more than others). Despite this, the videos were selected because these issues did not occur often nor did they significantly affect possible understandings of on-going interactions (see Appendix D for links to all video clips viewed).

2.5.2 Noticing with purpose. It is clear video can significantly impact PST learning and help them develop knowledge and skills usable in their teacher programs and careers. However, watching video alone may not promote deep understandings as often attending and interpreting is contingent on having clear viewing goals (Jacobs et al., 2010). PSTs tend "to focus on irrelevant features" of a classroom environment by bringing attention to the teacher's tone, appearance, and hand gestures, rather than interactions and student learning (Fuller & Manning, 1973; Santagata et al., 2007, p. 124). The classroom is a complex ecology and at any given moment several interactions and/or features are at play – each equally important in creating a space that fosters student learning. Observing such a dynamic scene can be 'overwhelming' and 'messy' if not viewed with purpose (Santagata et al., 2007, p. 124).

The literature has identified several supports for focusing teacher noticing: (a) viewing norms, (b) transcripts, (c) frameworks, and (d) the facilitator. As discussed in further detail in Chapter 3, this literature informed the design of the supports for this study.

Viewing norms focus viewing by helping teachers and PSTs adopt an "interpretive" (van Es & Sherin, 2002) and "critical stance" (Santagata et al., 2007). An interpretive stance refers to,

> looking at a teaching situation for the purpose of understanding what happened, what students think about the subject matter, or how a teacher move influenced student thinking, as opposed to examining a situation for criticism or to take action. (p. 575)

As previously discussed, without guidance, PSTs tend to reflect superficially (Seago, 2003). By promoting an interpretive stance, PSTs are encouraged to focus noticing towards more salient components of a classroom environment (van Es & Sherin, 2002). Although noticing ongoing interactions in a classroom is essential, it is equally important to be able to assess what is happening critically. An ability to reason critically about problematic interactions and reflect on possible alternatives is a valuable exercise than can promote PST learning (Santagata et al., 2007).

Coupled with video, transcripts have been shown to focus viewing and promote richer reflections (Borko, Koellner, Jacobs, & Seago, 2011; Kersting, Givvin, Sotelo, & Stigler, 2010; Santagata & Yeh, 2014; van Es & Sherin, 2002). It is common to misrepresent events that occurred when watching a video (van Es & Sherin, 2002). Thus, if a transcript is readily available to PSTs both before and after video viewing, they can reflect on what actually happened in the video as they can point to evidence from the transcripts to substantiate their claims.

Scholars continue to bring attention to the facilitator as an agent in cultivating understandings and focusing viewings (Borko et al., 2008; Horn, Garner, Kane, & Brasel, 2017; van Es & Sherin, 2006). Borko et al. (2008) found that, in their study, facilitators were able to guide discussions and encourage critical reflections during video viewings. Similarily, van Es and Sherin (2006) explained that the facilitator helped to develop teachers' ability to notice and "fostered the narrowing of the teachers' perspective toward a particular Agent, Topic, and Stance"

(p. 131). In light of this, during video analysis sessions, the facilitator (i.e., myself as the researcher) was present to answer any questions PSTs had and prompt them to make connections and think more deeply.

Likewise, frameworks have been implemented in studies that use video to support noticing as they can help focus viewing (McDuffie et al., 2014; Santagata & Angelici, 2010; Santagata & Guarino, 2011). Frameworks can include explanations/definitions and/or questions to guide noticing. For this reason, frameworks are considered a valuable support because they pace learning and help PSTs zoom in to what is of importance within a classroom lesson. This helps PSTs focus their viewing by allowing them to acknowledge the "complexities of the classroom," while simultaneously attending to its specific features (Star & Strickland, 2008, p. 124). In addition to focusing viewing, frameworks that also include prompts have been shown to promote more in-depth reflections, as the questions can provoke PSTs to make connections between various features of the classroom and how they support learning (McDuffie et al., 2014; Santagara et al., 2007). In light of such affordances, during and after viewing video footage, PSTs in my study worked in and referred to what I call the Detailed noticing framework (DNF) (I discuss this in more detail in Chapter 3).

2.5.3 Decomposition of practice to support noticing. In addition to focusing viewing, frameworks can help decompose practice. Goodwin (1994) and Grossman et al. (2009) have shown how noticing can be supported through decompositions, which are considered categories designed to break down practice (e.g., frameworks that aim to break apart components of a practice, etc.). For example, the three components of PSC that I outlined earlier in this chapter can be a decomposition of the practice of PSC: (1) acknowledge all student contributions to

highlight their value; (2) provide students with opportunities to make sense of and author mathematical ideas; and (3) position students competently with teacher moves.

Video representation is a window into teaching; however, this alone is not enough to support in-depth reflections. Deconstructing practice (e.g., teaching practice) into more manageable components can make noticing easier and allow PSTs to acquire a more thorough understanding of how these parts work individually and in turn contribute to and affect the classroom environment as a whole (Boerst et al, 2011). Similar to what researchers do when analyzing data, the act of relating seen instances to a decomposition of practice can be considered coding (Goodwin, 1994). It is important that PSTs are able to decompose PSC to better make sense of what they see in the video to attend to and interpret PSC with more ease. For this reason, within the DNF, PSTs were provided with a decomposition of general teaching practice and a decomposition of PSC specifically to help them attend to what the teacher was doing.

It is important to note that other supports can assist PSTs in attending to decompositions of practice as they provide them with opportunities to highlight what they see when watching video footage (Goodwin, 1994; Grossman et al., 2009). Highlighting means making complex ideas more visible and "relevant to [one's] own work" (Goodwin, 1994, p. 610). The facilitator, in particular, can help PSTs highlight decompositions represented in the video (van Es & Sherin, 2008). In addition, transcripts, unlike video footage, are static and can make it easier to locate decompositions. During this study, PSTs and the facilitator used highlighting when attending to specific components of PSC when viewing video and when later interpreting various dimensions of the practice.

2.5.4 Envisioning new ways of proceeding to deepen understandings. The DNF was also designed to explicitly provoke PSTs to consider alternative teaching methods. Within the noticing literature, envisioning alternative strategies has been shown to support PSTs to articulate more in-depth reflections (Santagata & Angelici, 2010; Santagata & Guarino, 2011). Santagata and Guarino (2011) explain that:

> [t]o be able to propose alternatives, PSTs first need to identify a problem with student learning as portrayed in the video. They then need to access their knowledge of teaching strategies to make the case that a strategy different from the one the teacher used in the video would be more effective. (p. 143)

Such a task requires that PSTs attend to and interpret various elements from the video and make connections to their understanding of PSC and its application in practice. This is a complex task that has the potential to promote in-depth reflections and learning. Related to this, Horn et al. (2017) suggest that it is important to highlight how envisioning alternatives can encourage teachers to bridge theory and context, as teachers should attend to both what is happening and broader aspects of teaching.

2.6. Chapter Summary

This chapter explored the literature that underpins my study. I discussed the literature guiding both my research motives and theoretical perspectives (i.e., positioning theory, PSC, noticing, and situative perspectives). This also included an overview of design principles and what the literature suggests about how to design supports to promote those principles. Chapter three will build from this discussion, as I explore my methodology, the design of my study, data collection procedures, and my data analysis procedures in more detail.

Chapter 3: Methodology

Following from situative theory, guiding this study was the belief that learning is situated in various contexts, and is socially mediated and distributed across participants and materials (Putnam & Borko, 2000). With this in mind, in order to answer my research questions, I used a design study methodology, as this paradigm posits learning environments as "learning ecologies" in which complex interactions shape learning (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003, p. 9).

Design-based research (DBR) initially arose because researchers could not gain an in-depth understanding of learning when it was restricted to the context of a laboratory, nor did the types of learning they wished to study always occur in accessible learning environments. For these reasons, traditional ethnographic methods could not yield sufficient data for answering desired research questions (Cobb et al., 2014). Thus, DBR directs attention towards the potential supports needed to design learning ecologies that will create the conditions to study learning (Cobb et al., 2014). Despite such a focus on supports, design studies are not created to *evaluate* them and for this reason differ from evaluation studies. Evaluation studies seek to *judge* existing supports including "project[s], intervention[s], or polic[ies]" (Borman, Clarke, Cotner, & Lee, 2012), whereas the goal of a design experiment is to engineer an environment to better understand "learning and what contributes to it" (Schoenfeld, 2012, p. 196 – 197).

In my own context, despite PSTs having limited experiences in the field, many teacher education programs struggle with finding the time to bridge theory and practice (Santagata & Yeh, 2014; Santagata et al., 2007). Likewise, PSTs participating in this study did not have a course that focused on PSC through video analysis. Thus, in order to understand trajectories of

PST learning and how designed supports affect learning, I "engineered" this environment (Cobb et al., 2003).

3.1 Participants and Setting

Seven PSTs from an eastern Canadian university participated in this study. Participants were recruited from two different university courses in the Faculty of Education; participants were enrolled in the Bachelors of Education Kindergarten-Elementary program, and one was enrolled in TESL. Five assenting PSTs were in their first year of studies and two in their second year. Both first and second year students had already completed one field experience, which involved observing classroom lessons and in some cases teaching. The majority of participants were female (five female and two male), representative of B.Ed. Elementary programs. The study lasted three months (February – April). During this time, participants individually took part in one-on-one noticing sessions with myself (see Section 3.2 for a detailed account of each session), which took place in a quiet room on the university campus. As participants volunteered their time to participate in this study, sessions were complimented by refreshments, and at the end of the study participants were given a $5.00 gift card as a token of appreciation.

For my thesis, I focus on data from four of the seven participants. Three were female and one male. These participants were chosen because they were all in their first year of studies, and had not taken the required B.Ed. mathematics methods course (whereas second year students had taken the course). Although there were five first year participants, one PST could not complete the post-interview and was thus excluded from the sample.

Each of the four participants had unique experiences and dispositions towards mathematics. Participant A took regular math courses (and was taking one in university), but the participant explained that math was not always easy and struggled, especially on tests. The only

experience she had with teaching mathematics was during her field experience. Participant B also took regular math courses (those that were "mandatory") but also took statistics in college, prior to university. Participant B enjoyed math because it is "structur[ed]" and involves "rules." She correlated struggles in mathematics with the instructional approaches used by teachers. Participant C had taken advanced mathematics classes due to being enrolled in a science program in college. Like Participant A, she explained that math was difficult. However, allocating a lot of time towards mathematics along with having support from tutors made grasping mathematical content easier for this PST. Participant C gained teaching experience in mathematics through tutoring her sister and through a volunteer tutor program for children. Participant D took regular courses in high school and also enrolled in calculus courses. Participant D found math difficult, and although the participant did not like the time and repetition needed to learn mathematics, he still enjoyed learning math, as it was "gratifying." Participant D gained experience teaching through tutoring "workshop math."

Table 1. Participant Profiles

Participant A	**Mathematics courses taken:** 1) Took regular mathematics courses 2) Is taking a mathematics course in university **Experience with mathematics:** 1) Was not always easy 2) Struggled, especially on tests **Experiences teaching mathematics:** 1) During university field work
Participant B	**Mathematics courses taken:** 1) Took regular mathematics courses 2) Took statistics in college **Experience with mathematics:** 1) Enjoys math because it is "structur[ed]" and involves "rules" 2) Struggles in mathematics are a result of poor instruction **Experiences teaching mathematics:** 1) During university field work
Participant C	**Mathematics courses taken:** 1) Took regular mathematics courses (French program) 2) Took advanced mathematics classes (enrolled in a science program in college) **Experience with mathematics:** 1) Difficult, but made it easier by dedicating time to mathematics and enrolling in tutoring **Experiences teaching mathematics:** 1) Tutored sister 2) Volunteered time to tutor children
Participant D	**Mathematics courses taken:** 1) Took regular mathematics courses 2) Took calculus

	Experience with mathematics: 1) Experienced difficulties with mathematics 2) Did not like repetition and the time dedication needed to "properly lear[n]" 3) Enjoyed learning mathematics because it was "gratifying." **Experiences teaching mathematics:** 1) Helped tutor "workshop math"

3.2 Data Collection and Design Supports

As discussed in Chapter Two, in relation to my design principles, various design supports were implemented to facilitate PST learning throughout the study. Here I chronologically describe the phases of data collection and the corresponding supports in more detail. I also explain their purpose during video analysis sessions one to three. See Figure 2 for an overview of each design principle and its related support(s). Note that some supports are repeated as they often targeted more than one principle.

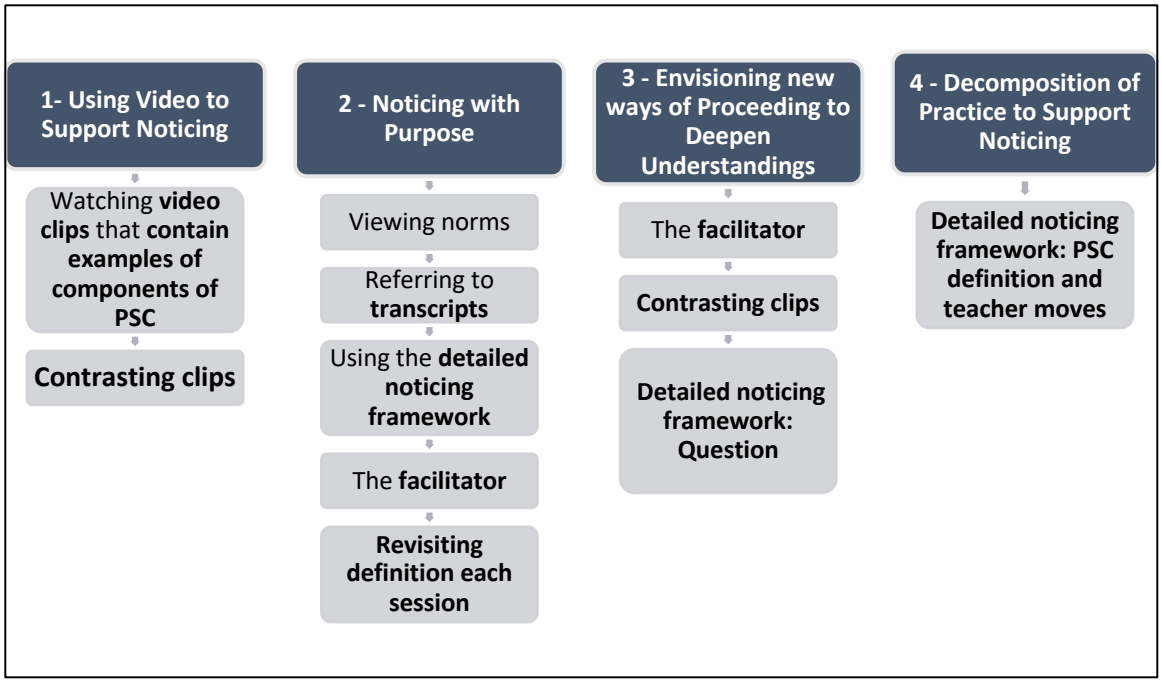

Figure 2. Design Principles and Supports.

Multiple sources of data were collected during each phase (Table 2). These included: (a) one audio- and video-recorded pre- and post-interview per participant; (b) three audio- and video-recorded video analysis sessions per participant; (c) written researcher observations from

the three video analysis sessions; and (d) artifacts, including written work from the viewing norms handout, DNF, and transcripts.

Table 2. Data Collection Timeline

Timeline	Data Collection Methods	
Phase 1 February - March	Pre-interview	1) Audio 2) Video 3) Researcher observations
Phase 2 February - April	Video analysis sessions	1) Audio 2) Video 3) Artifacts (i.e. written work) 4) Researcher observations
Phase 3 February - April	Post-interview	1) Audio 2) Video 3) Researcher observations

3.2.1 Phase 1: Pre-interviews. Pre- and post-interviews lasted between approximately 30 to 60 minutes[1] and took place in a quiet room on campus. Data were collected through video-recordings, audio-recordings, and researcher observations (i.e., field notes that included excerpts of what participants said and personal reflections).

I had two main objectives for the pre-interview. First, the pre-interview was conducted to build a profile for each participant. Thus, questions were asked in relation to: (a) the pre-service teacher's experiences in learning and teaching mathematics, (b) their characterizations of students' sources of difficulty, (c) the teacher's current experience using video to support their development as mathematics teachers, and (d) their perspectives on using video to support their development as mathematics teachers. Second, I sought to understand whether or not PSTs had been exposed to the term "positioning students competently," and, if not, how they conceptualized the practice. Related to this, questions were asked about their current

[1] Note. One interview lasted approximately 111 minutes.

understanding of practices used to position students as competent learners during mathematics instruction (see Appendix A for a complete interview protocol).

3.2.2 Phase 2: Video analysis sessions. Following the pre-interview, three video analysis sessions took place for each participant. Video analysis sessions were developed to scaffold PSTs' learning of PSC. Each session lasted between one to two hours and took place in a quiet room on campus. It is important to note that each session was video-recorded to capture both verbal and non-verbal interactions. Following from a situative perspective, verbal interactions can reveal social aspects of learning (i.e., dialogue between PST and facilitator), while non-verbal interactions can equally reveal how PSTs' learning was distributed among the activities they engaged in and/or the artifacts (i.e., design supports) they used (Putnam & Borko, 2000).

Table 3. Video Analysis Session Overview

	Session Overview	Goal
Session one	1- Review PSC • Facilitator reviews definition of PSC with PST • PST links each teacher move to PSC • PST discusses their written reflections with facilitator 2- Review Viewing Norms • The facilitator reviewed viewing norms with PST 3- Watch first video clip • The facilitator briefly contextualizes clip (i.e., grade level, topic, etc.) • PST watches clip (during this time PST can refer to the PSC framework at the beginning of the DNF, viewing norms, the transcripts, and the question part of the booklet) • PST writes in booklet (PST has access to all resources during this time, including the video) • PST and facilitator discuss PST reflections 4- Watch second video clip • Refer to step three	1. Support PST in understanding PSC and how it can be enacted with teacher moves. 2. Provide PST with opportunities to notice and interpret PSC in two contrasting video clips where students struggle with a mathematical concept or task.
Session two	1- Revisit viewing norms 2- Review PSC definition • Facilitator asks PST to explain PSC 2- Watch first video clip	1. Provide PST with opportunities to notice and interpret PSC in

	• The facilitator briefly contextualizes clip (i.e., grade level, topic, etc.) • PST watches clip (during this time PST can refer to the PSC framework at the beginning of the DNF, viewing norms, the transcripts, and the question part of the booklet) • PST writes in booklet (PST has access to all resources during this time, including the video) • PST and facilitator discuss PST reflections 3- Watch second video clip • Refer to step 2 (except for this video clip the PST wrote in their booklet after viewing the first half, then again after viewing the second half)	two contrasting video clips where students have expressed misunderstandings in mathematics.
Session three	1- Review PSC definition • Facilitator asks PST to explain PSC 2- Watch first video clip • The facilitator briefly contextualizes clip (i.e., grade level, topic, etc.) • PST watches clip (during this time PST can refer to the PSC framework at the beginning of the DNF, viewing norms, the transcripts, and the question part of the booklet) • PST writes in booklet (PST has access to all resources during this time, including the video) • PST and facilitator discuss PST reflections 3- Re-watch video clip • Refer to step 2	1. Provide PST with opportunities to notice and interpret PSC in one video clip (viewed twice) where students are engaged in a debate.

3.2.2.1 Session one. Session one began with a decomposition of a) PSC (i.e., the definition) and b) the general teaching practice for orchestrating discussions. The PST was asked to review the definition and fill out the PSC teacher move framework located within the DNF (see Figure 3). The framework included a list of teacher moves that can be used to PSC: representing student ideas, pressing on student thinking, highlighting student ideas, and revoicing. To support PSTs to *notice with purpose* and *make sense of this decomposition of practice*, beside each teacher move, PSTs were asked to relate it back to the definition – this was meant to support them in better understanding PSC theoretically and in practice. Following this, we discussed their reflections, which provided me as the facilitator with the opportunity to press or

prompt if needed. Figure 3 shows an example of how this looked in the DNF; for more examples refer to Appendix D.

Pressing on student thinking	**Definition:** Asking students to explain or expand on their thinking to prompt them to think more deeply. **Example:** "Could you please explain your thinking?" "Can you think of another way you could have solved this problem?" **How can this teacher move position students competently?** _____

Figure 3. Example from Detailed Noticing Framework.

Before watching video footage, the PST was asked to consider the viewing norms. These norms asked PSTs to consider various questions that could be useful in focusing their viewing to adopt a more "interpretive" and "critical stance". Although PSTs had access to the viewing norms every session, they were only focused on briefly during session one and two. Examples of such questions are shown in Figure 4.

Interpretive stance:	*Involves noticing with the intent of understanding various influential factors that affect classroom interactions and student understandings, rather than passing judgment (van Es & Sherin, 2002, p. 575).* To achieve this ask yourself: • How do you understand this particular moment and exchange between the student and teacher? • How do you think students are learning mathematics content in a way that positions them competently? (e.g., which teaching practices, manipulatives, or actions is the teacher using to teach students mathematics by positioning them competently) • "How has the teacher influenced student thinking?" (e.g., which teaching practices, manipulatives, or actions is the teacher using to influence students' thinking)
Critical stance:	*Involves reflecting and commenting on practices or methods the teacher uses and proposing alterative paths (relating to positioning students competently) (Santagata, Zannoni, & Stigler, 2007).*

	To achieve this ask yourself: • Why do you believe students could have been positioned more competently? • If students weren't successfully positioned competently, which teacher practices or methods could have the teacher used instead? Why do these alternative strategies better position students competently? • What evidence in the video can support your claims (e.g., refer to transcripts and video)

Figure 4. Viewing Norms.

Related to my first and second design principles, *using video to support noticing* and doing so *with purpose*, during this session, participants watched two publically accessible video clips that highlighted the three components of PSC (i.e., acknowledge all student contributions to highlight their value, provide students with opportunities to make sense of and author mathematical ideas, position students competently with teacher moves). Rather than have PSTs watch a full lesson or a randomly selected video clip that may or may not have included PSC, clips were specifically chosen to include one or more clear interactions that related to PSC. Clips ranged between four and eight and a half minutes in length. My supervisor and I reviewed the clips to consider their relevance in relation to PSC and the learning opportunities they could yield. It was conjectured that by having clear examples it would be easier for PSTs to notice and develop this skill in a short amount of time. To support PSTs in envisioning alternatives, contrasting video clips were selected and shown (see Appendix D for links to all video clips viewed). Session one included two contrasting clips. The first showcased an exemplary example of positioning, as a struggling student was supported in making sense of and authoring mathematical ideas. The second showcased a less exemplary example of positioning, as the student was not fully supported as a sense maker and author of mathematical ideas, which could have negatively impacted the student's disposition toward math and willingness to volunteer

answers in the future. It is important to note that throughout sessions clips ranged from less complex interactions to more complex interactions, as the number of speakers increased and the amount of moments that could be reflected on were more frequent.

As this was the first session, before watching the first clip, the facilitator and PST reviewed the questions together. To focus viewing, the DNF prompted PSTs to break down what they saw in the video. Each question was created to allow them to parse their noticing, focus solely on one moment, and link it to: (a) PSC generally, (b) how students were PSC, (c) the importance of PSC at that moment, and (d) how else the teacher could have PSC. The questions helped them focus either on the decomposition of teaching moves or the components of PSC to in turn notice with purpose as their attention was directed towards specific moments. The same four questions were asked during each session (see Figure 5).

Video Clip: _____ 1. Description: _____

_____

Time Stamp: _____ _____

2. **How** does this specific interaction relate to positioning students competently?

3. **Why** was it important that a student(s) was positioned competently at this time?

4. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)

5. Looking back on the entire video, **how else** could have the student(s) be positioned competently?

Figure 5. Questions from Detailed Noticing Framework. This format was modified to clarify what question PSTs focused on.

During the first session, question one was worded more generally (as seen in Figure 5) than in sessions two and three (as I discuss in the following section). This was purposefully done to allow the researcher/facilitator to gain a deeper understanding for each PST's current

understanding of PSC and how they attended to and interpreted interactions related to PSC without additional scaffolding that directed their attention to exemplary and problematic interactions. By changing the first question each session, PSTs' learning was scaffolded in hopes that they would consider varying types of interactions. However, questions two and three remained the same throughout all sessions. The fourth question specifically asked: "If you were in this situation what would you have done differently to help position student(s) competently, if anything (This can relate to talk, actions, teacher moves, etc.)?" This question focused viewing, as it was meant to support PSTs in considering possible teacher moves that could be used to PSC and why the moves would help PSC. Engaging in such an activity has been shown to foster rich reflections to envision new ways of proceeding (Santagata & Angelici, 2010; Santagata & Guarino, 2011); however, this question was challenging, and if needed, when discussing PST responses, the facilitator pressed or prompted PSTs to think about this question more deeply. Additionally, for each clip, the DNF had a second set of optional questions which asked PSTs to notice another instance where a student was or was not PSC (see Appendix D).

When watching the video and later writing in the DNF, PSTs could use all the supports they felt would help them notice. These included the DNF (especially the framework of teacher moves), the transcripts, and viewing norms (although the norms were rarely referred to). When viewing video and later writing in the DNF, transcripts helped PSTs more readily grasp on-going interactions, and more importantly, allowed PSTs to point to evidence when reflecting on the video footage. Pointing to evidence was conjectured to support PSTs in validating their interpretations and focus their attention towards significant moments of interaction.

Once PSTs finished writing in their booklet, we then discussed their reflections, as this allowed the facilitator to press or prompt to discipline PSTs' perceptions (Stevens & Hall, 1998).

As discussed earlier, part of the facilitator's role was to press on PSTs' thinking by asking questions. These questions and presses were meant to promote purposeful noticing by helping them attend to both students and the teacher, as well as interpret each aspect of PSC (i.e., acknowledge all student contributions to highlight their value, provide students with opportunities to make sense of and author mathematical ideas, position students competently with teacher moves). For example, the facilitator asked: "Why did you flag that particular moment?; Tell me more about that.; What is one thing the teacher did well that successfully positioned?; Where do you see this move in the framework?; Refer to the video transcripts - how can you support your claims?" (see Appendix C for more examples).

Following this, the second clip was played and the process repeated itself (watch, write, orally discuss).

3.2.2.2 Session two. The following session followed a similar structure. However, rather than reviewing the positioning framework in its entirety, at the beginning of the session, the facilitator asked the PST to explain the definition of PSC in their own words. Revisiting the definition was not initially a support, but was added to the design because my supervisor and I noted that during session one, PSTs focused more on teachers supporting students as sense makers rather than on valuing. The PST then watched video footage. Session two included two clips showing students who expressed misunderstandings in mathematics. Similar to the first session, an exemplary and less exemplary example was shown to PSTs. Following video viewing, the PST answered questions in the DNF. As mentioned in the previous section, the DNF questions changed slightly each session. To focus viewing, the first question was changed to direct PSTs' attention towards either moments where students were or were not positioned competently. For instance, during the second session, after the first video viewing, question one

asked: “How was the student(s) positioned competently?” In contrast, following the second video clip, PSTs were asked: “How wasn’t the student(s) positioned competently?” As before, each viewing was followed by an oral discussion in which the facilitator could comment on and ask questions about PST responses.

3.2.2.3 Session three. The third session was similar to the second. All that differed were the clips and DNF questions. The PST only viewed one clip that showcased a debate in which students’ ideas were acknowledged, valued, and students were supported as sense makers and authors of mathematical ideas. Due to the complexity of this clip, it was shown twice and after both viewings, PSTs were asked to focus on how a student(s) *was/were* positioned competently. This is not to say that the PST had to notice these particular moments, however, they were present in the clip(s) to facilitate learning (the same applied to all prior sessions).

3.2.3 Phase 3: Post-interviews. One goal of the post-interview was to understand how the design supports contributed to PSTs’ development. The second goal was to gain an understanding of shifts in PSTs’ understanding of PSC and thus, similar to the pre-interview, they were asked about their conceptualization of PSC (for more examples refer to Appendix E). After answering interview questions, PSTs were also asked to watch the second video clip they viewed during the first session once again and answer the same questions (see Figure 5). This was done to track how teachers’ noticing of moments of positioning changed through their engagement in video viewing sessions. Similar to video analysis sessions, PSTs had access to all supports (i.e., viewing norms, transcripts, and DNF). However, unlike video analysis sessions, I did not assume the role of the facilitator. I prompted and pressed much less, this time with the purpose of asking the PST to further elaborate or clarify their responses. I did this to avoid

disciplining participants' perceptions as I wanted to gain a clear understanding of their learning thus far.

3.3 Data Analysis

As previously discussed, various forms of data were collected; however, before I discuss my analysis of data, I will first explain which data sources were analyzed and why. To answer question one (*How do pre-service mathematics teachers' conceptualizations of PSC change through their engagement in video analysis sessions?*), I analyzed transcribed audio footage from each participants' pre- and post-interviews. Since my focus was only on what the participants said, verbal transcriptions were sufficient to answer my research questions. When transcribing interviews, words that did not significantly alter the nature of a sentence or idea (i.e., um, uh, like, etc.) were not always included, especially when repeated frequently within one turn of talk. All pauses that could not be accounted for with punctuation symbols (e.g., "," or "."), were accounted for using three dots (i.e., ". . .").

To answer my second research question (*How do pre-service mathematics teachers' noticing of moments of positioning change through their engagement in video viewing sessions?*), I analyzed video data from Sessions 1, 2, and 3 using Studiocode video analysis software (described in more detail later). When analyzing video analysis sessions, audio recordings were not considered as they alone could not adequately shed light on non-verbal interactions. The post-interview video analysis component was not included since these video analysis sessions were reviewed in-depth to answer my second research question.

Similarly, to answer my third research question (*How do the design supports help to contribute to the development of PSTs' understanding and noticing?*), I also analyzed video footage from Sessions 1, 2, and 3. Memos and written artifacts were not considered for analysis.

Still, it is important to note that throughout the study, memos allowed for ongoing researcher reflection and to consider changes in the design from session to session. Written artifacts enabled me to better understand PSTs' reflections; however, they were not analyzed because PSTs spoke about what they wrote, and thus, video recordings and post-interview questions were sufficient to answer my research question.

I conducted analysis in three phases: (1) To answer my first research question, all participant responses were considered as I analyzed questions relating to PSC from both pre-and post-interview data sets; (2) To answer my second research question, I purposefully selected three participants and analyzed video footage from their video analysis sessions (one to three); (3) To answer my third research question, all participants' post-interview data (focusing on questions explicitly discussing design supports) were considered, and one participant was purposefully selected for a fine-grained analysis of video analysis sessions. In what follows, I will describe each phase in further detail.

3.3.1 Understanding PSTs' conceptualization of PSC. To analyze my first research question, I coded data from pre- and post-interviews. To begin the process, I first transcribed interviews using InqScribe[2]. Interviews included primarily verbal interactions. Non-verbal interactions were not used as they were not needed to answer my first research question because I was only concerned with what the participants said about PSC. I then organized interview transcriptions to include only the interview questions that directly related to PSC: "When you hear the phrase positioning students competently, what comes to mind?;" "Please explain what you would observe if you saw a teacher positioning students as competent learners in a math

[2] InqScribe is a transcription software that displays the audio and text file in the same program. The software also includes features that can facilitate the transcription process.

class?;" Probe 1: "What kinds of problems or mathematical tasks would you expect to see the students working on for instruction to position students competently? Can you give me an example of what that looks like? Sounds like?;" Probe 2: "What are some of the things you would expect to find the teacher actually doing in the classroom for instruction to position students competently? Can you give me an example of what that looks like? Sounds like?;" Probe 3: "What would the classroom discussion look and sound like if instruction were to position students competently? Can you give me an example of what that looks like? Sounds like?;" "Are there benefits to positioning students as competent learners? Explain why or why not."

Each participant's response was then categorized and clumped to form broader categories. To do this, I began by reviewing each participant's response. I then highlighted text in different colors to distinguish emerging categories. Once I color-coded responses, I systematically reviewed responses from the same question for each participant and considered each color-coded segment. Segments began to inform categories. Once a category was created, a description was added. After reviewing approximately two questions, responses started to repeat themselves and as a result, color-coded segments began to be grouped with pre-existing categories. If an idea could not be captured through existing categories, a new category was added. Once this process was completed, categories were reviewed and similar categories were grouped together to form a single category. During this process, my supervisor coded a sample of the data for accuracy and to provide alternate interpretations. By doing this I was able to compare codes and revise my coding scheme further. I reviewed all segments and categories twice more. Categories did not significantly shift during the second round of coding (see Appendix F for a table that presents the finalized categories in the coding scheme).

Following this, I began my third round of coding – the final coding process. My unit of analysis when coding was the PST response for each question. When coding responses, if relevant, multiple codes were applied since participants often spoke about multiple categories in the same response. A participant response for one question often consisted of several categories.

3.3.2 Understanding developments in PSTs' noticing of PSC. To analyze my second research question, I coded data from video analysis sessions. To begin the process, following the first phase of coding, three of the four participants' video analysis sessions were analyzed to further investigate how PSTs' noticing of PSC changed through their engagement in the study. Based on the aforementioned interview data, it was clear that two of the four participants had similar learning trajectories and had shown similar changes in their conceptions of PSC from the pre- to post-interview. Thus, only one of these two participants was chosen for further analysis. I focused on the one who demonstrated a more limited initial understanding of the practice. Such a selection was important given that I aimed to understand developments in PSTs' noticing of PSC. The remaining two participants were selected because one showed a significant improvement in conceptualizing PSC, whereas the other struggled with understanding PSC. Through this selection I was able to compare three different cases to better understand their developments in noticing of moments relating to PSC.

Video analysis was parsed into several stages. To begin, I did not take notes but instead viewed all video footage in its entirety. I then watched all video footage once more to create episodes that captured discussion related to each *post* video viewing question (i.e., after PSTs watched clips and wrote about the moment they noticed in the DNF). Thus, episodes were created for each booklet question discussed (e.g., the "description" and questions "a" to "d" – see

Appendix D). After the PST had discussed the booklet questions, any additional questions about the instance they noticed were coded as additional episodes.

Second, in order to capture the nuances of PSTs' noticing, I developed a coding scheme to code episodes for turns of talk in which PSTs attended to and interpreted what they saw in the video. I chose to use turns of talk as my unit of analysis because this allowed me to account for shifts in PSTs' attending and noticing as mediated through moment-to-moment interactions. A turn of talk began when the PST started talking (i.e., discussing what they noticed in the video) and ended when the PST stopped talking to write in the DNF or when another speaker began talking (e.g., the facilitator interjected and/or asked a question). To develop my coding scheme, I considered the work of van Es and Sherin (2009), as they conceptualized noticing as focusing on significant aspects of a learning environment. The analysis framework they developed included, but was not limited to, *attending* to specific actors and *interpreting* interactions by making inferences. Based on this framework, I developed a coding scheme that included: 1) *actors* – that is, who they attended to and 2) *interpretation of actors in relation to PSC*. Ultimately, the aforementioned literature along with initial video viewing, helped me create a working coding scheme for *actors* and for *interpretation of actors in relation to PSC*. Once created, the initial scheme was tested and fine-tuned to create a finalized coding scheme (see Appendix F). The coding scheme for *actors* included three codes: (a) *teacher*, (b) *student*, or (c) *both teacher and student*. Turns of talk were coded as *teacher* when the PST explicitly talked about what the teacher did, did not, or could do to value student contributions or support them as sense makers and authors (this included moments when PSTs discussed which student interaction afforded the teacher the opportunity to PSC). Alternatively, turns of talk were coded as *student* when the PST explicitly talked about how instruction affected students' feelings or understandings. Finally,

turns of talk were coded as *both teacher and student* when the PST explicitly shifted focus from the teacher to students within the same turn of talk. I created these guidelines when coding to assure that I remained consistent, as well as, to ensure that attending did not simply include the PST only mentioning the teacher and/or student, but rather, the PST needed to focus on *and* interpret the actors' interactions for it to be coded as either student or teacher. It thus followed that turns of talk also included codes related to PSTs' interpretations. When coding for *interpretations of actors in relation to PSC*, turns of talk coded as *teacher* or *both* could include one or more of the following three codes: (a) *valuing*, (b) *sense makers and authors*, and (c) *other*. Turns of talk were coded as *teacher valuing* when the PST clearly discussed a moment when the teacher acknowledged or valued a student contribution. Turns of talk were coded as *teacher supporting students as sense makers and authors* when the PST reflected on how the teacher supported students in developing their mathematical understandings/learning. Alternatively, turns of talk coded as *student* or *both* could include one or more of the following three codes: (a) *feelings*, (b) *understandings*, and (c) *other*. Turns of talk were coded as *student feelings* when the PST reflected on how students were affected emotionally by a specific interaction. Turns of talk were coded as *student understandings* when the PST reflected on how students' understandings and learning of mathematical content were affected by a specific interaction. Finally, turns of talk were coded as *teacher other* or *student other* when their interpretations were not covered by the other categories and/or were not clear.

Once finalized, I used the aforementioned scheme to code turns of talk. A turn of talk was assigned only one *attending* code (e.g., teacher, student, or both) and one or more *interpreting* codes. As described earlier, because I only coded for actors when there was also interpretation, some turns of talk were not coded at all. Following this, tables were created to make sense of

coded data. To do so, I summed the number of attending codes that occurred during discussion of a single set of questions (e.g., the "description" and questions "a" to "d" – see Appendix D) for *one* moment in the video. This was done to understand how often PSTs spoke about either the *teacher*, *students*, or *both teacher and students* when discussing a single moment of interaction. I then used the sums to calculate percentages of turns of talk for each code in relation to total coded turns of talk that occurred during discussion of the single set of questions (i.e., during discussion of the moment of interaction). Further, interpreting codes assigned to turns of talk were summed within a single session (e.g., session one, two, and three). Percentages were calculated using the number of turns of talk per code in relation to the total turns of talk coded in the session. This was done to understand how often PSTs interpreted the various aspects of PSC.

3.3.3 Understanding how designed supports contribute to PSTs' development.

3.3.3.1 Interview data. Post-interview transcripts and a fine-grained analysis of one participant were both used to answer my final research question. To analyze the interviews, I used the same process described earlier, but this time focused on PSTs' responses to the questions explicitly about design supports. As aforementioned, to analyze interview data, I began by coding/describing participant responses of selected sections related to each of the design supports: the DNF, facilitator, viewing norms, transcripts, and video. I later clumped these into themes to develop a coding scheme for each support (see Appendix F). One interview question was generally worded and so was considered when creating coding schemes for each support: "During video analysis sessions (1-3), what contributed to your learning as a pre-service teacher, if anything? In what ways? Examples? (Probe 1: During the study, what did you find less supportive? Considering this, do you have any suggestions for what can be changed?)." However, specific questions that attended explicitly to each support were also asked.

When developing a coding scheme for responses related to the DNF, the questions analyzed include: “How did or didn’t the positioning session booklets contribute to your learning as a pre-service teacher? Examples?;” “What was your general impression of using the detailed noticing framework?;” “Has the detailed noticing framework supported your learning? Please explain how it has or has not. Probe 1: What was an example when the detailed noticing framework supported your learning – you can show me in the framework here? Could you please edit it based on the changes or additions you would make? You can also note directly on the sheet which parts you found useful and would keep. Probe 1a (once done): Can you please walk me through the edits you made to the framework and explain to me your rationale for choosing to exclude and include what you did? Probe 2: Can you think of an example when the detailed noticing framework did not support your learning – you can show me in the framework here? Probe 2a (once done): Can you please walk me through the edits you made to the framework and explain to me your rationale for choosing to exclude and include what you did? Probe 3: Do you have any suggestions for improving the framework?);” “How did using the framework while watching videos compare to your previous experiences using video to support your learning? Please explain why. (Probe (if applicable): Can you think of an example that highlights this difference?);” “If you had to create your own detailed noticing framework to support your learning of mathematics techniques that can position students as competent learners, how would or wouldn’t it differ from the framework you used during this study? Please be as detailed as possible.” See Appendix F for a coding scheme of interview responses related to the DNF.

In addition to the aforementioned more general questions, when creating a coding scheme for PST responses related to the facilitator I reviewed answers from the question: “How did or

didn't the facilitator contribute to your learning as a pre-service teacher? Examples?" See Appendix F for coding scheme of interview responses related to the facilitator.

Similarly, when creating coding schemes for PST responses related to the transcripts, viewing norms, and video, the same general questions were considered (i.e., During video analysis sessions (1-3), what contributed to your learning as a pre-service teacher, if anything? In what ways? Examples? Including probes). The following questions were individually considered in relation to the three remaining supports: "How did or didn't the viewing norms contribute to your learning as a pre-service teacher? Examples?;" "How did or didn't the transcripts contribute to your learning as a pre-service teacher? Examples?;" "How did or didn't watching videos of other teachers teaching contribute to your learning as a pre-service teacher? Examples?" See Appendix F for a coding scheme of interview responses related to transcripts, viewing norms, and video.

3.3.3.2 Case analysis. Based on my initial analysis and coding of video analysis sessions, one case was chosen for a fine-grained interaction analysis. I selected Participant A because her noticing and interpretations of PSC shifted drastically through engagement in the study. Using Studiocode, I reviewed footage from sessions one to three and identified moments of breakdowns and repair. Stevens and Hall (1998) refer to breakdowns as breaks in "shared understanding" (p. 111) – thus, breakdowns and repair can signal moments when shifts in understanding occur (Jordan & Henderson, 1995). I used breakdowns and repairs when coding because I conjectured that they would support me in better understanding what Participant A was struggling with (i.e., breakdown) and in turn how this was resolved (i.e., repaired) through the design supports. Thus, when reviewing episodes, I paid close attention to interactions that revealed a clear break in shared understanding (facilitator and pre-service teacher) relating to

PSC (definition and teacher moves). This did not include clarification questions – as a breakdown was not coded for unless the response to the question revealed a lack of shared understanding of PSC. A repair was coded for when the PST had successfully negotiated meaning through verbal and/or non-verbal interactions in order to reach a shared understanding relating to PSC. Likewise, a shared understanding relating to PSC meant that the PST successfully reasoned about the definition or the definition in relation to the video clip and/or teaching moves. From a situative perspective, both verbal and non-verbal cues were considered to understand the social interactions with the facilitator and how learning was distributed amongst people, the video, and the DNF. For instance, when learning was supported by the DNF, the PST may not have been verbalising their reflections, however the non-verbal interactions taking place were significant as they created a more comprehensive image of which artifacts mediated learning.

Out of seven of the episodes coded for breakdowns, two contrasting cases (i.e., the first breakdown was not repaired, whereas, the second was) were selected for fine-grained analysis. In both breakdowns, the participant was clearly grappling with understanding the various components of the definition (i.e., acknowledging, valuing, and supporting students as sense makers and authors). However, in one episode, the breakdown was resolved and in the other, the breakdown was not resolved. Meanwhile, other breakdowns were not selected because they were less central to the participant defining PSC; these included teaching moves or misunderstanding of video content.

The two episodes were transcribed using the conventions outlined by Dressler & Kreuz (2000) (see Appendix G for a list of conventions used in this study). However, learning is situated and mediated by people (e.g., the facilitator) and resources (e.g., design supports). Usage

of the designed supports could not only be captured with verbal transcription, and thus, non-verbal interactions (e.g. gestures) were analyzed (Jordan & Henderson, 1995). These transcripts were then reviewed to understand which part of the definition the breakdown related to and how it was repaired (either through interactions with the facilitator and/or designed supports).

3.4 Validity and Reliability

3.4.1 Validity. Several methods were employed to increase the validity. First, Creswell and Miller (2010) refer to triangulation as "a step taken by researchers employing only the researcher's lens, and it is a systematic process of sorting through the data to find common themes or categories by eliminating overlapping areas" (p. 127). To do this, when developing themes and codes, rather than focusing only on one PST's video analysis sessions, three participants' sessions were focused on. During this time, I actively looked for disconfirming evidence (e.g., learning trajectory as expressed through interviews versus video analysis sessions). Through this, and an analysis of all four participants' interview data relating to PSC and design supports, I was able to "corroborat[e] evidence collected through multiple methods (Creswell & Miller, 2010, p. 176). Second, credibility was established through a fine-grained analysis of one case, as the interaction analysis revealed a detailed and "rich" (Creswell & Miller, 2010, p. 128) account of both verbal and non-verbal actions from both interlocutors. Third, to increase validity, I was reflexive as I often considered how my biases could skew data. This was achieved primarily through seeking to create non-biased interview questions that did not sway the participants to answer in a certain way. When conducting the interviews, I was also actively mindful of how I framed my presses (i.e., as to not influence the PSTs' responses) and of how I maintained my tone/body language. This was especially difficult during the post-interviews as PSTs had grown accustomed to my participation and support during video analysis sessions, and

thus, during this time I made sure to respectfully remove myself from discussions (unless I needed to clarify a statement or needed further details) and keep a neutral stance.

3.4.2 Reliability. Reliability will be discussed in relation to: stability and equivalence (Long & Johnson, 2000). Stability was achieved through pre- and post-interviews. Across pre- and post-interviews only some questions about video remained the same, meanwhile, the majority of questions about PSC stayed the same in order to ensure comparability between data sets. Although Long and Johnson (2000) only talk about stability in relation to interviews, I think it is also important to bring attention to video analysis sessions, as each session's questions were, if not the same, similarly phrased. Doing this allowed for more reliable and dependable results. On the other hand, equivalence was achieved as several interview questions were carefully phrased to target the similar ideas while being asked in a different way. For instance, one question about the DNF stated: "What was your general impression of using the detailed noticing framework?" Whereas, another question asked: "Has the detailed noticing framework supported your learning? Please explain how it has or has not." The goal of these two questions was similar but they were worded differently in order to assure that PSTs deeply reflected on their answer and did not exclude details.

3.5 Chapter summary

This chapter explored my study's methodology, design, and analysis procedures. I described how this design study was conducted to reveal the various components and supports that were implemented to create rich learning opportunities for PSTs. A detailed explanation of my analysis procedures was also described. In the following chapter, I will discuss my findings in relation to my three overarching research questions.

Chapter 4: Results

To understand how this design study supported PSTs in understanding and noticing PSC through video analysis sessions, results in this chapter are sequenced and discussed in relation to my three research questions:

1. How do pre-service mathematics teachers' conceptualizations of PSC change through their engagement in video viewing sessions?
2. How do pre-service mathematics teachers' noticing of moments of positioning change through their engagement in video viewing sessions?
3. How do the design supports help to contribute to the development of PSTs' understanding and noticing?

Two sets of data were considered when writing this chapter (data from interviews and from video analysis sessions). In order to answer my first research question, I will present PSTs' expressed understandings of PSC at the beginning and end of the study by synthesizing findings from the interview data for Participants A, B, C, and D. To answer my second question, I will discuss video analysis session data from three contrasting cases (Participants A, B, and D) to show how PSTs' ability to notice shifted through their engagement in the study. For my third question, a synthesis of interview data will show how PSTs perceived the design supports to support them throughout their engagement in the study. One case will then be discussed in finer detail to further highlight which supports may have contributed to shifts in understanding and noticing instances relating to PSC.

4.1 Conceptualizing PSC: A Comparison of Pre- and Post-Interviews

Related to question one, by the end of the study, interview data revealed that three of the four participants (Participants A, B, C) were able to clearly define PSC and consider all facets of

the definition (i.e., acknowledge all student contributions to highlight their value, provide students with opportunities to make sense of and author mathematical ideas, position students competently with teacher moves). In contrast, one participant (Participant D) conceptualized PSC similarly both at the beginning and end of study and did not discuss how or why the teacher should value students' responses. Table 4 shows differences in how each PST conceptualized PSC during the pre-interview and post-interview. I elaborate on these differences in what follows.

Table 4. Comparison of PST Interview Responses Relating to Positioning Students Competently

	Pre- interview	Post-interview
Participant A	• Ranking students • Providing students with graded assignments to distinguish which students are competent • Guiding students towards the right answer • Administering tests • Calling on students who know the answer	• Credit students for their understandings • Help students feel accomplished • Consider your (the teacher) tone • Focus on both correct and incorrect answers • Use classrooms discussions • Use group work • Keep an open mind • Other
Participant B	• Ranking students • Adapt lesson plans • Use group work to make students competent • Use classroom discussions	• Support students in understanding their errors • View all students as capable • Use diverse teaching methods to support all students • Find the right teaching method to convey message • Allow students to take on teacher role • Use group work • Use classroom discussions
Participant C	• Scaffold student learning • Help students feel accomplished • Use diverse teaching methods to support all students	• Scaffold student learning • Help students feel accomplished • Use diverse teaching methods to support all students • Guide students towards the right answer • Avoid directly critiquing students • Represent student ideas • Use group work • Use classroom discussions
Participant D	• Scaffold student learning • Let students work independently • Provide students with a foundation • Assign authentic mathematical problems • Provide students with completed examples	• Let students work independently • Scaffold student learning • Should have students explain their thinking

At the onset of the study, Participant A described PSC as: ranking students, providing students with graded assignments, guiding students towards the right answer, administering tests, and calling on students who know the answer as this is “a way that they set their gauge on who's more competent than each other." Overall, the PST initially understood PSC as a potential means to evaluate students’ competence. For example, when describing how graded assignments can PSC, the PST said, “Like, I guess a shallow way is like, if they finish . . . they get like A's on their tests, like I would assume that is how.” However, the PST also stated that competence revealed through exams does not make students incompetent (i.e., it helps paint a picture of students’ competence but in itself does not distinguish competence). In contrast, by post-interview, the PST focused on what can be done to value and support students as sense makers and authors of mathematical ideas. During the post-interview, the PST explained that to PSC the teacher can: credit students for their understandings, help students feel accomplished, consider their tone - especially when responding to right or wrong answers, focus on both correct and incorrect answers, use classroom discussions, use group work, keep an open mind, and avoid favoritism. For instance, group work was mentioned as it gives teachers a “more in-depth sense, because there is no way you're able to have everyone contribute in a math class.” Avoiding favoritism was mentioned because “sometimes it’s something we do I think unconsciously…Especially in math like it’s really hard, like some students who don't feel as confident would be very affected by these things.” By the post-interview, Participant A’s responses were clearly related to PSC. In stark contrast to the pre-interview, by the post-interview, the PST not only considered PSC in relation to the teacher and students, but also discussed acknowledging student contributions by valuing them and supporting them as sense makers and authors.

At the onset of the study, although Participant B seemed to conceptualize PSC similarly to Participant A, she was firmly against the practice. That is, the PST was not familiar with the term "positioning students competently," but seemed to hold views that aligned with the values of PSC. For instance, in response to the question, "Please explain what you would observe if you saw a teacher positioning students as competent learners in a math class?" The PST said:

> . . . but at the same time if you label students as competent, the students that are incompetent will have a hard time because students aren't stupid, they understand when a teacher prefers others and so, if they know that certain people are competent and they're not, they will have a hard time learning too . . . I think as a teacher it's our job to make sure that all students are competent, they can all do it, it's just you just need to find a way to allow the student to be able to do it.

For this reason, it is important to note that there were not many codes assigned to Participant B's responses because the PST mainly explained how PSC should not be used in classrooms. Participant B initially explained that to PSC the teacher can: rank students, adapt lesson plans, use group work, and lead classroom discussions. For instance, ranking students consisted of "a sense of favoritism if they label students as competent, because that means that there is incompetent students." Similarly, activities were discussed as a means to make students competent (e.g., "I know that to make everyone competent, I think students can work together to work through problems"). However, by the post-interview the PST revealed an understanding of the practice that was aligned with all components of the definition. The participant explained that the teacher should: support students in understanding their errors, help students feel accomplished, use diverse teaching methods to support all students, allow students to take on the teacher role, use teacher moves especially "if a student had a question wrong," use group work,

and classroom discussions. To elaborate, when the PST discussed supporting students in understanding their errors, the PST said, "not everyone views math the same way or solves problems the same way, but you need to find out where their errors are and help them work through it." It is clear that the PST's ability to explain PSC shifted from the pre- to post-interview. In the post-interview, Participant B described PSC in completely new terms, especially as pre-interview responses revealed a minimal understanding of the term PSC.

Participant C consistently expressed an understanding of PSC, as during the pre- and post-interview, the participant was able to consider how teachers need to both value students' responses and support them in making sense of and authoring mathematical ideas. However, during the pre-interview, her understanding was not fully developed, revealed by a clear contrast between her pre- and post-interview responses. Post-interview responses included and expanded upon what the PST discussed during the pre-interview. During the pre-interview, the PST explained that to PSC the teacher should: help students feel accomplished (e.g., "encouragement, I think, is a big one, to position students as competent learners"), scaffold student learning by asking questions, and use diverse teaching methods to support all students. For example, when describing the use of diverse teaching methods, the participant said,

> like, diversity, diversity, diversity . . . So I think it would be, what I mean 'diversity,' it's like making sure that everyone is able to understand things in their way . . . Like, no matter the amount of time that it asks from the students, that they get to reach the same goal as everybody . . . That's what I mean. So that, like diversity to encourage equality. See what I mean?

To start, Participant C understood PSC as a means to encourage and scaffold all students to use different methods. Accordingly, during the post-interview, the PST similarly explained that the

teacher: should scaffold student learning, help students feel accomplished since they should "feel like their knowledge has evolved at the end of the day, because they've been getting to the right answer," and use diverse teaching methods to support all students. In addition, the PST also said that the teacher should guide students towards the right answer by "tak[ing] in what is being said, and really guid[ing] them through the right answer, or the right group of answers", avoid directly critiquing students, use teacher moves, use group work, and use classroom discussions. Classroom discussions were said to allow "students to discuss and… and give an argument for each of the answers and almost like a debate with the ruler exercise [from the video] where the teacher was allowing students to really say why they thought this was the right answer and why did a student thought it was wrong." Participant C came into the study with a partial understanding of what PSC could mean and emerged with a deeper, more developed understanding of the practice.

Unlike the previous three participants, participant D's responses did not seem to significantly shift from the beginning to the end of the study nor did they reveal that the PST emerged with a deeper understanding of the practice. Initially, the PST explained that to PSC the teacher: should scaffold student learning by "breaking down how a problem or an example can be tackled with what the teacher's taught them so far," assign authentic mathematical problems (i.e., "workshop math"), provide students with a foundation, provide students with completed examples "to [help them] figure out 'where did I go wrong,' 'okay, what did I do right?'," and support students while letting them work independently. The above comments are centered primarily on the teacher and not readily considered in relation to students. Further, valuing students' responses was not discussed. Similarly, during the post-interview the PST focused on ways the teacher could better support students in understanding and authoring mathematical

ideas. He explained that to PSC the teacher: should have students explain their thinking to check for understanding, let students work independently, scaffold student learning, and put students on the spot during classroom discussions. Although some of these categories could be seen as valuing, the PST placed a greater focus on how teachers can support students' understandings than on the their role in making sure all students' contributions are acknowledged and valued. For instance, when describing classroom discussions the PST explained that, "everybody kind of has a fear of being wrong, so they won't always put up their hand. So just kind of like, make them answer." Participant D demonstrated a limited understanding of PSC as only some focus was placed on teachers supporting students to make sense of and author mathematical ideas, while no focus was placed on valuing student contributions.

4.2 Noticing Moments of Positioning: A Look at Changes in Noticing Across Three Cases

Positioning students competently is a complex practice that includes various interconnected components. Through situating PST learning in video analysis sessions (i.e., when viewing and discussing video footage), it was hoped that they would be able to equally attend to students and the teacher, as well as interpret students' feeling and understandings, and how the teacher valued students' contributions and supported them as sense makers and authors of mathematical ideas.

Across all three cases, PSTs attended more to the teacher than to students, and as a whole they focused more on the teacher supporting students as sense makers and authors of mathematical ideas, rather than on how the teacher valued students' contributions. Similarly, when interpreting students, the majority of PSTs tended to focus on their understandings. However, when considering each case and comparing their reflections across three sessions, PSTs' growth in how they attended to and interpreted PSC differed. Out of the three participants,

Participant A's noticing shifted most substantially through participation in the study. During sessions one and two, Participant A focused primarily on the teacher supporting students as sense makers and authors, while during the third session, she attended to both the teacher and students. Interpretations during this session varied as focus was placed on each dimension of the definition. Participant B's attending varied slightly between sessions, as she attended more evenly to the teacher and students across all three sessions. Further, apart from supporting students as sense makers and authors, which was considerably high for the first two sessions, she more or less consistently focused on all remaining aspects of PSC. Participant D displayed similar trends to Participant B in attending throughout. However, when interpreting, rather than focusing on all aspects of PSC, he focused mainly on the teacher supporting students as sense makers and authors of mathematical ideas. When the PST did focus on the students, it was usually in relation to their understandings and occasionally mentioned their feelings. In what follows, I will elaborate on the trends for each participant.

4.2.1 Participant A. Similar to the interview data, analysis of the video sessions revealed that through engagement in this study, Participant A emerged with an improved noticing of PSC, and by the final session was interpreting all aspects of PSC in relation both to the teacher and students (see Figure 6 and 7 below).

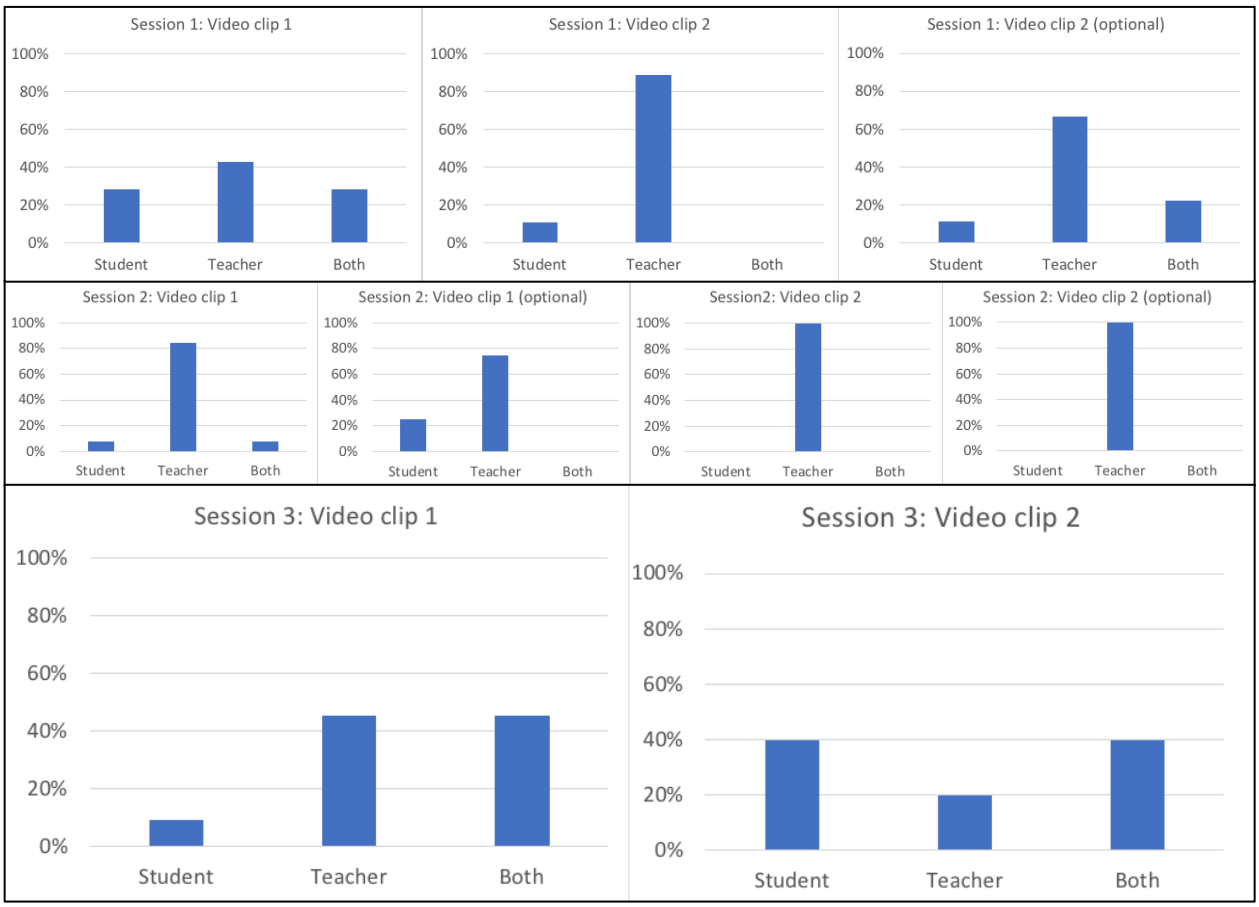

Figure 6. Changes in Participant A's Attending Across Sessions 1 to 3.This figure shows changes in PSTs' attending for each video clip (i.e., moment of interaction discussed) (see Appendix D). Percentages in this table represent how often each actor was discussed in relation to the total coded turns of talk during the discussed video clip.

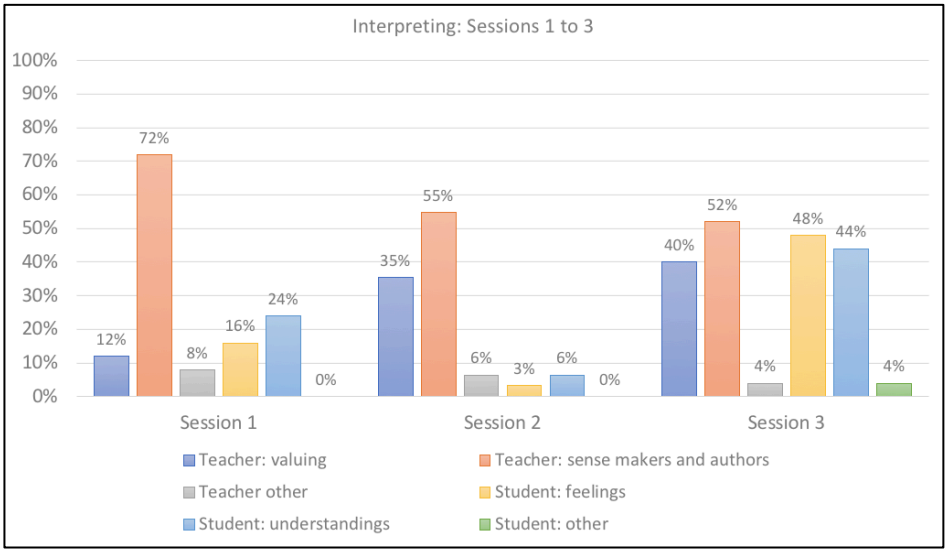

Figure 7. Changes in Participant A's Interpreting Across Sessions 1 to 3. This figure shows changes in PSTs' interpreting across session 1 – 3. Percentages in this table represent how often

each component was discussed within a coded turn of talk, located in a single session. Percentages may equal more than 100% as turns of talk could be double coded.

During the first session, when discussing each set of questions from the DNF (see Appendix D), Participant A attended more to the teacher. For instance, when discussing clip one, she attended to the *teacher* slightly more than *students* or *both the teacher and student* (i.e., by 14%). Similarly, during discussions linked to clip two, she focused primarily on the teacher. When discussing the first set of questions she attended to the *teacher* 78% more than *students,* and when discussing the second set of questions, the *teacher* was discussed 56% more than *students* and 45% more than *both teachers and students*. For instance, when discussing the teacher, the participant said,

> Then the way he [the teacher] went through with the whole class, um he made sure that, everyone was able to.. I guess, he was, well he kind of caught the mistake everyone was making while doing the group work (. . .) Um so, by doing that he was able to like correct them or like remind them 'Oh, this is not just 89 you need to know the value of it.'

In terms of her interpretations, throughout the entire first session, Participant A focused on how the teacher *supported students as sense makers and authors* (72%), rather than on how the teacher *valued student ideas* (12%). When attending to students, Participant A focused slightly more on interpreting students' *understandings* (24%), rather than students' *feelings* (16%).

During the second session, the PST continued to focus on the teacher – during each post viewing discussion, she attended to the *teacher* between 50% to 100% more than *students* and *both*. However, unlike during session one, she began to focus on how the teacher *valued students' responses* (35%), as well as how students were *supported as sense makers and authors* (55%). Still, since students were attended to significantly less - interpretations related to how students'

feelings and understandings were affected by instruction were drastically low (student *feelings* 3%; student *understandings* 6%).

Unlike session one and two, during the third session, Participant A began to focus less on the *teacher* alone, and when attending, either focused on the *teacher* or *both teacher and students*. For instance, after watching the first clip she attended to the *teacher* and *both teacher and students* equally (45%), while *students* were discussed less (9%). In contrast, after the second clip, the *teacher* was discussed 20% less than the *students* (40%) and *both teacher and students* (40%). Despite fluctuations in attending, compared to past sessions in which the *teacher* was focused on between 14% and 100% more than *student* and *both*, attending during the third session was distributed more evenly. Further, in past sessions, Participant A did not often discuss how the teacher positioned students and how this affected students in the same turn of talk (e.g., *both teacher and students*). Yet, in session 3, she attended to *both teacher and students* 40 – 45 % of the turns of talk, whereas in past sessions, only focused on *both teacher and students* between 0% and 29% of turns of talk. Considering it was hoped that participants would reason about both the teacher and students, without placing a significant focus on one actor more than another, session 3 indicated a noteworthy shift towards attending more evenly to teachers and students. During this session, Participant A also interpreted all dimensions of PSC more evenly. In past sessions, she focused on the teacher *supporting students as sense makers and authors* more than *valuing*, and students' *understandings* were focused on more than their *feelings*. However, during session 3, she attended to teacher *valuing* 40% and *sense makers and authors* 52% of the time. While, students' *feelings* were focused on 48% of the time and their *understandings* 44%. During this session, interpretations of each aspect of PSC varied by only between 5% and 12%.

Through the analysis of both interview and video data, it is clear Participant A's noticing of PSC shifted. Focus shifted away from primarily noticing how the teacher supported students, to attending to both students and the teacher. In contrast, interpretations focused more on each aspect of PSC, rather than focusing mainly on the teacher *supporting students as sense makers and authors of mathematical ideas*.

4.2.2 Participant B. Unlike Participant A, what Participant B attended to and interpreted did not shift drastically through engagement in the study (see Figure 8 and 9 below).

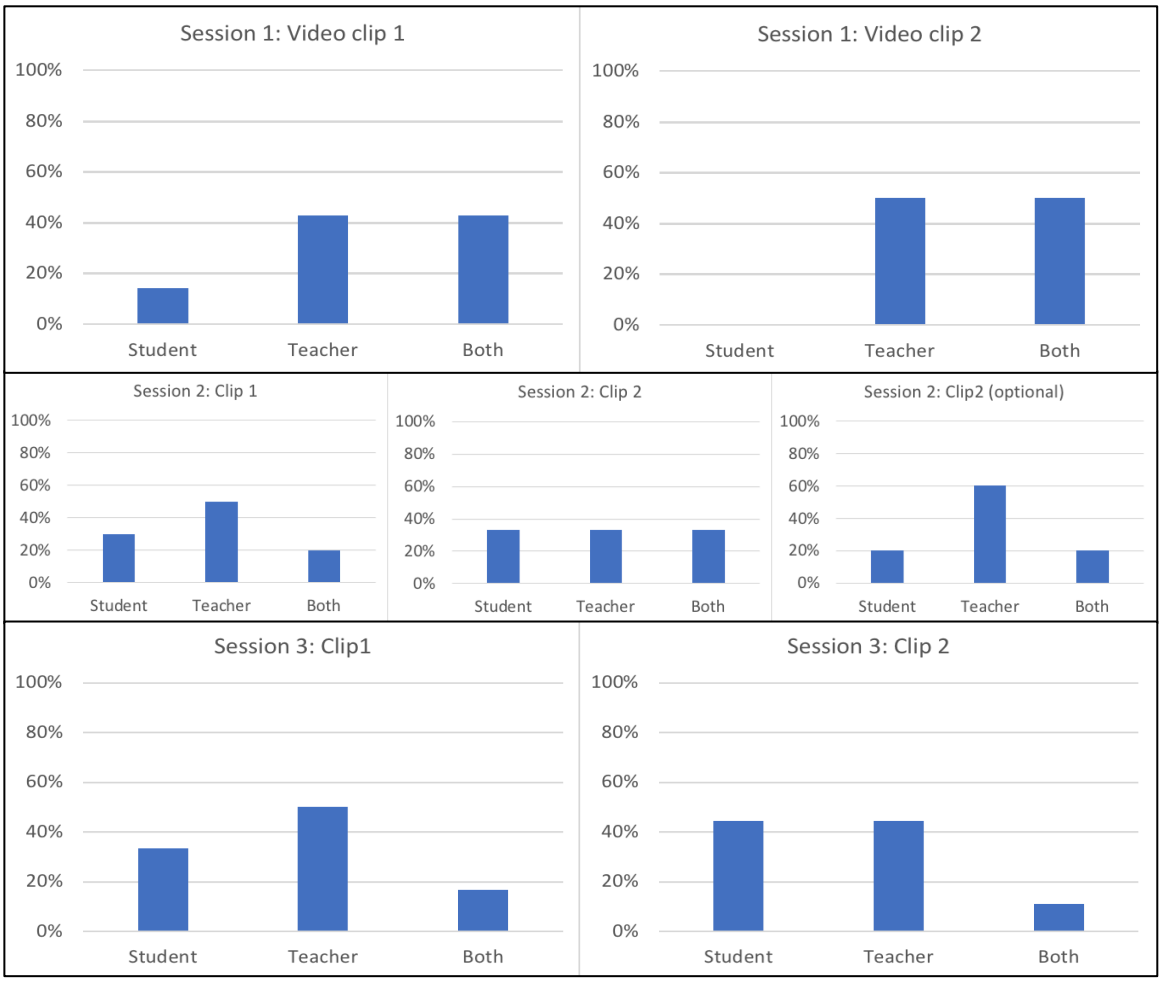

Figure 8. Changes in Participant B's Attending Across Sessions 1 to 3.

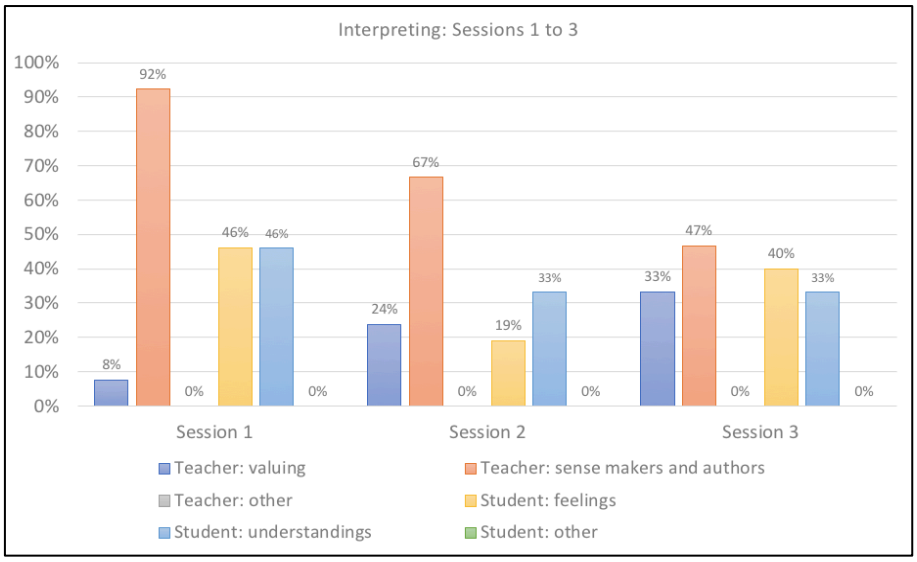

Figure 9. Changes in Participant B's Interpreting Across Sessions 1 to 3.

As shown through a comparison between pre-and post-interviews, despite not knowing the terminology, this participant came into the study advocating for PSC and emerged demonstrating a multi-faceted understanding of the practice.

During session one, when discussing the first and second clip, Participant B consistently attended to the *teacher* (clip 1: 43%; clip 2: 50%) and *both teacher and students* (clip 1: 43%; clip 2: 50%). This implies that students were primarily accounted for in turns of talk coded for *both teacher and students*, and when considering individual turns of talk centered on one actor, students were focused on less (clip 1: 14%; clip 2: 0%). During this session, when the PST interpreted student and teacher interactions, focus was placed mainly on how the teacher *supported students as sense makers and authors*, as this was discussed 84% more than *valuing*. In contrast, when interpreting students' *understandings* and *feelings*, she mentioned both equally (46%). For example, when describing student *understandings*, she noted, "Sometimes what they're [students] saying isn't clear because they're seeing it right, but when she [Ellan] saw it she was able to explain exactly what Mackenzie said without saying 'Mackenzie said this.'" When describing student *feelings*, she noted, "I, I felt like the student would know that they were the

one that couldn't figure it out. Like stating how many students got the answer right or wrong, made that particular student, whichever it is, feel singled out because they know that they made a mistake and they didn't have the opportunity to fix it."

During session two, Participant B's attending shifted only slightly. When discussing the first clip and second clip's optional section (see Appendix D), she attended to the *teacher* more than *students* (clip 1: *teacher* (50%), *students* (30%); clip 2 (optional): *teacher* (60%), *students* (20%). Students were also discussed during turns of talk that focused on *both the teacher and students* (clip 1 and 2 (optional): 20%). In contrast, when discussing the second clip, she focused equally on the *teacher* (33%), *students* (33%), and *both* (33%). When interpreting, Participant B began to focus more on the teacher valuing students' ideas. More specifically, teacher *supporting students as sense makers and authors* was still emphasized more frequently (67%) however, her interpretations relating to how the teacher *valued students' responses* increased by 16% from session 1 (session 1: *valuing* (8%); session 2: *valuing* (24%). Meanwhile, students' *feelings* were focused on 19% of the time, and *understandings* 33%.

Looking across sessions 1 and 2, unlike Participant A, Participant B's attending and interpreting shifted less. Although Participant B could not be described as equally attending to actors or consistently interpreting each aspect of PSC, the participant did show improvements between sessions 1 and 2, and despite a focus on the teacher, her noticing and understandings were more consistent across discussions relating to clips one and two.

During the final session, Participant B attended both to the *teacher* and *students* (focused slightly more on the teacher), and also interpreted all components of PSC more evenly. When discussing the first clip, she attended to the *teacher* 50%, *students* 33%, and *both* 17%. Similarly, when discussing the second clip she attended equally to the *teacher* (44.4%) and *student* (44.4%),

and attended to *both teacher and student* 11.1% of the turns of talk. Further, interpretations were more consistent as she focused on how the teacher *valued student responses* 33% and on how the teacher *supported students as sense makers and authors* 47% of the time. Likewise, she discussed students' *feelings* 40% and *understandings* 33% of the time.

Across all three sessions, although the *teacher* was attended to more, variation seen across all categories was less drastic in comparison to Participant A. Meanwhile, by the third session, similar to Participant A, Participant B began to more equally attend to all actors and express more varied interpretations.

4.2.3 Participant D. Participant D's attending followed a similar progression as Participants B, and notably by third session, attended equally to the *teacher*, *student*, and *both teacher and students*. However, unlike the other two participants, by the third session, Participant D did not evenly interpret all aspects of PSC (see Figure 10 and 11 below).

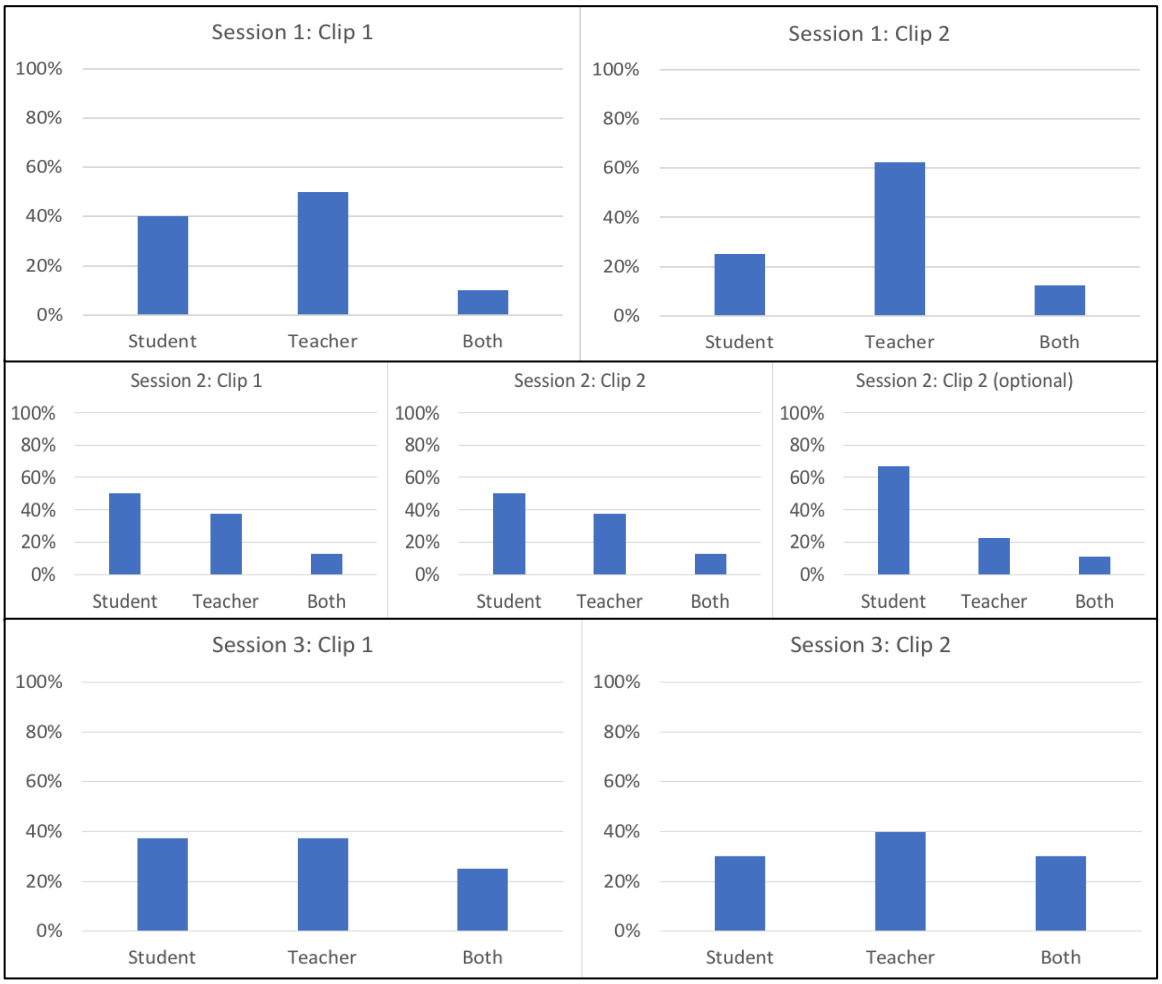

Figure 10. Changes in Participant D's Attending Across Sessions 1 to 3.

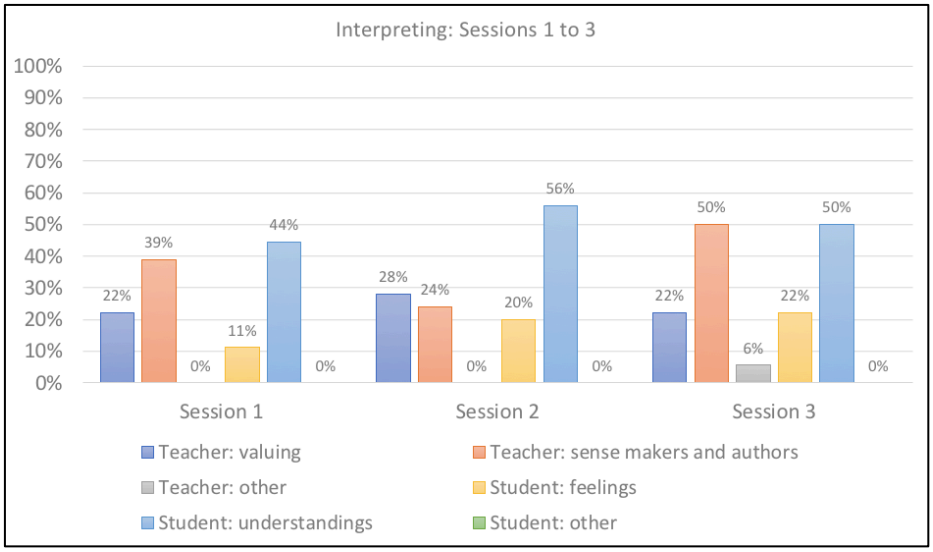

Figure 11. Changes in Participant D's Interpreting Across Sessions 1 to 3.

During the first session, Participant D focused on the *teacher* more than *students*, as discussions about clip one focused 10% more on the teacher, while when discussing clip two the teacher was discussed 38% more. In addition, the PST attended to *both teacher and students* 10% of the time during clip one and 13% of the time during clip two. Interpretations during this session centered on either the teacher *supporting students as sense makers and authors* (17% more than *value*) or on students' *understandings* (33% more than "feelings").

The second session differed from the first session as Participant D focused more on *students* (clip 1 and 2: *students* 50%, *teacher* 37.5%, and *both* 12.5%; clip 2 optional: *student* 67%, *teacher* 22%, and *both* 11%). When the PST discussed the teacher, moments were more equally interpreted both in relation to *supporting students as sense makers and authors* (24%) and *valuing* (28%). However, when discussing students, most reflections were about students' *understandings* (56%) and their *feelings* were less frequently discussed (20%). For instance, the PST said the teacher's instruction allowed "students" to "understand" mathematical tasks more autonomously, as through instruction, students "identif[ied] issues themselves instead just kind of on the spot talking about it and kind of realizing after they did something wrong. So that could have been an opportunity to make sense of their (. . .)."

Similar to Participants A and B, during the last session, the PST attended more equally to the *teacher* and *students*. Discussion about clip one centered on the *teacher* 37.5%, *student* 37.5%, and *both* 25%; discussion around clip two focused on the *teacher* 40%, *student* 30%, and *both* 30%. However, similar to the first session, when interpreting student and teacher interactions, Participant D once again focused more on *supporting students as sense maker and authors* (28% more than *value*) and students' *understandings* (28% more than feelings). Similar to Participants A and B, through engagement in the study, during the third session Participant D

attended more evenly to the teacher and students. Still, these results, along with previously discussed interview data, indicate Participant D did not emerge from the study with as nuanced an understanding of PSC as the participant did not often discuss how PSC can value student responses and affect students' feelings.

4.3 Understanding How Designed Supports Contributed to PSTs' Development

Both interview data and a fine-grained analysis of one case allowed me to understand how design supports contributed to PSTs' development throughout the study. Before discussing the single case, I will begin by considering interview data from all four participants.

4.3.1 Understanding How Design Supports Contributed to PSTs' Development: Post-Interview Data.

During the post-interviews, all participants stated that the DNF allowed for focused reflections. That is, rather than considering many aspects of classroom interactions at once, by using the DNF, PSTs could attend to and interpret specific moments. For instance, three of the four participants compared their experience with the DNF to past experiences they had with video in their teacher education program. One participant said that:

> Well, a lot of the times when I would watch videos to support learning in classrooms, I wouldn't have..like in uni[versity] I wouldn't have questions to reflect on my thinking. It would just be, I would have to take notes, like on my own and try to write as quick as I can, because the video would be shown once. So, umm, I think this framework helps because alongside the transcript it allowed me to really pinpoint what was important within the video to remember, instead of just writing down everything about the video.

To focus reflections, another participant mentioned how the DNF helped her "pin point the different [pedagogical] approach the teacher use[d]" in the video.

Each participant also stated that the DNF helped reinforce the teacher moves and how they related to positioning students competently. For example, similar to what others expressed, one PST said:

> I liked the teacher moves and the fact that I had to um, kind of write about the teacher move and how it places students competently because um, it's different knowing what the move is, but then versus understanding why this move is important and how it places students in a competent position. So, this actually really helped me build a better understanding of the teacher move.

The PST highlighted how the DNF made it easier to make connections between the teacher moves and the focal practice - as knowing a teacher move is different from knowing how it can be used to PSC. Making such connections fosters a deeper understanding of the teacher moves.

All PSTs also mentioned that consistently having access to the DNF reinforced terms or teaching methods. Unlike the previous category that highlighted how PSTs considered moves in relation to the definition, this category specifically relates to terms or methods that were not expressed in connection to the definition. Several PSTs equated this to being able to look back at the descriptions in the positioning framework during the sessions. One PST explained that, “And so, I'll actually like remember that, and I kept going back to it while I was writing to make sure I like, I fully understood and was using the right terms and stuff. And umm, yeah.” In this case, the moves were reinforced as the PST looked back on them to validate their interpretations and understandings of the move and its application.

Three of the four participants said that the DNF has future learning benefits and all but one PST specifically identified knowing the teacher moves as something they can use in the future:

> Well I learnt about teacher moves, which is good for like my future knowledge, because . . . having those teacher moves will aid me in my classroom, because I'll have kind of I can go back to this and remember different ways to help position my students competently. Yeah.

Based on the aforementioned, PSTs considered the moves and/or DNF yielding more general learning opportunities that could later be used in their teaching careers.

Two PSTs had more general comments about how the design of the DNF was appealing. For instance, a participant said,

> I feel that like, doing this process repeatedly like, it- it wasn't monotone at all, and I didn't feel like it was boring at all, because I was always like in front of different scenarios and with the same questions, it allowed me really to like put things into categories.

This comment, along with those expressed by the other PSTs, were general and related to how parts of the DNF or its structure were appealing.

During post-interviews, PSTs also expressed several limitations regarding either questions or the design of the DNF more generally. Firstly, three of the four participants explained that envisioning new ways of proceeding was difficult to answer. For instance, one participant mentioned that,

> e and f [i.e., booklet questions “e” and “f”] I always had trouble I think filling it out because again, I didn't necessarily have a like solid example and experience in the classroom, so I might not be able to think in the top of my head how I would position them competently

Participants attributed their difficulty in answering question(s) e and/or f to a lack of experience, or because they agreed with the technique used in the video and consequently found it difficult to

devise an alternative strategy. Second, three PSTs found the questions redundant as they seemed to yield similar answers.

> Uhmm, like I. hmmm there were a lot of re-, not redundant questions, but there are, I feel like there were questions asked differently. Or, yeah, like the answer is sort of the same but it's asked differently. So it was, um, yeah I don't know how I feel about that…

Further, another participant explained that due to the redundancy, they were more reluctant to answer the following optional section (i.e., the second set of optional noticing questions). Third, all PSTs had general suggestions that related to limitations of the DNF. One participant explained that they would have liked to have a diagram that allowed them to input how efficiently students were positioned competently (i.e., "like from one to five or how do you think the teacher positioned students competently"). Other comments that fell within this theme were also suggestions about how the design could be improved.

Relating to the facilitator's roles, each participant's response differed. Participants said that the facilitator: (a) helped PSTs clarify thoughts as it "really helped [the PST] explain [their] thoughts more."; (b) supported PSTs in remembering terminology; (c) supported PSTs in furthering their understanding (booklet and video); and (d) helped focus viewing by relating everything back to PSC. For example, related to this last point, one PST said:

> [the facilitator] really stressed on was how teachers position, [she] I guess [brought] us back to the focus of the study in general. Like the focus of how to, I mean position students competently and uhm. Yeah so that was very helpful, because when you analyze something it's very easy to go off on a tangent and um, to stay really focused and really just think about not necessarily.. uh like leveling your students or categorizing them, um

> is something that I have to constantly keep in mind and like it's a great reminder to not just uh judge your students.

Although all remarks differed, each highlighted how the facilitator supported PSTs' development throughout the study.

When discussing the transcripts, all participants said that the transcripts made it easier to follow the video. For instance, one participant explained:

> [since] students that don't speak super loud and very articulately, or that have like accents that for me are a little bit hard to decipher, it was really helpful just to see like the succession of what was said. Um but yeah, I think I would have had only the transcript I would have been lost, and only the video I think would have been tough, so both are really helpful.

In addition, two participants explained that the transcripts allowed them to point to evidence.

Video was the support that PSTs spoke most extensively about. All PSTs said that video allowed them to experience different viewpoints, teaching perspectives, teaching styles, and teaching strategies. For instance, one participant said,

> And so, being able to have those different perspectives and different teachers, they're almost like models. And they model how we could be acting in a classroom in the future," while another explained how the video "gave [them] a kind of insight into different ways [they] can engage a student . . . getting that view of how to engage younger students with questions and how you kind of explain things to them in terms they can understand.

In addition, three participants said that viewing videos can inform their professional development and careers. Another participant also mentioned that viewing videos allowed for a more hands-on experience that could not have been possible during their field experience or university classes.

One participant had extensive comments relating to video. This participant explained that video: allowed them to observe without altering students' behaviour; supported them in seeing what not to do; allowed them to re-watch it and see new things; and helped to bridge theory and practice.

When prompted, viewing norms was the sole support that most PSTs did not readily remember, which can be considered indicative of it being less central to their development during the study. Three out of four PSTs had trouble remembering this support, and needed to be reminded of it before attempting to respond to the interview question. However, when prompted, out of the three who needed to be reminded, one said the norms provided them with a lens to focus viewing. Whereas, the other two, in addition to the PST who did remember the support, said that it supported their professional development or professional careers. For instance, one participant said,

> Okay, well with critical stance, . . . it helps me because um I get to kind of um, uh I get to build myself as a teacher by, just kind of critiquing others. As mean as that sounds, but I want to be able to make myself the best teacher possible, so I have to be very like critical in the way I view other teachers and how they view their students, kind of thing. Like, and so then I can be able to position students competently with using certain moves to see what does work and what doesn't work.

Although PSTs did not readily remember the support, some benefits were yielded. A focus was placed on this support primarily during the first session (briefly during the second) while PSTs had access to it the following sessions. Still, had the support been focused on each session, the learning outcomes of this support may have been clearer.

4.3.2 A Closer Look at How Design Supports Contributed to a PST's Development: A Case Study. Through my analysis of the aforementioned three cases, Participant A was

chosen for fine-grained analysis to understand what supported shifts in her noticing. This case differed from the other two, in that the participant's noticing shifted drastically through engagement in the study. It is however important to note that Participant D was also an interesting case for analysis, as this PST did not emerge from the study attending to and interpreting all aspects of PSC. This may have been due to less focus on decomposing the definition of PSC and on addressing the PSTs lack of attention towards students' feelings-an action that would have been prompted by the facilitator. Nevertheless, to answer my third question, focusing on Participant A was optimal. Following from the work of Stevens and Hall (1998), two episodes of breakdown were focused on: one breakdown that was not repaired and one that was. By contrasting the interactions during each breakdown, I was able to identify interactional differences that appeared to contribute to repair in the second breakdown. The following section will include a detailed description of each breakdown and which supports may have contributed to repair.

4.3.2.1 Breakdown one: Lack of repair. The first segment that was coded as a breakdown took place during session two. After watching the first video clip, the PST and facilitator discussed her reflection from the DNF. When Participant A was struggling to verbalize her answer to question two from the DNF ("Why was it important that a student(s) was positioned competently at this time?"), the facilitator noticed the PST focused less on valuing student responses. Thus, the facilitator tried to shift Participant A's attention towards valuing student ideas:

Verbal	Nonverbal
FACILITATOR: Lets go back to /our\- So always relating it back, to positioning students competently. So, >PSC calls on the teacher to value all contributions. **So I think you mentioned< <author>?**	Facilitator looks at detailed noticing framework and follows definition with finger while reading it aloud

	Facilitator looks at Participant A's response in booklet
PARTICIPANT A: >Yeah<	Participant A follows her response with pencil
FACILITATOR: Sense?	Facilitator looks at Participant A's response in booklet
PARTICIPANT A: Yeah	Participant A follows her response with pencil
FACILITATOR: Um, did you mention acknowledge? **Yeah, acknowledge.**	Facilitator looks at Participant A's response in booklet Facilitator point at phrase in response that mentions author.
PARTICIPANT A: Yeah	Participant A follows her response with pencil
FACILITATOR: And then value, so the only one that is left is . . . [value].	Facilitator looks at Participant A's response in booklet – this time leans over.
PARTICIPANT A: [value]	
FACILITATOR: So how would that one . . . um value all student-	Facilitator look down at sheet and moves it slightly towards Participant A

To do this, the facilitator read aloud and through her pointing, highlighted (Goodwin, 1994) the definition written in the DNF. She paused at each aspect of the definition and asked the PST whether her response had touched upon it. Once the facilitator brought attention to valuing, the PST grappled with understanding how valuing could be considered independently, and thought that acknowledging shared a similar meaning. Participant A verbally and non-verbally emphasized this by talking about the definition while pointing at it. Following this, the facilitator tried to repair the breakdown with an example:

FACILITATOR: Let's say I am Domenico **() /and um, so she acknowledges my answer\-**	**Facilitator laughs when she says "Domenico" and Participant A joins in. Facilitator continues to use hand gestures while speaking**
PARTICIPANT A: Well she was still able to position you in your ability to apply /it\=	Participant A looks at facilitator and gestures with pencil

FACILITATOR: =ok=	
PARTICIPANT A: =um but she also I guess can position you as like "oh you have some careless mistakes or your concept with nine . . nine in ten place you are having trouble with that" **um yeah**	Participant A gestures with pencil while speaking Participant A gazes down and puts pencil down
FACILITATOR: /okay\ . . .	Facilitator looks at Participant A's response

These interactions revealed attempts at repair through the facilitator's use of an example. However, this alone did not seem to repair the situation given that no closure was reached at the end of the conversation. Participant A's expressed example did not reflect the goals of PSC, as she stated: "=um but she also I guess can position you as like 'oh you have some careless mistakes or your concept with nine . . nine in ten place you are having trouble with that.'" The term "some careless mistakes" shows a lack of value for a student's contribution. It acknowledges their work but at the same time undermines their efforts. To PSC, the PST could have said, "Domenico, that's a great first step. Walk me through what you did." Although this may not have entirely supported Domenico in authoring and making sense of the mathematical task, it shows value for his efforts and encourages him to author his own understanding by revising his initial response. If the student did not realize his mistake, the PST could have then used other teacher moves to support the student.

However, the facilitator did not bring attention to such a distinction nor provide an additional example. Following the aforementioned set of interactions, the facilitator acknowledged Participant A's response, and after a moment of silence, Participant A asked if her answer was clear. The facilitator did not correct the PST but rather went on to say that,

I just wanted to walk through it, it's not even that it is not clear, it's really just to walk through how it relates to this so that by the end, {PARTICIPANT A: >yep<} cause the clips are going to get more technical I guess {PARTICIPANT A: >Yeah, okay<}

A shared understanding did not emerge during this segment – neither the DNF or the facilitator repaired the breakdown.

4.3.2.2 Breakdown two: Repair in understanding. During the same session, another breakdown in shared understanding of PSC was closely examined. This breakdown took place after viewing the second video. Like the abovementioned segment, the following discussions also focused on valuing student contributions. However, unlike the other, this breakdown was repaired.

The segment began while Participant A was writing in the DNF. She paused at the second question in the DNF and asked the facilitator if this question (e.g., "Why was it important that a student(s) was positioned competently at this time?") would be the same in all cases. Here, she struggled to grasp that the importance of using PSC may change based on what is happening in the video. As previously discussed in Chapter 2, a teacher may want to value a student's contribution with the primary goal of supporting them in authoring a mathematical idea and making sense of it autonomously, while in another case, the teacher may simply value a student's contribution by highlighting or representing it.

In response to this, the facilitator explained that the importance of PSC may or may not be the same depending on the situation. To elaborate on this idea, the facilitator provided Participant A with an example and drew on teacher moves present in the DNF:

FACILITATOR: =It could. (.) It doesn't have to, but it can. It depends really on (. . .) like what the <°student expressed°>. (..) Like let's say u:m:, (.) a student just gave like a correct answer=	Facilitator uses hand gestures while speaking to the PST

PARTICIPANT A: =>Right<=	
FACILITATOR: = and you wanted to position that student competently, (.) your reason would be like, to highlight, you know, to validate the student's idea=	Facilitator looks at DNF and uses hand gestures while speaking
PARTICIPANT A: =>Right<=	
FACILITATOR: If the student expressed some misunderstanding, (.) then it would really, it would like cha::nge. (.) Like, in nature, it stays the same, because you want to value that student's contribution=	Facilitator uses hand gestures while speaking to the PST
PARTICIPANT A: =Right=	
FACILITATOR: =But you [also=]	
PARTICIPANT A: [=But in terms] of positioning, it would have changed?	Facilitator looks at PST and nods
FACILITATOR: Yeah, [because you want to support them.]	
PARTICIPANT A: [/Okay\. Okay.]	
FACILITATOR: °Yeah°. (…) Does that make sense? Does that clarify it?	
PARTICIPANT A: Yeah.	
FACILITATOR: >Okay<.	Facilitator nods and smiles

The interaction illustrated above did not seem to repair the breakdown in shared understanding as, following this exchange, Participant A continued to define PSC as a practice used to differentiate who is or is not competent. Participant A explained that competence can be seen as a specific level (i.e., "line") that students may fall above or below. This starkly contrasts to the goals of PSC, as ideally the teacher would support *all* students in competently participating in a mathematics lesson and not make judgments about which students are or are not competent. When considering positioning theory, assessing students' competency may position students (i.e.,

interactive positioning) as competent or not; if the latter position were taken up by a student (i.e., *reflexive positioning*) their engagement in course content could be adversely affected. In response, the facilitator tried to support Participant A in shifting focus from evaluating students' competency towards positioning students competently:

FACILITATOR: I think it's also like (…) it is kind of like having (..) Rather than I guess having a line=	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: =Right.=	
FACILITATOR: = It would be really, there isn't a line, like all students are competent, they're just, not able to fully express themselves in a way. Like they're {PARTICIPANT A: Okay} all able to achieve that competence. I guess it's really going in with that mindset, so like (.) really gauging student's body language. {PARTICIPANT A: Okay} Like there's just so many things, so like knowing that everyone is competent, but (.) like things happen we do make mistakes. {PARTICIPANT A: Yup} But just never showing the students that they're incompetent. {PARTICIPANT A: Okay} Like, always supporting them in, the sense that "I know you're capable", if that makes sense?	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: R:ight.	
FACILITATOR: Like, [kind of like] bringing everyone to the same level [regardless] like, if they misunderstand or not. (..)	
PARTICIPANT A: [Okay. Okay.] [Yeah]. Okay.	
FACILITATOR: Does it kind of, make sense? [(unintelligible speech)]	

In the above transcript the facilitator asked Participant A if PSC is clear. However, following this exchange, the PST continued to maintain her former stance and tried to validate it by providing a counter example. Following from the idea of PSC being used to consider students' competence, Participant A said:

PARTICIPANT A: So then, what you just said, would have to (.) be applicable in a classroom where (.)°there's no learning disabilities°.	

Ethically, this statement raises some issues and once again does not reflect the definition and goals of PSC. In contrast to what the participant expressed, using PSC in an inclusive environment would help encourage all students (i.e., students with and without learning disabilities) to participate and author mathematical ideas. At this point, the PST did not yet grasp how PSC can be used to support *all* students, especially since the idea of evaluating is continually implied (e.g., "but what if there is someone . . . incompetent"). To support the participant in better understanding PSC, the facilitator built on the aforementioned example and tried to place herself in the perspective of a student with a learning disability that had not been positioned competently. The facilitator also explained why it would be important that a student with learning disabilities be placed competently (see transcript below).

FACILITATOR: It could be a classroom where there is learning disabilities, it's just you have to. (.) I guess cause let's say if I had a disability and I express a misunderstanding, she wouldn't want to position me in a way that (.) tells me that I can't really=	
PARTICIPANT A: =>Right<.	
FACILITATOR: Cause I'm already. (.) I'm open-, like I'm opening up enough to say like "Oh, I got this answer" {PARTICIPANT A: Okay}. Especially in a number talk, you {PARTICIPANT A: Yeah}, right or wrong. PARTICIPANT A: Yeah, yeah.} Like everyone's giving different answers, so if someone got a wrong answer, and she knows that let's say they have a disability, you still want to be able to position them to say like even if parts-h of their answer is correct.	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: Right.	
FACILITATOR: Let's say they give like a, "nananaaa," and	Facilitator continues to use

I got the first part, it would be like "oh, that's awesome thinking, {PARTICIPANT A: Yeah} let's consider:".	hand gestures while speaking
PARTICIPANT A: Okay.	
FACILITATOR: But it would really be: (.) like, (.) at the end of it you want the student to feel like "Oh I, like you know, I was able to [figure that out".]	Facilitator continues to use hand gestures while speaking

In the transcript above, the facilitator tried to characterize positioning as a practice that is used to encourage students who express misunderstandings and to value their efforts. Unlike previous interactions, this example seemed to, if not fully, partially repair the breakdown in shared understanding. Following this, Participant A explained that,

PARTICIPANT A: [Okay ,] cause my initial idea was that the teacher has different levels for different students {HA: °Okay°} in terms of their competency. [But like] {[HA: °Okay°]}, I would, like I see your point in saying like, sh- her job is to (.) bring everyone to, up to feel like they're all competent. Um, I was just I guess more focused on like the right or wrong (unintelligible speech).=	PST uses hand gestures while holding pen when speaking Facilitator nods

This excerpt shows that Participant A was developing an understanding of PSC, as she contrasted her former understanding (teacher determines each student's level of competence) to her new interpretation (help students "feel like they're all competent"). Following this, the facilitator and the PST continued to build on this new understanding.

FACILITATOR: =And that's okay.	Facilitator nods
PARTICIPANT A: Like, well like, um, making sense, and ability to make sense and to author their mathematical ideas.	Facilitator nods
FACILITATOR: Yeah, and that's a huge component of it. Like {PARTICIPANT A: Yeah}, it really is. But there's, that's why it's such a complex idea, cause the reality is there are classes like that where students are at different levels.	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: Right.	

FACILITATOR: And, you really, I know it's /ha\rd but I guess the whole idea of this is really going in like wanting to support everyone.	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: Yeah.	
FACILITATOR: And regardless of that level, like it's not a consideration, you're just trying to (.) like-	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: So the question is kind of different then {Ha: Okay}, it's like how is- Like, I don't know, like the way I interpret it is like >how teacher position student to be competent?< °Or like°.	PST uses hand gestures while holding pen when speaking
FACILITATOR: I guess, as competent learners?	Facilitator looks directly at PST and uses her eyes to stress the utterance "learners"
PARTICIPANT A: Yeah, °or like as competent?°	Facilitator nods head PST softly reads definition to herself from DNF
FACILITATOR: >Yeah.<	Facilitator nods
PARTICIPANT A: Cause, (unintelligible speech) ((Facilitator and PST laugh) (unintelligible speech) your research or anything.	
FACILITATOR: It doesn't, [it doesn't.]	
PARTICIPANT A: [But, um.]	
FACILITATOR: This is actually really great that we're working [through it]	

In the above excerpt, Participant A started to build on her understanding. The PST tried to make sense of this information by referring to the DNF and reading the definition quietly back to herself.

Following this conversation, the breakdown was more visibly repaired as Participant A read the definition of PSC from the DNF and once again explained that she formerly thought the practice was used to, "evaluate the competence of the [students.]" The brief segment of

interactions following this further exemplifies that the participant had deepened her understanding of PSC:

PARTICIPANT A: [Okay,] so the teaching moves to provide- (.) Cause uh- uh::, Like actually, {HA: Mhm} >yeah, yeah, yeah<. (.) was it? Or like, I always thought it was like how does the teacher (.)°like°, evaluate the competence of the [students.]	PST begins by reading part of the definition from and following along with finger. Then the PST continues to follow with finger in DNF and gestures.
FACILITATOR: [[Oh::]] {[PARTICIPANT A: Okay]}, that's what you thought then?	
PARTICIPANT A: Yeah.	
FACILITATOR: And that's fine. That's actually, like really common und-, like {PARTICIPANT A: Yeah}, it's [easy to misinterpret].	Facilitator continues to use hand gestures while speaking
PARTICIPANT A: [Okay, Okay]. So, but like, you're trying to figure out like what methods she used to make students feel like they're more competent.	PST and facilitator laugh Facilitator nods
FACILITATOR: [/Yeah\.]	Facilitator gestures with hand and nods
PARTICIPANT A: [OKAY, Okay]	PST laughs while speaking and facilitator joins in.
FACILITATOR: Yeah, exactly. Like competent [learner.]	PST and facilitator continue to laugh while speaking Facilitators gestures with hands
PARTICIPANT A: [/Ok\ay], okay, okay, now I get it.	PST continues to laugh while speaking
FACILITATOR: Does that, does that, [help with the-]	
PARTICIPANT A: [Yeah]. So like, how to make the students feel goo:d, sort of.	
FACILITATOR: Y:e:a:h	Facilitator hesitantly nods head to side while speaking
PARTICIPANT A: Okay. I was like oh- It's just like how she evaluates the ability of each student, which is not the way it would work.	
FACILITATOR: /No\::, it's really like by the end of it the student will hopefully like have figured it out.	Facilitator gestures with hand

(. . .)	
FACILITATOR: Oh, I'm glad we talked about this.	Facilitator laughs and PST joins in.
(unintelligible speech)	PST writes answer in DNF

The transcripts above reveal that the breakdown was repaired as Participant A and the facilitator were able to reach a shared understanding for the practice of PSC. As they started to build a shared understanding, the conversation was less formal, evidenced as the participant and facilitator began laughing as the situation was repaired. Overlapping talk throughout much of the segment suggests that both the PST and facilitator were engaged in co-constructing their understanding. Towards the end of this segment, the PST said, "So like, how to make the students feel goo:d, sort of." Of note, the PST added elongation on the word "goo:d," suggesting her emphasis on that feature. After receiving confirmation from the facilitator, the PST continued, "Okay. I was like oh- It's just like how she evaluates the ability of each student, which is not the way it would work." These examples reveal the PST's new conceptualization (using PSC to help them feel good) in contrast to her initial one (evaluate students' responses to assess competence).

Looking across these two breakdowns, repair is present in the second. When considering my third research question (i.e., *How do the design supports help to contribute to the development of PSTs' noticing?*) based on this analysis, the second breakdown was repaired primarily through the facilitator's guidance. In the first breakdown, although the facilitator did attempt to repair the situation by highlighting the definition in the DNF and providing the PST with an example that reinforced the idea of valuing student responses, this idea was not taken up by the participant, nor did the facilitator continue to press on this point further. In contrast, in the second breakdown, the facilitator elaborated on the definition of PSC and built on Participant A's examples in order to support her in understanding the practice. The facilitator can be described as having employed a move to support the PSTs' learning. This move can be

characterized as the facilitator *envisioning alternative teaching situations* to support the PST in making sense of the teaching practice. To do this, by building on Participant A's ideas, the facilitator described a teaching context, in which she was an actor (i.e., the student) and used this example to emphasize the importance of PSC. In addition to the facilitator's role in supporting the participant in understanding the practice, the way the participant engaged with the supports also changed. During the first breakdown, Participant A only referred to her written reflections and despite the facilitator's efforts, did not refer to the definition (decomposition of practice) to help grapple with the ideas. On the other hand, during the second breakdown, once the PST started to develop a deeper understanding of the practice, she went back to the DNF and quietly read the definition and silently responded ("°or like as competent?°") to correct her prior explanation (e.g., "I interpret it is like >how teacher position student to be competent?<"). Through this interaction, it appeared that the designed support was only accessible to the PST once she had developed enough understanding to "see" the definition differently. Learning was mediated by the social interactions and *tools* made accessible to the PST, as in the second breakdown was clearly repaired largely through the facilitator's guidance and partially through the PST's engagement in the discussion and use of the DNF.

4.4 Chapter summary. In this chapter I explored results relating to my three research questions. During this design experiment, to support PSTs in attending to and noticing instances relating to PSC, their learning was situated in various video noticing activities. As revealed through data from pre- and post-interviews, the DNF along with other supports were found to contribute to PSTs' conceptualization and noticing of PSC. In the next chapter, I will discuss the aforementioned results and situate them among like studies, while also bringing attention to the

unique contributions several findings afforded. The chapter then concludes with a discussion of the study's limitations and implications for future work.

Chapter 5: Discussion and Conclusion

The results revealed that the majority of PSTs' conceptualizations of PSC developed through their engagement in this study. Although their noticing generally shifted focus (i.e., there was more of a focus on both teacher and students when discussing a moment of interaction), overall, PSTs still attended more to the teacher. Factors that contributed to these developments were primarily attributed to the designed supports, especially the DNF, video, facilitator, and transcripts. In what follows I will: (a) consider the contributions of my results in relation to each research question and relevant scholarly works, (b) review this study's limitations, and (c) discuss the practical implications of this research.

5.1 Contributions

5.1.1 Conceptualizing PSC. Gresalfi et al. (2009) *problematized how* competence is typically treated - as a students' ability, a trait that is revealed through how they express their understanding of content knowledge during classroom lessons. Through an analysis of two mathematics classrooms, Gresalfi et al., (2009) showed how competence is defined and re-defined through the opportunities given to students and the forms of participation that are valued (i.e., in contexts where all contributions are valued demonstrating one's competence does not mean finding the right answer). My results provide new insight, as competence was explored through the perspective of PSTs instead of in-service teachers. In line with what Gresalfi et al. (2009) describe as typical views of competence, three of the four PSTs initially described PSC as a way to evaluate competence. They explained that competence could be revealed through: providing students with graded assignments; ranking students; administering tests; calling on students who know the answer. While students can be supported in being competent by: adapting lessons; using group work to make students competent; scaffolding student learning; letting

students work independently; assigning authentic mathematics problems; and providing completed examples. Whether or not a PST believed evaluating competence was a useful practice, at the beginning of this study, PSTs had trouble considering *competence* outside of a traditional mindset. These results provide new insight into how novice PSTs understand competence. This is an important consideration, as understanding competence narrowly can impact the teaching methods employed in the field (Gresalfi et al., 2009).

This study, however, proved to be supportive in shifting traditional conceptions of competence. By the end of this study, three of the four participants equally interpreted all components of PSC (i.e., acknowledge all student contributions to highlight their value, provide students with opportunities to make sense of and author mathematical ideas, position students competently with teacher moves). When PSTs considered valuing students' contributions and/or supporting students as authors and sense makers, they stated that the teacher should: credit students for their understandings; help students feel accomplished; consider their tone - especially when responding to right or wrong answers; avoid favoritism; avoid directly critiquing students; focus on both correct and incorrect answers; use classrooms discussions; use group work; keep an open mind; support students in understanding their errors; use diverse teaching methods to support all students; allow students to take on the teacher role; use teacher moves; scaffold student learning; and guide students towards the right answer. Although Santagata's (2010) work is not centered on what can support PSTs in understanding PSC, my results similarly showed the potential of supporting PSTs to elaborate on their reflections. Given the challenges teacher educators face when designing courses that bridge theory and practice, it is comforting that the majority of PSTs emerged from the study with a deeper understanding of PSC. This work begins to construct an understanding of PSTs' learning trajectories when trying

to understand PSC. Such understandings can inform how teacher educators support PSTs' understanding of PSC.

5.1.2 Noticing moments of positioning. Despite designed supports, PSTs generally attended more to the teacher. This finding is not surprising: Santagata (2007) found that PSTs focused mainly on the teacher when watching video of classroom interaction. Other studies have also found similar results. For example, McDuffie et al. (2014) noted that when PSTs were noticing at 'lower levels' they held "a teacher-centric perspective" (p. 267). During video analysis sessions in this study, in most cases, participants attended to the teacher more than students (see Figures 6,8, and 10). This is not to say that the supports had no impact. In fact, by the third session, all three PSTs did begin to place focus on both the teacher and students. Regardless of such improvements, overall attending to students did prove more difficult. Since noticing student interactions is crucial for PSC, during video analysis sessions, PSTs could have benefited from questions that centered more on students. Such a need was also expressed by a participant that said, "it would be more thorough to analyze if there were like, you could see the student responding with the teacher." Thus, in future iterations of the design study, attending to and interpreting students' interactions should be emphasized more in the DNF.

Further, this study revealed that when interpreting moments in the videos, PSTs struggled with understanding how teachers can value students' responses to PSC (*valuing* was discussed 12% to 84% less than *author and make sense*), and how this in turn affects students' feelings. In light of this, when investigating PSC in future design studies, explicit emphasis can be placed on the importance of valuing students' responses and how PSC can in turn impact students' feelings. Frameworks would benefit from including clear decompositions of PSC that highlight the importance of valuing.

Despite the aforementioned difficulties PSTs experienced during video analysis sessions, when looking across sessions, most PSTs' noticing developed as they began to attend to both the teacher and students, and began to interpret both how the teacher valued and supported students and how this then impacted students' understandings and feelings in mathematics. Such developments are important to consider as they can shed light on *how* PSTs' noticing shifts over time. Van Es et al. (2017) analyzed PSTs' learning trajectories over time to understand how their noticing shifted through video analysis and activities. Their study revealed how designed supports were crucial in managing complex ideas over time to support noticing. My study contributes to such findings, while uniquely considering how PSTs' noticing specifically of PSC developed over time. Essentially, considering more manageable aspects of ambitious instruction and/or other reform oriented teaching approaches can shed light on which aspects of these practices PSTs struggle with, which they more readily grasp, and how the designed supports tend to such struggles or not. Considering individual components of instruction (such as PSC) can build a clearer image of how PSTs can be supported in understanding ambitious instruction as a whole.

On a different note, the impact of maintaining a traditional understanding was further exemplified through the fine-grained analysis of Participant A's video sessions. Holding such a narrow view of competence (i.e., a delineation of a students' ability) not only made it difficult for the participant to "see" how PSC can be used to value students' responses but it also restricted the contexts she thought the practice could be used in (e.g., only possible in non-inclusive classrooms). This suggests the importance of considering PSTs' understandings when trying to develop noticing. Although this may be due to a lack of experience (as mentioned by Santagata & Guarino (2011) in relation to envisioning alternatives), PSTs may not always

experience the same things when observing lessons in fieldwork. Thus, it is important that teacher educators are aware of how understandings can influence noticing.

5.1.3 Role of design supports in supporting PSTs' conceptualization and noticing. Despite the aforementioned struggles, during this study, several supports did prove to be useful in fostering PSTs' learning by helping them focus on significant interactions with purpose. Unlike past research centered on using frameworks to support noticing (Barnhart & van Es, 2014; McDuffie et al., 2014; Santagata & Guarino, 2011; Santagata & Yeh, 2014; Santagata et al., 2007; Star, Lynch, & Perova, 2011; Star & Strickland, 2007; van Es & Sherin, 2002; Walkoe, 2014; Yeh & Santagata, 2014), by incorporating interviews as a source of data, this study uniquely asked participants to share their personal experiences with design supports. Findings yielded through interview data helped confirm findings revealed through an analysis of video sessions, while also shedding light on possible ways the supports can be improved to better facilitate PST learning in the future. In the proceeding sections, several design supports will be discussed both as unique contributions to the field and in relation to existing research.

Design supports, including the DNF, the facilitator, and video, were shown to be especially useful in allowing PSTs to bridge theory and practice. That is, PSTs began to reason about how decompositions of PSC (i.e., the teacher moves used to a) acknowledge and value or b) support students as authors and sense makers) manifest in representations of practice and, in turn, how these affect students (i.e., understanding that PSC affects students' learning and feelings towards mathematics). By bridging theory and practice, PSTs started to develop a shared way of understanding PSC. If not fully, this can be partially attributed to PSTs being expected to direct their attention to specific types of interactions (i.e., interactions that relate to PSC) and use specific vocabulary (i.e., "positioning students competently," "revoicing," "highlighting," etc.)

when interpreting the video instances they noticed. PST's also brought attention to video representations as being an important tool in bridging theory and practice. PSTs explained that video "could actually really help cause we can have an example of how to talk about such a touching subject." This statement aligns with results found in van Es. et al. (2017), as they bring attention to the important role video has in supporting PSTs in gaining experience noticing/understanding reform oriented teaching approaches without being present in a classroom and the potential learning opportunities this affords.

Using frameworks when video noticing has been found to foster learning and facilitate more focused noticing (McDuffie et al., 2014; Star & Strickland, 2008; Walkoe, 2014). Similarly, the DNF helped PSTs focus their video noticing and consider teacher moves in relation to students. While previous studies have not confirmed such findings with PSTs themselves, during post-interviews in this study, all PSTs explained that the framework uniquely supported them in reinforcing the teacher moves in relation to PSC. For example, one PST said,

> Okay, yeah. So um, I think it has helped with my learning because it made me um, like, thoroughly reflect on what I was thinking about the video and stuff. Because **I could have easily just said what I liked and didn't like about the video**, **but this asked specifically (. . .) for like the teacher moves, why or why not it was important for students to be placed competently at that moment and it made me go "oh, yeah.. why is it important?**

This sentiment was similarly shared by all four PSTs, making a strong case for the usefulness of frameworks in focusing noticing in relation to a specific practice or learning outcome.

By the end of the study, PSTs explained that the DNF and facilitator reinforced terms or teaching methods relating to PSC. Similarly, van Es (2006) explains that facilitators were pivotal

as they motivated teachers in directing their attention "toward a particular Agent, Topic, and Stance" (p. 131). Such findings were further mirrored through the fine-grained analysis done on Participant A, as during the second breakdown, the facilitator appeared to play an important role in helping the PST develop her understanding of PSC. Unlike previous work, here I highlight a new facilitation move: *envisioning alternative teaching situations.* To do this, the facilitator supported the PST in fully understanding the definition using hypothetical examples that highlighted why it is important for teachers to PSC in any teaching situation (e.g., in inclusive learning environments). This example supported her in successfully 'narrowing' in on significant moments in the video clips and interpret these in a more informed manner. Based on the work of Stevens and Hall (1998), this move can also be understood as a form of "disciplining perception" since the facilitator succeeded in helping the PST "carefully describe visual practices, both in relation to the tasks, artifacts, and settings where they are deployed and in relation to other embodied practices" (p. 108). During post-interviews, PSTs acknowledged that the facilitator supported them in developing a shared language. This finding is noteworthy as developing a shared language has been found to positively impact learning and ultimately professional development (Walkoe, 2014; van Es et al., 2017). Although forging shared ways of knowing and vocabularies is challenging and has proven to be difficult to achieve in teacher education programs (van Es et al., 2017), strides have been made to facilitate PSTs in learning a common language. However, it is clear that there is still room for improvement, and a need for it.

Introducing PSTs to terms and a common language was largely stressed during this study, as a means to decompose practice (Grossman et al., 2009). The DNF included both a definition and a list of teacher moves to help break down PSC into more manageable components. In the case study of the two contrasting breakdowns in shared meaning, the researcher-facilitator

highlighted (Goodwin, 1994) these decompositions of practice during the first breakdown. These decompositions were later used by Participant A when the second breakdown was repaired. Although the facilitator's attempt to highlight the components of the definition to further support the PST in decomposing practice did not help repair the situation, it is worth noting that the PST did return to the definition (decomposition of practice) when articulating a deeper and more informed understanding of the practice. As mentioned earlier, during the second breakdown the PSTs' expanded understanding of PSC supported her to "see" new things as she was able to refer to the DNF and read through the definition in light of recent developments. This finding is noteworthy as it sheds light on the importance of considering PSTs' current understandings of practice and how this affects the tools that are available to them. That is, the PST was not able to properly access the decomposition to support her learning as she still struggled with conceptualizing competence in reform-oriented classrooms. This implies that decompositions can support learning, however, future work targeting more specifically the role of decompositions in supporting PSTs' conceptualizations and noticing of PSC would help create a clearer image of how decompositions can be effectively implemented in frameworks to support learning. Relating to this, these results have implications for how university courses are designed, as richer learning opportunities can be afforded to PSTs with instruction that adequately represents and decomposes practice. PSTs' learning trajectories observed throughout this study suggest that gains can be made by using a "framework for parsing teaching and a common technical vocabulary for describing essential components" (Grossman, 2008, p. 198). Future work can benefit from exploring how engagement in such practices affects students' participation in methods courses.

The results also revealed areas for needed improvement in the design supports. When video noticing and later interpreting, PSTs struggled to envision alternative teaching strategies. Although this form of reflection has the potential to cultivate rich learning outcomes (Santagata & Angelici, 2010; Santagata & Guarino, 2011), three participants explained that they were not sure how to respond to the question either due to a lack of experience or not being able to conceptualize an alternative situation as successful as the one shown in the video. One participant said,

> I always had trouble I think filling it out because again, I didn't necessarily have a like solid example and experience in the classroom, so I might not be able to think in the top of my head how I would position them competently.

These findings are insightful as past studies focusing on frameworks to support PSTs in video noticing have not been able to confirm why PSTs struggle with this question. For instance, Santagata & Guarino (2011) stated that, "the limited teaching experience most likely restricted access to these alternative strategies" (p. 143). Findings from this study suggest a need to further explore what supports could facilitate PSTs' ability to engage with this question. While a solution to this problem is not clear, when designing noticing frameworks, a greater emphasis should be directed towards envisioning alternatives. Rather than just including a question in the framework, this may entail explicitly discussing with PSTs *why* the question was included.

Out of all the supports, the viewing norms seemed to have less of an impact on PSTs' learning. However, PSTs did mention that they can support professional development or their professional careers and provide them with a lens to focus viewing. Such stances can potentially lead to significant learning opportunities (van Es & Sherin, 2002; Santagata et al., 2007); however, due to a lack of focus placed on them during video analysis sessions, it would be

beneficial for future work centered on supporting conceptualizations of PSC to explore the learning impacts adopting such stances can yield.

The aforementioned supports worked together to create a comprehensive learning experience, and while more can be done to refine the learning opportunities afforded by these supports, it is noteworthy that this study revealed developments in noticing (e.g., attending and interpreting) over a short period of time. Likewise, research that has explored the merits of using frameworks has also found that significant learning gains can be achieved in a brief period (Santagata & Angelici, 2010; Santagata & Guarino, 2011; Santagata et al., 2007). Considering learning within a more limited time frame helped reveal which aspects of PSC and supports were more difficult to interact with – which can direct future research efforts.

5.2 Limitations

Although the results from this study do indicate that gains can be had by using video analysis activities to support PSTs in learning PSC, several limitations are present.

While rich studies have been conducted within a short amount of time, having only three 1-2 hour long sessions could be seen as a limitation of this study. Having more time would have afforded more opportunities to support PSTs' learning, as well as create a better understanding of how design supports contributed to their development. Further, as this was a design study, actively making major changes to the design in order to understand what the supports can afford was difficult considering PSTs only partook in three video analysis sessions. Still, having less video analysis sessions is representative of the constraints present in teacher education courses (i.e., as spending a prolonged period of time on one topic is not always feasible) and can help to support an understanding of the learning benefits such an approach can yield in a short amount of

time. More research conducted with similar and different constraints can shed more light on these trade-offs.

Several video clips selected for viewing during video analysis sessions can also be seen as a limitation of this study. Although many videos were adequately filmed and highlighted both student and teacher interactions, this was not easy to find on publically accessible websites. Thus, in some videos it was difficult to hear and/or see all interactions taking place at a given time, which may have affected PSTs' ability to notice. As discussed by Seago (2003), purposefully selecting video clips is essential. Although such concerns were tended to when selecting footage, not all video footage afforded equal learning opportunities. Future studies should be wary of this constraint and be mindful when selecting clips. Relating to this, a clearer image can be gained about the affordances and constraints different video clips can yield if future studies were to examine differences in what PSTs notice about PSC in different videos.

5.3 Implications and Concluding Remarks

This study has several implications for teacher education and educators. Firstly, through an analysis of video sessions and post-interviews, the designed supports used in this study have shown to be useful in supporting PSTs to understand PSC and to notice and interpret student and teacher interactions related to PSC. In light of this, the designed supports presented here can be used in teacher education programs, either to expand understandings and noticing of PSC or revised to target other teaching practices. Secondly, the analysis of teacher learning presented here can support teacher educators in anticipating PSTs' understandings and noticing of PSC and competence more generally to better plan for instruction. For example, emphasis can be placed on considering shifting PSTs' perspectives of competence and on supporting them in attending to

and interpreting students' understandings and feelings in moments when they are or are not positioned competently.

This study contributes to a growing body of studies within the noticing literature. Like Santagata et al. (2007), I believe more research in this field is needed to understand "how the specific observation framework used in this study compares to other frameworks commonly used in teacher preparation programs" (p. 139). Related to this, it would also be interesting to see how this framework can support PSTs in understanding other ambitious practices. Given PSTs' limited experiences within reform classrooms (Santagata & Yeh, 2014; Santagata et al., 2007), finding approaches that can facilitate their learning of reform teaching approaches is crucial. Further, supporting PSTs in becoming lifelong learners, who actively seek such learning ventures outside the classroom would tremendously affect the practices they adopt once in the field (Santagata & Yeh, 2014).

Similarly, it would also be helpful to consider which design supports can enable PSTs to independently learn PSC and other ambitious practices. This study includes publically accessible video clips and a framework that can be used outside the context of video analysis sessions. Although the number of design supports provided to PSTs would be more limited, this study can inform future work that explores the use of video analysis activities within online courses (i.e., distance learning) or outside of university classroom contexts.

Finally, similar to other studies in this field, this study revealed gains. During a brief period of time, PSTs were able to value PSC and understand its applications in practice and the effects this has on students' learning and dispositions towards mathematics. Although more work is needed in understanding how designed supports promote noticing, this study provides an initial step in this direction.

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Appendix A: Pre-interview

The **goal of this interview** is to gain an understanding of (a) the pre-service teacher's experiences in learning and teaching mathematics, (b) their characterizations of students' sources of difficulty, (c) the teacher's current experience using video to support their development as mathematics teachers, (d) their perspectives on using video to support their development as mathematics teachers, (e) their current understanding of practices used to position students as competent learners during mathematics instruction.

Say: Hello, I would like to learn about your thoughts and experiences in learning and teaching mathematics, your current experiences with and outlook on using video to support your learning, as well as your current understanding of practices used to position students as competent learners during mathematics instruction. To learn about this, I have some questions to ask you, please answer them to the best of your ability. Do you have any questions for me before we begin?

To start, I would like to know more about your current experiences in learning and teaching mathematics, as well as how you view students' sources of difficulty.

Throughout your education, what math classes have you taken?
Can you please describe to me your experiences thus far in learning mathematics? Probe 1: How have you found mathematics classes? Probe 2: What aspects of mathematics classes do you associate positively with? Probe 3: What aspects of mathematics classes have you had negative experiences with?
How would you describe yourself as a math learner?
Can you please describe what opportunities you have had to teach mathematics? Probe 1: What level did you teach at? Probe 2: What topics did you teach? Probe 3: What was your responsibility?
Can you please describe to me your experiences thus far in teaching mathematics? [3]
I am interested in learning about what you consider to be high-quality mathematics instruction. If you were asked to observe another teacher's math classroom for one or more lessons, what

[3] Munter, C. (2014). Developing visions of high-quality mathematics instruction. Journal for research in mathematics education, *45*(5), 584-635.

would you look for to decide whether the instruction was high quality? Probe 1: What kinds of problems or mathematical tasks would you expect to see the students working on for instruction to be of high quality? Can you give me an example of what that looks like? Sounds like? Probe 2: What are some of the things you would expect to find the teacher actually doing in the classroom for instruction to be of high quality? Can you give me an example of what that looks like? Sounds like? Probe 3: What would the classroom discussion look and sound like if instruction were of high quality? Can you give me an example of what that looks like? Sounds like?
If a student is having difficulty in mathematics, to what do you tend to attribute this difficulty and why?[4]

My Second set of questions is going to be about your current experience with and outlook on using video to support your development and learning as a mathematics teacher.

<table>
<tr><td colspan="3">Have you ever used video to support your learning as a teacher? Please answer with yes or no.</td></tr>
<tr><td>If yes:</td><td colspan="2">If no:</td></tr>
<tr><td>Can you describe the times when you used video to support your learning as a pre-service teacher?</td><td colspan="2" rowspan="2">Do you believe that using video would support your learning as a pre-service teacher? If so, how (example)?</td></tr>
<tr><td>What have you found useful or less useful about using video? If so, why (example)?</td></tr>
<tr><td>In what ways has video not supported your learning as a pre-service teacher?</td><td colspan="2">In what ways do you think video may not support your learning as a pre-service teacher?</td></tr>
<tr><td>Have you ever watched videos of other teachers teaching?</td><td colspan="2">Have you ever watched videos of other teachers teaching?</td></tr>
<tr><td>Have you found that watching videos of other</td><td>If yes:</td><td>If no:</td></tr>
</table>

[4] Wilhelm, A. G., Munter, C., & Jackson, K. (2017). Examining relations between teachers' explanations of sources of students' difficulty in mathematics and students' opportunities to learn. *The Elementary School Journal*, *117*(3), 345-370.

teachers teaching supported your learning as a pre-service teacher? If so, how (example)?	Have you found that watching videos of other teachers teaching supported your learning as a pre-service teacher? Probe 1: If so, how (example)? Probe 2: If not, why not?	Do you believe that watching videos of other teachers teaching would support your learning as a pre-service teacher? Probe 1: If so, how (example)? Probe 2: If not, why not?
In what ways has watching videos of other teachers teaching not supported your learning as a pre-service teacher?	Would you recommend using video to your peers? Explain why?	Would you recommend using video to your peers? Explain why?
Would you recommend using video to your peers? Explain why? Probe 1: What would you suggest about how video should be used (e.g., what they would tell a friend)?		

My Third set of questions is going to be about your current understanding of practices used to position students as competent learners during mathematics instruction. This is a concept we will learn more about in future sessions, so don't worry if you aren't sure what it means. Just try your best to answer the questions.

When you hear the phrase positioning students competently, what comes to mind?
Please explain what you would observe if you saw a teacher positioning students as competent learners in a math class? (If time) Probe 1: What kinds of problems or mathematical tasks would you expect to see the students working on for instruction to position students competently? Can you give me an example of what that looks like? Sounds like? Probe 2: What are some of the things you would expect to find the teacher actually doing in the classroom for instruction to position students competently? Can you give me an example of what that looks like? Sounds like? Probe 3: What would the classroom discussion look and sound like if instruction were to

position students competently? Can you give me an example of what that looks like? Sounds like?
Do you position students competently when teaching? If so, how (examples)? If not, why not?
Are there benefits to positioning students as competent learners? Explain why.
Thus far, which methods (in university) have best supported your learning of ways to position students as competent learners? Probe 1: Do you think positioning students competently is the same in other subjects? If so, how? If not, why not?

Say: Before we end our interview, is there anything else you wanted to add?
Thank you for talking with me about your experiences and beliefs!

Possible probing questions:
Can you please tell me more about that?
What did you mean by that?
Can you give an example?

Adapted form: Pereira, L. C. (2017). Interviewing skills: preparation and practice. Lecture presented in McGill University, Montreal.

Appendix B: Viewing Norms

Interpretive stance:	*Involves noticing with the intent of understanding various influential factors that affect classroom interactions and student understandings, rather than passing judgment (van Es & Sherin, 2002, p. 575).* To achieve this ask yourself: • How do you understand this particular moment and exchange between the student and teacher? • How do you think students are learning mathematics content in a way that positions them competently? (e.g., which teaching practices, manipulatives, or actions is the teacher using to teach student's mathematics by positioning them competently) • "How has the teacher influenced student thinking?" (e.g., which teaching practices, manipulatives, or actions is the teacher using to influence students' thinking)
Critical stance:	*Involves reflecting and commenting on practices or methods the teacher uses and proposing alterative paths (relating to positioning students competently) (Santagata, Zannoni, & Stigler, 2007).* To achieve this ask yourself: • Why do you believe students could have been positioned more competently? • If students weren't successfully positioned competently, which teacher practices or methods could have the teacher used instead? Why do these alternative strategies better position students competently? • What evidence in the video can support your claims (e.g., refer to transcripts and video)
If you have any norms you wish to add, please do so here.	

References

Santagata, R., Zannoni, C., & Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Mathematics Teacher Education, 10*(2), 123-140.

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*(4), 571-595.

Appendix C: Facilitator Guide

Review pre-selected video clips of mathematics teaching (public videos)

- During this time, the pre-service teacher will use the detailed noticing framework to:
  - Flag important instances of interaction and explain why such moments are considered important
  - Consider how students are or aren't being positioned as competent learners
  - Explore possible teaching methods/practices that could have been used to position students competently
- **Facilitator/researchers role:**
  - To support pre-service teacher in developing an "interpretive stance" by (when appropriate) asking the following questions:
    - Why did you flag that particular moment?
    - How do you understand this particular moment?
    - How do you think students are learning mathematics content?
    - "How has the teacher influenced student thinking?"
    - Tell me more about that?

Post viewing discussion

- During this time, the pre-service teacher will share with the facilitator her/his reflections on noticed instances that relate to positioning students competently
- **Facilitator/Researchers role to discipline perceptions:**
  - Why did you flag that particular moment?
  - How do you understand this particular moment?
  - Can you walk me through your comments relating to positioning students as competent learners?
    - What is one thing the teacher did well, that successfully positioned?
    - Which teaching move was the teacher using?
    - Reference the detailed noticing framework, why and how did this teaching move support the teacher in positioning students competently?
    - What is one thing the teacher could improve on to successfully position?
    - Which teaching move was the teacher using?
    - Reference the detailed noticing framework, why and how did this teaching move not support the teacher in positioning students competently?
  - Where do you see this move in the framework?
    - If applicable: Is there something in the framework we should add?
  - Refer to the video transcripts - how can you support your claims?
  - How do you think students are learning mathematical content?
  - "How has the teacher influenced student thinking?"
  - How was this different from your own experience?

The aforementioned questions were partially influenced by ideas expressed by Santagata, Zannoni, and Stigler (2007); van Es and Sherin (2002)

Appendix D: Detailed Noticing Framework

SESSION ONE

Detailed Noticing Framework

For Positioning Students as Competent Learners

Note. The formatting for this table was slightly altered to fit into fewer pages, given page constraints for the thesis. Links to publically accessible video clips were also added.
Positioning students competently *calls on the teacher to value all contributions by acknowledging them and using teaching moves to provide students with opportunities to make sense of and author mathematical ideas.*

Teacher Moves used to Position Students Competently	
Representing student ideas	**Definition:** Orienting the class to a student's contribution by replicating it through manipulatives or writing it on the board. **How can this teacher move position students competently?** _____ _____ _____ _____ _____ _____ _____ _____
Pressing on student thinking[5]	**Definition:** Asking students to explain or expand on their thinking to prompt them to think more deeply. **Example:** "Could you please explain your thinking?" "Can you think of another way you could have solved this problem?" **How can this teacher move position students competently?** _____ _____ _____

[5] van Es et al., 2014
[5] Ibid.

	_____ _____ _____ _____ _____
Highlighting student ideas[i]	**Definition:** Commenting on and crediting a student for their contribution. **Example:** "Tim made an interesting point. In their own words, can someone explain to the class what he did?" "Ella used a very interesting and helpful strategy to get the answer 9. How can this strategy be used to help us double check our work?" **How can this teacher move position students competently?** _____ _____ _____ _____ _____ _____ _____ _____
Revoicing	**Definition:** Restating or reformulate a student's contribution. **Example:** "Jordan I am going to repeat your explanation, when I'm done please tell me if it is what you meant." "Katie Said that (. . .)." **How can this teacher move position students competently?** _____ _____ _____ _____ _____ _____ _____ _____
The spaces provided below are meant to provide you with the opportunity to add onto this framework. For instance, if you already know of or saw a teacher move being used in a video clip that positioned students competently but was not mentioned above, please feel free to add it below. If not, this space can be left blank.	
Teacher move: _____	

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Teacher move: _____
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Teacher move: _____
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VIDEO CLIP 1

As you watch this video clip, please identify at least one moment where a student **was or was not positioned competently** and fill in the questions below.

Instances can include those where they **were or weren't positioned competently**.
Video: https://youtu.be/yhNcUQCu1w0 (3:12 - 9:10)

1. Video Clip: _____ Description: _____
   _____
   Time Stamp: _____ _____
   _____

   a. **How** does this specific interaction relate to positioning students competently?_____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

_____
_____

b. **Why** was it important that a student(s) was positioned competently at this time? _____
_____
_____
_____
_____
_____
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_____
_____
_____

e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? _____
_____
_____
_____
_____
_____
_____
_____
_____

2. Video Clip: _____ Description: _____
_____
Time Stamp: _____ _____
_____

a. **How was or wasn't** the student(s) positioned competently?_____

b. **Why** was it important that a student(s) was positioned competently at this time? _____

e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? _____

VIDEO CLIP 2

Positioning students competently *calls on the teacher to value all contributions by acknowledging them and using teaching moves to provide students with opportunities to make sense of and author mathematical ideas.*

As you watch this video clip, please identify at least one moment where a student **was or was not positioned competently** and fill in the questions below.

Instances can include those where they **were or weren't positioned competently**.
Video: https://youtu.be/R8UGaFy-NMU (5:15 - 11:35)

1. Video Clip: _____ Description: _____
   _____
   Time Stamp: _____ _____
   _____

   a. **How** does this specific interaction relate to positioning students competently?_____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

   b. **Why** was it important that a student(s) was positioned competently at this time? _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

   e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____
   _____
   _____

_____
_____
_____
_____
_____
_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? _____
_____
_____
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_____
_____
_____
_____

Note. The original document contained a set of optional questions (these remained the same each sessions). Please refer to session one, clip one, part two, for a copy of these questions.

SESSION TWO
VIDEO CLIP 1

As you watch this video clip, please identify at least one moment where a student **was positioned competently** and fill in the questions below.

Other instances can include those where they **were or weren't positioned competently**.
Video: https://youtu.be/xKC3eijnUNw (0:00 - 8:34)

1. Video Clip: _____ Description: _____
_____
Time Stamp: _____ _____
_____

a. **How was** the student(s) positioned competently?_____
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b. **Why** was it important that a student(s) was positioned competently at this time? _____
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_____

e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____
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_____
_____
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_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? **Time stamp: _____** _____
_____
_____
_____
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_____
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_____

Note. The original document contained a set of optional questions (these remained the same each sessions). Please refer to session one, part two, for a copy of these questions.

VIDEO CLIP 2

Positioning students competently *calls on the teacher to value all contributions by acknowledging them and using teaching moves to provide students with opportunities to make sense of and author mathematical ideas.*

As you watch this video clip, please identify at least one moment where a student **was not positioned competently** and fill in the questions below.

Other, instances can include those where they **were or weren't positioned competently**.
Video: https://youtu.be/WAhkbSFtvAI (0:00 - 4:34)

1. Video Clip: _____ Description: _____
   _____
   Time Stamp: _____ _____
   _____

   a. **How wasn't** the student(s) positioned competently?_____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

   b. **Why** was it important that a student(s) was positioned competently at this time? _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

   e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____
   _____

_____
_____
_____
_____
_____
_____
_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? **Time stamp:** _____ _____
_____
_____
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_____
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_____
_____

Note. The original document contained a set of optional questions (these remained the same each sessions). Please refer to session one, part two, for a copy of these questions.

SESSION THREE
VIDEO CLIP 1

Positioning students competently *calls on the teacher to value all contributions by acknowledging them and using teaching moves to provide students with opportunities to make sense of and author mathematical ideas.*

As you watch this video clip, please identify at least one moment where a student **was positioned competently** and fill in the questions below.
Video: https://youtu.be/7naHsQH3J10 (0:00 - 6:49)

1. Video Clip: _____ Description: _____
_____
Time Stamp: _____ _____
_____

a. **How was** the student(s) positioned competently?_____
_____
_____
_____
_____

b. **Why** was it important that a student(s) was positioned competently at this time? _____

e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? **Time stamp: _____** _____

2. Video Clip: _____ Description: _____

Time Stamp: _____ _____

a. **How was** the student(s) positioned competently?_____

b. **Why** was it important that a student(s) was positioned competently at this time? _____

e. If you were in this situation **what would you have** done differently to help position student(s) competently, if anything? (This can relate to talk, actions, teacher moves, etc.)_____

f. Looking back on the entire video, **how else** could have the student(s) be positioned competently? **Time stamp: _____** _____

Appendix E: Post-interview

SECTION 1

The goal of this interview is to gain an understanding of shifts in the pre-service teacher's: (a) experience using video-based sessions to support their development as mathematics teachers (which designed aspects of these sessions contributed to their development); (b) outlook on using video to support their development as mathematics teachers; (c) understanding of practices used to position students as competent learners during mathematics instruction.

Through this interview, I also hope to gain insight on how useful the pre-service teachers deemed the detailed noticing framework, as well as how they think it can be improved to better support their noticing of specific interactions and their learning of how to position students as competent learners.

Say: Hello, similar to our first interview, I would like to learn about your experiences with and outlook on using video to support your learning, as well as your understanding of practices used to position students as competent learners during mathematics instruction. To learn about this, I have some questions to ask you, some of these questions will be similar to those from our first interview, please answer them to the best of your ability. Do you have any questions for me before we begin?

My first set of questions is going to be about your experience with and outlook on using video to support your development and learning as a mathematics teacher.

Have you had any other experiences with watching video since the project started? if so, what have you found beneficial? a. What kinds of videos? Examples?
Would you recommend using video to your peers? Explain why? Probe 1: What would you suggest about how video should be used (e.g., what they would tell a friend)?
During video analysis sessions (1-3), what contributed to your learning as a pre-service teacher, if anything? In what ways? Examples? Probe 1: During the study, what did you find less supportive? Probe 2: How did or didn't the facilitator contribute to your learning as a pre-service teacher? Examples? Probe 3: How did or didn't the positioning session booklets contribute to your learning as a pre-service teacher? Examples? Probe 4: How did or didn't the transcripts contribute to your learning as a pre-service teacher?

Examples?

Probe 5: How did or didn't the viewing norms contribute to your learning as a pre-service teacher? Examples?

Probe 6: How did or didn't watching videos of other teachers teaching contribute to your learning as a pre-service teacher? Examples?

Probe 5a: Would you recommend using video of teacher teaching to your peers?
Explain why?
What kind of videos? Examples?

Probe 6b: What would you suggest about how video should be used (e.g., what they would tell a friend)?

My second set of questions is going to be about your current understanding of practices used to position students as competent learners during mathematics instruction.

If someone asked you to explain what it means to position students as competent learners in the context of a mathematics classroom, how would you respond?

Please explain what you would observe if you saw a teacher positioning students as competent learners in a math class?

Probe 1: What kinds of problems or mathematical tasks would you expect to see the students working on for instruction to position students competently? Can you give me an example of what that looks like? Sounds like?

Probe 2: What are some of the things you would expect to find the teacher actually doing in the classroom for instruction to position students competently? Can you give me an example of what that looks like? Sounds like?

Probe 3: What would the classroom discussion look and sound like if instruction were to position students competently? Can you give me an example of what that looks like? Sounds like?

Are there benefits to positioning students as competent learners? Explain why or why not.

Thus far, which methods (in university) have best supported your learning of ways to position students as competent learners?

Probe 1: Do you think positioning students competently is the same in other subjects? If so, how? If not, why not?

My third set of questions is about your experience using the detailed noticing framework.

What was your general impression of using the detailed noticing framework?
Has the detailed noticing framework supported your learning? Please explain how it has or has not. Probe 1: What was an example when the detailed noticing framework supported your learning – you can show me in the framework here? (Could you please edit it based on the changes or additions you would make? You can also note directly on the sheet which parts you found useful and would keep.) Probe 1a (once done): Can you please walk me through the edits you made to the framework and explain to me your rationale for choosing to exclude and include what you did? Probe 2: Can you think of an example when the detailed noticing framework did not support your learning – you can show me in the framework here? Probe 2a (once done): Can you please walk me through the edits you made to the framework and explain to me your rationale for choosing to exclude and include what you did? Probe 3: Do you have any suggestions for improving the framework?
How did using the framework while watching videos compare to your previous experiences using video to support your learning? Please explain why. Probe (if applicable): Can you think of an example that highlights this difference?
If you had to create your own detailed noticing framework to support your learning of mathematics techniques that can position students as competent learners, how would or wouldn't it differ from the framework you used during this study? Please be as detailed as possible.

Possible probing questions:
Can you please tell me more about that?
What did you mean by that?
Can you give an example?

Adapted form: Pereira, L. C. (2017). Interviewing skills: preparation and practice. Lecture presented in McGill University, Montreal.

SECTION 2
Facilitator Version

PART ONE

1. Give student a photocopy of their initial responses.
2. Say: Please look over what you wrote about positioning during our first session and if you have any changes or revisions to make feel free to do so.

PART TWO (Same booklet as first session – section for second clip)

1. Students watch clip and answer booklet questions.
2. Have students read their answers and prompt when more explanation is needed.

Appendix F: Coding schemes for Interview and Video data

Coding Scheme for Pre- and Post-interview Responses Relating to Positioning Students Competently

Category	Description	Example
Ranking or labelling students to PSC	PST explains that PSC involves ranking or labelling students by considering students' competence/incompetence or their academic level	"Um, I guess that's a, a sense of favoritism if they label students as competent, because that means that there is incompetent students."
Providing students with graded assignments to PSC	PST explains that students' grades can help the teacher distinguish students' competence (however this is not to say students who don't perform well on exams are not competent)	"Like, I guess a shallow way is like, if they finish, like, get, they get like A's on their tests, like I would assume that is how." . . . "Yeah, grades, um, some, um. There's just like, I guess, I don't know, like paradox where a lot of students know the answers but they don't know how to show their work, and so like marks would be deducted from that. So, I think teachers would still deem them as competent, just not able to show their competence through like, showing their mental work."
To PSC the teacher should help students feel accomplished	PST explains that for students to be PSC they need to feel that their knowledge has evolved or be acknowledged for their efforts.	"that they feel like their knowledge has evolved at the end of the day, because they've been getting to the right answer."
Group work can help PSC	PST explains that group work can be used to PSC	"I think uh one on one is very important too because there are some videos where teachers have students work in smaller groups before they discuss their findings and what not, so that like attention that you give to younger stu, uh to students individually uhm gives you a more in-depth sense, because there is no way you're able to have everyone contribute in a math class if uh the whole session, the whole class you just did classroom discussion uh yeah."
To PSC the teacher should be open-minded	PST explains that to PSC the teacher needs to be open minded	"And mm, teachers are definitely very open minded and they don't just, again, like shut students off. Like some teachers they talk over students or they just assume they're done because they are wrong, they gave a wrong answer or.. and they want to like move the lesson like onwards, like keep it going.
Crediting students for their understandings to PSC	PST explains that acknowledging students' responses by giving them credit for their work can help PSC	"giving credit to students for their understanding, even though it might to be fully, the full extent of where you're supposed to be"
Call on students who know the answer to PSC	PST explains that to support students that are having trouble, the teacher would call on students who know the correct answer	"and when students have trouble, go to someone who knows the answer. Obviously that's a way that they set their gauge on who's more competent than each other. Yeah."
Classroom discussions help PSC	PST explains that classroom discussions PSC and can provide the teacher with more opportunities to use the practice	"Classroom discussions and problems definitely. Uh, I think it was very stressed in the videos we watched, a lot, most of them are in a class discussion context. So that really helps, just listening to, having the student like tell uh explain their thoughts and then having the class to listen to it, I think it fosters a very respective attitude towards different people, and a deeper understanding as well as a, yeah so that was one of them."
Administer tests to PSC	PST explains that tests would	"I guess the easiest would be like tests"

	reveal if students are competent	
To PSC the teacher should focus on both correct and incorrect answers	PST explains that in a classroom where students are PSC the teacher would value both correct and incorrect answers	"um really focusing/reiterating uh students concept whether they're right or wrong and not just uh praise the right one and skim over the ones who gave wrong or insignificant contribution"
The teacher should consider their tone when PSC	To PSC the PST thinks it's important to consider the tone the teacher uses when responding to student thinking	"The tone of the teacher, how he or she responds to right or wrong answer, because sometimes we do it subconsciously too"
Scaffold student learning to PSC	PST explains that to PSC the teachers needs to guide students and provide them with the proper support	"breaking down how a problem or an example can be tackled with what the teacher's taught them so far."
To PSC the teacher needs to guide students towards the right answer	PST explains that to PSC you need to guide students towards the right answer	"take in what is being said, and really guide them through the right answer, or the right group of answers"
PSC by supporting students in understanding their errors	PST explains that in order to PSC the teacher must support students in understanding their errors	"not everyone views math the same way or solves problems the same way, but you need to find out where their errors are and help them work through it and yeah"
To PSC teachers can avoid directly critiquing students	PST explains that to PSC the teacher should avoid directly critiquing students	"never having like a, like direct critique on what they are saying, on what, like what they are putting out to the teacher or to their peers."
To PSC teachers can have students explain their thinking	PST explains that to PSC the teacher should know students' understandings by having them explain their thought processes	"Having them being able to explain their thought process, because if you can't explain it you don't actually understand it."
When positioned competently students take on teacher role	PST explains that to PSC the students can take on the teacher role	"But placing them competently means kind of like, students can also be teachers you know?"
Teacher can use authentic mathematical problems to PSC	PST explains that to PSC the teacher can support students' understanding with mathematical tasks that are relatable	"Uhh, I guess problems that maybe they could apply to themselves or something like that. Or, it kind of puts their learning in a context that they can understand. Kind of helps relate whatever they're working on to themselves instead of just being a rote formula learning and things like that." (. . .) "In uhh, like say something like workshop math, like I worked with, it's kind of easier to quantify. With harder math it isn't. But say, in like workshop math you'd say.. you're trying to build a staircase and then, and how much materials would you need? How much all that? What kind of measurements and everything like that? Kind of helps them kind of "okay this is what I want to do, so.." "and this is how I would do it", so it's just going to help me learn with this."
To PSC teacher can provide students with	PST explains that providing students with completed examples can PSC	"Again, like tutoring, they uh… giving completed examples that maybe are not the same as they have, and then they kind of figure out what kind of, how that applies to the example. Or, if like they go through a math equation and they're given the full like, work formula, or whatever the case, that's finished and the right answer isn't all that, they kind of have to figure out "where did I go wrong"

completed examples		"okay, what did I do right?" and things like that."
Using independent work to PSC	PST explains that to PSC the teacher can let students work independently but give them active support when needed	"Just like formulate problems I guess, like, stuff that they can independently work on, but that you can give active support to, so like say you know."
Adapting lesson plans to PSC	PST explains that to PSC the teacher can adapt lesson plans	"and um, I know there's adapting lesson plans, which I am going to be learning about lesson plans later, so I am still not, like, I'm not competent in that section yet, but I know that you would have to just adapt the lesson plan to each student's needs.
To PSC teachers should lead classroom discussions	PST explains that to PSC the teacher provide a lecture-based lesson where they lead classroom discussions	"I think maybe uh if students are positioned competently, I think the lesson plan would be one thing, like it would, they would teach uh, teachers would teach the subject in a certain way like you know they go through on the board for example they write you know what would one plus one look like for example, and they would expect students to understand. And um, I guess discussion would be um, um, I guess it would be more teachers asking the students questions, expecting the students to answer back rather than the students asking the questions for the teacher to answer I guess."
To PSC the teacher should avoid favouritism	PST explains that to PSC teacher should avoid favoring students as this can affect their confidence	"Like definitely avoid favoritism and sometimes it's something we do I think unconsciously, but yeah. Especially in math like it's really hard, like some students who don't feel as confident would be very affected by these things so yeah."
PSC by putting students on the spot during classroom discussions	PST explains that calling on all students during classroom discussions can PSC	"I'd probably be putting students on the spot, trying to get them to think about this stuff, you know, asking everybody who puts up their hand, because they know, if they're putting up their hand, they kind of like have a confidence in what they want to say. I want to try and get the students to maybe not be able to answer so easily, to kind of get out of their comfort zone answering questions on the spot, or just answering in general, because not everybody would,... everybody kind of has a fear of being wrong, so they won't always put up their hand. So just kind of like, make them answer"
Use teacher moves to PSC	PST explains that teachers can use various teacher moves to PSC	"Ummm, well if a student had a question wrong, well answered a question wrong within a discussion, um the teacher would pull out some teacher moves and do and press on their thinking and ask them to work through the problem to them a"
Using diverse teaching methods to PSC	PST explains that to PSC all students the teacher must find the right technique (this means having various methods available)	"it just involves finding the proper, like the right technique for them"
Other	PST mentions an idea but it is not clear what they mean	"And I think that the time allocations too I think, in terms of like how teachers position students competently in a math room context, the time allocation and um . . . "

Coding Scheme for Video Analysis Sessions

Codes for Capturing What PSTs Attended to (Actors)	
Teacher	**Student**

A turn of talk will be coded as teacher when the dialogue is primarily about the teacher (e.g., teacher moves, teacher valuing, etc.)	Example: "The teacher can specifically position, um Jameer, on his way of thinking and the way he problem solved because it was like visually represented. Then um. Then the way he went through with the whole class, um he made sure that, everyone was able to.. I guess, he was, well he kind of caught the mistake everyone was making while doing the group work where they stopped it at, where they stopped at 89 nickels. Um so, by doing that he was able to like correct them or like remind them 'Oh, this is not just 89 you need to know the value of it.'"	A turn of talk will be coded as student if the conversation is primarily about the student (e.g., student feelings, student understandings, etc.)	Example: "Cause like, she (. . .) was able to deduce it was six, but she was having trouble to explain her ideas so that Ellan understood, but probably also because of the way she talks."
Both Teacher and Student			
A turn of talk will be coded as both teacher and student, if part way through talking, the PST clearly switches focus onto students or vice versa. Note: Teacher and student are defined in the same way as the above examples.		Examples: "So for example, like, pressing on student's thinking, when um Majorie [the student] first made her point, like he [the teacher] understands that she's on the right track, and then he pressed on for her to like explain it better, and like he helped her visualize that on the board, [focus switches to student here] so like obviously, then she.. I think it really helps the student to like understand her own thinking better like when you see it visually on the board, and obviously that also helps like having the other students be on the same page"	
Codes for Capturing How PSTs Interpreted Moments (Interpretation of Actors in Relation to PSC)			
Teacher supporting students as sense makers and authors		**Student understandings**	
A turn of talk will be coded as teacher supporting students as sense makers and authors when the PST reflects on how the teacher supported students in developing their mathematical understandings/learning.	Example: "[The teacher] helps walk him through while he does it. So like he's both like pressing on student thinking to get Jameer to, to kind of reflect on the problems and uh figure out the answer himself and kind of uh (. . .) yeah he is also having him represent his ideas also on the board (. . .)	A turn of talk will be coded as student understandings when the PST reflects on how students' understandings were affected by a specific interaction.	Example: "Well it positions him competently because then now he's being able to like, first of all, realize that he.. made a mistake, but it wasn't like, he was totally off. Like he still, like he understood, I think the concept of like subtracting, (. . .)"
Teacher valuing		**Student feelings**	
A turn of talk will be coded as teacher valuing when the PST clearly discusses a moment when the teacher acknowledges or values student contributions.	Example: "I guess it also helps the teacher he was unable to value all contributions, in class, since she did not do a class check in. Like, (. . .) she like chose one and then someone else gave a different, but um collectively she wasn't able to consider their contributions."	A turn of talk will be coded as student feelings when the PST reflects on how students were affected by a specific interaction.	Example: "Well, uh in the video he seemed like he was really struggling and you can see like the antsyness while he was sitting, he was, literally on the edge of his seat, leaning on the desk, kind of being like, (inaudible) sense of like agitation that he didn't understand. so, if he had left Tim to kind of try to understand it himself, he probably would have been even more agitated in a sense. So, um it was important for him to place him in a competent position,

			because um, Tim was like, he probably would have felt a little insecure about himself if he wasn't."
Teacher other		**Student other**	
A turn of talk will be coded as teacher other, when it is an idea that is either 1) not covered by the other categories or 2) is not clear.	Example: "I guess it also helps the teacher understand, which part of the student's understanding they're having trouble with."	A turn of talk will be coded as student other, when it is an idea that is either 1) not covered by the other categories or 2) is not clear.	Example: "Yeah I don't know how he got. Like, yeah. I just don't. Like this part obviously it just doesn't make sense. Because like it wouldn't be six inches once you subtract three. so like the way of thinking is obviously like (inaudible)."

Coding Scheme for Interview Responses Related to DNF

Category	Description	Example
DNF has future learning benefits	PST explains that using the DNF and/or knowing the teacher moves outlined within it can support PST learning in the future.	"Well I learnt about teacher moves, which is good for like my future knowledge, because" . . . "having those teacher moves will aid me in my classroom, because I'll have kind of I can go back to this and remember different ways to help position my students competently. Yeah."
DNF allowed for focused reflections	PST explains that using the DNF allowed PST to focus their reflections	"So before when I used video I was just writing notes of what I thought was interesting or how could it apply to my classes. So it wasn't really as focused on one, on one part of the video on one part of teaching, it was more me looking at it overall. And so the booklet really, in this process and the different sessions was really helpful because I was, because I needed to identify certain things in the video"
The DNF design was appealing to PST's	PST explains that the way the DNF was arranged and/or the sections included was appealing to PSTs	"I feel that like, doing this process repeatedly like, it- it wasn't monotone at all, and I didn't feel like it was boring at all, because I was always like in front of different scenarios and with the same questions, it allowed me really to like put things into categories."
DNF reinforced terms or teaching methods relating to PSC	PST explains that using the DNF and having access to it during and after video viewing reinforced terms and/or teaching methods	"And so, I'll actually like remember that, and I kept going back to it while I was writing to make sure I like, I fully understood and was using the right terms and stuff. And umm, yeah."
DNF (questions) helped reinforce the teacher moves and how they relate to positioning students competently	PST explains that post video viewing questions helped PSTs make connections between teacher moves and PSC during and/or after video viewing	"Well it helped me be more aware of the different I guess method you could use to position students competently with like rephrasing and like other terminologies, and it helps me really be analytical and critical with the whole student teacher interaction environment. Uhm, like for example in the worksheet… in the booklet I had to fill in, I had to like pin point like that exact term so like I would be more aware of what like the specific interaction with the student, and how like it helped students, position them competently or not help them position, or not position them comp/incmp. not position them competently"
Envisioning new ways of proceeding was difficult to answer	PST explains that the question that prompted PSTs to envision alternative teaching strategies was difficult to answer	"And um e and f [i.e., booklet questions "e" and "f"] I always had trouble I think filling it out because again, I didn't necessarily have a like solid example and experience in the classroom, so I might not be able to think in the top of my head how I would position them

		competently”
Questions in the DNF seemed redundant	PST explains that several questions in the DNF seemed redundant	“Uhmm, like I. hmmm there were a lot of re-, not redundant questions, but there are, I feel like there were questions asked differently. Or, yeah, like the answer is sort of the same but it’s asked differently. So it was, um yeah I don't know how I feel about that”
Limitations and suggestions relating to the DNF's design	PST explains that the DNF design could be limiting and/or components could be added/removed to improve its learning benefits	“like from one to five or how do you think the teacher positioned students competently because I think even though there are instances, certain videos that are obviously that they are positioned them competently or obviously they’re not but maybe also like within that level like compare which one is better or worse off than other, I think maybe that is a more, that uh, that could a more quantitative data that you could work with.”

Coding Scheme for Interview Responses Related to the Facilitator

Category	Description	Example
Facilitator helped PST clarify thoughts	PST explains that during video analysis sessions the facilitator prompted PSTs to clarify their thoughts	“And that really helped like, me explain my thoughts more. And I thought that was very useful, and like, it was very supportive, and I appreciate that, because a lot of the times, I talk a lot. So a lot comes out without me really thinking too much about it, so when someone asks me questions about it, it helps me clarify my thoughts, even for myself.”
Facilitator supports PST in remembering terminology	PST explains that during video analysis sessions the facilitator supported the PST in bridging theory (i.e., PSC vocabulary) and practice (i.e., video noticings)	“Uhh, you helped me remember every time, like, you'd always remind me to like integrate the vocabulary of when I'm describing things, I guess you know, that's important.”
Facilitator supported PST in furthering their understanding during video analysis sessions	PST explains that during video analysis sessions the facilitator helped the PST understand content from the video and DNF	“So, um, English is my second language. And so, there were some times during the video where, even in the booklet, where I wasn't 100% sure what was being said, and I didn't understand everything, and the facilitator really helped me into really understanding every single like element that I had a question on.”
Facilitator helped focus viewing by relating everything back to PSC	PST explains that during video analysis sessions the facilitator prompted the PST to consider the video in relation to PSC	“Facilitate my learning as a pre-service teacher? Uhm, well I think one thing that you were, that you really stressed on was how teachers position, like you kept on, I guess bringing us back to the focus of the study in general. Like the focus of how to, I mean position students competently and uhm. yeah so that was very helpful, because when you analyze something it’s very easy to go off on a tangent and um, to stay really focused and really just think about not necessarily.. uh like leveling your students or categorizing them, um is something that I have to constantly keep in mind and like it’s a great reminder to not just uh judge your students. Not judge but you know like, um yeah just precon- just assume the ability of your students, but really give them the, um the chance to show what they know and like take-, appreciate their effort in doing so, yeah.”

Coding Scheme for Interview Responses Related to the Transcripts

Category	Description	Example
Transcripts allowed PST to point to evidence	PST explains that when watching video and interpreting interactions transcripts allowed the PST to consider exactly what was said	“Uhh, they were good. They like helped me kind of keep up with the videos and highlight you know, different details that I thought I was missing. Like the, in certain ones I thought the teacher or the student were detailing something. I was like "oh, that's good", but then I'd read the transcripts.."oh, nevermind". That was just kind of, just a tangent they kind of went on that doesn't really pertain to I suppose. So yeah, the transcripts were really useful.”

Transcripts made it easier to follow video	PST explains that the transcripts enabled the PST to more readily understand interactions taking place in the video	"Yes. Especially with the students that don't speak super loud and very articulately, or that have like accents that for me are a little bit hard to decipher, it was really helpful just to see like the succession of what was said. Um but yeah, I think I would have had only the transcript I would have been lost, and only the video I think would have been tough, so both are really helpful."

Coding Scheme for Interview Responses Related to the Viewing Norms

Category	Description	Example
PST did not remember viewing norms	PST explains that they would often have difficulty remembering the viewing norms and would need to be reminded of them before being able to answer interview question	"Oh, those. Oh yeah, I don't think I've looked back at them, but yeah they were good."
Viewing norms can support professional development or professional careers	PST explains that viewing norms can be used as a tool for professional development.	" Oh yeah, the stance. Oh, ok. It's really interesting, because even watching a video, it's something that you have to apply in your classroom all the time, and as a first-year I know it's something that I'm going to use in my second stage and in the stage that are to come" (. . .) "Umm, I think is really going to help me in the future."
Viewing norms provide PST with a lens to focus viewing	PST explains that viewing norms guided the PST to consider and attend to specific aspects of the video and purposefully disregard other aspects	"kind of look at the videos instead of, just kind of watch them and kind of figuring it out after. So I was kind of like "alright, this is what I'm looking for, this isn't what I'm looking for".
Note. The symbol "(. . .)" indicates that a quote was reduced in length, and thus signifies additional text.		

Coding Scheme for Interview Responses Related to Video

Category	Description	Example
Video allows PST to build different viewpoints, teaching perspectives, teaching styles, teaching strategies	PST explains that viewing video provides the PST with an opportunity to gain new insights relating to teaching.	"Cause when you're kind of sitting in a classroom on stage students notice you so they act different, but if you get to see the class, as a class with the teacher alone it kind of builds a different- a different view point, so I can kind of see a classroom work in a different way than if I were to be sitting there and observing the class.
Video allowed PST to re-watch it and see new things	PST explains that viewing video afforded the PST with the opportunity to re-watch and attend to new things.	And it also allows me to like observe everything that is going on in the class or like re-watch it and get to see new things."
Viewing videos can inform PSTs' professional development and careers	PST explains that viewing video can be used as a tool for professional development.	"I think they should be used for kind of like a personal investment, if people want to improve on themselves they should be used, but certain people don't see that, and so watching videos will just not work I guess. So, if people do want to improve on themselves and want to learn different teacher moves and how to manage classroom, videos should be used and they should also be used within classrooms."
Viewing video helps bridge theory and practice	PST explains that viewing video can support the PST in gaining a richer understanding of theoretical concepts and their application in practice.	"Like in [university] for instance, cause they'll be talking a lot about um, different situations and how to like talk about tough scenarios in a classroom but then there is like nothing to show it. Like, uh for example, talking about a tragedy or something, they keep saying, uh, it's keep being mention in class that we should talk about tragedies and stuff, but they never show how to, so a video could actually really help cause we can have an example of how to talk about such a touching subject. And so, yeah. Videos can be used for a bunch of different reasons and yeah. Peers should definitely use them."
Videos provided with a more hands on experience as that they could not otherwise see during stage or	PST explains that viewing video allowed PST to access more hands-on experiences than possible when in stage	"It gave me a sort of more hands-on experience, because, which doesn't necessarily, um, isn't necessarily available for me if I were in say my stage, because um yeah it really depends on the teacher you are assigned to, so like if they don't teach math then you won't have that experience."

university classes		
When viewing video it would have been useful to see more student interaction	PST explains that during video analysis sessions it would have been useful if all videos clearly showed student interactions	"but there are some videos that it's harder to see student interaction with the teacher uh that could have been more, I guess, if we were to like, it would be more thorough to analyze if there were like, you could see the student responding with the teacher. But that's like the only thing."
Video helped PST avoid making assumptions	PST explains that viewing video allowed the PST to reflect on the importance of not making assumptions about student learning	"So that definitely gave me a good basis, like a good foundation as to what it looked like even. I don't know it sounds silly but like, but yeah just like not have any assumptions, and uh it really I think helped me like put things into perspective and like be patient again with my students and not assume anything"

Appendix G: Transcribing Conventions for Fine-Grained Analysis

Symbol	Examples
"Rising intonation: ?" **Rising intonation was used when an increase in pitch indicated the speaker meant to ask a question.**	Um, did you mention acknowledge?
"Falling intonation: ." **Falling intonation was used when a decrease in pitch indicated the speaker completed their statement.**	Yeah, acknowledge.
"Rising and falling intonational contours: / \" **Rising and falling intonational contours were used to indicate when a speaker increased their pitch and subsequently decreased it either after accentuating a word or phrase.**	/okay\
"Continuing intonation: ," **Continuing intonation was used when brief pauses occurred during one turn of talk (i.e., sentence).**	Like, in nature, it stays the same, because you want to value that student's contribution
"Stress: TEXT" / "Spoken loudly: TEXT" **Stress and spoken loudly occurred at the same time and marked a clear rise in pitch.**	[OKAY, Okay]
"Pause: (tenths of a second)" **Pause was used to delineate a pause longer than 4 seconds**	what does that do in terms of supporting the students like by acknowledging them? (4 seconds. . .) So acknowledge shows
"Short untimed pause: . . or . . ." **Short untimed pause was used to delineate a pause no longer than 4 seconds**	So how would that one . . . um value all student
"Spoken slowly: <text>" **Spoken slowly was used when a speaker clearly shifted their pace and began speaking more slowly.**	<author>
"Spoken rapidly: >text<" **Spoken rapidly was used when a speaker clearly shifted their pace and began speaking more rapidly.**	>yeah, yeah, yeah<
"Lengthened syllable: :" **Lengthened syllable was used when a speaker clearly accentuated a syllable(s) when uttering a word.**	cha::nge
"Word cutoff: -" **Word cutoff was used when a speaker abruptly ended their turn of talk – and often this signified they did not finish their statement.**	um value all student-
"Latched talk: =" **Latched talk was used when turns of talk quickly preceded each other – this often occurred when a single turn of talk was broken and resumed.**	Facilitator: Rather than I guess having a line= Participant A: =Right.= Facilitator: = It would be really
"Backchannel: { }" **Backchannel was used when a speaker acknowledged the others speakers comment during a single turn of talk.**	that's a huge component of it. Like {Participant A: Yeah}, it really is.
"Overlapping speech: [ ]" **Overlapping speech was used when two utterances clearly overlapped.**	Facilitator: HA: Does that, does that, [help with the-] Participant A: [Yeah].
"Spoken softly: °text°" **Spoken softly was used when a speaker clearly shifted pitch and uttered a word or phrase in a softer tone.**	Okay so, my °second° question is.
"Paralinguistic behavior: ((behavior))" **Paralinguistic behavior was used to account for audible laughter or chuckles.**	((Facilitator and PST laugh))
"Unclear or unintelligible speech: ( )" **Unclear or unintelligible speech was used when an utterances was not audible or was unclear.**	( ) *or* Cause, (unintelligible speech)
***Note.* Symbols originate from Dressler & Kreuz (2000), p. 29-33**	