DEVELOPING PROFESSIONAL VISION FOR PRACTICE: PRESERVICE TEACHERS USING STUDENTS' SCIENTIFIC IDEAS IN SIMULATIONS OF PRACTICE

By

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Abstract

Learning to teach science is difficult for preservice elementary teachers. It involves adopting the practices and principles valued in the teaching profession. A central challenge novice teachers face is learning to interpret students' ideas as they construct explanations of phenomena. The particular ways that teachers see and understand instructional interactions has been referred to as professional vision (Goodwin, 1994). This dissertation examined the ways in which a simulation of practice called "Peer Teaching" supported the development of novices' professional vision in the context of an elementary science methods course. Designed as an approximation of practice, the Peer Teaching lessons provided novice teachers with an opportunity to practice science lessons and to receive targeted feedback. Each novice teacher role-played a "teacher" and taught three science lessons to a team of novices and a teacher educator who acted as "elementary students" with the help of research-based science misconceptions.

The central research question in this study was: How do preservice teachers develop professional vision for practice in the context of Peer Teaching feedback discussions? Qualitative data were collected from 16 novice teachers in four Peer Teaching teams. These data included 48 videos of Peer Teaching feedback discussions, Peer Teaching artifacts, and interviews with one novice teacher from each team.

The findings of the study suggest that developing professional vision in simulations involves learning to notice and use what is valued in the profession, the professional Discourse. Specifically, my analyses indicated that opportunities for developing professional vision occurred as the novices and the teacher educators (1) established a professional Discourse through tools; (2) approximated the professional Discourse through roles; (3) identified challenges of

the professional Discourse; (4) used the professional Discourse to articulate thinking about the challenges; and (5) used the professional Discourse to envision alternatives to the challenges.

Novices' noticing was supported and constrained by the features of the Peer Teaching as located in the interacting contexts of the course and the teacher education program. This was evident in the ways novices expressed a contradiction between two competing objects of developing professional vision: identifying problems of practice and affirming peers' practice. The concepts of professional Discourse and interacting contexts have implications for the design of practice-based opportunities in teacher education. In particular, these concepts have implications for the design of teaching simulations to support novices' development of professional vision.

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CHAPTER 1

INTRODUCTION

Preservice teachers face significant challenges in learning to teach science. These challenges are related to their limited understanding of science concepts and the discourses of science (Abell, 2007). In addition, novices are typically not familiar with engaging students in reform-oriented science teaching approaches (National Research Council, 2012) given their experiences as learners in K-12 education. Novices often have naïve ideas about students and how they learn science (Zembal-Saul, Blumenfeld, & Krajcik, 2000). They recognize that attending to students as learners is important (Peterson & Treagust, 1998), but mainly focus on their interest or engagement (Abell, Bryan, & Anderson, 1998). Furthermore, novices do not have clear ideas about what they should do with students' prior conceptions (Davis, Petish, & Smithey, 2006). Likewise, they often equate science teaching with hand-on activities that do not include opportunities for sensemaking (Thompson, Windschitl, & Braaten, 2013).

Teaching that focuses on students' sensemaking is uncommon in American classrooms, where activities rather than explanations are emphasized (Banilower, 2013). In science classrooms, helping students learn to construct explanations of phenomena and to use evidence to justify claims relies on teachers' capacity to attend to students' ideas (Windschitl, Thompson, Braaten, & Stroupe, 2012). This attention involves learning to anticipate, elicit, and facilitate students' ideas before, during, and after instruction. These teaching practices are all contingent on teachers' capacity to notice and make sense of student thinking (M. G. Sherin, Jacobs, & Randolph, 2011).

However, learning to notice student thinking is not a practice that comes naturally. In particular, attending to someone else's thinking in a subject matter domain that one knows well is unusual (M. G. Sherin et al., 2011). Moreover, questioning someone's ideas, when you know those ideas, is not common in daily life. Listening to and probing others' ideas to identify relationships and misunderstandings entails a level of attention to others that most normally do not give to friends or family members (Ball & Forzani, 2009). Further, learning how to attend to student thinking in elementary classroom settings is difficult for teachers who are faced with a "blooming, buzzing confusion of sensory data" to make sense of (B. Sherin & Star, 2011, p. 69). Even experienced teachers struggle to attend to and make sense of student thinking in elementary classrooms (Jacobs, Lamb, Philipp, & Schappelle, 2011).

For novice teachers in teacher education programs, they have few opportunities to practice attending to students' scientific thinking. In their school field placements, they may be paired with mentor teachers who dedicate a limited amount of time to teach science each day (McMurrer, 2008). When novices do have an opportunity to teach science, many may be so overwhelmed by the complexities of simultaneously teaching science and managing student behavior, that they fail to notice student thinking in relation to features of inquiry-oriented science instruction (Zembal-Saul et al., 2000).

To address these challenges, the field of teacher education is undergoing a major shift in the ways they prepare novices for professional practice (McDonald, Kazemi, & Kavanagh, 2013). In particular, teacher educators are rethinking the pedagogies they have relied on in the past to foster novice teachers' learning. Pedagogical approaches such as case methods, computer simulations, or practitioner research have emphasized the acquisition of knowledge for teaching over an emphasis on teachers' professional knowledge and practice (Grossman, 2005; McDonald et al., 2013). In learning to teach, novices teachers have struggled to use these approaches to make meaningful connections across course and classroom teaching experiences (Kennedy, 1999).

To enhance novices' preparation, teacher educators are taking steps to re-conceptualize the ways "practice" is emphasized in teacher education course settings. Lampert (2010) recommends four ways to conceive of using "practice" to help novices learn to teach. First, she asserts that focusing on practice should entail teaching theory in a way that is situated in practice, rather than an approach to teaching theory (in university courses) separate from practice (in field placement experiences). Second, she argues that teacher education could be organized around doing and studying a core set of teaching practices that teachers routinely use during instruction, such as ways to orchestrate classroom discussions (Hatch & Grossman, 2009), or pressing students for evidence-based explanations (Windschitl et al., 2012). Third, she suggests that preparing novices for interactions with students in classrooms could involve teaching simulations like "rehearsals" where novices practice a task and receive targeted feedback. Fourth, she concludes that like *the practice* of medicine, preparing novices to learn *the practice* of teaching should center on learning the work that teachers do as professionals.

Learning to teach in this way does not suggest going into one's classroom, shutting the door, and learning through a process of trial and error (Lortie, 1975); rather, it entails learning "what teachers do in common…it is about more than acquiring skills or best practices. It involves adopting the identity of a teacher, being accepted as a teacher, and taking on the common values, language, and tools of teaching" (Lampert, 2010, p. 26). This process of learning to teach then involves drawing on professional knowledge and skill to make interactions with students around content productive for student learning (Ball & Forzani, 2009).

This movement to better prepare novices for professional practice is also redefining what it means to prepare novices to teach in equitable and rigorous ways. Learning to engage all students—across ethnic, racial, class, and gender categories—in opportunities to reason about subject matter, participate in the discourses of the discipline, and solve authentic problems is being referred to as ambitious teaching (Cohen, 1990; Lampert & Graziani, 2009). In science, this vision for teaching centers on helping students use scientific practices to construct new understandings of science concepts (Windschitl et al., 2012). The *Framework for K-12 Science Education* defines scientific practices as asking questions, developing and using models, carrying out investigations, analyzing data, constructing explanations, and engaging in argument from evidence (National Research Council, 2012). This kind of ambitious science teaching is complex to enact on a day-to-day basis in classrooms (Crawford, 2000; Kennedy, 2005) because it challenges teachers to adapt their instruction to students' thinking.

A growing number of educators are focusing on the ways in which teachers notice and make sense of their students' ideas. These scholars describe *teacher noticing* in a variety of ways. Some conceive of noticing as where teachers focus their attention while teaching (Star, Lynch, & Perova, 2011; Star & Strickland, 2008). Others have also investigated how teachers interpret what they see (M. G. Sherin & Han, 2004; van Es & Sherin, 2008), including their capacity to reflect on and consider alternatives to instructional strategies (Santagata, 2011). Many of these scholars refer to teachers' ability to notice and interpret classroom instruction as *professional vision*. Goodwin (1994) used the term professional vision to characterize the socially organized ways practitioners see and understand phenomena relevant to their profession.

Like these scholars, I am interested in investigating what teachers attend to in instructional interactions, and how they make sense of what they see. In particular, as an elementary science teacher educator, I am interested in helping novices learn to use student thinking to inform their practice. Given that teaching that focuses on students' thinking has been connected to gains in student achievement (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Wilson & Berne, 1999), and attending to student thinking can provide a rich source of information to help teachers continually improve their teaching practice (Franke, Carpenter, Levi, & Fennema, 2001), it should be emphasized in teacher education. Towards that end, in this study I employ a teaching simulation called "Peer Teaching" to help novices learn to attend to and make sense of students' scientific thinking. Using simulations of practice in methods course settings has recently attracted attention in terms of their affordances for preparing novices for professional practice (e.g., Grossman, Compton, et al., 2009). While the literature base for studying practice-based approaches in methods course settings is growing (Ghousseini, 2008; Nelson, 2011; Shah, 2011), the particular ways in which these approaches could foster novices' professional vision for practice has not been fully investigated.

Study Overview and Research Questions

This study capitalized on the existing work being done in a teacher education program (Ball, Sleep, Boerst, & Bass, 2009) and an elementary science methods course (Davis & Smithey, 2009) to emphasize practice-based learning opportunities. In particular, the elementary science methods course had been engaged in innovative work to foreground opportunities for novices to practice science teaching in the context of the course (see Nelson, 2011). Building on the contributions of prior research conducted in the elementary science methods course (Beyer & Davis, 2009; Forbes & Davis, 2010), this study focused on a particular practice-based pedagogy referred to as "Peer Teaching." Peer Teaching lessons were simulations in the methods course setting where novices took turns teaching reform-oriented science lessons (NRC, 2012). Novices were placed in Peer Teaching teams of four novices, and they remained in these teams throughout the course to facilitate collective knowledge building and camaraderie. During the three methods course sessions dedicated to Peer Teaching, each of the four novices had a chance to teach a 20-minute science lesson to his or her peers and the teacher educator who acted as “elementary students.” When the novices were in the role of a “student,” they role-played misconceptions. These misconceptions were derived from research and enabled novices to learn about the kinds of ideas students might have about particular science concepts. In addition, role-playing the misconceptions contributed to the authenticity of the instruction, and provided the teachers an opportunity to practice eliciting and probing students’ misunderstandings. After each 20-minute Peer Teaching lesson, the teacher educator and novices engaged in a group feedback discussion, in which they offered targeted feedback to the “teacher” about his or her lesson. During the science methods course, novices taught three Peer Teaching science lessons and offered feedback to peers nine times. This study specifically focused on the feedback discussions that occurred after the Peer Teaching lessons. The purpose of this study was to contribute to current work in teacher education focused on exploring the affordances of practice-based experiences in novices’ teacher preparation. In particular, this study sought to examine how the innovative features of the Peer Teaching design, including tools such as the student misconceptions and shared language of science teaching, might foster novices’ profession vision.

Peer Teaching feedback discussions were investigated to examine the mechanisms through which novice teachers could develop professional vision for science teaching in simulated settings. Guiding my study was the following research question: How do preservice teachers develop professional vision for practice in the context of Peer Teaching feedback discussions? Three sub-questions drove the analysis:

(a) What challenges of science teaching and learning are noticed in the Peer Teaching feedback discussions?

(b) What is the process through which novice teachers notice the challenges of science teaching and learning in the Peer Teaching feedback discussions?

(c) What interactions occur among the challenges, the process, and participants' noticing in the Peer Teaching feedback discussions?

Data were collected during the winter semester of January 2012. Study participants included 16 novice teachers and five teacher educators. Qualitative data were collected from 16 novice teachers in four Peer Teaching teams. These data included 48 videos of Peer Teaching feedback discussions, Peer Teaching artifacts, and interviews with four focal participants. To analyze the data, I used a combination of open coding and codes derived from the literature. The overarching goal of this study was to explore the mechanisms through which novices develop professional vision for practice in the context of Peer Teaching feedback discussions.

The remainder of this dissertation is organized into five chapters. Chapter 2 describes the research base related to the study of teacher noticing and the theoretical work that informs and underlies this study. In Chapter 3, I provide a detailed description of the Peer Teaching lessons and the research design, including the instructional context of the study, data set, and the methods of analysis. Chapter 4 presents the findings of the three analytic sub-questions related to what challenges the novice teachers with the teacher educators noticed, how they noticed them, and the interactions that occurred around the noticing. In Chapter 5, I use these findings to answer the central research question. Also in Chapter 5, I illustrate the mechanisms through which the novice teachers with the teacher educators develop professional vision in the context of the Peer Teaching feedback discussions. I conclude this work in Chapter 6 by considering the theoretical implications of the study for conceptualizing professional vision and its process of development as acquiring a professional Discourse. I also discuss implications for designing practice-based opportunities to support novice teachers in acquiring a professional

Discourse in teacher education program settings. Finally, I discuss the limitations of the study and outline directions for future research.

CHAPTER 2

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

This chapter begins with an overview of research in teacher noticing. The extant literature has studied noticing through a cognitive perspective, which identifies noticing as one of several aspects of expert teacher cognition. I outline the contributions of these scholars, and I suggest that employing a sociocultural theory to study teacher noticing could extend the literature base. I then use sociocultural theory to conceptualize the process of developing professional vision. I conclude this chapter by drawing on Activity Theory to explain how the Peer Teaching lessons could provide opportunities for developing novices' professional vision in the elementary science methods course.

Approaches to Studying Teacher Noticing

Teacher Noticing Research Informed by the Nature of Expertise

In this section, I summarize the research on teacher noticing to situate this dissertation study in the current literature in order to justify its contribution to the existing research base. I argue that research on teacher noticing has primarily taken a cognitive approach to noticing. The cognitive perspective of noticing emphasizes the role of an individual's attention, and minimizes other aspects, such as the social and situated nature of learning (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008; van Es & Sherin, 2002). As such, I explore the ways in which the methods and findings of the studies have overlooked the role learners and their learning contexts play in influencing teacher noticing.

The early work on teacher noticing was informed by research on the nature of expertise. Noticing scholars (e.g., van Es & Sherin, 2002) used identified features of expert thought and action to propose key features of expert teachers' thoughts and actions. For instance, expertise research argued that experts have well-structured knowledge systems, and deploy that knowledge in flexible ways (Schoenfeld, 1985). Experts also focus on substantive issues and patterns, compared to novices who may only attend to superficial aspects (Chi, Feltovich, & Glaser, 1981). In addition, experts consider specific situations in terms of the concepts and principles that they represent (Larkin & Simon, 1987). Finally, expertise research argued that as individuals gain more experience they become more skilled at making sense of situations (Chi, Glaser, & Farr, 1988). Building on the ideas developed around expertise, van Es and Sherin (2002) proposed three key aspects of teacher noticing:

(a) identifying what is important or noteworthy about a classroom situation;
(b) making connections between the specifics of classroom interactions and the broader principles of teaching and learning they represent; and
(c) using what one knows about the context (students, school, content) to reason to reason about classroom interactions (p. 573).

In regards to teachers using their knowledge to reason about classroom events, van Es and Sherin stressed the importance of teachers *interpreting* classroom interactions. They argued that teachers need to develop skills to interpret a situation with the aim of understanding it, such as what students think about mathematics, rather than critiquing a situation and taking action. In other words, although teaching is action-driven, their goal was to help teachers learn to develop skills in interpreting classroom interactions, and to use those interpretations to inform pedagogical decisions. I emphasize interpretation here because examining and helping teachers interpret student thinking is a central aim of the research on teacher noticing. Yet, how novice teachers learn to do this is underconceptualized. Thus, this dissertation study will investigate what is means to interpret student thinking in the context of the methods course setting.

Teaching Noticing Research Emphasizes the Topics and Stance of Noticing

Building on the research about expert thinking, many studies on teacher noticing emphasize *which topics* teachers notice and *the stance of* their noticing. In this section, I first talk about the studies that have focused on which topics teachers have noticed, and then move to address the studies that have examined both the topics and stance of teaching noticing. My aim here is to argue that this research on teacher noticing should be supplemented with a sociocultural approach to develop a more complete conceptualization of teacher noticing. I conclude this section by reporting on recent studies on teacher noticing that begin to examine the role of the *who* in teacher noticing; or more specifically, the ways in which group members shape which topics and how teachers notice.

Citing research on the routinized nature of teacher attention (Ethel & McMeniman, 2000), many scholars of noticing focused solely on *which topics* teachers noticed (e.g., Rosaen et al., 2008). They tied changes in teacher practice to teacher noticing by arguing that if teachers do not notice, they cannot make decisions to teach differently. For instance, Rosaen and colleagues examined changes in what topics three elementary pre-service teachers noticed before and after using a multimedia editor to view excerpts of their videotaped lessons. No specific prompts were offered to help the novices analyze the excerpts of their videotaped instruction. Instead, the aim of this research was to examine how the act of reflecting on a lesson before and after viewing it on video created dissonance. They argued that the dissonance created between what the novices remembered from memory and what they saw in the video directed them to be more discriminating in what topics they noticed. As such, they found that the video-supported reflections were more specific and more focused on classroom instruction (versus classroom management) and children. Similar to the noticing research conducted by van Es and Sherin, Rosaen and colleagues argued that video could help teachers develop an "analytic mind set," which is not just knowledge of next steps, but also knowledge of how to interpret classroom instruction.

Although Rosaen and colleagues' study focused on novice teachers whose practice is typically not routinized (see Ericsson, 2008), a central aim of their work was to examine how videotaped instruction could be used to disrupt teachers' routinized patterns of thought and action. They referenced research from Putnam and Borko (2000) to argue that the role of the video could help novices "experience things in new ways" (p.6). What is interesting is that the Putnam and Borko's article was written, in part, to highlight the inadequacies of using a cognitive perspective to research teacher learning. In this article, Putnam and Borko argue that the physical and social contexts in which learning occurs is an integral part of that learning. In doing so, they challenge the assumption that teacher cognition could be "independent of context and intention" (p. 4). They add that whereas the "traditional cognitive perspectives focus on the individual as the basic unit of analysis, situated perspectives focus on interactive systems that include individuals as participants, interacting with each other as well as materials and representational systems," (p. 4). Thus, Rosaen and colleagues cite Putnam and Borko's work, but minimize the role of the novice as a participant in the teacher education program (context) and do not consider ways that video prompts could reinforce what was being learned in the program. It is surprising that the authors, themselves teacher educators in the program they studied, did not acknowledge the potential role of the teacher education program in shaping what topics the novices noticed. In other words, this research, which focused on the individual teacher as the unit of analysis, minimized the social contexts in which the novices were situated as learners of teaching.

Talanquer, Tomanek, and Novodvorsky (2013) also investigated *which topics* pre-service secondary science teachers noticed, but they considered the role of the teacher education program in shaping what novices noticed. With one of the larger data sets in studies on teacher noticing, Talanquer and colleagues examined what topics 43 pre-service teachers noticed when evaluating evidence of student understanding in another teacher's science inquiry-based unit. The units were provided to the novice teachers in the form of a video case with written artifacts. Talanquer and colleagues found the novice teachers showed preferential attention to the process skills of designing an investigation, rather than the scientific practices of analyzing data and generating conclusions. In addition, the novices' attention was largely focused on students' process skills instead of their ideas. Like Rosaen and colleagues' research, they concluded that the patterns of topics the novices' noticed represented important findings about novices' beliefs and knowledge of inquiry. In particular, they credited the novices' attention to students' process skills as indicative of their "incomplete or naïve views of inquiry" (p. 203).

In their discussion, Talanquer and colleagues considered multiple social factors that might have constrained novices' noticing. First, they emphasized that novices' understanding of the purpose of the task, rather than their individual beliefs, may have influenced the patterns of noticing. Second, they acknowledged that the school culture where the student teachers were teaching could have contributed to students' lack of attention to student thinking. They recognized that "teachers work in professional environments in which powerful contextual factors focus their attention on classroom routines, students' behaviors, and curriculum fidelity, rather than on student thinking" (p. 204). Finally, they pointed to the role of the science education courses, "The observed lack of attention to the substance of students' ideas may thus be indicative of the failure of such courses in promoting the type of thinking that is desired" (p. 204). They concluded by suggesting ways for the science methods courses to design and implement activities to foster attention to student thinking.

The research conducted by van Es and Sherin has primarily focused on *the topics* and *stance* of teacher noticing with the aid of technology. Their work is motivated by expertise research, which argues that experts are able to interpret significant features of their domain. Their initial research (van Es & Sherin, 2002) focused on the noticing of pre-service teachers earning a secondary mathematics or science certification. They examined the topics and stance of novices' noticing after watching videos from their own classrooms with a software Video Analysis Support Tool [VAST]. A series of scaffolds in VAST prompted the novices to analyze three aspects of their videos: (a) student thinking, (b) the teacher's roles, and (c) classroom discourse. Like Rosaen and colleagues' study, the novices each wrote two narrative essays, before and after the use of the VAST software. Van Es and Sherin determined a change occurred in the kinds of interactions that were noticed and discussed by the novice teachers before and after the video prompts. They found that novices adopted three different stances in their noticing: descriptive, evaluative, or interpretative. Initially, the novices described everything as noteworthy. After seeing the video prompts, the novices became more discriminating in what they identified as important, and they organized their essays around key interactions (e.g., student thinking and classroom discourse). They noted that novices interpreted rather than evaluated the classroom interactions, and used evidence from their videos to support their interpretations.

Van Es and Sherin concluded that the VAST technology may have influenced the novices' analysis practices because VAST and the teacher education program emphasized similar knowledge and skills. Both emphasized facilitating classroom discussions and using students' ideas to inform decisions. The authors conjectured that the VAST technology "may have provided teachers with a framework to help them analyze what they were being asked to do in the certification program," (p. 592). Their findings suggest that a framework as represented by the VAST prompts, could foster novices' noticing. It has this potential because it reinforces what is valued in the teacher education program—particular interactions to notice, particular ways to think about those interactions, and particular ways to talk about those interactions. Recognizing that the specific prompts could embody what is valued in the institution has specific implications for this dissertation study, as it is situated in a teacher education program which privileges particular ways of thinking about and talking about teaching.

Similarly, in their later work (2009; 2006, 2008, 2010), van Es and Sherin explored the social influences of in-service teachers' noticing in video clubs. Their research focused on a group of seven fourth and fifth grade elementary teachers who participated in monthly video clubs to help teachers learn to attend to students' mathematical thinking. In their 2008 article, they identified three discrete trajectories of teacher noticing: direct, cyclical, and incremental. The trajectories were determined based on which topics were noticed (math thinking, pedagogy, climate, management, other), the different stances (describe, evaluate, interpret) and levels of specificity (general, specific) used during the 10 video club sessions over the year. The teachers on the direct path maintained a narrow perspective on students and mathematical thinking; the cyclical path occurred when the teacher cycled between a broad and narrow perspective, and the teachers on the incremental path appeared to develop gradually in their noticing over time.

In their conclusion, Sherin and van Es stated that the noticing trajectories did not account for the particular video clip or facilitator in the video clubs—two key social factors. They explained that some video clips provided greater access to student thinking than others.

They pointed out that when clips from two teachers' classrooms were shown, it always prompted shifts in the veteran teachers' noticing. These clips consistently showed teachers probing students' ideas. They also emphasized that the facilitator in the group likely influenced the trajectories. The facilitator adopted several roles, including selecting the video clips, inviting teachers to notice in an evidence-based manner, and prompting them to notice student thinking. They asserted that "these facilitation methods, therefore, likely had a strong influence on teachers coming to focus their comments on interpreting students' mathematical thinking" (p. 263).

Van Es's (2012a, 2012b) recent work on teacher noticing has focused on the role of the social context in shaping teacher noticing. In these two studies, she revisited the video club data set to conceive of the seven teachers as a teacher learning community. Here, she considered that "bringing teachers together to collaborate does not ensure that learning occurs" (van Es, 2012b, p. 5). As a result of new analyses, she argued that the discourse and participation norms in the group could facilitate or impede the group from attending to student thinking and doing so in an evidence-based manner. She asserted that learning to collaborate, as well as developing participation and discourse norms may be important elements of building community. She found that once the participants developed these practices, they appeared to narrow their focus on the specifics of teaching and learning. Teachers needed to develop group norms before they could focus on analyzing the instruction. In fact, she argued the "dimension of probing and pressing each other's ideas is more challenging than the other dimensions [of attending to student thinking]" (van Es, 2012a, p. 192). She concluded that attending to student thinking is not natural for teachers, and problematizing student thinking is not something that occurs in everyday conversations. An important contribution of her study was to highlight the social factors that need to be considered in supporting teachers to notice teaching and student thinking in an analytic manner.

The findings from these studies raise two important questions for this dissertation. First, the findings question the value of using an individual teacher's noticing as a unit of analysis. While the studies noted that individuals' beliefs and knowledge could shape noticing, they also pointed to the social context of individuals' noticing. Second, scholars defined noticing as identifying and making sense of important or noteworthy interactions. However, the research also suggested that teachers face challenges in attending to what is important in teaching—student thinking. This suggests that novice teachers in particular may struggle to be able to identify and make sense of what is important—student thinking—in instructional interactions. For instance, focusing on how a student is talking loudly with her peers, rather than listening to her science-related sensemaking, may distract a teacher from what is important to notice. Thus, what teachers see may stem from their experiences as former students or camp counselors, their "apprenticeship of observation" (Lortie, 1975). These challenges suggest that novices may need support in learning to notice what is valued in the profession of teaching. To elaborate the conceptualization of learning to notice that informs this study, I use the concepts of professional vision and professional Discourse. I define these concepts in the next section.

From Noticing to Professional Vision and Professional Discourse

In the previous section, I argued that which topics teachers notice and how they make sense of those topics may be idiosyncratic in nature. As such, novice teachers may need support in learning what it means to attend to the work of teaching. They may also need help in using the practices, beliefs, and language of the profession to make sense of what they notice. In this study, I use the concept of *professional vision for practice* to characterize the ways that novices learn to see as teachers. I also use the concept of *professional Discourse* to elaborate what it means to see and make sense of the work of teaching by operating from the same practices, beliefs, and language.

Professional Vision for Practice

Framing the process of learning to notice as professional vision emphasizes the social nature of what teachers see and how they make sense of it. Goodwin (1994) used the term professional vision to characterize the socially organized ways practitioners see and understand phenomena relevant to their profession. Many scholars of noticing draw on the concept of professional vision to characterize what teachers as professionals see in instructional interactions (e.g., Borko, Jacobs, Eiteljorg, & Pittman, 2008). Four aspects of Goodwin's argument inform the way I conceive of developing professional vision for practice in this study:

- members of a profession use social practices to build and contest socially organized ways of seeing and understanding relevant phenomena
- ways of seeing are distributed across practitioners and tools in a profession
- learning to use the tools of a profession is complex and profession-specific, so novices must learn it with members of the profession
- employing tools in investigations is a process through which practitioners transform

phenomena into objects of collective professional inquiry.

Drawing on sociocultural theory, Goodwin used the concept of professional vision to represent the collective ways practitioners approach their work. He found that professionals used practices of coding, highlighting, producing and articulating material representations to transform phenomena into "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (p. 606). Building on the work of Lave and Wenger (1991), he argued that practitioners develop professional vision as members of communities. In particular, Goodwin emphasized how ways of seeing are distributed across practitioners and tools in a profession. To clarify this idea, he described how an archaeologist uses a Munsell soil color chart to classify artifacts based on the color of the soil. The Munsell color chart is a tool that archaeologists all over the world use to determine evidence of earlier human action. He argued that the tool is an embodied representation of knowledge that helps archeologists identify more types of soil than they could on their own. It does so because it encapsulates the theory of classifying soil, and it provides solutions to challenges that previous archeologists faced in determining how to investigate evidence of earlier humans. Goodwin asserted that the ability to use the tools of the profession to investigate phenomenon "is embedded within a web of socially articulated discourse" (p. 626). For instance, using the Munsell color chart tool is not an inherently easy task because the color patches on the chart are glossy, while the dirt is not, so the two colors are never quite the same. Moreover, sometimes the color of the dirt falls between the discrete categories depicted on the chart. He stressed that it is through this investigative process that phenomena are transformed to become objects of collective inquiry. Insofar as the tools and the knowledge are established by the community, they must be learned by new members. And as new members, this learning process inevitably involves challenges as novices acquire the ability to see the new objects. In short, Goodwin emphasizes the socially constructed nature of what professional practice entails and how it is learned. Moreover, learning to see what is valued in the profession only occurs as practitioners problematize what they see and draw on tools and one other to investigate those problems.

Establishing a Professional Discourse

Gee's (1989) concept of Discourses elaborates professional vision by specifying what members of the teaching profession should notice—the ways that teachers think, believe, practice, and use language. Gee argues that Discourses with a capital "D" act as a type of "identity kit"; they stipulate shared ways of acting, talking or writing[1]. As such, Discourses are acquired by enculturation into social practices with others who know the Discourse. An individual's Primary Discourse is acquired through socialization in an individual's home community. Secondary Discourses are obtained through a process of apprenticeship with an institution; this entails adopting the common values, language, and tools of the institution. For novice teachers, this implies that learning to teach as a professional practice involves acquiring a capital "D" Discourse, which stipulates socially-shared ways of doing and talking about the work of teaching. In addition, it suggests that learning to teach is a collective process through which novices acquire the practices of the institution (e.g., the teacher education program) through a process of socialization. In short, Discourse emphasizes two points for novices' professional preparation. First, learning to teach involves adopting a kind of teacher identity, a shared way of

[1] He distinguishes discourse with a little "d" from "Discourses" with a capital "D." He uses the little "d" to mean "connected stretches of language that make sense" (p. 6).

seeing, doing, and talking about the work of the profession. Second, teachers acquire the Discourse of teaching as they use it with other practitioners who know it.

If developing a professional vision for practice entails identifying the professional Discourse, then what is the Discourse of teaching? Teacher educators lament that the field is still "dreaming of a common language" (Grossman & McDonald, 2008). Lortie stated in 1975 that "teaching is not like crafts and professions, whose members talk in a language specific to them and their work" (p. 123). He argued that the lack of a "common technical vocabulary" prevented teachers from accessing a repertoire of shared practices and knowledge about teaching. It is widely accepted that "more than 30 years later, the field still lacks a framework for teaching, with well-defined common terms for describing and analyzing teaching" (Grossman, Hammerness, & McDonald, 2009, p. 186).

In addition to lacking shared language and practices, the field also lacks common principles and views of instruction and student learning to undergird the teaching practices. Instead, prospective teachers and practitioners hold a range of personal and idiosyncratic views of teaching and learning. They developed these ideas during years of observing teaching from the vantage point of a student, coach, or parent. Lortie (1975) referred to this phenomenon as the "apprenticeship of observation." He explained that the ideas prospective teachers hold are based on their experiences as students observing teachers' work but not being privy to the knowledge, plans, and decisions informing teachers' actions. These unexamined tacit ideas are often deeply ingrained from years of experiences, and they can act as filters to shape what teachers attend to, and what they ignore or do not see (Feiman-Nemser, 2001).

Articulation

Learning to notice entails attaching language to experiences. If teachers bring unexamined views to the process of learning to teach, then developing professional vision for practice should account for the mechanisms through which they draw on the Discourse to make sense of their work. Freeman's (1991, 1992, 1993, 1994) study characterizes how a group of teachers in an in-service master's degree program used the professional discourse[2] of the program to rename their experiences and to assign new meanings to their teaching practice. Freeman found that as the teachers developed an understanding of the Discourse of the teacher education program, they engaged in "articulation" in which they used the teaching practices and principles of the program to gain access to their thinking about their classroom practice. Before the Discourse was established, the teachers used a local language to express their tacit and unanalyzed conceptions of teaching. The local language reflected their ideas of teaching and student learning prior to the teacher education program. As the teachers engaged in articulation, they were able to be more analytic in their noticing of their own practice. In doing so, they were able to rename their experiences and to assign new meanings to their professional practice as teachers.

Freeman's concept of articulation suggests that teachers will make sense of their practice according to the language that they are able to access—their local language or the professional language of the teacher education program. In terms of supporting novice teacher noticing, this implies that novices could benefit from a shared Discourse. Freeman (1993) clarifies that establishing a Discourse involves more than just coming up with similar terms, it

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[2] Freeman uses professional discourse with a lower case "d" to emphasize the language dimension of the Discourse identity.

should help teachers "operate from a common view of teaching and learning—a shared set of socially constructed facts—which is made explicit in talk and action" (p. 495). Like Goodwin's assertions about developing professional vision, Freeman emphasizes that novices should have opportunities to acquire the professional discourse in practice with others.

Building on Freeman's work, I adopt the concept of *professional Discourse* with a capital "D" to denote the work of teachers' professional practice (the ways of being, and the language, actions, values, and beliefs that embody teaching). What teachers do and how they talk about their work is established socially, so learning the professional Discourse is inevitably a social process. In the next section, I explore the efforts in teacher education and science education to establish a professional Discourse.

Efforts in Teacher Education and Science Education to Establish a Professional Discourse

Scholars in teacher education and science education are working to establish statements of professional Discourse. Given the challenges novices face in identifying and making sense of what is important in teaching (e.g., student thinking), they need to be able to access a professional Discourse to articulate their thinking in terms that are shared by their colleagues. In particular, the field of teacher education is taking steps to specify core teaching practices and principles that could serve as the fulcrum of novices' teacher preparation (Grossman, Hammerness, et al., 2009). Identifying core teaching practices could support teachers in engaging in ambitious instruction which aims to provide equitable instruction for all students (Windschitl, Thompson, & Braaten, 2009). Scholars argue these high-leverage practices (Sleep, Boerst, & Ball, 2007) could be grounded in research on both how children learn and how novice teachers learn.

Grossman, Hammerness, and McDonald (2009) suggest that core teaching practices should include the following characteristics:

- Practices occur with high frequency in teaching
- Practices that novices can enact in classrooms across different curriculum or instructional approaches
- Practices that novices can actually begin to master
- Practices that allow students to learn more about students and about teaching
- Practices that preserve the integrity and complexity of teaching
- Practices that are research-based and have the potential to improve student achievement (p. 277).

For instance, using particular discourse routines (e.g., How did you figure that out?) to engage students in mathematical discussions is one example of a core teaching practice being implemented and studied in mathematic methods courses (Ghousseini, 2008). In elementary instruction, the core practices of teaching science could center on helping students learn to construct explanations of phenomena, understand how to justify claims, and how to revise their ideas in response to evidence (Thompson et al., 2013).

Recent efforts in science education are also attempting to establish statements of professional Discourse for the science education community. In particular, The *Framework for K-12 Science Education* (National Research Council, 2012) and the new standards, the *Next Generation Science Standards (NGSS)* were written in part to provide a more coherent picture of how students learn science. The Framework articulated that students should develop facility with the scientific practices that scientists use to investigate and build models of phenomena. The Framework uses the term "practices" instead of skills to clarify that "engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice" *Education* (National Research Council, 2012, p. 2) . The Framework acknowledges the over-use and ambiguity of the term "inquiry" in the science education community and the necessity for re-defining the work of teaching and learning science: "'inquiry'…has been interpreted over time in many different ways throughout the science education community, part of our intent in articulating the practices is to better specify what is meant by inquiry in science" (NRC, 2012, p. 2). The *Framework* accomplishes this effort by specifying eight scientific and engineering practices that students, as scientists, should employ to learn science concepts. The scientific practices include: asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data, using mathematics and computational thinking; constructing explanations; engaging in argument from evidence; and obtaining, evaluating, and communicating information (NRC, 2012). These practices serve as the means through which teachers can support students in learning science concepts. Towards that end, this study conceives of professional vision for practice in elementary science teaching as focusing on attending to and making sense of students' scientific thinking in interactions with science concepts.

Pedagogies for Supporting Novices' Professional Vision

To foster novices' professional vision for practice, the field of teacher education would benefit from developing shared pedagogies. These pedagogies could establish the professional Discourse and then help novices notice the professional Discourse (develop professional vision) in teaching interactions. Such "practice-based" approaches could situate the work of teaching (i.e., the professional Discourse) as the content and context of novices' learning (Ball & Cohen, 1999). Recent work by Grossman, Compton, Igra, Ronfeldt, Shahan, and Williamson (2009) reflect efforts to specify a framework for preparing novices for professional practice.

Grossman and colleagues conducted a cross-professional study to describe and analyze the teaching of practice in seminaries, schools of professional psychology, and teacher education programs. They identified three central and interrelated components for understanding practice in professional education: representations, decomposition, and approximations of practice. *Representations of practice* illustrate an aspect of a practice, such as lesson plans, case studies, or videos of teaching (see for example, Brophy, 2004; Hatch, Sun, Grossman, Neira, & Chang, 2009). A video representation of an expert professional, for instance, can be used by an instructor to identify facets of practice. *Decompositions of practice* parse the representations into essential parts for teaching and learning. In the preparation of clergy, Grossman and colleagues observed an instructor of a *Reading for Preaching* course decompose the reading of scripture into specific topics: voice and diction, phrasing and emphasis, and nonverbal communication. These topics were all informed by principles of reading scripture. Taking apart and naming the components of reading scripture helped the novices know what to bracket and attend to while practicing reading and observing others practice reading.

Only after novices know what to look for, and how to do it, can they begin to practice, or *approximate* the task. Practice begins in a setting that is less complex and less authentic. For instance, novice clergy approximated the task of reading scripture in front of their peers in a course before reading scripture in front of a congregation. While the approximations of practice may not fully resemble the work of a professional, removing the professional practice from its authentic setting serves to highlight its complex features (Rose, 1999). For instance, in clinical psychology, novices role-play situations in which one acts as the “therapist” and the other the “client.” Here, they simulate a clinical therapy session as they envision how a virtual therapist and a virtual client might work together to develop a therapeutic alliance. The opportunity for these novices to develop a model simulation of an interaction with a client resembles the concept of embodiment addressed earlier.

The degree of inauthenticity also allows the novice’s learning to be more deliberate. Deliberate practice theory argues that professionals attain superior performance when they practice a carefully sequenced set of activities, receive targeted feedback from an instructor, and repeat the tasks to remedy the errors (Ericsson, 2008). Approximations of practice provide opportunities for deliberate practice because novices are practicing tasks at different grain sizes. For instance, in Grossman and colleagues’ study novice clergy practiced reading scripture before integrating scripture into their sermon.

This study adopts Grossman and colleagues’ framework to conceptualize the ways that novices could develop professional vision in the elementary science methods course. Representations of practice are used in the course to establish the professional Discourse. Decompositions of practice help novices to identify and name aspects of the professional Discourse. Finally, approximations of practice in the form of Peer Teaching are used to provide novices with opportunities to enact the science teaching practice advocated by the *Next Generation Science Standards*. The Peer Teaching approximations also include opportunities to give and receive feedback, which allow novices to practice noticing and making sense of the professional Discourse.

Activity-Theoretical Illustration of Peer Teaching

In this chapter thus far, I have defined the process of developing profession vision for practice as attending to and making sense of the professional Discourse. I have argued that professional Discourse represents who teachers are, what they do, and the social mechanisms through which they acquire professional practice with others who know the Discourse. In terms of science teaching, I specified that professional vision for practice in elementary science teaching involves attending to and making sense of students' scientific thinking in interactions with scientific practices and science concepts. In this section, I employ Activity Theory (Engeström, 1987) to highlight the complexities involved in developing professional vision.

Activity Theory's emphasis on socially mediated learning provides a lens for understanding the social factors that may facilitate or constrain novices' learning in the Peer Teaching. According to Activity Theory, the Peer Teaching feedback discussions are "activity systems" (Engeström, 2001). This means the discussions are an "object-oriented, collective, and culturally mediated human activity" (Engeström, 1999, p. 9). Given their social nature, activity systems are made up of competing demands that shape how the goals of an activity system are accomplished. The elements of an activity system and their interactions are illustrated in Figure 2.1. Activity Theory has been used increasingly by scholars to investigate the competing factors involved in novice teachers' learning (Grossman, Smagorinsky, & Valencia, 1999; Smagorinsky, Cook, Moore, Jackson, & Fry, 2004; Tsui & Law, 2007; Valencia, Martin, Place, & Grossman, 2009).

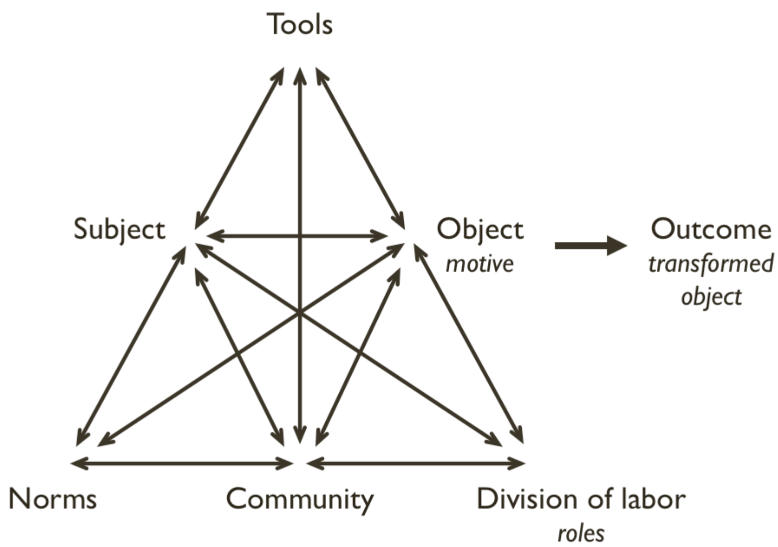

Figure 2.1 Activity Theory Model

Activity Theory maintains that an activity system is directed by a collective *object* or motive (e.g., acquiring the professional Discourse) (Leont'ev, 1981). All actions within the activity systems are interpreted in light of the object (motive or problem space) of the activity system and accomplished by one or more participants, the *subject(s*). For instance, from the perspective of a teacher educator, the object (motive) of the Peer Teaching is to provide novice teachers with an opportunity to develop professional vision for science teaching in the context of the methods course. Attending to and making sense of the professional Discourse is accomplished through the use of mediating *tools* (Leont'ev, 1981), such as the EEE Framework and research-based student misconceptions and scientific practice challenges in the Peer Teaching. A tool is described by Gee (2008) as a mediating device or other individual that a person uses to bolster her performance beyond what she could do alone. When people use tools or each other, knowledge is distributed. Moreover, when people collaborate with others to use tools, it allows them to "accomplish more than they could by themselves, and that knowledge is stored as much in the network and the practices of the group as it is in any one person's head" (Gee, 2008, p. 92). As such, tacit knowledge or prior experiences (such as the novices' apprenticeship of observation) may also be employed as tools to attend to and make sense of teaching.

The interactions in the top half of the triangle (*subject↔ tool↔ object)* are implicitly influenced by the social structure of the Peer Teaching, represented by the bottom half of the triangle (*community↔ roles↔ norms)* (Engeström, 1987). The *community* includes all of the participants who share the same object, such as the teacher educators and the novices. The *division of labor* refers to the roles of who does what within the activity system, and who is privileged with the power and status (Johnson, 2009). For instance, the participants take turns role-playing as "teachers" and "students" during the Peer Teaching lessons. Engeström, Engeström, and Suntio (2002) explain that the division of labor element characterizes the possible hierarchical or horizontal distribution of power and social position within the activity system. In the Peer Teaching feedback discussion, this idea of power and roles may manifest in the ways novices do or do not problematize aspects of their peers' instruction. Participants' actions in the community are determined by *norms*, explicit and implicit rules and expectations that shape the interactions and their work to achieve the object (motive) of the activity system. The purpose of Figure 2.1 is not to merely identify the components of the Peer Teaching but to illustrate the interrelated nature of the concepts.

Towards that end, as the components of the activity system (e.g., tools, participants' roles, and norms) interact, the object may change. For instance, novices may see complimenting a peer as the object of the feedback discussions, instead of critiquing his teaching practice. This perception and implicit norm, which is shaped by the socially situated nature of the participants as novices and friends in the same teacher education program, may shift the object from investigating teaching to affirming teaching.

These structural tensions within and between activity systems, referred to as *contradictions,* act as sources of change for an activity system (Engeström, 2001). Contradictions can provide opportunities for the participants to re-envision the elements of the activity system. For instance, the introduction of the reform-based science teaching practices (as represented by the professional Discourse of the EEE Framework tool) could generate contradictions within the *tools* as novices grapple with their assumptions about students' learning from their apprenticeship of observation (another tool). However, the process of addressing contradictions enables new norms and new forms of knowledge to be produced (Tsui & Law, 2007). In short, Activity Theory provides a novel perspective for understanding the socially situated and collective nature of participants' actions within the Peer Teaching feedback discussions.

Summary

In this chapter, I argued that teacher noticing has primarily been conceptualized and researched according to a cognitive perspective of learning. Building on these scholars' contributions, I employed a sociocultural perspective to conceive of teacher learning and noticing as socially situated. In particular, I used *professional Discourse* to represent the work of teachers' professional practice (the ways of being, and the language, actions, and beliefs that embody teaching). What teachers do and how they talk about their work is established socially, so I argued that learning the professional Discourse is inevitably a social process. Developing *profession vision for practice* was used to characterize the collective nature of learning to attend to and make sense of the professional Discourse. I specified that professional vision for practice in elementary science teaching involves attending to and making sense of students' scientific thinking in interactions with scientific practices and science concepts. I described the steps that current work in teacher education is taking to establish a professional Discourse for teaching, and I explained how Grossman and colleagues' framework for the teaching of practice may provide opportunities for novices to develop a professional vision for practice in the context of methods courses. I also drew on Activity Theory to illustrate the social and complex nature of developing professional vision in the Peer Teaching feedback discussions. In Chapter 3, I elaborate the Peer Teaching design and show how it was created to capitalize on the work being done in the field of teacher education as well as in the teacher education program, which is the context of this study. In Chapter 3, I also detail the methods I use to conduct the study.

CHAPTER 3

METHODS

Overview

The research question for this dissertation is: *How do preservice teachers develop professional vision for practice in the context of Peer Teaching feedback discussions?* This study adopted a phenomenological approach to explore the mechanisms through which novice teachers develop professional vision for practice in simulated settings. I use profession vision for practice to denote what teachers attend to and how they make sense of instructional interactions that embody the professional Discourse.

This definition draws on work from linguistic anthropologist Goodwin (1994) and teacher noticing researchers van Es and Sherin (2002). Taking a phenomenological approach to noticing entails exploring the ways in which participants in the Peer Teaching feedback discussions experienced noticing; how they made sense of what they noticed, and how they did so with their colleagues. Qualitative data were collected from 16 novice teachers in four Peer Teaching teams in the elementary science methods course. These data included 48 videos of Peer Teaching feedback discussions, Peer Teaching artifacts, and interviews with four focal participants. To analyze the feedback discussion data, I used a combination of open coding and a *priori* codes derived from the literature. The purpose of this chapter is to elaborate these methods and to explain the study design, context, and data set I used to investigate the phenomenon of noticing as it occurred in the context of the Peer Teaching feedback discussions.

Study Design

To reiterate, this dissertation used a phenomenological approach to study the phenomenon of developing professional vision for practice in Peer Teaching feedback discussions in the context of an elementary science methods course. The first step in a phenomenological analysis is to find ways to "make the familiar strange" (Erickson, 1973, p. 16). This step requires "a new way of looking at things, a way that requires that we learn *to see* what stands before our eyes, what we can distinguish and describe" (Moustakas, 1994, p. 33). A part of understanding professional vision then involves an examination of the context that shapes novice teachers' noticing. In the following section, I describe the context for the study and then explain the details of the study and my approach to analysis.

Study Context

The study was conducted in a teacher education program within the School of Education at a large Midwestern university. During the yearlong program, the novice teachers earned a teaching certification and a master's degree in education. The preservice novice teachers had already earned a bachelor's degree in a particular subject area. The novice teachers in the program included both recent college graduates and individuals pursuing a second career, and as such, their ages and experiences varied.

Novices began the program in June and typically finished the following June, unless they pursued an additional ESL endorsement. Throughout the year, the novices took courses at the university and worked in elementary field placements in local school districts (see *Table 3.1*).

Table 3.1 *Teacher Education Program Course Sequence*

Summer Term - Courses and fieldwork in a summer school program in a local school district	**Fall Term** - Courses on campus and in local elementary schools - Novices work in their school placements
EDUC 401 Developmental Reading and Writing Instruction in the Elementary School **MATH 485** Mathematics for Elementary School Teachers **EDUC 510** Teaching and Learning	**EDUC 403** Individualizing Reading and Writing Instruction in Elementary Classrooms **EDUC 431** Teaching of Social Studies in the Elementary School **EDUC 518** Workshop on Teaching Mathematics **EDUC 650** Reflective Teaching Experience (fieldwork) **Cognate course**: Educational Linguistics
Winter Term - Courses in January - Feb-April, novices in their school placements full-time "student teaching"	**Spring Term** - Graduation; courses May – June
EDUC 490 Literacy for English Language Learners **EDUC 528** Workshop on the Teaching of Science **EDUC 649** Foundational Perspectives on Educational Reform **EDUC 510** Teaching and Learning **EDUC 650** Reflective Teaching Experience (fieldwork in school placements)	**EDUC 604** The School Curriculum **EDUC 695** Research and Educational Practice

This study took place in the elementary science methods course (ED528) during the novices' third semester of coursework. During the month of January, the novices were on campus, taking courses before they began to work in their school placements full time ("student teaching") in February through April. This means that the majority of the course assignments took place in the context of the elementary science methods course, since the novices only visited their school placements one afternoon a week.

Elementary Science Methods Course

The elementary science methods course, which is a required course in the teacher education program, was designed to help the preservice novice teachers develop the knowledge, skills, and ways of reasoning necessary to become a teacher of science at the elementary and middle school level. The course focused on both the science content resources needed for teaching science and the instructional practices of science teaching. The course was also intended to help novices develop a greater sense of themselves as professionals, joining a community that shares norms, specialized knowledge, and ethical commitments (i.e., a professional Discourse). The course emphasized four main learning goals for the novice teachers:

- To describe the four strands of science learning—understanding scientific explanations (content), generating scientific evidence (through scientific practice), reflecting on scientific knowledge (and the nature of science), and participating productively in science
- To incorporate the four strands of science learning into effective elementary science teaching to support students as they engage with an investigation question, experience the scientific phenomenon in order to answer the investigation question, and explain the scientific investigation with evidence.
- To identify and enact instructional strategies that make science accessible to all students, including through connecting it to their lives
- To learn how to prepare, teach, and analytically reflect on elementary school science investigation lessons (See Appendix H EDUC 528 Syllabus[3]).

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[3] The EDUC 528 syllabus was adapted from Dr. Betsy Davis's syllabi development in EDUC 421

Peer Teaching Lesson Feedback Discussions

The Peer Teaching lessons in the context of an elementary science methods course were designed to provide novices with opportunities to develop a professional vision. The Peer Teaching lessons enabled novices to draw on the knowledge of their colleagues and the teacher educators (as members of the profession) as well as the professional Discourse through mediating tools. These tools included the EEE Framework for science teaching and learning and representations of students' misconceptions. The novices with the facilitating teacher educators used the professional Discourse and the tools to collectively envision challenges novices might face in science teaching lessons.

Mediating Tools for Science Teaching and Learning: EEE Framework and Student Misconceptions

The Peer Teaching lessons provided opportunities for novices to draw on and use the professional Discourse of the science education community through the mediating tools of the EEE Framework and representations of student misconceptions. The course conceptualized the professional vision for science teaching through the identification of three phases of elementary science teaching. The phases emphasized the role of using investigations to support students in learning science content and scientific practices. These practices were embodied in the "EEE Framework for Science Teaching and Learning" and they included:

- *Engage* with an investigation question,
- *Experience* the scientific phenomenon to generate evidence to answer the investigation question; and
- *Explain* the scientific investigation with evidence

These practices were deliberately identified, named, and practiced in small grain sizes to facilitate novices' capacity to notice and use them.

The EEE Framework was designed by the EDUC 421 Elementary Science Teaching Methods course planning team[4] and this study centered on the EEE framework's second iteration. I led the development of the EEE framework, and it was introduced in the undergraduate elementary science teaching methods course in Fall 2011, when I taught one section of the course.

Although the EEE framework was designed by the Elementary Science Planning Team, the framework closely resembles the Biological Sciences Curriculum Study (BSC) 5E Instructional Model (*Engagement, Exploration, Explanation, Elaboration, Evaluation)* (Bybee et al., 2006). This model was developed in the late 1980s based on the theories of learning advocated by Johann Herbart (1901) and John Dewey (1910), and the Atkin and Karplus (1962) learning cycle proposed in the early 1960s, which was used in the Science Curriculum Improvement Study (SCIS) curriculum program. More recent iterations of the BSCS 5E Instructional Model rest on the theories of student learning as reported in the National Research Council (NRC) report, *How People Learn* (National Research Council, 1999). We adapted some of these ideas in our development of the EEE framework.

The science teaching and learning practices of the EEE Framework phases were made accessible to the novice teachers through Grossman and colleagues' components of professional practice described earlier. One course session was dedicated to representing and decomposing each phase. For instance, for the *Engage* phase, novices learned about ways to use an investigation question to establish a meaningful purpose for students' investigations and data collection. In the *Experience* phase, novices learned how to support students in collecting and

[4]At the time of this study, the group included Dr. Betsy Davis, Carrie Beyer, Michele Nelson, Mandy Benedict-Chambers, James Hagerty, and Anna Arias

recording data that answered the investigation question. In the *Explain* phase, novices learned to support students in constructing scientific explanations based on the data students collected during the *Experience* phase. On the sixth, ninth, and eleventh session of the 12-session methods course, the novices engaged in approximations of practice in which they taught an *Engage*, *Experience* and *Explain* Peer Teaching lesson, respectively. The novices were placed in Peer Teaching teams of four novices, and they remained in these teams throughout the course to facilitate collective knowledge building and camaraderie. During the three course sessions dedicated to Peer Teaching, each novice took on the role of a "teacher" and taught a 15-20 minute lesson to his/her peers who acted as "students." When the novices were teaching, their peers acted as elementary students (intellectually, not behaviorally). *Table 3.2* presents the instructions provided to the group.

Table 3.2 *Peer Teaching Instructions for the Experience Peer Teaching*

9:20- 9:40 First Ecosystem teacher teaches lesson. The "teacher" will identity the specific grade of the students. Teacher educator and others act as "elementary students" using their assigned scientific alternative ideas and scientific practice challenges during the lesson. The teacher educator may interject in the middle of the lesson to offer feedback
9:40- 9:50 Debrief with feedback about the teacher's efforts to support students in *establishing data collection for answering the investigation question and carrying out the investigation.* - Teacher evaluates him/herself using the green rubric - Teacher educator and others jot down notes from the lesson on the blue feedback form - Group discusses the lesson and the teacher shares one thing that s/he would like to revise from the enactment
9:50- 10:10 Second Ecosystem teacher teaches lesson. If feasible, s/he may want to take up the feedback offered to the first Ecosystem teacher.
10:10- 10:20 Debrief with feedback
10:20- 10:30 Class Break
10:30- 10:50 First Motion teacher teaches lesson.
10:50- 11:00 Debrief with feedback
11:00- 11:20 Second Motion teacher teaches lesson. If feasible, s/he may want to take up the feedback offered during the previous lessons.
11:20- 11:30 Debrief with feedback
Return to the Science Methods Room. All teachers complete the reflection questions on the back of the green EEE framework rubric.

In addition to the EEE Framework, representations of students' misconceptions served as tools to mediate novices' abilities to acquire the professional Discourse and to envision student thinking in a context where actual children were not present. The misconceptions were derived from research about student thinking in the areas of ecosystems and force and motion, the topics of the two Peer Teaching lessons (e.g., Driver, Guesne, & Tiberghien, 1985). Each "student" was assigned a particular alternative idea to guide his or her contributions in the lesson. The list of student alternative ideas (misconceptions) is indicated in *Table 3.3*.

Table 3.3 *Assigned Alternative Ideas for the Ecosystems and Motion Lessons*

Alternative Ideas for the Ecosystems Unit	**Scientific Concepts**
One species or animal exists in an ecosystem to fulfill a need for a different population.	A species exists to fulfill its own needs.
Organisms may include nonliving things	Organisms are only living things.
Organisms may refer to only certain living things (only animals, not plants)	All living things are organisms.
Humans feed other organisms. Without humans, organisms would not be able to survive.	An ecosystem can exist and remain stable without human interference. Sunlight provides the source of energy for producers. Consumers eat producers for their energy.
Producers make food for other organisms.	Producers make food for themselves and they can be consumed as food for other organisms.
Plants, algae, and seeds are not living	A living organism responds to stimuli, grows, reproduces, and is made up of cells[6]
Alternative Ideas for the Motion Unit	**Scientific Concepts**
Energy and force are the same.	A force is a push or a pull; it will not result in work unless it results in moving a mass in the direction that the force is exerted. Energy measures the amount of work done.
If a body is not moving there is no force acting upon it.	Rest and constant motion are the same thing to a scientist. In both cases the forces acting on the object are balanced. Whether an object is at rest or in motion depends on your frame of reference.
If a body is in motion, there is a force acting upon it in the direction of motion.	Constant motion does not require that a force be acting on an object.
Large objects exert a greater force than small objects. Objects of specific colors exert a greater force.	Gravitational force between objects depends on the mass of the objects, not their volume or density. The two objects exert equal forces on each other—the forces you exert on the earth is equal to the force the earth exerts on you.

In addition, to simulate the types of challenges a teacher might face in an elementary classroom in engaging students in complex investigations, the "students" were also assigned scientific practice challenges to express in the instruction. For instance in the motion lesson, students might struggle to make and record the quantitative measurements in a precise way. In the ecosystems lesson, "students" may struggle to collect the qualitative data (see *Table 3.4*).

Table 3.4 *Ecosystems and Motion Lessons Scientific Practice Challenges*

Ecosystems Lesson: Student Scientific Practice Challenges
• Adding smiley faces to the living or non-living things. • Using inaccurate colors in their pictures of the objects in the ecosystems (students like to color the rocks red and purple). • Not drawing the objects true to scale, e.g., the animals are larger or smaller than the other things in the aquarium. • Pictures lacking specificity – not identifying the specific animal or plant. • Not being objective in the observations, "We see roots and they look cool!" • Making inferences rather than stating observations, "The fish is happy!" rather than noting that the fish is swimming around in the tank. • Spending large amounts of time coloring one thing in the aquarium and missing the other things. • Giving the animals and plants human features or qualities (anthropomorphizing the animals and plants). • Becoming so excited by the objects in the aquarium that students miss the purpose of making the observations to answer the investigation question.
Motion Lesson: Student Scientific Practice Challenges
• Not taking careful measurements of the distance of the track ball. • Not starting the track ball at the same point for the trials. • "Taking over" the investigation while other students may "sit back" and not get involved, either in the work of conducting the investigation or in the intellectual work of figuring out what is happening. • Acting as if one thing has an effect (but in fact it doesn't) but students keep looking for it (e.g., students looking for the temperature to increase in the thermometers in the sweaters in the Watson & Konicek article). • Recording the data in the table in an unsystematic manner. • Not filling out the table as they conduct the investigation because they think they'll remember it later. • Becoming so excited by the marbles and the collisions that students miss the purpose of doing the investigation to answer the investigation question. • May not understand the importance of controlling some variables, and they may try to change multiple variables at the same time.

The list of scientific practice challenges was also derived from science education research (e.g., Driver et al., 1985), and the teacher educators' research and experiences. Some of the teacher educators were involved in studying the enactment of the ecosystems unit in local elementary schools (Davis et al., 2012).

The Peer Teaching lessons and feedback discussions were designed to enable the novices with the teacher educators to use these tools as a means to acquire the professional Discourse and to attend to student thinking as it interacted with the instruction and science concepts. One affordance of the Peer Teaching lesson was that it did not require novices to attend to student thinking while simultaneously managing the complexities of actual elementary science classrooms, such as time, curricula demands, and student behavior challenges (Davis et al., 2006).

A part of developing professional vision involves practicing how to notice and do the work of the profession. As such, the Peer Teaching lessons provided a setting in which the novices could try out the work of the profession and make inevitable mistakes without the fear of impacting children's learning. For instance, they practiced probing students' ideas, and responding to misconceptions when the "students" in the lesson offered them.

Goffman (1974) elaborates this purpose of simulating practice:

> The capacity to bring off an activity as one wants to—ordinarily defined as the possession of skills—is very often developed through a kind of utilitarian make believe. The purpose of this practicing is to give the neophyte experience in performing under the conditions in which (it is felt) no actual engagement with the world is allowed, events having been "decoupled" from their usual embedment in consequentiality. Presumably muffing or failure can occur both economically and instructively. What one has here are dry runs, trial sessions, run-throughs—in short "practicings" (p. 54).

By focusing on "dry runs" in a context where elementary children are not present, the novice teachers could refine their teaching before they were faced with the responsibility of attending to children's learning in an elementary classroom. As such, in the context of approximating practice, teaching mistakes were privileged for the ways in which they made transparent the complex interactions between instruction, student thinking, and concepts (Lampert, 2001). I refer to this feature as allowing preservice teachers to experience "instructive teaching mistakes."[5] For example, during a Peer Teaching lesson, a novice teacher may have neglected to begin her science lesson by posing an investigation question that established the purpose of the lesson. Instead of allowing the novice to continue teaching and to undoubtedly provide instruction that lacked a clear purpose, the teacher educator could interrupt the lesson and bring the teaching mistake to the attention of the group to discuss. After a brief discussion, she may ask the novice to rewind and reteach the beginning of the lesson. In the context of the methods course, the teaching mistakes could be leveraged to benefit the learning of the group,

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[5]Grossman and colleagues (2009) refer to this concept as "instructive failures" (pg. 11). Given that I use this concept with preservice teachers and want to de-emphasize the severity of failure, I refer to it as "instructive teaching mistakes."

the collective. Novice teachers no doubt make teaching mistakes in their lessons in elementary classrooms, but in the elementary classroom setting, there may not be an opportunity to transform the mistakes into instructive moments. In an elementary classroom, students' learning and instructional time are privileged, so a lesson would not be interrupted to address a preservice teacher's instruction. Additionally, stopping a preservice teacher's lesson to discuss the instruction is not part of the culture of elementary teaching in the context of school settings. However, in the university methods course setting, there are no children, so the preservice teacher's learning can be privileged.

The Peer Teaching feedback discussions were designed to leverage the instructive teaching mistakes by offering the "teacher" feedback that was targeted, just-in-time, and intended for the collective. When a novice made an instructive teaching mistake during a Peer Teaching lesson, the teacher educator could intervene and stop the lesson. For instance, the teacher educator may focus his feedback on the questions the group was using to probe students' ideas. For instance, the novice may have needed to ask her "students" more questions such as, "Why do you think that?" or "What is your evidence to support that claim?"

Furthermore, since the Peer Teaching lesson did not take place in an actual classroom, the teacher educator could manipulate the element of time to offer just-in-time feedback. Manipulating time in a lesson by stopping it allowed the teacher educator to offer "just-in-time feedback" right when the peer teacher needed it, instead of waiting until after the lesson. The teacher educator could leverage the richness of the instructive teaching mistake, before it passed and was forgotten. Additionally, she could ask the preservice teacher to rewind her lesson (or fast forward) and re-teach an aspect of it. In the context of the methods course, the preservice teachers' learning was not ruled by time, something that is a precious commodity in elementary classrooms.

The Peer Teaching setting also allowed for feedback that was intended to build collective knowledge. Feedback that is offered to preservice teachers in the context of an elementary classroom is typically private. Rarely are teaching mistakes viewed as problems of practice that teachers can grapple with and learn from (Lampert & Graziani, 2009). Yet in the methods course, teaching mistakes were positioned as common problems of practice and were leveraged for their insights into complex practice. Furthermore, the problems of practice were opened up to the group, so the mistakes and ways to manage them could develop the professional Discourse among the members. In this way, feedback may be offered to an individual novice, but given in a way that was intended to build the knowledge of the *collective*. This approach to feedback as building collective knowledge and the professional Discourse does not often resemble the discussions that occur in teacher education programs or in novices' field placement settings (Lampert, 2010; Little & Horn, 2007). Thus, as the novices joined their colleagues and the teacher educator in studying, approximating, and articulating the complex aspects of science instruction, they were able to draw on and contest their visions of the professional Discourse.

During the lessons, the "students" used the EEE Framework Feedback Form to record their observations of the "teacher's" instruction (see Appendix C. EEE Framework Feedback Form). After each lesson, the teacher educator and the novices took a few minutes to record more observations on the Feedback Form, and the "teacher" used the rubric to evaluate his/her teaching and to note ways the lesson could have been revised. Then the teacher educator and novices engaged in a 10-15 minute feedback discussion, in which they offered targeted feedback to the "teacher" about the lesson. Here, the teacher educators encouraged the group to share what effective teaching moves they noticed in the "teacher's" lesson. After talking about strengths, the group might move to discuss missed opportunities. The feedback discussions typically ended with the "teacher" expressing how he or she might revise the instruction. In total, novices practiced teaching science three times (Engage, Experience, Explain lessons) during the course and offered peers feedback nine times.

To reflect on the Peer Teaching experience, novices wrote a memo in which they analyzed their instruction, "student" learning, and the feedback they received (see Appendix D. Peer Teaching Memo). All of the lessons were video recorded, so novices used the timestamps from their videoed lesson as evidence to support their claims about their enactment of the EEE Framework teaching practices. In the Engage, Experience, and Explain memos, they also stated their takeaways about science teaching and learning from the Peer Teaching lesson and the group discussions.

Novices used one of two lessons from elementary science curricula to teach the Peer Teaching lessons. The first lesson was from the *Ecosystems* unit from the *Science and Technology Concepts* (STC) curriculum materials. The Ecosystems unit emphasized the relationships between living and nonliving things. Here, students explored the investigation question, "How do living things depend on other living and nonliving things?" Students recorded observations of interactions between fish, snails, duckweed, elodea, and algae in a small-scale ecosystem aquarium (2-liter bottle) to investigate the concept of an ecosystem (see Figure 3.1).

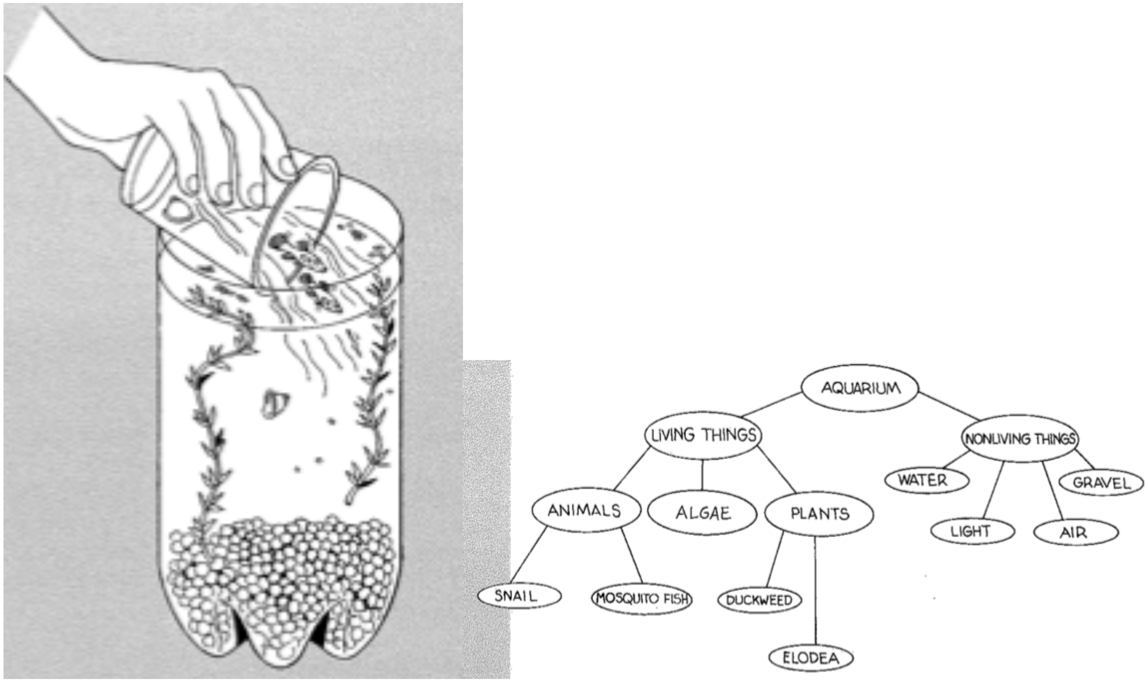


Figure 3.1 Ecosystem lesson aquarium setup and webbing activity from STC, *Ecosystems Unit*

The second lesson was from the *Motion* unit from the *Science Companion* curriculum materials (Chicago Science Group, 2000-2010). In this lesson, the novice teachers acting as "students" performed controlled collisions with balls of different masses on a meter stick track. One ramp ball was rolled down a toilet paper tube to collide with a track ball placed at the bottom of the tube on a meter stick track (see Figure 3.2). "Students" collected data to answer the following investigation question, "What makes a big and small collision?" Six balls were tested in the experiment, including a rubber ball, a large and small steel ball, a wooden ball, and a large and small marble. Some of the "teachers" also changed the length of the tube (by using a paper towel roll) and varied the height of the ramp by using different quantities of blocks.

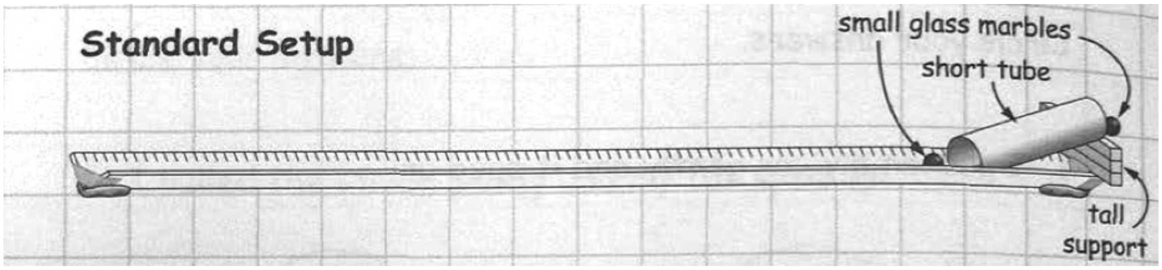


Figure 3.2 Ball and Track Apparatus Setup of the Motion investigation from *Chicago Science Group, 2000-2010*

Different teacher educators worked with the teams to facilitate the discussions. Although the teacher educators usually worked with different groups for each lesson, Priti's team worked with the same teacher educator for both the Experience and Explain lessons. I did not want the teacher educators working with the novices whom they interviewed, so this arrangement was necessary for the Explain Peer Teaching (described more later). This means that the same four novices worked together for all three Peer Teaching lessons, but they worked with different teacher educators. I describe the teams further in the next section.

Study Participants

Participants in this study were the novice teachers in the master's level elementary science methods course. The participants were selected based on their willingness to participate in the study, in terms of written and audio/visual capacities. Although 21 out of 24 novices in the course gave consent to participate in data collection that surpassed the regular artifacts collected for pedagogical purposes, two of those novices were eliminated from the study because of their status as undergraduates. The two undergraduates were student athletes who were unable to take the undergraduate science methods course because of their schedules. As such, they were eliminated from the study because their course experiences in the undergraduate teacher education program were different from the rest of the class.

Four focal participants were selected for the study based on the following criteria:

- Novices' responses to two questions on the survey distributed on the first and last day of class (see Appendix E. Survey Questions.) This survey used two five-level Likert item questions to elicit information about the novices' perceptions of science teaching and their ability to effectively teach elementary science. These two questions served to identify novices who varied in terms of their experiences with and confidence in teaching elementary science.
- The novice's mentor teacher teaches science (some mentor teachers teamed with another colleague so they did not teach science.)
- The novice's grade level, major and minor, age, and gender were considered to represent a range of novices given the focus on investigating how a variety of preservice teachers offered and used feedback.
- The stability of the novice's placement. Many of the novices moved to new placements, and new grade levels in January when the course began.

Table 3.5 indicates how the four focal participants were selected for the study.

Table 3.5 *Focal Participant Selection by Criteria*

Survey Criteria	**Focal Participant Selection**[6]
Science major or minor and Perceived confidence in knowledge of science and confidence in ability to effectively teach elementary science	5 novices in the class met this criteria • 2 novices were science majors, neither gave consent • 3 novices were science minors • 1 novice changed her placement in January • 1 novice left the second question about ability blank • Priti was selected: science minor, indicated confidence for both questions, female, 30s, 4th grade field placement
Perceived not confident in knowledge of science and confident in ability to effectively teach elementary science	1 novice in the class met this criteria • Noelle was selected: female, mid-twenties, 5th grade field placement
Perceived not confident in knowledge of science and not confident in ability to effectively teach elementary science	2 novices in the class met this criteria • 1 novice's mentor teacher did not teach science which would constrain her opportunities to teach it in her placement • Noemi was selected: female, early 20s, 1st grade field placement
Unsure in perceived knowledge of science and unsure in ability to effectively teach elementary science	5 novices in the class met this criteria • 1 novice who did not give consent • 2 novices changed placement in January • 1 intern wrote, "*unsure--depends, love science*," female, mid-twenties, 4th grade • Scott was selected, he wrote, "felt unprepared, making sure things haven't changed too much since I learned them in high school and undergrad science," male, 40s, 4th grade field placement

[6] All names are pseudonyms.

Four teams of four novice teachers were created around each of the focal participants. In total, the data in the study were collected from the 16 novices in the four teams (see *Table 3.6*).

Table 3.6 *Novices in the Peer Teaching Teams*

Peer Teaching Teams	
Priti Lea Sam Camille	Noelle Gina Lacey Lana
Scott Lori Diane Julie	Noemi Cade Nina Joyce

The Role of the Researcher

My role as both the instructor and researcher informed the design of this dissertation study. For instance, I identified sources of data that could be used for pedagogical purposes, and other sources that would be sequestered after the novices' grades were posted. Given the nature of the pedagogical sources of data, some of these sources did evolve throughout the course to better facilitate the novices' learning. For example, based on feedback that the novices and the teacher educators provided after the first iteration of the Peer Teaching lessons, I revised the Peer Teaching feedback forms to include a two-column chart for observations and inferences. The first column provided space for the peer students and teacher educators to record observational notes during and after the lessons. In the second column, the peer students and teacher educators identified the ways in which the teaching moves reflected the practices of the EEE framework.

Given my dual role as the course instructor and researcher, I recruited four individuals to conduct the interviews of the four focal participants and to serve as teacher educators during the Peer Teaching lessons. The four teacher educator-interviewers were not notified of the identities of the focal participants. This decision served to protect the privacy of the novices during the Peer Teaching lessons and to remove the pressure the teacher educator may feel as he or she offered feedback to the different novices during the lessons. Furthermore, this anonymity was intended to strengthen the validity of the study in terms of understanding the phenomenon of noticing in the feedback discussions. In addition, the other novices in the class did not know the identities of the focal participants.

Three of the teacher educator-interviewers were School of Education science education doctoral students, and the fourth was a former science education master's student who was now a staff member in the School of Education. The three doctoral students and the one staff member had all previously worked with the Peer Teaching lessons, and three of the four had served as former apprentices in the elementary science methods course. As such, these individuals were familiar with the course and had helped to design the course and earlier iterations of the Peer Teaching lessons (See Benedict-Chambers, 2012 for more information about the history of the Peer Teaching lessons).

Data

This dissertation employed a phenomenological approach to investigate the process through which novices develop professional vision for practice in Peer Teaching feedback discussions in the context of an elementary science methods course. Adopting a phenomenological approach involves "capturing and describing how people experience a phenomenon—how they…make sense of it, and talk about it with others" (Patton, 2002, p. 104). In the next section, I describe the sources of data I collected to gain insight into the participants' experiences of noticing in the Peer Teaching feedback discussions.

Data Sources

As a part of the course and the study, a variety of qualitative data were collected (Green, Camilli, & Elmore, 2006). The initial large data set is represented in *Table 3.7*. These data included videos of the Peer Teaching lessons and feedback discussions, reflection memos, EEE Framework feedback forms and rubrics, and interviews with the four focal participants. Some of the initial sources of data were collected for pedagogical purposes. Other data, such as the interviews, were collected and put aside until after grades were posted. *Table 3.7* indicates the initial data that were collected from the 16 participants in the study.

Table 3.7 *Overview of the Initial Data Set*

Data source	Number of files	Format
Focal Participant Interviews n=4x5	20	Audio (transcribed)
Science teaching surveys n=16	16	Paper copies
EEE Rubric n=16x3 lessons=48	48	Paper copies
EEE Feedback Forms 16x3 novices per team x3 lessons= 144	144	Paper copies
Peer Teaching Lesson Plans and Reflection Memos 16x3= 48	48	Paper copies
Video of methods course sessions (12 sessions)	12	Video
Videos of Peer Teaching lessons and feedback discussion n=16x3 lessons=48	41*	Video (transcribed)

*Seven Peer Teaching lesson feedback discussions were not recorded due to technical difficulties with the camera, or the novices forgot to turn on the camera.

I deliberately selected a subset of the initial data set for this study. In order to examine the ways in which the novice teachers with the teacher educators drew on the professional Discourse to develop professional vision, I focused my analyses on the videos of the Peer

Teaching feedback discussions. The interactions in the discussions revealed the patterned ways that group members used the professional Discourse to articulate their thinking about the challenges of science teaching and learning. I used the Peer Teaching artifacts and interviews with focal participants to provide contextual information that refined my analyses.

Peer Teaching Lesson Feedback Discussion Videos

The Peer Teaching feedback discussions for the four Peer Teaching teams served as the primary source of data for this study. The feedback discussions were the main source of data because they provided insight into the ways in which the novices interacted to draw on the professional Discourse to identify and to make sense of science teaching and learning. In a phenomenological study, the data are "treated as a text or a document that is being studied; that is, as an instance of the phenomenon that is being studied" (Denzin, 1989b, pp. 55-56). Thus, video data from the feedback discussions were used to gain insight into instances in which the novices were developing professional vision. In particular, the video data provided information of which challenges the novices noticed, how they noticed the challenges, and who noticed the challenges. The Peer Teaching lessons and feedback discussions were recorded by either a camera used for research, and or the novices' personal cameras used for pedagogical purposes in the teacher education program. Seven of the 48 feedback discussions from the Engage Peer Teaching were not recorded due to technical difficulties or the participants forgetting to turn on their cameras. In addition, the research camera malfunctioned during Noelle's group's Explain feedback discussion, and Noelle and Laura's cameras cut off in the middle of their feedback discussions.

Peer Teaching Artifacts

The Peer Teaching artifacts, as secondary sources of data, were also collected to contextualize the discussions and to strengthen my interpretations of the feedback discussions. These Peer Teaching artifacts included the Peer Teaching lesson plan, EEE Rubric and feedback forms, and the reflection memos. These documents provided insight into the process through which the novices' noticing developed throughout the three Peer Teaching lessons. All together, the Peer Teaching lesson feedback discussion videos with the Peer Teaching artifacts informed claims about the mechanisms through which novice teachers with facilitating teacher educators developed professional vision in the context of the Peer Teaching feedback discussions.

Interviews with Focal Participants

Interviews with the four focal participants also served as secondary sources of data to illuminate the experiences of the novices in noticing in the feedback discussions. The focal participants were interviewed five times, once after the three Peer Teaching lessons and the science lesson they taught in their school field placements in February, and once at the end of their student teaching in May. The teacher educator-interviewers conducted the first four interviews and these transcripts were sequestered until after course grades were posted. I conducted the final interview in May. The purpose of the interviews was to corroborate what the novices noticed in their own Peer Teaching lesson, and what they noticed in their peers' lesson.

In the fall, the interview protocol went through various iterations based on feedback from the committee members. The interview protocol was also tested during the fall semester with two undergraduate novice teachers in the undergraduate elementary science methods course. Two of the teacher educator-interviewers conducted the pilot interviews and I observed. Afterwards, we debriefed the interview and refined the questions based on the novices' responses. I trained the other two teacher educator-interviewers to use the protocol; we discussed the interview questions and talked through possible novice responses, specifically referring to the two pilot interviews. See the interview protocol provided in Appendix F. Interview Questions. *Table 3.8* shows the timetable for the collection of data associated with this study.

Table 3.8 *Data collection timeline*

Time (relative to methods course)	Data collected
Session 1	Science Teaching Survey
Session 6	Video of Engage Peer Teaching lesson feedback discussion Peer Teaching feedback forms and rubrics collected Interview #1 with focal study participants Peer Teaching Engage reflection memo
Session 9	Video of Experience Peer Teaching lesson feedback discussion Peer Teaching feedback forms and rubrics collected Interview #2 with focal study participants Peer Teaching Experience reflection memo
Session 11	Video of Explain Peer Teaching lesson feedback discussion Peer Teaching feedback forms and rubrics collected Interview #3 with focal study participants Peer Teaching Explain reflection memo
Session 12	Last session of the course
After the course	Interview #4 with focal study participants after teaching science lesson in their school field placements
After student teaching	Interview #5 with focal study participants after student teaching

Data Coding and Analysis

Consistent with a phenomenological analysis, my approach to analysis for this study was to "hold the phenomenon up for serious inspection. It is taken out of the world where it occurs. It is taken apart and dissected. Its elements and essential structures are uncovered, defined, and analyzed " (Denzin, 1989b, pp. 55-56). In my initial pass through the data set, I identified patterns in the Peer Teaching feedback discussions in which the novice teachers with the facilitating teacher educators consistently attended to challenges of science teaching and learning. In subsequent iterations, I focused my analysis on the interactions that occurred as the participants identified and discussed the challenges.

In particular, three analytic questions concerning the *what*, the *how*, and the *who* of noticing guided my analysis:

(a) What challenges of science teaching and learning are noticed in the Peer Teaching feedback discussions?

(b) What is the process through which novice teachers notice the challenges of science teaching and learning in the Peer Teaching feedback discussions?

(c) What interactions occur among the challenges, the process, and participants' noticing in the Peer Teaching feedback discussions?

Analysis of Peer Teaching Feedback Discussion Data

My analysis of the feedback discussion transcripts occurred in four iterative stages: transcribing and segmenting into episodes, coding, representing, and writing analytic memos. I describe the steps I took in this section.

First, I transcribed each feedback discussion. Given the complexity of transcribing the group discussions, I relied on the secondary data sources to accurately transcribe aspects of conversation or meanings that were difficult to comprehend. In particular, I watched the video and listened to the audio, read the novices' Peer Teaching lesson plans, memos, rubrics, and feedback forms. After all of the feedback discussions were transcribed, I compiled them in Dedoose. Dedoose is a software application for analyzing text, video and spreadsheet data, qualitative, quantitative and mixed-methods research.

After the feedback discussions were transcribed, I segmented the data into episodes of attending to challenges. In my initial pass through the data, I established a unit of analysis, termed an episode, based on when the novices and teacher educators introduced a new challenge about the Peer Teaching instruction. This method draws from Little and Horn's (2005) notion of dividing a discussion transcript into "episodes of pedagogical reasoning." I focused on challenges as a way to package the data into units. I then was able to determine the challenge topics, or the object of inquiry in the discussions, and the moves the participants enacted to make sense of the challenge topics. An "episode of attending to challenges" began with a participant's move to *identify a challenge* These moves were statements in which participants described interactions in the Peer Teaching lesson as challenging, confusing, worrisome, or worthy of questioning. Both the "teachers" and "students" from the Peer Teaching lesson introduced challenges in the feedback sessions. I marked the end of an episode by noting topical shifts and or participation structure. The episodes of attending to challenges could involve one participant acknowledging a challenge, or it could occur over multiple turns of talk. I focused specifically on moments in the feedback discussions in which the participants grappled with challenges of science teaching and learning to examine how novice teachers with the teacher educators developed professional vision in the context of the Peer Teaching feedback discussions.

Second, I coded the episodes of attending to challenges to develop analytic categories according to *which challenge topics* the novice teachers and teacher educators noticed, *how* they noticed them*, and who* noticed them. I located challenge topics in the feedback sessions by engaging in line-by-line coding of the 41 Peer Teaching feedback discussion transcripts. I worked chronologically through the entire set of feedback discussions, coding the topics when they first appeared in the episode. The nine categories of science teaching and learning challenge topics noticed in order of frequency included:

(1) Student thinking topics

(2) Science concepts from the Peer Teaching lesson curricula

(3) Designing Investigations and Making and Recording Observations

(4) General Pedagogy not specifically related to the EEE Framework

(5) Investigation Questions

(6) Constructing Evidence-based Claims

(7) Analyzing and Interpreting Data

(8) Making Predictions

(9) Defining Terms

I then coded *how*, or the ways in which the novices and teacher educators noticed the challenges. I used participant talk in the feedback discussions to characterize how they noticed. I drew on Johnstone's (2008) description of discourse moves. She argues that asking a question about something noticed is defined by its function, rather than its structure. Johnstone compares these moves to the kinds of interactions that might occur in a chess game, in which one player's move on the chessboard affects the next player's move. To characterize how participant talk serves a function in the interaction, I refer to the phrases participants used as "moves to notice." Identifying the patterned and recurring phrases in the discussions as constituted by moves allowed me to examine how one person's move to notice shapes the interaction by setting up and constraining another's response (Horn & Little, 2010).

The moves to notice were identified and refined through several iterations of coding. Again, I worked chronologically through the Peer Teaching feedback discussions, and engaged in line-by-line coding that closely attended to the patterns of talk used by the novices and the teacher educators. This analysis work reflected a grounded theory approach as I moved between the words and phrases of the novices and teacher educators and my interpretation of those words (Corbin & Strauss, 2008). The codes emerged based on my understanding of the data and my knowledge of the professional Discourse as an instructor in the teacher education program[7] and in the science methods course. I developed codes to reflect the moves in each discussion, and then codes to reflect the moves enacted across the discussion data set. This was an iterative process, as I compared codes across the feedback discussion transcripts to revise and refine the coding scheme. A former instructor of the elementary science methods course also coded 20% of the data set. After checking for agreement on codes after coding independently, the codes were readjusted and the data were recoded (Remillard & Bryans, 2004). Some of the codes were combined and in other cases, the codes were eliminated (Miles & Huberman, 1994).

[7] I served as a research assistant to the instructors, Dr. Hala Ghousseini and Heather Beasley, in the novices' mathematics methods course during their first semester in the teacher education program. I was also an instructor and field instructor in the program in the three years prior to the research study. As such, I was fluent in the professional Discourse and could be considered a participant observer (Patton, 2002).

I identified five categories of moves to notice that occurred across the episodes of attending to challenges:

(1) Identifying challenges

(2) Articulating thinking about challenges

(3) Envisioning alternatives to challenges

(4) Describing instruction

(5) Evaluating instruction

The third step in the analysis process involved creating representations of the data. The representations occurred in two forms: data displays and tables. The representations allowed me to identify and then interpret patterns that I had encountered while coding. To reiterate, three analytic questions guided my analysis of the representations: (a) what challenge topics the novices and teacher educators noticed; (b) how they noticed them; and (c) what interactions occurred among the challenge topics, the moves, and participants' noticing.

The data displays informed subsequent iterations of the coding process. In particular, the data displays showed patterns of how the novices and teacher educators noticed the challenge topics by using the professional Discourse to articulate their thinking and to envision alternatives (see *Table 4.3*). I created tables to show the results of analyses relating to the challenge topics, the moves to notice, and who noticed the challenges in each of the 41 feedback discussions (see *Table 4.4*). The consistency of the tables enabled me to compare the codes across all of the feedback discussions and to develop concepts to reflect the findings.

As I have already depicted, the fourth step in the analysis involved finding patterns, examining the data for anomalies, and making interpretations. In studying a phenomenon such as developing professional vision, the final step requires an integration of the parts "to offer a tentative statement, or definition of the phenomenon in terms of the essential recurring features identified" (Denzin, 1989b, pp. 55-56). To do this, I looked across the data set and wrote analytic memos that focused closely on the patterns. I also created theoretical models to try to explain the patterns I was seeing (Patton, 2002). These efforts led to additional analyses in which I sought more confirming and disconfirming evidence.

Analysis of the Secondary Sources of Data

The analysis of the secondary sources of data, including the Peer Teaching artifacts and the interviews, occurred in a different manner, given their purpose to contextualize the feedback discussions. As I transcribed the feedback discussions, I simultaneously transcribed the interviews with the focal participants. I regularly reviewed the novices' artifacts to fill in any gaps as I made sense of the feedback discussions. For example, as I was analyzing Lori's Explain feedback discussion, I could not understand the comment the teacher educator made about the wording of Lori's investigation question. Her comment prompted a long discussion between the novices about the relationships between investigation questions, science concepts, and student thinking. In order to more fully understand the exchange, I reviewed Lori's lesson plan and her rubric, the teacher educator's feedback form, and Lori's memo to better understand the context of the comment. I describe the findings of this work with Lori's lesson in Chapter 5.

The analysis of the interview transcript data reflected a similar approach. I read and re-read the transcripts to more fully understand the experiences of the novices in noticing in the feedback discussions. For instance, the interview with Noemi after her Experience feedback discussion illuminated the ways in which she had interpreted the teacher educator's feedback in the discussion. In her interview, Noemi expresses her frustration about the challenge topics the teacher educator identified in her lesson; she felt she was being judged unfairly about a teaching topic that she had not been taught. Her interview prompted me to re-examine the topics that were raised in her feedback session and the role of the other novices in the group's discussion. I discuss her lesson more in Chapter 5. I now turn to Chapter 4 where I report the findings of the three analytic questions that guided my analysis. I use these findings to answer the central research question in Chapter 5.

CHAPTER 4

MOVES TO NOTICE AND CHALLENGE TOPICS

The purpose of this chapter is to present the findings of the three analytic questions that guided my analysis. I use these findings to answer the central research question in Chapter 5. The three analytic questions include:

(1) What challenges of science teaching and learning are noticed in the Peer Teaching feedback discussions?

(2) What is the process through which novice teachers notice the challenges of science teaching and learning in the Peer Teaching feedback discussions?

(3) What interactions occur among the challenges, the process, and participants' noticing in the Peer Teaching feedback discussions?

To address the analytic questions, I first describe the science teaching and learning challenge topics that novice teachers and the teacher educators noticed to indicate which aspects of the professional Discourse were made available in the discussions. I then explain the interactions of the novices and the teacher educators around the challenge topics to show the mechanisms through which the challenge topics became available to the group. Finally, I describe the two representations I created, which enabled me to look across the data set to identify salient themes.

Identifying Challenges of Science Teaching and Learning in Feedback Discussions

Episodes of Attending to Challenges

In my initial pass through the data, I identified patterns in which the novices and the teacher educators engaged in discussions of challenges that involved multiple participants and turns of talk. To bound these interactions into units to examine, I established a unit of analysis, termed an "episode of attending to challenges." This method draws from Horn's (2005) notion of "episodes of pedagogical reasoning." The episodes of attending to challenges began with a participant's move to Identify a Challenge. Identifying Challenges were statements that participants used to characterize the Peer Teaching interactions as challenging, confusing, worrisome, or worthy of questioning. Both the "teachers" and "students" from the Peer Teaching lesson introduced challenges in the feedback discussion. I marked the beginning and end of an episode by noting topical shifts and/or participation structure. The episodes of attending to challenges could involve one participant acknowledging a challenge or it could occur over multiple turns of talk.

For instance, the following is an episode of attending to challenges in Noelle's Experience feedback discussion. This episode, which lasted 7 minutes, was the second episode in Noelle's feedback discussion that lasted a total of 12 minutes. As explained earlier, the Experience lesson was the second Peer Teaching lesson in the series of three lessons in the science methods course. Noelle was assigned to teach the ecosystems lesson, which centered on helping students understand the relationships between living and nonliving things. In the ecosystems lesson, students explored the investigation question: How do living things depend on other living and nonliving things? "Students" recorded observations of interactions between fish, snails, duckweed, elodea, and algae in a small-scale ecosystem aquarium (2-liter bottle) to answer the investigation question. In the Engage phase of the ecosystems lesson, the “teacher” used a picture of a riverbank ecosystem to provide an initial common phenomenon and to elicit students’ ideas about the interactions between the living and nonliving things. In the Experience phase of the lesson, “students” made and recorded observations about the interactions between the fish, elodea, snails, etc., to investigate the concept of an ecosystem. In the following episode, Noelle, with the teacher educator and the other novices, discuss the challenges of helping students develop the scientific practice skills (process skills) of making and recording accurate observations to learn science concepts about ecosystems. As shown in *Table 4.1*, the feedback discussion is in the left column of the table, with the analysis of the mechanisms indicated in the right column.

Table 4.1 *Noelle's Experience Feedback Transcript*

Feedback Discussion Transcript	Analysis (topics in italics)
TE: (1) What would you revise?	TE poses a facilitation question
Noelle: (2)…what I'm struggling with most is how to integrate the investigation question into this aspect… of the observations…(3) But I think I could have reminded students… that's the question we want to answer. We need to collect evidence to answer this question… (4) I think I focused so much on the process of observing and recording and what that meant that I kind of lost the content.	Noelle identifies a challenge about connecting the *investigation question* with students' observations of what *animals depend on (science concepts)* in the eco-column *investigation*. She envisions an alternative She articulates her thinking about neglecting the science concepts in the lesson
TE: (5) Yeah, I was wondering that a little bit. (6) you did such a nice job on the process but then on the actual sensemaking of the scientific content…(7) I wonder if it would work to stop the kids in the middle of the observations and say, "Okay, remember our investigation question…can we have some initial ideas--answers to this investigation question based on our observations?"	TE agrees and identifies the challenge She articulates her thinking about process skills and scientific content She envisions an alternative in which the teacher reminds students of the investigation question.
Noelle (8) Yeah and that would be a good way for them to notice because when I was looking through the [EEE Framework] rubric I didn't really provide an opportunity at all for them to make a prediction about the outcome.	Noelle articulates her thinking about how that alternative would connect to making *predictions*.
TE: Yes, Gina didn't either; I didn't think about that.	
Noelle (9) I didn't think about that as part of this lesson…it makes sense because it would also help them to refocus their observations so that they can start collecting evidence.	Noelle articulates her thinking that the purpose of the observations is to collect evidence
TE: (10) What were some of the observations that you noticed us making that you could have drawn on to help us think about the investigation question?	TE identifies the challenge by asking Noelle to elaborate her thinking
Noelle: (11) You said you thought you saw the fish eating the junk at the bottom of the aquarium, the snails moving down the elodea…some of Gina's were like, "I noticed gravel. I noticed plants. I see fish talking to each other." But then she said, "I see a snail eating the plant." …I did see observations that had to do with the dependencies.	Noelle articulates her thinking by referencing some specific "student" comments *(student thinking)* from the lesson and how their observations connected to the concepts in the investigation question
Lacey: (12) I think something that's hard (13) which I was thinking about while you were doing this because I work with fifth graders too…is when students are mislabeling things…I wonder as a teacher how you deal with 25 students doing that and how you can make sure that they're not spending their whole investigation period calling one thing another thing.	Lacey identifies the challenge and articulates the difficulty of supporting students in recording observations *(investigations)* in an accurate manner
Noelle: (14) I think--pulling from Gina's lesson a little bit, if I was doing it with the whole class I might	Noelle draws on Gina's Ecosystems lesson to envision an alternative and then articulates her

have them do partner observations…(15) maybe some small group work…so they could present their evidence, and then those other people would have the hats of being critical scientists…	thinking to emphasize the importance of students attending to the evidence
Lacey: And that wasn't really necessarily like a criticism.	
Lana: (16) That reminded me that I have some fourth graders where the problem might not be that they draw inaccurately. It might be that they spend their entire time making a single snail look awesome…I guess it hadn't occurred to me that we would have to worry about that, but I definitely have some students that that would be the problem.	Lana identifies a challenge in which she imagines another difficulty students might face in recording their observations (*student thinking)*

The episode in *Table 4.1* from Noelle's Experience feedback discussion started with Noelle's move to Identify a Challenge. This episode lasted until the end of her feedback discussion. I provide Noelle's feedback discussion here to illustrate the analytic categories I describe in the next section. Noelle's episode was one of 99 episodes of attending to challenges that I identified across the 41 feedback discussions (see *Table 4.2*).

Table 4.2 *Episodes of Attending to Challenges Across the Data Set*

Team	Novice	Engage Feedback Discussion	Experience Feedback Discussion	Explain Feedback Discussion
Team 1	Cade	N/A	1	3
	Noemi	N/A	2	2
	Nina	2	1	2
	Joyce	1	1	2
Team 2	Noelle	2	2	2
	Gina	2	4	4
	Lana	2	2	1
	Lacey	4	1	3
Team 3	Priti	N/A	2	2
	Camille	N/A	2	3
	Lea	N/A	2	5
	Sam	N/A	6	3
Team 4	Scott	4	1	4
	Julie	N/A	2	3
	Lori	3	3	2
	Diane	0	3	3
Total Episodes		20	35	44

N/A indicates feedback discussions that were not recorded due to technical difficulties.

The number of episodes of attending to challenges ranged from none in Diane's Engage feedback discussion to six in Sam's Experience feedback discussion (see *Table 4.2*). Coding the episodes of attending to challenges enabled me to examine the specific topics participants raised in the discussion and the means through which they explored the different facets of the challenge. In the next section, I describe how I used the episodes of attending to challenges to investigate which challenge topics were identified in the discussions.

Challenges of Science Teaching and Learning

Examining the episodes of attending to challenges enabled me to focus on the specific exchanges that occurred in the feedback discussions as the participants interacted around challenge topics. In order to pinpoint the challenge topics, I engaged in line-by-line coding of the discussion transcripts for each of the four teams. I worked chronologically through the entire set of feedback discussions, only coding the topics when they *first* appeared in the discussion. I coded the topics in this way to reflect the dynamic nature of the group discussions. Although one novice may have identified a challenge topic, the other participants may have elaborated that topic with additional comments. In other words, I endeavored to characterize the topics (as aspects of the professional Discourse) that were made available for the group to discuss in the Peer Teaching team; not the topics that a particular individual noticed. Consistent with my conceptual framework, I intended to examine the process of developing professional vision in the context of the group discussions, not in one individual teacher. *Table 4.3* provides a description of the challenge topics that I identified as emergent and grounded categories in my analysis. *Table 4.3* also indicates the frequency of the challenge topics that all four Peer Teaching teams introduced across the 41 feedback discussions.

Table 4.3 *Categories of Challenge topics*

Frequency across Data Set	Challenge topic	Description
58	Student thinking	Reference to student thinking in three ways: (1) specific student misconceptions related to the science concepts of ecosystems or force and motion; (2) specific student issues related to using the scientific practices to learn science concepts; (3) confusions as teacher-learners in the lesson
47	Science concepts	Science concepts emphasized in the lesson, e.g., weight or mass of the balls, force, ecosystems, interdependence, depends
36	Designing Investigations, Making and Recording Observations	Setting up the investigation to establish a plan for collecting data; carrying out the investigation by collecting and recording observations such as drawing pictures or taking measurements
25	General Pedagogy	Pedagogy not specifically related to the EEE Framework, e.g., discussion moves, using charts, behavior management
22	Investigation Questions	Reference to investigation questions, which were used to provide a purpose for students learning. Students collected data to construct scientific explanation to answer the investigation question.
19	Constructing Evidence-based Claims	Reference to constructing claims with evidence, writing scientific explanations
18	Analyzing and Interpreting Data	Reference to compiling data and identifying patterns to construct scientific explanations
13	Making Predictions	Reference to predictions
11	Defining Terms	Reference to defining the meaning of terms; explaining terms to provide access to students, such as English Language Learners.

The topic category of Student Thinking refers to scientific ideas and understandings that participants introduced in the discussions. They referenced student thinking in three main ways.

First, they imagined specific alternative ideas (misconceptions) related to the science concepts of ecosystems or force and motion. These ideas often reflected the assigned misconceptions participants used in the instruction.

For instance, in move #11 in Noelle's feedback discussion presented earlier, Noelle references the specific comments "students" made in the lesson as evidence of students beginning to think about how living things depend on non-living things:

> You said you thought you saw the fish eating the junk at the bottom of the aquarium, the snails moving down the elodea…some of Gina's were like, 'I noticed gravel. I noticed plants. I see fish talking to each other.' But then she said, 'I see a snail eating the plant.'

Second, they envisioned issues elementary students might face in learning to employ the scientific practices to learn science concepts. For instance, in move #16 in Noelle's feedback discussion, Lana commented, "That reminded me that I have some fourth graders where the problem might not be that they draw inaccurately. It might be that they spend their entire time making a single snail look awesome." As depicted in Noelle's discussion, the alternative ideas and scientific practice challenges often related to the specific ideas that particular individuals in the group were assigned to use as "students" in the lessons. Third, participants acknowledged their own sensemaking and confusion as teacher-learners in the lesson. For instance, in Lori's Experience feedback discussion, Scott acknowledged his confusion, "My problem was figuring out how did the track ball fit into the chart. Actually, as an adult, I was looking for, 'Okay, so we have the wooden ball here,' …and not realizing that we were using the same track ball every time, and I know you talked about it, but for some reason, that just slipped my mind."

The topic of Science Concepts is related to the ecosystem and force and motion concepts emphasized in the Peer Teaching lesson curricula. The topic categories of scientific practices were the different practices the teachers noticed in the discussions. These included Investigation Questions, Making Predictions, Designing Investigations, Making and Recording Observations, Interpreting Data, and Constructing Evidenced-based Claims. These categories reflected the practices emphasized in the EEE Framework. For instance, the Engage lesson teaching practices centered on helping students ask investigation questions and make predictions. The Experience lesson teaching practices emphasized helping students to design investigations and to observe and record data. The Explain lesson teaching practices focused on supporting students in analyzing and interpreting data and constructing evidence-based claims.

General Pedagogy refers to techniques and strategies not explicitly represented in the EEE Framework. For instance, in Lea's Experience feedback discussion, Lea grappled with the challenge of managing students' behaviors as they conducted the force and motion investigation: "I was worrying about that because if they were in small groups that could become a huge management issue; there's certain kids that I wouldn't trust to be able to do it, and how constructive they'd be in groups." Defining Terms refers to defining the meaning of terms to provide access to all students, including English Language Learners. As noted earlier, the novices were also taking a literacy course for English Language Learners while in the science methods course.

Table 4.3 also shows the frequency of challenge topics that were noticed across the 41 feedback discussions. As indicated in the table, novices attended to Student Thinking 58 times, Science Concepts 47 times, and Investigations 36 times across the data set. Taken together, these finding suggests that the novices noticed Student Thinking, Science Concepts, and Investigations more than they noticed the other topics. These data raise the question of the mechanisms through which the novices with the teacher educators noticed these challenge topics of science teaching and learning.

Moves to Notice in Peer Teaching Feedback Discussions

Consistent with my interest in the process through which novice teachers develop professional vision, I specifically focused on what happened in the discussions when challenges were introduced. Examining the *how* of noticing provides insight into the patterned nature of novice teacher and teacher educator interactions around challenge topics of science teaching and learning. I used participant talk in the feedback discussions to characterize how they noticed. I drew on Johnstone's (2008) description of discourse moves. She explains that a statement, like asking a question about something noticed, is defined by its function, rather than its structure. To characterize how participant talk serves a function in the interaction, I refer to the statements participants used as "moves to notice." Identifying the patterned and recurring statements in the discussions as constituted by moves allowed me to examine how one person's move to notice shapes the interaction by setting up and constraining another's response (Little & Horn, 2007).

The moves to notice were identified and refined through several iterations of coding. Again, I worked chronologically through the Peer Teaching feedback discussions, and engaged in line-by-line coding that closely attended to the patterns of talk used by the novices and the teacher educators. This was a painstakingly iterative process as I identified distinctive patterns and developed categories of moves for each feedback discussion. I then took those categories and used them across the feedback discussion transcripts to ascertain their robustness. The categories of moves to notice were revised and refined throughout the process.

Five categories of moves to notice occurred across the episodes of attending to challenges in the 41 Peer Teaching feedback discussions. Through the analysis, I determined that the grain-size of a move to notice varies. Several moves to notice may occur in one sentence, or one move to notice may span several sentences. Moves to notice may refer to one's own lesson or another's lesson. The five categories are described in *Table 4.4*.

Table 4.4 *Categories of Moves to Notice in Episodes of Attending to Challenges*

Frequency across Data Set	Moves to Notice	Description	Phrase
305	Identifying Challenges	Statements in which novices and teacher educators attend to the complexity of teaching science in the Peer Teaching context or in an elementary classroom	"I struggled….it's hard" "I have a question…" "I didn't know…" "Why did you…?" "That could be confusing…" "I wonder why…?"
400	Articulating Thinking about Challenges	Statements in which novices and teacher educators use the professional Discourse to articulate their thinking	"I believe…" "This happened because..." "I think when you…" "Because I think…" "….so…."
240	Envisioning Alternatives to Challenges	Suggestions of alternatives for improving instruction in the Peer Teaching lesson or in an elementary classroom	"I would have..," "I should have.." "You could..." "In a 4th grade class you'll need to…."
25	Describing Instruction	Statements in which novices and teacher educators recount the events that occurred in the lesson. A describe statement does not include an articulation	"I noticed…" "You said" "You gave" "I said…"
24	Evaluating Instruction	Statements in which novices and teacher educators comment on what was effective about the instruction. An evaluate statement does not include an articulation	"I liked when you…" "That was good when you…"

As noted earlier, the first move to notice category identified through the analysis was the move to Identify Challenges. This move to notice refers to statements in which participants described interactions in the Peer Teaching lesson as challenging, confusing, worrisome, or worthy of questioning. Next, I identified moves I refer to as Articulating Thinking about Challenges and Envisioning Alternatives to Challenges. The Articulating Thinking move represents the process whereby novices use the professional Discourse of the teacher education program and elementary science methods course to express their thinking. This category reflects the concept of "articulation" identified by Freeman (1991). There is one central difference in the way Freeman refers to articulation and the way I use it in this study. Freeman's study was a longitudinal study in which he focused on teacher learning in an in-service master's teacher education program. Given his focus on in-service teachers, he uses articulation to refer to the process through which teachers draw on the teacher education program Discourse to rename their tacit experiences. As they gain entry into the community of Discourse, their initial use of the Discourse is not entirely correct. He explains that the members of the Discourse recognize the gaps in the newcomer's use. As the teacher becomes more fluent in the Discourse, she begins to use the Discourse to explain her thinking. This is the process through which she begins to sounds like a member of the Discourse community.

Given the setting and design of this study, Articulating Thinking about Challenges represents the process through which novices begin to acquire the professional Discourse of the science education community (along with the literacy, mathematics and social sciences community through the teacher education program) in the timespan of the science methods course. This means that Articulating Thinking reflects the somewhat circuitous process through which novices draw on prior experiences, as well as experiences in the teacher education program, to make sense of their noticing. Accordingly, the category of Articulating Thinking does not denote that participants explicitly reference the professional Discourse; instead, the category reflects the ways in which participants' efforts to articulate their thinking is expressed as an amalgam of prior experiences and professional Discourse.

The second move to notice is Envisioning Alternatives to Challenges. As the Peer Teaching groups took-up the challenges of science teaching and learning through the moves to

Identify Challenges, and Articulate Thinking, they also Envisioned Alternatives to manage the challenges. These moves indicated novice teacher and teacher educators' attention to alternatives that could improve instructional interactions in the Peer Teaching lesson or in an elementary classroom.

Like Articulating Thinking, the final two categories of Describing Instruction and Evaluating Instruction reflect prior research. Scholars who study teacher noticing in video clubs (e.g., van Es & Sherin, 2008) found that teachers often describe or evaluate classroom instruction. However, in this study in the context of the feedback discussions, participants often justified what they noticed, by using the professional Discourse to Articulate Thinking, so there were fewer instance of novices Describing and Evaluating Instruction.

The novice teachers and teacher educators enacted these moves to notice across the 41 Peer Teaching feedback discussions. As recurring patterns of talk, they may be considered "scripts." In other words, these exchanges may represent "standard plots of types of encounters whose repetition constitutes the setting's interaction order" (Barley, 1986, p. 83). In addition to these five moves to notice, I recognized patterns in which the teacher educators employed Facilitation Questions in the discussions. The questions, such as, "What were some things that you noticed?" (Lea's Experience feedback discussion), or "What were some of the good things you noticed Scott doing?" and "What would you revise?" (Scott's Engage feedback discussion) were offered to facilitate the novices' noticing. The teacher educator facilitation questions were enacted 36 times across the data set. Examining the challenge topics and the moves to notice provided insight into understanding the mechanisms through which the novices with the teacher educators used challenges of science teaching and learning to develop professional vision.

Interactions Focused on Investigating Student Thinking

After establishing categories to characterize which challenge topics the participants identified and the moves they enacted to notice them, I created two types of representations to gain insight into the patterns that I had encountered while coding. To reiterate, I investigated the interactions between: (a) which challenge topics the novices and teacher educators noticed; (b) the process through which they noticed them; and (c) the interactions between the challenges, the process, and participants' noticing. First, I created data displays to map the interactions across the discussions. Figure 4.1 and Figure 4.2 present two interaction timeline displays that represent excerpts from two Peer Teaching feedback discussions: Cade's Experience feedback discussion and Sam's Experience feedback discussion. Cade's discussion represents the 30 feedback discussions where two or more novices Identified Challenges to investigate. These discussions afforded opportunities for developing novices' professional vision. Sam's discussion represents the 11 feedback discussions where two or more novices did *not* Identify Challenges to discuss. In these discussions, a teacher educator or a novice may have introduced a challenge, but another novice did not take up the challenge to explore with the group. These discussions were characterized by moves to evaluate discrete topics that hindered novices' opportunities to develop professional vision.

Creating the interaction timeline was an iterative process as I continued to revise it to determine the best way to "see" the patterns and nuances of the interactions. A part of the revision process involved sharing the display and my interpretations with the committee members and other instructors of the elementary science methods course. Their comments helped clarify my presentation of the findings.

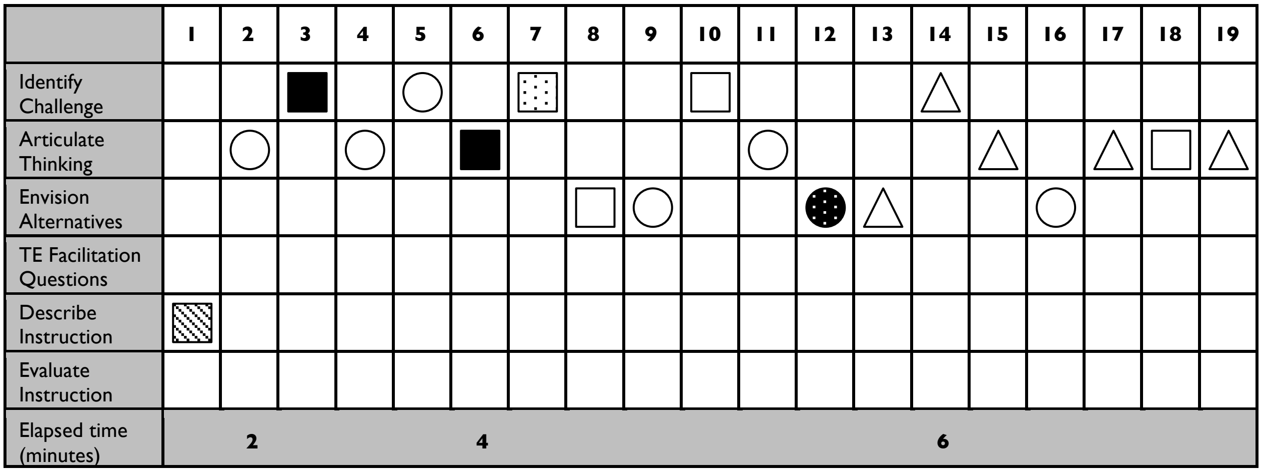


Figure 4.1 Cade's Experience Feedback Discussion: Investigating a Challenge Related to Scientific Practices and Student Thinking about Motion

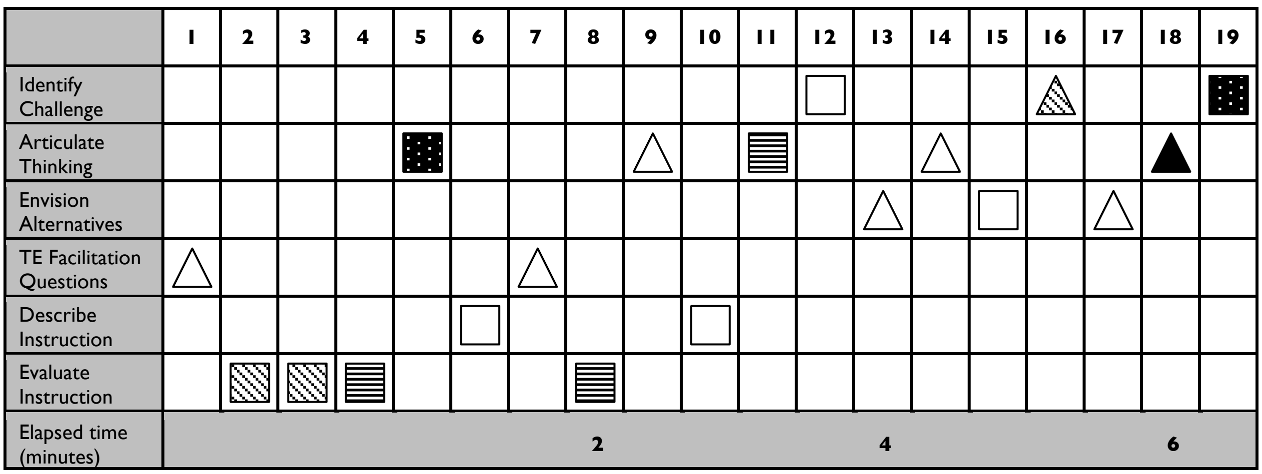
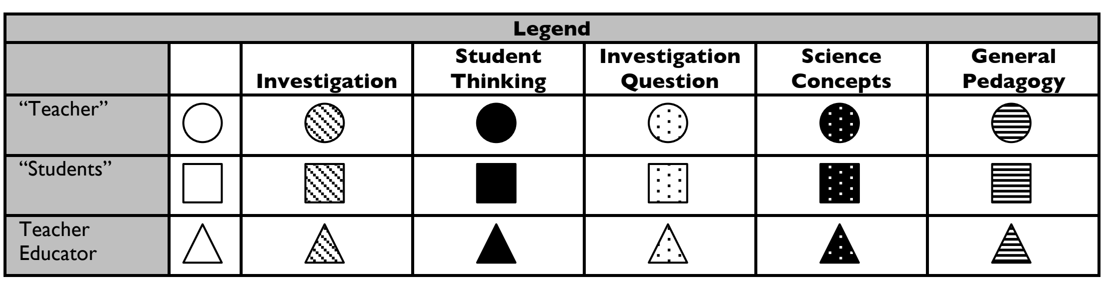


Figure 4.2 Sam's Experience Feedback Discussion: Evaluating a Range Of Discrete Topics



The left column of the display indicates the moves to notice categories that the participants enacted across the feedback discussion. The numbers in the topic row represent participants' moves to notice enacted across the feedback discussion (e.g., see the transcript of Cade's Experience feedback discussion in Chapter 5).

Each shape represents a particular move to notice made by a participant over the course of the discussion. For instance, in Cade's feedback discussion, the circles represent the moves to notice made by Cade as the "teacher"; the triangles, moves made by the teacher educator; and the rectangles, moves made by the other novices who were "students" in his lesson. The shades of the shapes, shown in the legend, indicate the point in the discussion in which a new topic was introduced via a particular move. The bottom row denotes the elapsed time in the discussion. As I examined the interaction timelines for Cade and Sam's Experience feedback discussion, I noticed that the participants in Cade's feedback discussion investigated science teaching challenges related to student thinking, scientific practices, and science concepts. More specifically, they discussed science teaching and learning challenges about using investigations and investigation questions to develop students' understandings of force and motion. In contrast, the participants in Sam's Experience feedback discussion evaluated a range of discrete topics. In particular, they discussed three different topics of general pedagogy.

As shown in Cade's Experience feedback discussion interaction timeline, the moves to notice all occur near the top of the timeline. The moves are clustered around Identifying Challenges, Articulating Thinking, and Envisioning Alternatives. Participants identify the five topics through the moves to Describe Instruction, Identify Challenges, Articulate Thinking, and Envision Alternatives. For instance, in move #6, Noemi contributes the topic of student thinking in her move to Articulate her Thinking. Then in move #7, she acknowledges the role of the investigation question in eliciting student thinking; she contributes this topic to the discussion through a move to Identify a Challenge. In move #12, Cade introduces the topic of science concepts via a move to Envision Alternatives. The display also points to the involvement of the novices, including Cade, in enacting the moves to Identify a Challenge. Paired with the analysis of his feedback session transcript, Cade's interaction timeline suggests a discussion in which the group members were engaged in identifying challenges, articulating their thinking, and envisioning alternatives about investigations, student thinking, investigation questions, and science concepts. These rich discussions occurred in 18 of 41 Peer Teaching feedback discussions.

In Sam's Experience discussion, nine topics are introduced through the moves to Evaluate Instruction, Articulate Thinking, and Identify Challenges. The topics introduced through the Evaluate Instruction moves, in particular, suggest a discussion that was not focused on investigating a central challenge through the moves of Identifying Challenges, Articulating Thinking, and Envisioning Alternatives. Instead, the display shows various topics related to general pedagogy and investigations introduced through a range of different moves that did not advance the discussion.

In terms of the participants' involvement in the discussion, the display points to the two teacher educator facilitation questions and the subsequent moves to evaluate enacted by the novices. As I explained earlier, in my initial analyses I focused on the process of noticing and how it occurred in the group. As such, I had backgrounded the specific roles of the novices and the teacher educator. Thus, in analyzing the displays, I was surprised to see differences in the novices and teacher educators' participation. In terms of the teacher educators, I saw the facilitation questions, which teacher educators had been encouraged to use to facilitate the discussions often precede moves to Evaluate the Instruction. These Evaluate moves often introduced new topics into the conversation that did not serve to facilitate a coherent discussion. I also identified patterns in which the teacher educators' moves to Identify Challenges were not followed by novices' move to Identify Challenges. For instance, a teacher educator raises a challenge, and a novice agrees and notes that he had a similar question, or had also struggled with the teaching topic.

Instead of the subsequent moves to Identify Challenges, I noticed novices Describing or Evaluating the Instruction, which in fact minimized the challenge (Horn & Little, 2010). For example, the following exchange in Sam's feedback discussion reflected this pattern; the teacher educator was trying to alert the group to the ways in which Sam could have emphasized the investigation question to direct students' thinking in the investigation.

> The teacher educator asks Sam, "I didn't know what your question was; so what was your [investigation] question?"
>
> Lea deflects the teacher educator's move to Identify a Challenge, "Yes, you said it."
>
> Priti agrees, "You said it then you brought our attention to what we're going to be doing for the day" (Sam's Experience feedback discussion).

As illustrated in Sam's Experience feedback discussion, the moves to Evaluate seemed to minimize the challenges and not invite the group to engage in further analysis. In Sam's feedback discussion, there were no instances in which two or more novices Identified Challenges (see Table 4.5). Rather than the novices collectively grappling with the challenges, as shown in Cade's discussion, in Sam's discussion the conversation occurred between the novices who acted as ("students") and the teacher educator. As illustrated by the absence of circles in Sam's timeline (see Figure 4.2) he largely remained silent as the participants discussed his lesson. In Cade's discussion in Figure 4.1, the seven circles suggest he was an active participant in the analysis of his instruction. Finally, the participants' moves to discuss or evaluate different aspects of Sam's lesson may have contributed to the high number of episodes of attending to challenges in his feedback discussion. The six episodes in Sam's discussion suggest the participants discussed six different issues in the 13-minute feedback discussion. In Cade's nine-minute feedback discussion there was only one episode of attending to challenges; thus, all of the topics introduced into his feedback discussion furthered the analysis. In particular, the topics in Cade's discussion related to supporting student's scientific thinking through the use of scientific practices.

The patterns I identified in the two timelines suggested the following: (1) novices' moves to Identify Challenges, Articulate Thinking, and Envision Alternatives often occurred together in the discussions; (2) the ways topics were introduced via moves to Evaluate or Identify Challenges shaped the length of the discussion; and (3) novices' enactment of moves to Identify Challenges and the teacher educators' Facilitation Questions. Taken together, these differences revealed two kinds of feedback discussions: ones where novices had opportunities to engage in collective analysis of science teaching and learning topics, and others where challenges were introduced but were not taken up by the other novices. Rather, novices engaged in moves to evaluate and compliment discrete topics, often about general pedagogy. Detecting these patterns among the moves, the topics, and the novice or teacher educators' involvement, led me to the focal participants' interviews. Here, I examined the interactions between the participants, their moves to notice, and the challenge topics contributed in the discussions.

A Novice's Perspective on Noticing: Insights into Developing Professional Vision

Based on these analyses, I re-visited the focal participant interviews to make sense of the patterns and to gain insight into the challenges that were being identified. I conducted the final interview with the focal participants at the end of their student teaching semester. I used feedback in the interview as a context for asking the novices about noticing. Before this excerpt, Noelle mentions that she had not received constructive feedback from her mentor teacher and realizes that her most critical feedback in the future will most likely come from her students and from herself. She acknowledges that the feedback she received from her peers in Peer Teaching was different from the feedback her mentor teacher gave her. Her mentor teacher did not address the topics that Noelle wanted feedback about. Noelle also acknowledges the social factors that impede teachers from sharing constructive feedback.

(1) Interviewer: I'm curious about the feedback that you received during the course and if anything was still salient and influenced your [science] lesson in the field.

(2) Noelle: …I feel like I probably could have gotten more constructive feedback on my science teaching from my peers, from my mentor teacher, from my professors… I think there's a lot of tiptoeing because you don't want to hurt people's egos because so much of being a teacher is being confident in what you are doing and …I think people in the field, in *this field* have a really hard time giving critical feedback.

(3) Interviewer: …so the feedback that you've received from others this semester, in student teaching, what kind of feedback did you receive, who offered that?

(4) Noelle: …I feel like the best feedback I've gotten is based on noticing something within myself and asking someone else in a question form to then elaborate on that…it seems like there has to be some level of self-awareness that something is going wrong…if you are in an environment where people don't want to give constructive feedback because they feel like they are going to hurt your feelings, if you can say, "Oh, I've noticed this about myself," then…it gives them the opportunity to say, "You are right, you know, this was something…" …and I feel like I get more information that way, and so if I can figure out a way to ask better

> questions in receiving the feedback, questions...in relation to students, is something that I want to think more about…it probably would have been helpful for my mentor teacher, [for me] to share, "This is what I have been learning … can you look for these things in me?"

In line #2, Noelle expresses her frustration about not receiving more constructive feedback, and then offers a suggestion. If she can determine what she needs help with, and can express that in a question, she believes that she could receive more useful information about her instruction. Her comments about feedback are relevant to this discussion of challenges because she emphasizes the importance of the teacher in acknowledging a challenge in her practice, by naming the challenge. She states that acknowledging a challenge seems to invite the other person to offer more information about what could be revised.

In line #4, she points out that she could have shared with her mentor teacher what she was learning in her teacher education program, and requested their feedback about those topics. Here, Noelle acknowledges that her mentor teacher might not notice the aspects of her instruction that she wants her to notice, i.e., topics related to what she has been learning on campus. In other words, Noelle recognizes two things: (1) identifying challenges in another teacher's instruction is shaped by social factors, but if you can name the challenge, it invites them to investigate it with you; (2) two teachers may not notice the same thing in an instructional interaction, but if you share your knowledge with them, you can help them learn to see teaching as you see it. Her comments point to the essential role of shared knowledge in noticing similar topics in each other's instruction.

Novices' Noticing across the Data Set

The final step in my analysis involved representing the findings of novices' noticing across the data set in tables. Given the themes that became evident in my analysis of the interaction timeline displays, I aggregated the data to examine patterns according to four features of the feedback discussions:

(1) number of episodes of attending to challenges in each feedback discussion
(2) presence of two or more novices Identifying Challenges in the episodes
(3) presence of moves to Identify Challenges, Articulate Thinking, and Envision Alternatives in the episode
(4) presence of student thinking as a topic in the episode

Table 4.5 presents the results of compiling the data set into one table. In the table, the "yes" indicates the presence of the feature in the feedback discussion, and the "-" indicates an absence of the feature in the feedback discussion. In 34 out of 41 feedback discussions (45 episodes) participants investigated science teaching and learning challenges related to student thinking. The 45 episodes are shaded in gray below. These feedback discussions, which center on investigating students' scientific thinking, suggest rich opportunities for developing professional vision for practice.

Table 4.5 *Novices' noticing across the data set: The presence of identifying challenges related to student thinking*

Teams	Novice	Engage Feedback Discussion				Experience Feedback Discussion				Explain Feedback Discussion			
		Episodes of Attending to Challenges	Two or More Novices Identifying Challenges	Student Thinking Present	Three Moves Present	Episodes of Attending to Challenges	Two or More Novices Identifying Challenges	Student Thinking Present	Three Moves Present	Episodes of Attending to Challenges	Two or More Novices Identifying Challenges	Student Thinking Present	Three Moves Present
Team 1	Cade	N/A				1	Yes	Yes	Yes	3	-	-	-
											Yes	-	Yes
											Yes	-	-
	Noemi	N/A				2	-	-	Yes	2	-	-	Yes
							-	Yes	Yes		-	Yes	Yes
	Nina	2	Yes	Yes	Yes	1	Yes	Yes	Yes	2	Yes	Yes	Yes
			-	Yes	-						-	-	-
	Joyce	1	Yes	Yes	Yes	1	Yes	-	Yes	2	-	-	Yes
											Yes	Yes	Yes
Team 2	Noelle	2	-	Yes	Yes	2	Yes	-	-	2	-	-	Yes
			Yes	Yes	-		Yes	Yes	Yes		-	-	-
	Gina	2	-	Yes	Yes	4	Yes	-	Yes	4	Yes	-	-
			Yes	-	Yes		Yes	-	Yes		-	-	Yes
							-	-	Yes		-	-	-
							-	Yes	Yes		-	Yes	Yes
	Lana	2	Yes	Yes	Yes	2	-	Yes	Yes	1	Yes	Yes	Yes
			Yes	-	-		Yes	-	Yes				
	Lacey	4	-	Yes	-	1	Yes	Yes	Yes	3	-	Yes	Yes
			Yes	-	Yes						-	-	Yes
			-	Yes	Yes						Yes	Yes	Yes
			-	-	-								
Team 3	Priti	N/A				2	-	-	Yes	2	-	Yes	Yes
							-	-	Yes		Yes	Yes	Yes
	Camille	N/A				2	-	-	Yes	3	-	-	Yes
							-	Yes	Yes		Yes	-	Yes
											-	Yes	Yes
	Lea	N/A				2	-	-	Yes	5	-	-	-
							-	-	Yes		-	-	-
											-	Yes	-
											-	Yes	Yes
											-	-	-
	Sam	N/A				6	-	-	Yes	3	Yes	Yes	Yes
							-	Yes	Yes		Yes	-	Yes
							-	-	-		Yes	Yes	Yes
							-	-	Yes				
							-	-	Yes				
							-	-	Yes				
Team 4	Scott	4	-	-	Yes	1	-	Yes	Yes	4	Yes	Yes	-
			-	-	-						Yes	Yes	Yes
			-	-	Yes						-	-	Yes
			-	Yes	Yes						-	-	-
	Julie	N/A				2	Yes	-	-	3	Yes	-	Yes
							-	-	-		-	Yes	-
											Yes	Yes	Yes
	Lori	3	Yes	Yes	Yes	3	-	-	Yes	2	Yes	Yes	Yes
			-	-	Yes		Yes	-	Yes		Yes	Yes	Yes
			-	-	Yes		-	Yes	Yes				
	Diane	0				3	-	-	-	3	Yes	Yes	Yes
							-	Yes	Yes		-	-	Yes
							-	Yes	Yes		-	-	Yes
Total		20	8	11	14	35	11	13	30	44	19	21	31

Table 4.6 presents the number of episodes in which multiple novices enacted moves to investigate challenges related to student thinking. These results are for illustrative purposes, not for statistical analysis.

Table 4.6 *When two or move novices attend to challenges about student thinking*

	Three Moves and Attending to Student Thinking	**Three Moves but Not Attending to Student Thinking**
Two or more novices attend to challenges	20 (53%)	18 (47%)
Fewer than two novices attend to challenges	19 (31%)	42 (69%)

The findings reported in *Table 4.6* indicate that in 53% of the episodes, when two or more novices Identify a Challenge, and enact the three moves (Identifying Challenges, Articulating Thinking, and Envisioning Alternatives), they investigate the topic of student thinking. In 69% of the episodes, in which fewer than two novices attend to challenges, student thinking is not discussed. Based on these findings, I can assert that in the discussions that lack two or more novices Identifying a Challenge, generally the groups are not focused on investigating student thinking as an object of collective inquiry.

These results emphasize the important and interrelated nature of the interactions between (a) which topics are noticed; (b) how they are noticed; (c) and who notices them. When fewer than two novices Identify a Challenge, the groups are less likely to identify the role of student thinking than when multiple novices acknowledge the same challenge. This suggests that identifying the challenges affords an opportunity for collective analysis. Moreover, collective attention facilitates opportunities to investigate topics related to students' thinking and their use of scientific practices to learn science concepts. In the next chapter, I explore the interaction between challenges and collective attention as mechanisms for developing professional vision. These feedback discussions, which focused on examining teaching challenges related to students' scientific thinking, suggest the discussions may have provided opportunities for developing novices' professional practice.

In this chapter, I presented the findings of the three analytic questions related to what challenges the novice teachers with the teacher educators noticed, how they noticed them, and the interactions that occurred around the noticing. In particular, I explained how I used the unit of analysis, an episode of attending to challenges, to identify analytic categories to characterize the challenge topics and the moves to notice participants used in the feedback discussions. I also described the two representations I created, the noticing interaction timeline display and tables, which enabled me to look across the data set to identify salient themes. Together, my analyses indicated there were feedback discussions in which participants investigated science teaching and learning challenges that reflected the ways of teaching advocated by the *Framework for K-12 Science Education* (National Research Council, 2012). Participants articulated their thinking and envisioned alternatives to challenges related to student thinking (58 times), science concepts (47 times) and scientific practices (e.g., investigations 36 times). These findings suggest opportunities for noticing and making sense of the professional Discourse of science teaching and learning; in other words, opportunities to develop professional vision in the context of the feedback discussion. In Chapter 5, I use these findings to answer the central research question.

CHAPTER 5

DEVELOPING PROFESSIONAL VISION FOR PRACTICE

In this chapter, I use the findings of my three analytic questions to answer the central research question: *How do preservice teachers develop professional vision for practice in the context of Peer Teaching feedback discussions?* I present the findings regarding how 16 novice teachers in four Peer Teaching teams develop professional vision in the context of the Peer Teaching feedback discussions. In particular, I illustrate the specific mechanisms through which novice teachers develop professional vision by investigating challenges of science teaching and learning. The opportunity to develop professional vision was evident in the topics of student thinking, scientific practices, and science concepts, or the professional Discourse, novices collectively investigated using moves to identify challenges, articulate thinking, and envision alternatives.

My analyses suggested that in the context of the Peer Teaching feedback discussions, developing professional vision for teaching involves: (1) *identifying challenges that embody the professional Discourse*; (2) *investigating those challenges by using the professional Discourse to articulate thinking and to envision alternatives in classroom contexts; and (3)* i*magining student thinking,* which occurs when the novices and the teacher educators transform a Peer Teaching interaction into an object of collective inquiry in which examining student thinking in relation to instruction and science concepts is emphasized. Articulation, the process whereby teachers draw on the professional Discourse of the teacher education program and elementary science methods course to make sense of and to re-conceptualize their experiences, mediates the interactions between the three mechanisms (Freeman, 1991). This work is supported by the use of tools (e.g., the EEE Framework and assigned student misconceptions) and the participants as embodied representations of the professional Discourse. As the novices and the teacher educators invoke the professional Discourse to make explicit their thinking about science teaching and learning, they have opportunities to develop professional vision. In other words, opportunities to become members of the profession as they draw on and contribute to shared ways of thinking, believing, practicing, and using language.

In the first section of the chapter, I provide two illustrations to show the three mechanisms for developing professional vision for teaching as they interact in the context of Peer Teaching feedback discussions. The first example is drawn from data from the Experience Peer Teaching lesson feedback discussions (the second Peer Teaching lesson). The second example is drawn from the Explain Peer Teaching feedback discussions (the third Peer Teaching lesson). In the second section of this chapter, I present two additional illustrations to depict the interactions that occur in the feedback discussions in which these mechanisms are *not* emphasized. The richness of having all three is even more apparent in examining instances where all three are not present. These examples also come from data from the Experience Peer Teaching lesson feedback discussions. Although these mechanisms were derived from the grounded analysis of all 41feedback discussions, I use specific excerpts from the feedback discussions as illustrations.

Three Mechanisms of Developing Professional Vision for Practice

The first illustration from Cade's Experience Feedback discussion shows the process through which the novices and the facilitating teacher educators develop professional vision by identifying challenges that embody the professional Discourse, and investigating those challenges by articulating thinking and envisioning alternatives. Across the data set of the Experience feedback discussions, there were 12 out of 17 feedback discussions (30 of 35 episodes) in which participants used the moves to identify challenges and investigate those challenges (see *Table 4.5*).

Although imagining student thinking is present in this illustration, I use the second illustration to emphasize the ways in which the group members use the professional Discourse to imagine student thinking as an object of collective inquiry. This 8:56 minute feedback discussion, which includes one episode, shows three of the four novices on the team, along with the teacher educator, attending to challenges of helping elementary students design investigations to learn about force and motion. Cade's feedback discussion is analyzed here because it has some unique features that make it useful for analysis.

Specifically, the feedback discussion begins with a move to attend to a challenge, instead of moves to describe or evaluate instruction that characterized many feedback discussions. In addition, the analysis of the challenge lasts the entirety of the discussion, with only three moves to evaluate shared to conclude the discussion. Moreover, this discussion lacks teacher educator facilitation questions, which often occurred in the other feedback discussions. Cade's feedback discussion also includes multiple instances in which the group members attend to challenges, articulate and envision alternatives, and imagine student thinking.

Cade's Experience Peer Teaching feedback discussion took place on January 17, the second out of three Peer Teaching lesson feedback discussions. Cade, Noemi, Nina, and Joyce are the four novice teachers in the Peer Teaching team. As described in Chapter 3, the novices teach one lesson, broken into three parts (Engage, Experience and Explain), over three different Peer Teaching lessons. Cade teaches the force and motion lesson. In this lesson, the novice teachers acting as "students" perform controlled collisions with balls of different masses on a meter stick track. One ramp ball is rolled down a toilet paper tube to collide with a track ball placed at the bottom of the tube on a meter stick track (see Figure 5.1). In the Experience Peer

Teaching lesson, the "teachers" practice helping "students" conduct investigations and make and record observations to answer the investigation question, "What makes a big and small collision?" Students use the observations, the distance in centimeters that the track ball rolls down the meter stick track, in the Explain Phase to answer the investigation Questions. Six balls are tested in the experiment, including a rubber ball, a large and small steel ball, a wooden ball, and a large and small marble. Some of the "teachers" also change the length of the tube (i.e., by using a paper towel roll) and vary the height of the ramp by using different quantities of blocks.

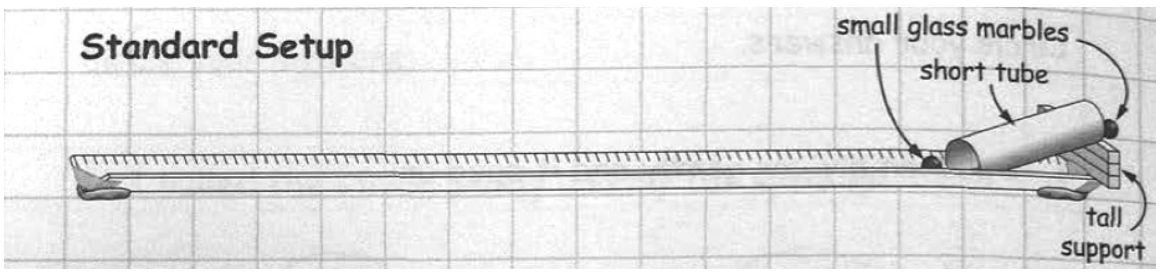


Figure 5.1 Ball and Track Apparatus Setup of the Motion Lesson Investigation (Motion Lesson, Science Companion)

The analysis provided here does not address the full discussion, but the selected excerpts provide a rich exemplification of the ways in which the novices teachers along with the teacher educators identify challenges which embody the professional Discourse, investigate those challenges by using the professional Discourse to articulate thinking and to envision alternatives, and imagine student thinking. The first excerpt illustrates the ways in which the novices with the teacher educator identify challenges that embody the professional Discourse. As shown in *Table 5.1* the feedback discussion is in the left column of the table, with the analysis of the mechanisms indicated in the right column.

Table 5.1 *Cade's Experience Feedback Discussion, Excerpt 1*

Cade's Experience Feedback Discussion	Analysis
Nina: (1) Yeah, I think that was one thing I noticed…you had students think about how they would set up the design.	Nina describes Cade's purpose for the lesson—having students design an investigation
Cade: (2) That was definitely part of my objectives was the science process stuff, and I mean, it is fourth graders so…	Cade articulates his objectives as focusing on the science process
Nina: (3) I was curious…with fourth graders, do you think they could really come up with an [investigation] design--and develop something? Or would you still just have them talk about it and then be like, "Here's how we going to record [the data]?"	Nina identifies a challenge of students' ability to design an investigation
Cade: (4) I thought this format would allow them to attend to what we're keeping the same and what's changing. (5) But I did struggle… [with] a format that still gave them freedom to design it.	Cade articulates his instructional decision about the two variables He identifies the challenge of giving support while allowing students to design
Noemi: (6) Yeah. I thought it was interesting when you did ask, "how could we organize this investigation to help us answer this question?" Obviously…we all have our [assigned] student confusions…when you asked that question we were all able to voice our set confusions. (7) I wonder… if you did give that investigative question, if that would have been an opportunity for students who were confused for you to be able to take out those alternative ideas. (8) …You thought about how we were confused about how the experiment would run and so that would give you the avenue to correct some of those student misconceptions.	Noemi articulates their assigned alternative ideas She identifies the challenge of student confusion by acknowledging the role of his IQ She envisions how posing that IQ might enable him to correct student misconceptions
Cade: (9) The size [of the balls] versus the weight? Maybe I should have taken that up.	Cade names the specific alternative idea and envisions that he could have responded to it
Nina: (10)…Would you let me run with that idea [if I was a student]?	Nina identifies the challenge of students' alternative ideas in designing an investigation
Cade: (11) The size versus the weight [misconception]? I think so, because that would have been a core learning at the end. Because if you had data that was organized by size and data that was organized by weight, (12) then we could have come to the fact that it didn't have to do with how big the [balls] are, it has to do with how much they weigh.	Cade articulates the purpose of the lesson and envisions how organizing the data by the misconceptions—size and weight, could emphasize the science concept learning goal

Challenges that Embody the Professional Discourse

In this section, I use the excerpt from *Table 5.1* to explore the ways in which novice teachers develop professional vision by identifying challenges that embody the professional Discourse. When an individual identifies a challenge, she signals a topic that is important to her. When two or more novices attend to a challenge that embodies the professional Discourse, the challenge becomes greater than the individual. It becomes a challenge that is relevant to the profession and relevant to the novices becoming members of the profession. As such, others are invited to examine the challenge and to offer their ideas in articulation.

In Cade's Experience feedback discussion, this challenge centers on helping students design investigations with multiple variables to learn about collisions, or the concepts of force and motion. Cade's Experience feedback discussion begins with Nina recounting how Cade encouraged his "students" in the lesson to consider how to set up the design for the investigation. Nina asks him in move #3, "I was curious …with fourth graders, do you think they could really come up with an [investigation] design?" This move to *identify a challenge* transforms his Peer Teaching instruction into two challenging aspects of science teaching and learning: (a) elementary students' ability to develop an investigation design; and (b) ways to help students develop an investigation design in an elementary classroom. She wonders if Cade would give students a pre-constructed worksheet with identified variables and constants (e.g., balls of different masses, ramp height, or tube length) or if he would allow students to determine how to test those variables. This move to identify a challenge in Cade's lesson directs Cade to a particular aspect of his lesson, and presses him to explain the reasoning underlying his instructional decision.

In move #5, Cade admits he struggled with the decision, which opens up the space for his and others' articulation. First, he articulates that he wanted students to attend to two aspects of the design process: attending to variables that do not change (control variables) and those that do (independent variables). In move #5, he elaborates his challenge as wanting to both provide support and allow for students' freedom to design. Then, in move #6, Noemi articulates her interpretation by acknowledging the key role of students' alternative ideas. As noted earlier, the novices and the teacher educator were assigned specific alternative ideas to hold and contribute during the lesson. In doing so, she names the scientific practice Cade used—an investigation question[8]—as one way to elicit students' alternative ideas. Here, she points out that one purpose of the investigation is to confront students' alternative ideas. Her articulation, in which she refers to the same concept using multiple terms: student confusions, alternative ideas, and misconceptions, provides evidence of the process through which novices articulate by drawing on the professional Discourse to rename their tacit and unexamined experiences (i.e., confusions and misconceptions). The professional Discourse of the science methods course emphasized how student misconceptions were reasonable and natural. As such, teachers referred to those ideas as "alternative ideas" to remove the pejorative meaning associated with "misconception" (ED528 Class Video, Session 3, January 5).

In the process of directing the group's attention to student ideas, Noemi conjectures that using the investigation question would enable a teacher to "take out" and "correct" those ideas. The notion of taking out and correcting students' alternative ideas was a possible reflection of the discourses of novices' prior experiences. In other words, learning to use the data collected in the investigation to confront students' alternative ideas, versus the teacher correcting the ideas, was a science teaching practice they grappled with throughout the course

[8] The science curriculum in the novices' school placements referred to the investigation question as the "investigative question," so the novices often used both terms to refer to the same idea.

(see EEE Framework). It is possible that Noemi's use of "correct" prompts Nina to ask in move #10 if Cade would let her continue to hold that misconception if she was an elementary student.

He articulates two important points in his response in moves #11 and #12, "The size versus the weight [misconception]? I think so, because that would have been a core learning at the end. Because if you had data that was organized by size and data that was organized by weight, then we could have come to the fact that it didn't have to do with how big the [balls] are, it has to do with how much they weigh." First, he emphasizes the role of the data in redirecting students' alternative ideas, versus the teacher correcting them. Second, his response underscores the importance of directing students' attention to patterns in the data. In this articulation, Cade references the scientific practice of interpreting data to develop an understanding of science concepts.

As illustrated in the first part of Cade's feedback discussion, the interactions that occurred as the novices identified challenges that embody the professional Discourse served two main purposes for developing novices' professional vision. First, when two or more novices identified a challenge, they signaled an interaction that is important to be investigated. Second, as they use the professional Discourse to examine the challenge, the thinking of individuals and the group is made available to be developed or contested. While Cade did not explicitly disagree with Noemi's use of "correct," he did emphasize that his learning goal was to help students develop that understanding through the data. Third, the interaction of the collective using the Discourse of the collective transforms a topic from merely a struggle to a challenge that teachers as professionals grapple with and can draw on the professional Discourse to make sense of. In Cade's feedback discussion, this challenge concerns how to best engage students in learning science in inquiry-oriented ways when students have not yet developed the capacity to use the scientific practices to learn science concepts (Davis & Smithey, 2009). This means that in the context of the Peer Teaching feedback discussions, novices are able to identify, name, and make sense of challenges that have been identified, named, and investigated by others before them. This experience is different from the kinds of trial and error experiences that teachers often face and conceptualize in individual and idiosyncratic ways (Lortie, 1975).

Investigating Challenges by Articulating Thinking

As I argued in the previous section, the mechanism of investigating challenges by using the professional Discourse to articulate thinking is another way that novices develop professional vision in the Peer Teaching feedback discussions. In particular, investigating challenges by drawing on the professional Discourse builds collective capacity as the group members examine and express aspects of the challenge via the Discourse (Kazemi & Hubbard, 2008). The excerpt in *Table 5.3* from the second section of Cade's Experience feedback discussion illustrates the concept of investigating challenges by articulating thinking. In move #13, the teacher educator joins the discussion to articulate her thinking about the challenge of helping students to design an investigation to confront alternative ideas.

Table 5.2 *Cade's Experience Feedback Discussion, Excerpt 2*

Cade's Experience Feedback Discussion	Analysis
TE: (13) …One of the first pieces of developing an investigation is coming up with a question… but some of the things we want to figure out don't necessarily fit with that…you are talking about the weight, right? …So, having a place of my question: "Does the weight affect how far the trackball travels?" And then you can talk about, "We are talking about weight, what do we want to keep the same?" (14) That was something I was struggling with… (15) whether or not your objectives were to help students develop an investigation or whether it was actually to determine the content involved in this.	The TE envisions an alternative way to structure the investigation, identifies a challenge, and articulates that Cade had two separate objectives
Cade: (16) It was both; I had content and process goals.	He articulates what the TE just stated as content and process goals
TE: (17) So being able to piece those apart because…it was hard to determine when we are suppose to gather the content, when we are supposed to set up the investigation.	TE articulates two distinct objectives of learning content and learning the scientific practice of investigation design
Noemi: (18) But…I'm sorry…my understanding in science is that the content goals and the process goals are very intertwined and that you get at the content through the process, (19) so I don't understand the idea.	Noemi articulates her thinking about content and process goals as she identifies and attends to a challenge in the TE's articulation
TE: (20) The set up part…You're using the opportunity for students to create an investigation to get to the content, but you still have to have students figure out what it means to create an investigation first before you can get that content… (21) You have to make sure you focus on the investigation part before saying, "Okay, it went this far, what does that show us?" But we haven't fully developed …what our investigation is…	TE reiterates her earlier articulation and envisions an alternative in which students understand how to do the investigation before being able to interpret the results

In moves #13-#20, the teacher educator, Cade, and Noemi engage in a discussion in which they clarify the meaning of teaching with science process skills (i.e., scientific practices) and science content goals. The teacher educator questions Cade about his goals as either helping students develop an investigation or learn content. In move #17, she articulates her thinking, "…it was hard to determine when we are suppose to *gather the content*, when we are supposed to *set up the investigation*." In move #15, Noemi draws on the professional Discourse to disagree, "But…I'm sorry…my understanding in science is that the *content goals* and the *process goals* are very intertwined and that you get at the content through the process, so I don't understand the idea." She does so as a way to express her understanding of the professional Discourse, by referencing the terms that others use in science teaching. This opportunity to use the professional Discourse signals the gap between her understanding of content and process goals (as embodied in the Discourse) and the understanding of the teacher educator. The teacher educator is then able to clarify in move #20 that students must have the scientific practice skills first (e.g., knowledge of which variables to change and which to keep the same) before they can apply the scientific practice skills to do an investigation and learn science concepts. This illustration shows how investigating by articulating enables the group to express their understanding of a Peer Teaching interaction through the lens of the professional Discourse. In doing so, they are able to draw on embodied representations of the professional Discourse to begin to envision alternatives to the challenges.

Investigating Challenges by Envisioning Alternatives

Novice teachers also develop professional vision in the context of the Peer Teaching feedback discussions through the mechanism of investigating the challenges by envisioning alternatives. In the final excerpt of Cade's Experience feedback discussion included in *Table 5.3*, the novices with the teacher educator build on their earlier analysis to envision alternative ways to scaffold students' efforts to learn about variables and the concepts of force and motion.

Table 5.3 *Cade's Experience Feedback Discussion, Excerpt 3*

Cade's Experience Feedback Discussion	Analysis
Cade: (22) No, I understand you're saying. No, no. What you're saying is for each experiment we basically would have a mini investigation question…	Cade draws on the professional Discourse to envision an alternative with a "mini investigation question"
TE: (23) Yes, and I think that would have helped guide it better so that we could use the investigation [to learn the content].	TE articulates why Cade's alternative might work
Cade: (24) No, I did struggle with that…it's like the struggle between having it so procedural and leaving it… (25) It's hard to make a plan that's supportive and also is open, in the sense like students are going to be able to guide it. (26) What I'm getting from what you're saying is it's really important before we actually went into this trial that we define…what are we looking at in this [investigation]? In this [group] it was weight, then this [group] could have been size, and then this [group] could have been the ramp.	Cade identifies the challenge the TE named to elaborate why he finds it difficult, and envisions an alternative in which each group investigates a different variable
TE: (27) And the nice thing is you could then take all those together at the end and then go back and have a whole class discussion to get back at your main investigation question. You could then take all those together at the end and go back and have a whole class discussion to get back at [the content] in your main investigation question.	TE envisions an alternative in which the teacher combines the groups' finding to reinforce the content in the IQ, Cade's initial goal
Cade: (28) That was my plan and also I thought if [the class] was in small groups then different groups would probably [complete different trials]…because there's a lot of different things you could take from it.	Cade articulates his rationale for his initial plan, connecting back to earlier vision of the lesson
Noemi: (29) And it's hard… being that this isn't the beginning of the year, (30) and I figure in the fourth grade class you're going to do some work on forming investigations that might be even more simple…supporting them in that. (31)…because this probably isn't the way that you would have introduced how to form an investigation, you might use something even simpler to do it all in one.	Noemi identifies another challenge, the time of year (Jan.), envisions helping students learn to form investigations at the beginning of the year, and articulates her idea that teachers might start with a simpler investigation.
TE: (32) Does that make sense, Noemi? What we are saying about the investigation and the content? (33) I didn't want to make that confusing because you are correct you do want to use the practices to get to the content.	TE identifies the challenge Noemi raised earlier, and articulates the idea that teaching science involves using practices to emphasize content
Noemi: (34) But if [students] don't understand the practices… (35) So, starting with something even more simpler, to really get at that process and then to apply the process to a more complex content.	Noemi identifies the challenge, noting it would be problematic if students do not understand the practices, and envisions starting with a simpler investigation to help students develop the scientific practice skills

TE: (36) To give an example, one of the teachers we worked with, just to get her students in the process… of what it means to do an investigation she has them use M&Ms and they have to figure out what can happen to get the color off the M&Ms (37) is something they can go through and they can talk about what they want to change and what they want to keep consistent. So it's very specific, very simple investigation I think in the sixth grade. This is a very complex investigation to do later on in the year.	TE envisions an alternative and articulates Cade's earlier goal of helping students identify variables that are the same and different. She provides an example of Noemi's suggestion to introduce scientific practices at the beginning of the year, articulating a way that Cade could meet his earlier vision

In move #22, Cade builds on the teacher educator's articulation and his own understanding of the professional Discourse to envision an alternative, "What you're saying is for each experiment we basically would have a *mini investigation question*…" Since the groups were investigating different variables (e.g., the length and height of different ramps, the size and mass of different balls) one overarching investigation question would not work. It seems that Cade recognizes the importance of the investigation question in establishing a purpose for the investigation; so, he proposes a mini investigation question to better scaffold students' efforts.

Later in move #26, he elaborates on his earlier insight and offers a more specific question to facilitate the work of testing different variables, "What I'm getting from what you're saying is it's really important before we actually went into this trial that we define…what are we looking at in this [investigation]? In this [group] it was weight, then this [group] could have been size, and then this [group] could have been the ramp." Here, he envisions a specific plan to help each group understand the variable being altered in their particular investigation. One group could change the variable of the mass of the ball, the other the size of the ball, another the height of the ramp under the track. He even points to the imaginary group of students as he expresses his idea for improving his instruction in an elementary classroom (Cade's Experience Peer Teaching video).

This illustration indicates the ways in which investigating by envisioning serves to help novices develop professional vision. Envisioning alternatives provides novices with an opportunity to apply the professional Discourse to new interactions in elementary contexts. Especially in the simulated context of Peer Teaching where children are not present, envisioning is a necessity as it invites novices to apply new ways of talking about, thinking about, and doing teaching. In essence, it invites novices to imagine student thinking in relationships with instruction and science concepts.

Using the Professional Discourse to Imagine Student Thinking

In the previous sections, I used an illustration from Cade's Experience Peer Teaching feedback discussion to argue that identifying challenges that embody the professional Discourse, and investigating those challenges by using the professional Discourse to articulate thinking and envision alternatives are mechanisms through which novices develop professional vision in the context of Peer Teaching feedback discussions. These two processes are more fully actualized when the novices with the teacher educators transform a Peer Teaching interaction into an object of collective inquiry. This occurs as they use the professional Discourse as a lens to imagine student thinking in relation to instruction and science concepts.

In this section I use an excerpt from Lori's Explain feedback discussion (*Table 5.4*) to illustrate how the participants employ the professional Discourse as a lens to imagine student thinking as an object of collective inquiry. Across the entire data set, participants in 34 out of 41 feedback discussions (45 of 99 episodes) attended to the topic of student thinking.

Lori's Explain Peer Teaching lesson was the third and final lesson in the series of three lessons in the science methods course. Like Cade, Lori taught a Peer Teaching lesson on force and motion. The members of her Peer Teaching team include Lori, Scott, Diane, and Julie. Both

Scott and Lori taught the force and motion lesson while Diane and Julie taught the Ecosystems lesson. The Explain Peer Teaching lesson centered on "teachers" helping "students" compile observations recorded in the Experience lesson, identify patterns in a sensemaking discussion, and construct evidence-based claims to answer the investigation question.

Before this excerpt, the teacher educator points out that Lori's claim is written in a way that is confusing, so she suggests rephrasing the claim to emphasize the biggest collision. Her move to attend to a challenge in Lori's lesson is then elaborated and refined as the novices invoke the professional Discourse to articulate their thinking and to envision alternatives to foster student thinking as it relates to instruction and science concepts.

Table 5.4 *Lori's Explain Feedback Discussion*

Lori's Explain Peer Teaching feedback discussion	Analysis
Scott: (1) …in my planning of this unit, I didn't like that investigative question, biggest and smallest collision (2) because I thought it was confusing…somehow to make that language more precise because biggest collision—what does that mean--the biggest fall? Yes, that's a hard thing to kind of wrap your mind around it, especially as a kid.	Scott identifies a challenge related to the investigation question. He articulates his thinking that the language of the investigation question may contribute to student confusion
Lori: (3) If they don't get the way you're measuring big and small is by the distance travelled, it's hard, (4) because I guess…you could have made the ramp ball the constant and made the track ball the variable. (5) So, then the variable would of tied in more with the actual collision instead of it being the result of the collision.	Lori identifies the challenge and elaborates it by noting that students must understand the variables of the investigation She envisions an alternative of changing the variables to facilitate student understanding
Teacher Educator: (6) Yes, it's a little bit tricky.	TE identifies the challenge in agreement
Scott: (7) But then, that's hard (8) because really it's the mass of the ramp ball that affects the distance that it goes, right? …I guess a heavier track ball would go less distance with the smaller ramp ball. Is that really based on the size of the collision?	Scott identifies the challenge, and uses the Discourse of the science concept to articulate questions about the relationship between the variables and the science concepts
Teacher Educator: (9) Yes, I think it's the same point, which is why in the original lesson they have you modify the ramp ball, the track ball, and the angle [of the ramp]. There are so many things going on (10) … so I think you could have them modifying either [the ramp ball or the track ball] and make the same point.	TE articulate her thinking about the complexity of the lesson She reiterates Scott's question to envision an alternative investigation design
Scott: (11)…I didn't even think about that. The only	Scott articulates his thinking about the variables

thing I thought about was changing the ramp ball, but I think that would …make it more clear.	prior to the feedback discussion
Teacher Educator: (12) Yes, I liked the idea of changing *either* the ramp ball or the track ball. But getting back to organizing the data-- you have to get them to look at modifying one thing which ends up being a little bit tricky if you have a complex set of data…	TE articulates the connection between the investigation variables and the data student collects
Julie: (13) I wonder—I know this question came right out of the unit-- but I wonder why [investigation question] wasn't just the biggest collision? (14) They could still answer the smallest, to extend their thinking.	Julie identifies the challenge and uses the professional Discourse of the investigation question to envision an alternative in which the question is simplified
Scott: (15) That would be like the third part of the [EEE Framework] rubric about applying it to new problems. (16) You could easily, like you say, extend it, into that last part of the rubric.	Scott uses the professional Discourse to articulate Julie's suggestion as an example of the Explain phase of the EEE Framework. He re-states the alternative Julie had envisioned
TE: (17) Yes. The one I kept thinking about when I was thinking about biggest and smallest collisions was car accidents. But, you don't want to tell kids that, but if they come up with it, you could say, "What are some collisions or what are some examples in the real world?" They might come up with bowling. They might come up with car accidents.	TE articulates her thinking about the alternative by noting some ideas that students might have about collisions
Lori: (18) So, would it be better …to not even [talk about] creating the biggest collision? (19) I know when we were doing the reading about giving the discussion for arguments and then posing just two variables and saying, "Is it the size?" or "Is it the weight?" Could that be, I mean, at this age for first graders and second graders, like an appropriate investigative question, "Is it the size of a ball or the weight of the ball that affects collision?" Because that way they are looking at both of them...	Lori identifies the challenge and draws on the professional Discourse as represented in a course reading to articulate her thinking about why a simplified investigation question could support student understanding
TE: (20) Yes, then, you could modify both of those things in the experiment and see which one — "Okay, these two weigh the same but they're different sizes, did they go different distances?" Yes, that sounds like a great question.	TE builds on Lori's articulation to envision the alternative of modifying the investigation to emphasize one main question

In this excerpt, Lori, Scott, Julie, and the teacher educator transform an aspect of the Peer Teaching lesson, Lori's explanation claim statement, into an object of collective inquiry. Here, they use the professional Discourse to imagine student thinking in relation to instruction and science concepts. For instance, in move #1 Scott acknowledges the role of the investigation question. He had also taught the motion lesson and had grappled with the complex language of the investigation question. In move #3-#5, Lori emphasizes that students must understand the variables of the investigation to use the results to gain insight into the science concepts of force and motion. In move #8, Scott elaborates this discussion by using the professional Discourse of the science concept to relate the distances with the size of the collision. In move #13, Julie leverages a facet of the professional Discourse, the investigation question, to suggest a way to simplify the investigation for the first graders. In move #18, Lori draws on the professional Discourse as represented in a course reading to articulate her thinking about how a simplified investigation question could support student understanding. Taken together, in this discussion the novices with the teacher educator identify a challenge that embodies an aspect of the professional Discourse. Then they leverage the professional Discourse, providing topics like the investigation question, the variables of the investigation design, student thinking, and the science concepts students are learning, to imagine student thinking and to envision alternatives to improve the instruction.

The challenge topics as well as the envisioned alternatives discussed in Lori's Explain feedback discussion resemble those offered in Cade's Experience feedback discussion and in Noelle's Experience feedback discussion (presented in Chapter 4.) These challenges relate to the complex work of using investigations to support student thinking and to help students learn science concepts. Although they are teaching in separate rooms, and working with different teacher educators, the three groups all emphasize the role of the investigation question in directing students' sensemaking in the Experience phase and how facets of the investigation may support or impede student thinking about science concepts. These discussions demonstrate the importance of the professional Discourse. Here, it facilitated a process whereby the novices with the teacher educators identified challenges that were accessible to the group and investigated the challenges through articulation and envisioning alternatives. These mechanisms facilitated a process through which novices with the teacher educators transformed a Peer Teaching interaction into an object of collective inquiry. As such, when student thinking in relation to instruction and content becomes the object of collective inquiry, it emphasizes the rich possibilities for developing professional vision in simulated settings like Peer Teaching lessons.

As I noted in Chapter 2, Goodwin (1994) argues that the process of transforming phenomena into an object of inquiry important to the profession is not an automatic or easy task, even with the support of tools and the collective. He maintains that it is something that professionals must learn in community. However, scholars have documented the difficulties teachers face in attending to student thinking (Borko, Koellner, Jacobs, & Seago, 2011). For instance, their experiences observing teaching from the vantage point of a student has emphasized the work of teaching as an individual performance instead of what teachers do in relationships with students and content in environments (see for example, Cohen, 1990; Lampert, 1990). These findings suggest that simulated experiences in methods course settings offer opportunities for fostering novices' professional vision.

Challenges not Expressed through the Professional Discourse

In the previous section, I argued that developing professional vision for teaching involves identifying challenges that embody the professional Discourse and investigating those challenges by using the professional Discourse to articulate thinking and envision alternatives in classroom contexts. These mechanisms facilitate a process whereby novices with the teacher educators transform a Peer Teaching interaction into an object of collective inquiry in which participants use the professional Discourse as a lens to imagine student thinking in relation to instruction and science concepts. In this section, I further develop this argument by examining the feedback discussions in which these mechanisms are *not* emphasized. The richness of having all three is even more apparent in examining instances where all three are not present.

Two illustrations drawn from the study offer insight into the interactions in these feedback discussions in which participants identify challenges that were not expressed through the professional Discourse. As such, the participants do not use the Discourse as a lens to investigate the challenge by articulating their thinking and envisioning alternatives, nor do they imagine student thinking in relation to the instruction and science concepts.

Lea's Experience Feedback Discussion

The first illustration comes from Lea's Experience feedback discussion (*Table 5.5*). Like Cade, Lea taught the force and motion lesson. I include another force and motion lesson here as one way to indicate the differences across the discussions. The members of Lea's Peer Teaching team include Sam, Priti and Camille. This 8:29 minute feedback discussion, which includes two episodes, shows the novices along with the teacher educator attending to challenges related to general pedagogy. In this discussion, there are no instances in which Lea or her colleagues collectively attended to challenges. In addition, there were only two instances across Lea's team's Experience Peer Teaching discussions when two participants (one novice and one teacher educator) attended to student thinking. In only 7 of the 41 feedback discussions (54 of 99 episodes) did the groups *not* mention student thinking; this discussion after Lea's Experience Peer Teaching is one example from the seven. In the excerpt included below, the feedback discussion begins with one novice, Camille, who evaluates Lea's instruction and compliments the ways she helped the first graders take precise measurements of the distance the balls rolled down the track.

Table 5.5 *Lea's Experience Feedback Discussion*

Lea's Experience Feedback Discussion	Analysis
Priti: (1) Then having the tape too to mark where the ball ended [on the track], I think that's cool.	Priti evaluates an aspect of Lea's lesson
Lea: Yes. (2) I mean, I was worrying about that just (3) because if they were each in small groups that would become…a huge management issue; there's certain kids that I wouldn't trust to be able to do it…that's one thing I kept going back and forth about how realistic it would actually be to do it in this way.	Lea identifies a challenge concerning how to manage student behaviors as they complete the investigation She articulates her thinking about the feasibility of arranging students in small groups
TE: (4) I think the way you set it up…everything was very well outlined…I don't think there's any gaps in what you want the students to know and do and how you're going to run the experiment…I think your discussion about how to measure the ball at the front and the back, an interesting way to get students to think about the preciseness of how they are going to measure…(5) What might be difficult in that situation is if you have a class of 30 kids and they can't see.	TE articulates his thinking about the organization of Lea's lesson and student understanding of what to do He identifies a challenge about the difficultly of the entire class being able to see the ways to measure the balls on the track
Lea: (6) Yes, and I think I would try to do a teacher version of the ramp or something or just have everybody crowd around…(7) it was difficult enough for Sam and Camille	She envisions an alternative and acknowledges the challenge that two "students" in the Peer Teaching lesson faced
Sam: (8) But I think you calling attention to the specifics, the little details like how to release the ball, the numbers on the ruler, the tape for the start point…all play a big role into making sure that the experiment went smoothly. I think it was explained to the level of first graders.	Sam articulates his thinking about how the procedures of the investigation were explained clearly
Lea: (9) Yes, was it too much? I mean, it was kind of awkward because we did a lot of that last week…like in a real classroom I wouldn't have had to do that because it'd all be on the board.	Lea identifies another challenge about the ways she emphasized the procedures for students. She acknowledges the awkwardness of the Peer Teaching instruction

This excerpt shows Lea expressing her concern about managing students in doing the investigation-based lesson. In move #3, she notes that there are some students that she "wouldn't trust to be able to do it." In moves #4 and #8, the teacher educator and Sam maintain this focus on topics related to general pedagogy in her lesson. Specifically, they articulate their thinking about different parts of her instruction related to the procedures of doing the investigation, "everything was very well outlined," "well organized," "calling attention to the specifics, the little details like how to release the ball, the numbers on the ruler, the tape for the start point." These comments all relate to students' behaviors as they engage in the investigation. What is absent in this exchange is the view of students as thinkers. It seems that students are viewed as needing to be managed, and Lea as the teacher-manager. The challenge of teaching discussed here is not elaborated or refined via the means of the professional Discourse. It may be that the challenge identified, managing student actions, instead of managing student actions in service of their learning, does not embody the professional Discourse. If the challenge then is not a part of the professional Discourse there is no need for participants to draw on the Discourse to investigate it. In other words, they are able to adequately draw on their prior experiences with children to make sense of the challenge. Towards that end, the novices do not acknowledge the complexity of the instruction in the discussion; there are no instances of other novices attending to a challenge in Lea's lesson.

One explanation for the absence of the novices attending to challenges relates to the topic Lea identified. The general pedagogy challenge topic was one Lea as an individual grappled with, but it was not one that the others found to be complex or worthy of further investigation. As noted earlier, they were able to draw on their individual prior experiences with children to ascertain how to manage the situation (Lortie, 1975). Moreover, they did not see it as a challenge, embodied in the professional Discourse, which other teachers grapple with as well (Berlak & Berlak, 2011; Lampert, 1985). A second explanation is that the novices may see their role as peers who encourage each other. So, the feedback discussions may serve as a context through which to compliment the "teachers" instead of questioning their instruction (Noddings, 2003). This role differs from one who sees himself as a colleague working with others in the profession to build and contest professional vision (e.g., Bacevich, 2010). In Chapter 4, I presented an interview excerpt with Noelle in which she acknowledges the "culture of nice" that pervades teaching. Noelle recognizes that teachers' desire to compliment may impede the opportunity to analyze instruction and to envision ways to improve student thinking as it interacts with instruction and concepts.

Noemi's Experience Feedback Discussion

The second illustration is drawn from Noemi's Experience feedback discussion (*Table 5.6*). In Noemi's feedback session, similar to Lea's discussion, the challenge that is identified does not embody the professional Discourse. As a result, the novices do not use the Discourse as a lens to investigate the challenge by articulating their thinking and envisioning alternatives. However, what is different about Noemi's Experience feedback discussion is that the teacher educator introduces the challenge topic. Across the Experience discussions, 7 of the 16 feedback discussions did not include two or more novices identifying challenges. This means that either the teacher educator, like in the case of Noemi's discussion, or one novice, identified a challenge that was not taken up by another novice.

As noted earlier, Noemi was a member of Cade's Peer Teaching team who taught the ecosystem lesson (described in Chapter 4 with Noelle's Experience lesson). Cade's Experience feedback discussion was analyzed earlier as an example of a session in which novices and the teacher educator attended to a challenge that embodied the professional Discourse, investigated it through articulation and envisioning, and imagined student thinking as an object of collective inquiry. Given that the context was the same (Noemi's lesson was the first for the team that day), with the same novice teachers and the same teacher educator, Noemi's Experience feedback discussion offers insight into the significance of the challenges discussed in the different feedback sessions. In this discussion, the teacher educator questions Noemi about the ways that she conflated the scientific practices of making predictions and observations. Then, she asks Noemi about the format of her handout, in which she had separated the practices of drawing and writing observations.

Table 5.6 *Noemi's Experience Feedback Discussion*

Noemi's Experience Feedback Discussion	Analysis
TE: (1) I have a question with the word bank. What was your reason for having us list off non-living things before having seen the aquarium?	TE identifies a challenge about the way Noemi used the word bank with the science concepts of non-living things.
Noemi: (2) Um, I struggled with that. (3) I thought because the reading had been done…the students have done this reading and…I thought that if I took off the bag [covering the aquarium] and then had you come back to the word bank, that would be too disjointed…I thought that making predictions might be more useful than just telling you myself, but I thought it would be behaviorally too difficult to have it, jumping back and forth between the two…	Noemi acknowledges the challenge and articulates her rationale about using the predictions to help "students" refer to the ecosystem reading
TE: (4) So something to consider then you are actually combining—what we consider an observation and a prediction, and so the non-living things become predictions, and yet the other pieces become almost observations because we've already read about them, and (5) so you're actually combining two very different scientific practices on one sheet and so gets confusing…	TE articulates Noemi's instructional decision as conflating the two separate practices of observations and predictions TE identifies the challenge of combining the two practices
Noemi: Okay.	
TE: (6) I just had another question with the worksheet. What was your motivation for dividing it up in that format?	TE identifies another challenge in Noemi's instruction related to her observation data sheet
Noemi: Um…you mean in picture and writing?	
TE: (7) So no, you have "I observe blank and blank" and then we have a picture and writing and you do another, "I observed blank and blank" and a picture and writing. So you are actually pulling out pieces of the aquarium instead of doing it as more of a consolidated unit.	TE articulates her thinking to explain that Noemi is directing students to draw and write about parts of the eco-column aquarium
Noemi: (8) Because I wanted to focus their observations on interactions, and then if I were giving them two spaces to fill in then they'd be able to focus on two animals because there are two things. Because there is so much going on that if I felt that using this would help them focus on the interactions and really specifically on just two	Noemi draws on the professional Discourse to articulate her reasoning; she wanted to support students in making observations that would enable them to answer the investigation question about how living things depend on living and non-living things

different components that would get them at the…dependence of living and non-living things…	
TE: (9) Both. Because one thing to consider, the structure of it for first grade is nice… but…one of the things that students have a lot of challenges in making observations is location. So for example, they'll put duckweed in the middle, because they're having a hard time figuring out the actual location of things, and so when you pull it out in pieces they don't get that practice.	TE references a specific student challenge to articulate her point that Noemi's handout may exacerbate the difficulty students face in making precise observations

This excerpt from Noemi's Experience feedback discussion shows the teacher educator identifies two challenges in Noemi's lesson. In move #3, she asks, "What was your reason for having us list off non-living things before having seen the aquarium?" In move #11, she asks, "What was your motivation for dividing it up in that format?" Noemi responds with uncertainty, "Um… you mean in picture and in writing?" Unlike in Cade's Experience feedback discussion where the novices participated in identifying challenges, investigating by articulating and envisioning, and imagining student thinking, here the teacher educator dominates the discussion with moves to identify challenges, articulate thinking, and envision alternatives. Noemi, as well her colleagues, mostly remain silent.

To offer additional insight into the interaction and the absence of the novices' moves to identify challenges, and investigate by articulating thinking and envisioning alternatives, I provide an excerpt from an interview with Noemi immediately following her team's Peer Teaching lessons. As I explained in the methods chapter, Noemi was one of the four focal participants who was interviewed in each Peer Teaching team.

In this excerpt, Noemi is asked to discuss which piece of feedback from the Peer Teaching feedback discussion stood out for her. She explains the challenge the teacher educator identified from her lesson surprised her.

(1) Interviewer: Which piece of feedback stood out for you..?

(2) Noemi: I guess the need [for students] to free observe first…I guess it was the in-class [science methods course] discussion yesterday; I was under the impression that it would be necessary to focus student observations on the investigative question…because the investigative question is the framework for the investigation… And I guess I didn't realize that it was necessary to have that open observation piece first.

(3) Interviewer: Okay. And why do you feel like that stood-out?

(4) Noemi: Because it surprised me…

(5) Interviewer: How did the feedback feel, either from the ….?

(6) Noemi: It felt really frustrating from the…teacher educator...it feels frustrating because I don't feel like I …understand completely how to teach in an EEE framework. So it feels like I'm being judged unfairly about something that I wasn't taught to do. So it's so frustrating to me. I do take feedback well normally, but in this instance it did make me like sort of borderline confrontational and very frustrated. …like if it had come from my peers where I've built more relationships with…and like I see their credentials so it's more meaningful…

In line #4, Noemi explains the teacher educator's feedback about not conflating students' predictions, observations, and explanations surprised her. It surprised her because she was under the impression, based on the discussion from the previous science methods class, that she should focus students' observations on interactions, the concept emphasized in the investigation question. In line #6, she describes feeling judged unfairly in the feedback and explains that she did not feel confident in teaching the EEE framework. As such, she felt she was being judged unfairly in something she had not been taught to do. Her comments suggest she had expected feedback that would resemble the topics she had been learning and practicing. She emphasizes that she had designed her lesson to purposefully reflect the previous day's discussion about helping students to record observations about interactions, so she was surprised when the Teacher Educator contested her instructional decision.

Similar to Lea's Experience feedback discussion, in Noemi's discussion, the novices do not enact the moves to identify challenges and investigate by articulating thinking and envisioning alternatives. Instead, the teacher educator enacts these moves. These findings raise the question of why the novices, active in questioning Cade during his lesson, are silent in Noemi's feedback discussion. Furthermore, their lack of involvement in Noemi's discussion did not resemble the ways they consistently enacted moves across their team's discussions to identify challenges in each other's instruction (see Table 4.5). For instance, Nina and Noemi both press Cade in his Experience Peer Teaching feedback discussion to articulate his instructional decisions.

To consider the novices' silence in Noemi's feedback discussion, I return to the concept of professional Discourse. In Noelle's interview provided in Chapter 4, she underscored the importance of having a shared understanding of the feedback a teacher could receive about her instruction. That is, she wanted others to notice what she saw in her own teaching practice. Likewise, in her interview Noemi expresses frustration in receiving feedback about topics that were not a part of what she was learning in the science methods course (the teacher educator with Noemi's group was not the instructor). She was surprised by the feedback because she felt like the goal of her lesson--to support students in making observations that connect to the investigation question—reflected the big ideas emphasized in the methods course the previous day.

In her interview, Noemi admits that if the feedback had come from a peer, it would have been more meaningful. One explanation for this assertion could be that as peers in a cohort-based teacher education program, the novices might in fact notice similar things because they are learning the same Discourse. Furthermore, they share a status as new members in the profession, and are inevitably grappling with similar challenges. This suggests the topics that novices notice in their peers' instruction may reflect the same topics they are struggling to master in their own teaching practice. Noemi's interview implies that the challenge identified in her instruction did not embody the professional Discourse she and her peers were learning. As a result, neither she nor her peers were able to use the professional Discourse as a lens to investigate the challenge and to envision alternatives. Moreover, they were not able to make available their thinking about the issue for others to examine. Instead, only the teacher educator, who identified the challenge, was able to engage in the analysis and articulate her thinking. This suggests that opportunities to develop professional vision for practice in the Peer Teaching feedback discussions involved identifying challenges of the professional Discourse, so that novices were able to leverage the professional Discourse to articulate their thinking about the challenges and to envision alternatives to the challenges in classroom contexts.

CHAPTER 6

CONCLUSION

The central research question in this study was: *How do preservice teachers develop professional vision for practice in the context of Peer Teaching feedback discussions*? The findings of the study suggest that developing professional vision in simulations involves learning to notice and use what is valued in the profession (the professional Discourse) through social mechanisms, and this process happens in interacting contexts. In particular, my analyses indicated that opportunities for developing professional vision occurred as the participants (1) established a professional Discourse through tools; (2) approximated the professional Discourse through roles; (3) identified challenges of the professional Discourse; (4) used the professional Discourse to articulate thinking about the challenges; and (5) used the professional Discourse to envision alternatives to the challenges. The Peer Teaching context, which was shaped by the science methods course and the teacher education program contexts, supported and constrained novices' noticing. This was evident in the ways novices expressed a contradiction between two competing objects of developing professional vision: identifying problems of practice and affirming peers' practice. Figure 6.1 shows the nature of developing professional vision for practice in simulations, as illustrated by this study. This illustration guides my discussion of the findings in this conclusion.

In this chapter, I first consider the theoretical implications of this study for the development of professional vision. In particular, I use the concept of professional Discourse to re-conceptualize the process of learning to notice as seeing and making sense of events in ways that reflect the practices and principles of the profession. I also consider the concept of interacting contexts, drawn from the idea of activity systems in Activity Theory to highlight the inherent complexities in developing professional vision. Next, I use the concept of professional Discourse and interacting contexts to explore implications for designing practice-based opportunities to foster novices' noticing. I conclude this chapter by discussing the limitations of this study and by outlining directions for future research.

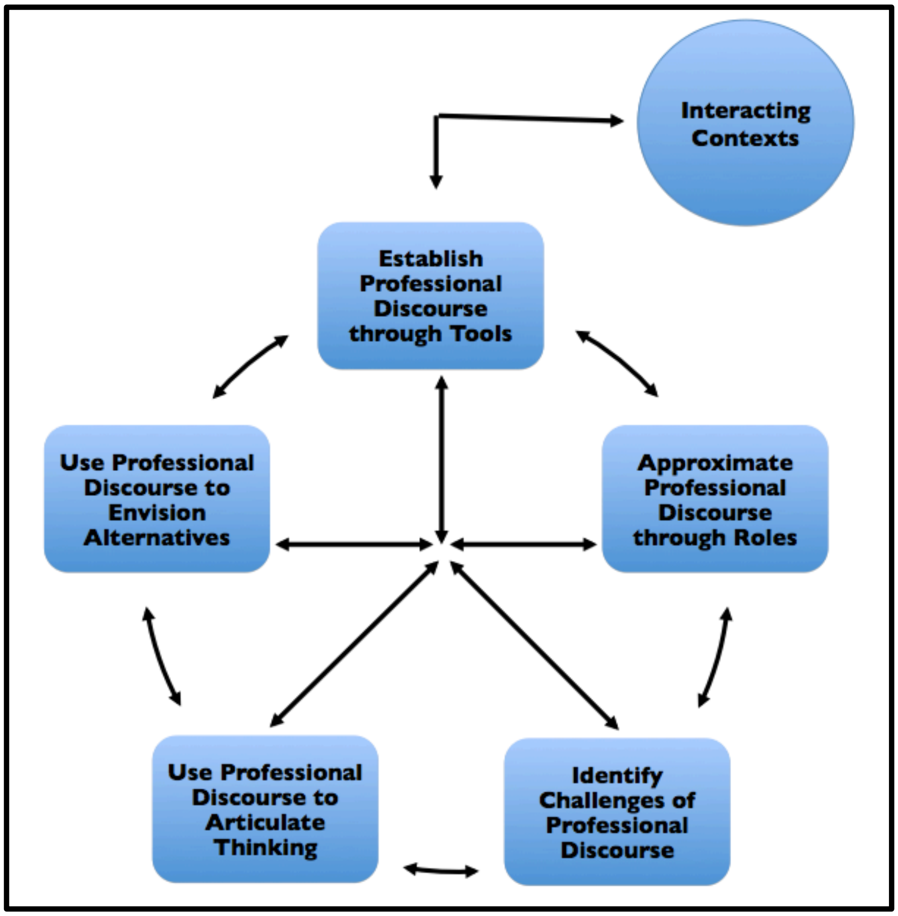


Figure 6.1 Developing professional vision for practice in simulations

Theoretical Implications

Professional Discourse

Developing professional vision in simulations involves learning to notice and use what is valued in the profession (the professional Discourse). Applying the concept of professional Discourse (Freeman, 1993; Gee, 1989) to the development of professional vision is an important theoretical contribution of this study because it emphasizes the socially situated nature of what and how novices notice. As new members of the profession, novices' attention may be drawn to topics that reflect prior experiences (e.g., apprenticeship of observation) rather than topics that are valued in the teacher education program. The findings of this study suggest that establishing a professional Discourse in the science methods course may have helped novices notice particular aspects of science teaching and learning. Consistent with prior research on noticing (van Es & Sherin, 2002) my analyses indicated that novices noticed a variety of topics, ranging from student thinking to general pedagogy. However, unlike prior work on noticing, the findings illustrated that novices attended to the topic of student thinking more than any other topic (58 times). They also attended to topics of scientific practices such as designing investigations and making and recording observations (36 times) more than general pedagogy (25 times). The top three of the nine topics participants noticed—student thinking, science concepts, and investigations—reflect the science teaching practices advocated in the science methods course and in the *Next Generation Science Standards* (National Research Council, 2012). These numbers serve to illustrate novices' noticing by suggesting that novices were supported to notice particular aspects of science teaching and learning.

Other scholars of noticing have found that teachers may struggle to attend to topics, such as student thinking, that reflect current reforms (M. G. Sherin et al., 2011). To foster teachers' attention to student thinking, these scholars are examining ways that facilitators (Borko et al., 2011) and technology in video clubs (van Es & Sherin, 2010) can direct teachers' attention and sensemaking towards student thinking. The socially situated nature of noticing evident in this study suggests that the work of the facilitators and technology prompts may in fact be establishing a professional Discourse. That is, developing a shared understanding of what to notice and how to reason about and name what teachers see. Conceiving of developing professional vision as socially constructed emphasizes the collective and shared, rather than the individual and idiosyncratic, nature of the process.

So, what was the professional Discourse that novices noticed? Consistent with Gee's (1989) work on Discourse, this study demonstrated that the professional Discourse constituted particular shared ideas, practices, and language of science teaching and learning that participants used. For instance, my analyses indicated that the novice teachers used jargon as shorthand to represent the instruction they noticed and their shared beliefs about it. In Nina's Engage feedback discussion, the novices articulated the concepts "Engage" or "Phase" to express shared ideas about the science teaching practices and principles of the Engage phase. In the science methods course, the concept "Engage phase" of science teaching and learning denoted particular science teaching practices and ways of viewing students as sensemakers with misconceptions. These practices and principles of engaging students at the beginning of a science lesson involved the following: (1) eliciting students' ideas and misconceptions, (2) engaging students with an investigation question, and (3) encouraging students to write predictions about the investigation question (see Appendix A).

Identifying challenges of the professional Discourse invited novices to employ their shared ideas to make sense of the challenges. For instance, after her Engage Peer Teaching, Nina identified a challenge of the professional Discourse related to responding to students' ideas in the Engage phase. In her lesson, she had elicited students' ideas about the investigation question from her ecosystems lesson, and Cade had responded with a misconception. He had role-played the documented science misconception in which students anthropomorphize plants and animals as helping each other in ecosystems. After Nina shared that her first reaction was to correct the misconception, Cade emphasized that in the Engage phase teachers should probe students' ideas but not correct any alternative ideas, "…as an *Engage stage,* you didn't sort of step in [and correct the misconception], but you acknowledged that we were wrestling with it and encouraged us to keep thinking about it" (Nina's Engage feedback discussion). Then Noemi agreed and added that in the Engage phase teachers should not redirect students' ideas, but rather record all of their questions on the board, "…in this *Phase*, I would have almost written everything we are wondering and I've sort of gotten to the same problem …in my [field placement] classroom, and not really knowing what I should write up and what's considered scientific, but I think in the *initial Phase* like getting all the questions up there" (Nina's Engage feedback discussion). Nina's Engage feedback discussion illustrates how the concept of *Engaging* students was an aspect of the professional Discourse, and it represented shared ideas about how to begin a science lesson. In sum, conceiving of professional vision as noticing the professional Discourse emphasizes the social and collective nature of the process. This suggests that novices' noticing may reflect what is valued in their social setting more than their individual beliefs or knowledge.

Interacting Contexts

Another important theoretical implication of this study is the conceptualization of learning to notice as occurring in interacting contexts. Applying the concept of interacting contexts to the development of professional vision emphasizes the competing demands that novices faced in learning to notice across the Peer Teaching and teacher education program contexts. In Activity Theory, Engeström (1989) refers to these contexts as separate but interacting activity systems. Activity systems are an "object-oriented, collective, and culturally mediated human activity" (Engeström, 1999, p. 9). Given their social nature, activity systems may be driven by different goals or governed by different rules. Engeström found that multiple perspectives within and between activity systems might generate contradictions. Contradictions are not the same as problems; they are structural tensions that can act as sources of change and development. They can provide opportunities for the participants to re-envision the elements of the activity system.

My analyses suggested that the process of developing professional vision in the Peer Teaching was subject to emergent contradictions. These tensions were expressed as two competing views of the object (motive) of Peer Teaching: identifying problems of practice and affirming peers. To illustrate this process, I present the contradictions of the Peer Teaching activity system in Figure 6.2. The purpose of the figure is not to merely label the elements but to show the dynamic interplay between them, which emphasize the collective and inherently complex nature of developing professional vision. Understanding these contradictions can provide opportunities to re-conceptualize the mechanisms through which novices develop professional vision.

The Peer Teaching activity system was directed by a collective *object* or motive (e.g., developing professional vision for practice) (Leont'ev, 1981). All actions within the activity systems are interpreted in light of the object (motive) and accomplished by the participants, the *subjects*. From the perspective of a teacher educator, the *object* (motive) of the Peer Teaching was to provide novice teachers with an opportunity to investigate problems of practice. To attend to these challenges of the professional Discourse, novices used mediating *tools,* such as the EEE Framework and research-based student misconceptions and scientific practice challenges. When people collaborate with others to use tools, the knowledge is stored in the practices of the group rather than one individual's mind (Gee, 2008). Novices' tacit knowledge and prior experiences (such as their apprenticeship of observation) were also used as tools.

The interactions in the top half of the activity system model (*subject↔ tool↔ object)* were implicitly influenced by the social structure of the Peer Teaching, represented by the bottom half of the model (*norms↔ community↔ roles)* (Engeström, 1987). The *community* included all of the participants who shared the same object, including the teacher educators and the novices. The *roles* represented the division of labor, or who did what within the activity system, and who was privileged with the power and status (Johnson, 2009). In the Peer Teaching, the participants acted as colleagues as they engaged in role-plays to help each other learn to teach. The novices and teacher educators' actions in the community were determined by *norms*, explicit and implicit rules and expectations that shaped the interactions and their work to achieve the object (motive) of the activity system.

The findings suggest that contradictions were expressed as competing views of the roles, norms, tools and object of the interacting contexts of the Peer Teaching and teacher education program. For example, my analyses demonstrated that participants used moves to evaluate the instruction 24 times across the data set (see Table 4.4). These moves represented instances in which novices complimented their peers' instruction (e.g., "I liked when you …")

rather than problematized the instruction (305 times) or expressed their thinking about the instruction through articulation (240 times). Contradictions may have occurred because the Peer Teaching activity system introduced a new element (e.g., the object of problematizing practice), which led to contradictions between the old element (affirming peers' practice) and the new one. This contradiction may have occurred because of the different roles (friends, colleagues, novice teachers) the novices adopted across the interacting contexts.

The following example from Priti's Experience Peer Teaching feedback discussion illustrates the contradictions that emerged due to the divergent views of the object, roles, and tools of the interacting contexts. Here, Priti's peers, Camille and Lea, minimize a problem of practice Priti identified about orienting students to others' comments in her lesson.

> Priti: The one thing that I saw myself that I would like to revise is that I didn't do a whole lot of orienting students to one another this time as much as I did last time. Last time I really made a move to direct them to one another, "What do you think about this? and Can you comment on that?" and I didn't do a whole lot of that this time.
>
> Camille: You set the bar for yourself really high last time.
>
> Lea: I liked that you paired us up into groups, to make it even smaller.

Rather than problematize Priti's instruction (object) and help her to investigate her teaching as a colleague (role), Camille and Lea minimize the problem and complexity of teaching (competing object) and take on the role of an encourager or friend (competing role). Here, the contradictions between the object and the role facilitated an outcome in which the novices avoided critique. A contradiction related to the use of the tool, the professional Discourse, was also evident in this episode. The professional Discourse was established to mediate novices' efforts to identify and make sense of problems of practice. However, in Priti's discussion, she did not draw on the professional Discourse to identify a problem related to helping students use scientific practices to learn science concepts. Likewise, Camille and Lea did not leverage the professional Discourse to discuss why it is important for teachers to orient students to one another's scientific ideas. Identifying topics that were not expressed in the professional Discourse, such as behavior management, occurred across Priti's team's Experience Peer Teaching discussions (see Table 4.5). There were only two instances of the participants, one novice and one teacher educator, imagining student thinking across the Experience feedback discussions for Priti's team[9]. The focus on students' behaviors rather than students' ideas reflect another tool—socially-constructed ideas about teaching from novices' "apprenticeship of observation" (Lortie, 1975). Similarly, in a discussion about how to improve her Experience Peer Teaching, Lea suggested conducting one teacher demonstration, because she believed the students would not be able to manage the complexities of the investigation in small groups (see Chapter 5). Thus, rather than apply the professional Discourse to envision alternatives, Lea instead looked to her prior assumptions about students' capacities to use investigations. These findings, that novices struggled to problematize their peers' instruction and to articulate the professional Discourse, resembles other studies on peer feedback (e.g., Bacevich, 2010; Benedict-Chambers, 2012).

---

[9] As shown in Table 4.5, during the Explain Peer Teaching feedback discussions, Lea's team did enact moves where the novices identified challenges and attended to student thinking, scientific practices, and science concepts.

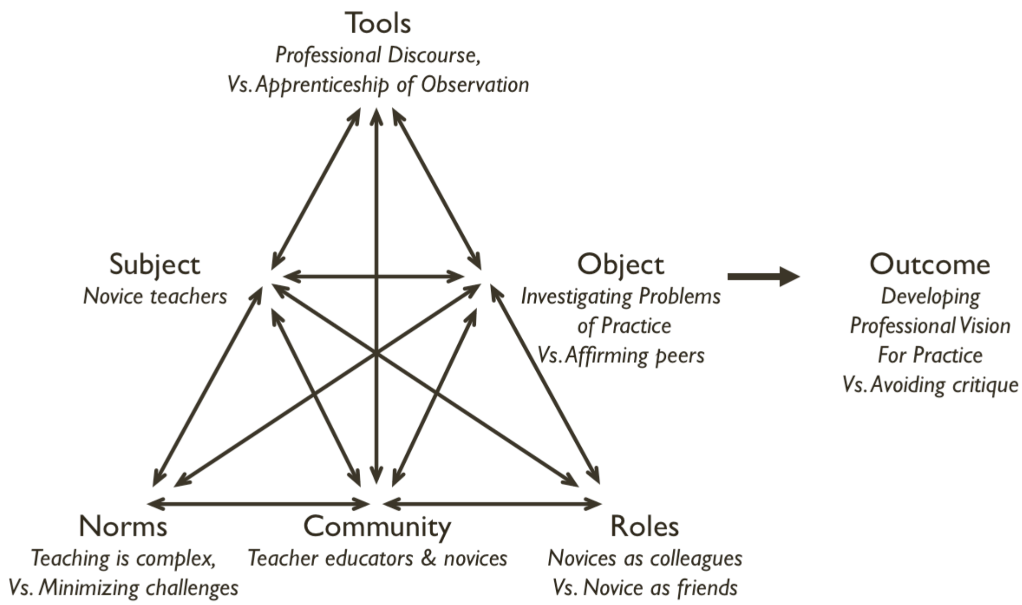


Figure 6.2 Activity Theory Illustration of the Peer Teaching Contradictions

Implications for Teacher Education

The concepts of professional Discourse and interacting contexts have implications for the design of practice-based opportunities in teacher education. In particular, these concepts have implications for the design of teaching simulations to support novices' development of professional vision.

Establishing Professional Discourse through Tools

The findings of this study suggest that tools may serve to establish a professional Discourse in simulations. My analyses demonstrated that the tools of the EEE Framework and the lists of student misconceptions and scientific practice challenges could reflect the views and ways of teaching advocated by the *Framework for K-12 Science Education Standards* (National Research Council, 2012). In particular, the EEE framework named and organized the practices and principles of science teaching. The EEE framework delineated teaching as *Engaging* students' ideas, and helping students to collect data to *Experience* and *Explain* scientific phenomena. The framework established a shared language the novices could use to make sense of the problems of practice.

The use of the tools was evidenced by the language novices employed to discuss and make sense of their noticing. For instance, in Nina's Engage Feedback discussion described earlier, Nina identified a problem of practice about responding to a student's misconception. Here, novices leveraged the concept of the "Engage phase" to express shared understandings. In Cade's Experience feedback discussion analyzed in Chapter 5, novices used the language of "student's alternative ideas," "investigation question" and "science process goals" (see Table 5.1) to collectively analyze Cade's Peer Teaching. Moreover, the fact that the participants articulated the scientific practice topics across the data set, for instance, making and recording observations (36 times), investigation questions (22 times), constructing evidence-based claims (19 times) and predictions (13 times) suggests the novices were drawing on the professional Discourse to support their noticing (see Table 4.3). These findings suggest that teacher educators may want to establish a shared language of teaching and learning that embodies the professional Discourse (Freeman, 1991). This shared language can then inform the problems of practice that novices with the teacher educators investigate in the simulations. Other scholars have emphasized the importance of establishing a shared language for novices teachers (e.g., Grossman, Hammerness, et al., 2009).

Consistent with Gee's (2008) argument that tools can help individuals develop knowledge by storing it in the language and practices of a group, the EEE Framework and the lists of student misconceptions and scientific practice challenges could represent the professional knowledge of experienced science teachers. The examples of student misconceptions used in the approximations represented documented ideas that children (and adults) hold about ecosystems and force and motion (e.g., Driver et al., 1985). The scientific practice challenges indicated actual difficulties students face in using scientific practices, such as making and recording observations and collecting qualitative data, as they conduct investigations. While teachers could likely learn these ideas over years of experience, making explicit students' challenges enabled the novices to collectively investigate and manage them in the simulated setting.

Establishing Professional Discourse through Roles

One implication of this study is the value of using role-plays in simulations. Consistent with Ronfeldt and Grossman's (2008) argument that opportunities to observe, experiment with, and evaluate new roles and new ways of teaching in approximated settings may provide novices with opportunities to develop a professional identity, my analyses indicated role-plays could help novices acquire a professional Discourse. Given that acquiring a professional Discourse involves becoming a teacher with particular views of teaching and learning, role-plays may be especially important for novices learning to teach science. Like other research on beginning science teachers (Zembal-Saul et al., 2000), the findings indicated that novices had few opportunities before the science methods class to practice teaching science lessons (Noelle, first interview; Scott, first interview; Noemi, first interview). In particular, novices tend to have few experiences using scientific practices, such as constructing scientific explanations, to help students learn science concepts (Davis et al., 2006). Guided by the tools of the EEE framework with the student misconceptions and scientific practice challenges, novices role-played "science teachers" and "elementary students" engaging in authentic interactions. Specifically, the role-plays provided novices with opportunities to enact the roles of "teachers" teaching science in ambitious ways (Windschitl et al., 2012) and responding to documented student misconceptions. "Teachers" had a chance to practice eliciting and interacting with the resilient nature of students' ideas (e.g., Watson & Konicek, 1990). Distilling the work of teaching to managing productive relationships among students' ideas, scientific practices, and science concepts meant that novices could focus their attention on essential interactions. Absent were the distractions and the competing demands novices often face in elementary classrooms, such as managing students' engagement in complex investigations (Davis et al., 2006).

One surprising finding and important implication of this study is that role-playing "elementary students" may help novices imagine students' thinking in interactions with scientific concepts and scientific practices. As indicated in the study, participants explored students' ideas in 34 of the 41 Peer Teaching feedback discussions (see Table 4.5). They problematized scientific practices in 37 of 41 Peer Teaching feedback discussions and science concepts in 33 of 41 feedback discussions. The emphasis on noticing student thinking, scientific practices, and science concepts was surprising to me given that research on novice and veteran teacher noticing suggest that teachers are more likely to attend to students' behaviors than their thinking (M. G. Sherin et al., 2011). Furthermore, novices were not explicitly prompted by the teacher educators to notice student thinking in the feedback discussions; rather, teacher educators asked open-ended questions such as, "What did you notice from Diane's lesson?" (Diane's Engage feedback discussion).

The findings of the study demonstrated that attending to student thinking occurred in two ways: (1) "students" offered feedback to the "teachers" by referencing specific ideas they had role-played; and (2) novices used their own thinking as learners to envision alternatives to the instruction to better support student thinking. These findings that novices could imagine students' thinking in a setting where children are absent are consistent with Gee's work (2008) on the concept of embodiment. He argues that learners are able to build model simulations based on experiences. He explains that in video games of skateboarding, players are able to draw on their experiences of skateboarding in a real skate park to design a virtual skateboarding park. Here, the players must solve problems (they've created) to skate in the park successfully. Gee asserts, "We build our model simulations to help us make sense of things and prepare for action in the world. We can act in the model and test which consequences follow before we act in the real world" (p. 85). The concept of embodiment suggests that while elementary children are not present in the Peer Teaching, novice teachers can draw on prior experiences with children to imagine their responses. Furthermore, they can envision student responses by leveraging the student misconceptions and scientific practice challenges tools. Finally, novices can use the simulated teaching experiences to inform future interactions with elementary children. For instance, they could reflect back on a problem of practice that was discussed to ascertain how to manage a similar challenge they face in the classroom setting.

Other scholars have documented the affordances of teachers observing teaching from the vantage point of an "elementary student" (Nelson, 2011; Shah, 2011). However, there are few studies that investigate the value of assigning novices to role-play particular research-based misconceptions and scientific practice challenges, examples of student thinking that embody the professional Discourse. Rather, studies emphasize how the teacher educator role-plays common student challenges in teaching simulations (Lampert et al., 2013). Thus, a contribution of this study is that it demonstrates the value of asking novice teachers to enact roles that personify aspects of the professional Discourse via tools that reflect student misunderstandings.

Identifying Challenges of Professional Discourse

In the conceptual framework of this study, I presented Goodwin's (1994) characterization of professional vision as socially organized ways of seeing and understanding phenomena relevant to a profession. In this study, seeing and understanding teaching involved identifying challenges of the professional Discourse (see Figure 6.1). My analysis indicated that in 40 of 41 Peer Teaching feedback discussions, participants identified science teaching and learning challenges (e.g., "I struggled…" "I have a question…" see Table 4.5). Across the four Peer Teaching teams' discussions of the three lessons, there was only one discussion, Diane's Engage feedback discussion, where participants did not identify any challenges. Furthermore, novices' noticing of the topics occurred within the episodes of attending to challenges in the feedback discussions. Thus, exploring challenges of the professional Discourse was a central means for learning to teach in the Peer Teaching. This suggests that teacher educators may want to consider ways to support novices in identifying teaching challenges in simulations. Collective investigations of teaching challenges afford an opportunity to build and contest the professional Discourse.

Using the Professional Discourse to Articulate Thinking

Consistent with Freeman's (1991) work on articulation, the findings indicated the novices employed the professional Discourse to articulate their thinking about the teaching challenges. Freeman used the term "articulation" to characterize the ways teachers use the Discourse of the teacher education program to rename their experiences and to assign new meanings to their teaching practice. Novices with the teacher educators engaged in articulation 400 times across the data set (e.g., "This happened because…" I think when you…"). Novices' moves to articulate their thinking occurred more than any other move across the 41 Peer Teaching feedback discussions (see Table 4.4). Articulation in learning the professional Discourse emphasizes the manner in which novices draw on the professional Discourse to express their thinking. In articulation, novices became members of the same community who value the same principles and practices of teaching. In the Peer Teaching feedback discussions, articulation helped to build collective understanding of the professional Discourse. It also enabled teacher educators to assess the emergent understandings of the novices, and to ascertain if novices' thinking resembled or diverged from that of the profession. This suggests that teacher educators could help novices to engage in articulation by establishing a professional Discourse through which novices could rename and reconstruct their practice (Freeman, 1993).

Using the Professional Discourse to Envision Alternatives

The novice teachers also developed professional vision in the simulations by using the professional Discourse to envision alternatives to the teaching challenges. The findings indicated that the move to envision alternatives occurred 240 times across the data set (e.g., "I would have…" "In a 4th grade class you'll need to…"). Envisioning alternatives provided an opportunity for the novices with the teacher educators to use the professional Discourse to manage challenges. For instance, in Nina's Engage feedback discussion described earlier, the challenge Nina identified had to do with responding to students' misconceptions in the Engage phase. Novices were able to leverage the shared practices and principles of the professional Discourse to consider ways they could elicit, and not correct, students' misconceptions in elementary classrooms. The mechanism of envisioning alternatives indicates that novices were able to use what was valued in their profession to make sense of the same challenges teachers face in elementary classrooms.

Implications for Developing Professional Vision in Interacting Contexts

A final implication of this study for the design of practice-based opportunities is the concept of interacting activity systems. Earlier, I highlighted the competing demands that novices faced in terms of the object (motive), roles, and tools of the Peer Teaching and teacher education program activity systems. In this section, I discuss the ways the interacting contexts could *facilitate* the object, tools, and roles of the professional Discourse. In doing so, I want to highlight an important implication for teacher educators—the objects, tools, and roles cannot be emphasized in just one activity system, like the Peer Teaching. Rather, the objects, tools, and roles must be used across the network of interacting activity systems.

Teacher educators may want to consider ways the teacher education program could develop shared tools, such as language, to emphasize a shared object (motive). In this study, the object was developing professional vision—learning the practices and principles valued in the profession (professional Discourse) by identifying challenges, articulating thinking, and envisioning alternatives. The findings indicated the teacher education program used shared tools to establish the same teaching practices and principles across the novices' methods courses. For instance, two instructors in the program articulated a list of "Principles of High Quality Teaching and Principles for Learning to Teach" (Scott & Lewis, 2008) to inform methods course instruction and syllabi. These documents contributed to shared principles and practices of teaching (e.g., "Children are sensemakers"). These documents also made explicit the ways in which people learn to teach. For instance, "Teaching is something that can be learned. Learning to do something requires repeated opportunities to practice. There is value in making teaching public" (e.g., Lampert, Ghousseini, & Beasley, 2010). As a research assistant to the instructors of the novices' first methods course in the program, I was able to observe how the norms and teaching practices of engaging with students as sensemakers were established. For instance, I saw that the instructional goals for novices' learning on day two of their mathematics methods course in a local summer school focused on "eliciting students' ideas and thinking around how they are using mathematics strategies" (field notes, July 6, 2011). Here, the novices were able to take on a new identity-kit via the values of the professional Discourse.

Developing feedback protocols is another way teacher educators can help novices develop a shared understanding about how to learn the professional Discourse. In particular, the protocols could serve as tools to help novices investigate (rather than evaluate) their peers' instruction (see Figure 6.3). Moreover, protocols could focus novices' attention on student learning rather than topics of general pedagogy. Other research has documented the benefits of teachers using protocols to offer feedback (e.g., Curry, 2008). The sentence frames in the protocol direct novices to question their instruction and their peer's instruction and to remain focused on how student thinking might be impacted by the lesson.

Likewise, feedback forms, like the EEE Framework form, could be used across a teacher education program to outline the work of teaching and to establish a professional Discourse. A framework for organizing the practices and principles of teaching might also support novices in using the Professional Discourse (rather than their apprenticeship of observation) to articulate their thinking (e.g., Freeman, 1993). In addition, feedback forms might direct novices to record evidence of the instruction, in the form of observed teaching practices and principles, rather than evaluating (complimenting) the instruction.

Protocol for discussing instruction and offering feedback: Use examples from the lesson as evidence to support your claims.

If you were a "teacher":

- "I struggled to know how to support students' learning when X happened in the lesson…"
- "When the "student" said X in the lesson, I struggled to know how to respond to his/her ideas…"
- "I think the way I did X could confuse students' learning of those concepts…"

If you were a "student":

- "I was confused by when you did/said X… I wonder how elementary students would respond to X in the classroom."
- "I think elementary students could be confused by X in the lesson…"
- I was wondering about the X decision you made in the lesson…?

Figure 6.3 Protocol for discussing instruction and identifying problems of practice

Finally, teacher educators may want to leverage roles to help novices acquire a professional Discourse across the interacting contexts. The findings of this study suggest the use of the "teacher" and "student" roles in simulations were emphasized across the teacher education program. For instance, in the novices' first math methods course in the teacher education program, they engaged in rehearsals before teaching children in summer school (field notes, July 6, 2011). The multiple opportunities to engage in role-plays may explain why the novices acknowledged their value. For instance in Priti's Explain feedback discussion, Sam explained that he wanted his responses to her lesson to resemble that of a fourth grader, "I wanted to be authentic of a kid really trying to grasp the concept …I think that we should try to get as much out of these, you know role-play scenarios, where it's like not over the top, but trying to be aware of real fourth graders." The science methods course occurred during the novices' third semester in the program, so they may have recognized the benefits of the roles in supporting their learning and teaching. Or, they may have come to accept the (albeit awkward) usefulness of the roles after hearing instructors throughout the program emphasize its value (e.g., Lampert et al., 2013). Activity Theory suggests that the social pressures of feeling silly acting as a “teacher” or “student” in a simulation with one’s peer could generate a contradiction in which the novice does not fully engage in the role-play (see also, Grossman, Compton, et al., 2009). This emphasizes the importance of providing multiple opportunities for novices to engage in the roles and to experience the benefits across the teacher education program.

Limitations

There are a few limitations to this study that are important to consider. First, this study cannot make claims about the long-term effects of the teaching simulations on developing novices' professional vision. However, the findings that suggest novice teachers were able to engage in and investigate authentic problems of practice in the teaching simulations underscores the value of these settings.

Second, the scope of the study was limited, and like many other studies in teacher education, it examined a small number of novice teachers working in a single methods course over a short period. However, studying the small groups enabled an in-depth examination of the ways in which they grappled with the complexities of learning to teach science and the social factors that shaped the process. As such, the results of this study provide powerful insights into the phenomenon of noticing for teaching as situated within a larger teacher education framework.

A third possible limitation of this study pertains to my particular approach to discourse analysis. I had not intended to closely examine how participants used language to develop professional vision and thus did not address the ways in which particular individuals' use of the language became more sophisticated over time. However, I did examine how the Peer Teaching teams' language reflected aspects of the professional Discourse (e.g., particular topics related to science concepts, student thinking, and scientific practices). Moreover, I examined how the members of the teams analyzed teaching and learning via the professional Discourse or prior experiences (the process of articulation). Despite these and other limitations, this work offers valuable insights into novice teacher learning.

Directions for Future Research

This study extends prior research, but additional questions remain. Here, I return to the concepts described earlier for understanding the mechanisms of developing professional vision for teaching in simulations of practice. One area for research focuses on the tools that embodied the professional Discourse: How do the tools help to establish the professional Discourse? How can teacher educators and novices use the tools to represent, decompose, and approximate teaching and learning? In addition, how do the tools help novices adopt roles and provisional identities where they can observe, experiment with, and receive feedback on teaching science in ambitious ways (Ronfeldt & Grossman, 2008)? Finally, how do the documented student misconceptions direct novices' attention to student thinking? In professional development settings, how might student artifacts, as tools of the professional Discourse, support practicing teachers in developing a professional Discourse?

Another area for further study concerns novices' use of the tools across the various interacting contexts. Specifically, do they continue to use the tools that embody the professional Discourse (e.g., EEE Framework) in elementary classroom settings, and if so, how? Moreover, how can the tools serve as boundary objects (Engeström et al., 2002; Gutierrez, Baquedano-López, & Tejeda, 1999) to scaffold novices' learning across multiple settings and into their first years of teaching? Relatedly, how do novice teachers identify, investigate, and envision alternatives to challenges of science teaching and student learning in elementary classrooms? Then, how do novices use their professional vision for practice to improve their teaching practice?

Given the ways in which the object (motive) of the teacher education program shapes the object (motive) of the Peer Teaching lessons, one ripe area for research concerns how a shared object develops across a program, and what tools, norms and roles could be used to mediate the process. A number of researchers are trying to develop and study a set of high-leverage practices that could support teacher learning across teacher education program contexts (Kazemi, Franke, & Lampert, 2009). These are but a few examples of areas for future research that could grow out of the outcomes of this study. The possibilities for future research into using interactive simulations of practice to develop professional vision for practice are numerous and will hopefully shape preservice and in-service teacher learning.

Appendix A. EEE Framework for Science Teaching and Learning

<table>
<tr><th colspan="3">EEE Framework for Science Teaching and Learning</th></tr>
<tr><th>Students may…</th><th>Likely dimensions of the lesson phase</th><th>Relevant science teaching practices
Teachers may….</th></tr>
<tr><td rowspan="2">Engage
with an investigation question</td><td>• Establish an investigation question/problem</td><td>Pose or co-craft a question or problem for investigation. This question/problem should establish a meaningful purpose for experiencing the scientific phenomenon, and it should generate interest and curiosity among students.</td></tr>
<tr><td>• Share initial ideas about the question/problem</td><td>Elicit students' initial claims (or models) to answer the problem/question. Encourage students to draw upon their prior knowledge and experiences.</td></tr>
<tr><td rowspan="2">Experience
the scientific phenomenon to generate evidence to answer the investigation question</td><td>• Establish data collection for answering the investigation question/problem</td><td>Support students in setting up one or more investigations that allow them to gather data that they can use as evidence to answer the question/problem. With varying degrees of guidance, have students...
• Determine what data will be gathered and how and why it will be collected and recorded
• Make reasoned predictions about the outcome of the investigation.</td></tr>
<tr><td>• Carry out the investigation</td><td>Support students in systematically collecting and recording data (e.g., making scientific observations, making systematic measurements) to generate evidence to answer the investigation question/problem.
This includes…
• Observing and listening to students as they interact
• Asking questions to help students begin to make sense of what their data mean, rather than "telling" students the answer.
• Redirecting students' investigations to be more systematic, precise, and objective when necessary
• Managing the distribution and collection of materials
• Facilitating productive small group work</td></tr>
</table>

<table>
<tr>
<td rowspan="3">Explain
with evidence</td>
<td>• Identify patterns and trends in the data for answering the investigation question/problem</td>
<td>Support students in making sense of the data so that they can generate claims with evidence. This includes …
• Compiling class data, and if relevant, organize/represent the data in meaningful ways (e.g., in tables or graphs).
• Directing students to particular aspects of the data to help them identify and make meaning of patterns or trends in the data.
• Helping students select appropriate and sufficient data to use as evidence to support claims.</td>
</tr>
<tr>
<td>• Generate scientific claims with evidence and reasoning</td>
<td>Facilitate a discussion that enables students to answer the investigation question by using the data to generate evidence-based claims.
Provide students with scaffolds, such as “I think ____(claim) because I observed _____ (evidence)” or "What I know: ____ (claim). How I know it: _____ (evidence)."
Provide opportunities for students to share their explanations with others, including peers, parents, etc. Help students…
• Revisit their initial ideas about the investigation question, expanding upon or developing new evidence-based claims
• Compare their own explanations with explanations reflecting scientific understanding, given via direct instruction, textbooks, models, etc. This includes introducing new terms to students, as appropriate.
• Question one another about their explanations.</td>
</tr>
<tr>
<td>• Apply knowledge to new problems and questions</td>
<td>Support students in applying their knowledge to new learning tasks. For example,
• Ask students “what would happen if…” to think through and explain their understanding of science concepts, and/or give a concrete new scenario that requires application of the new knowledge</td>
</tr>
</table>

Appendix B. EEE Framework Rubric

EEE Framework for Science Teaching and Learning Rubric

Intern teaching:__________________________ **Date:** __________________
Observer: ____
Science Lesson: ____

Engage with an investigation question

Likely dimensions of the lesson phase	***Proficient Performance***	***Developing Performance***	***Missed Opportunity Performance***
Establish an investigation question/problem	• Begins the lesson by posing or co-crafting a question or problem for investigation. • Establishes a meaningful purpose for upcoming activities and generates interest and curiosity among students.	• Begins the lesson with a question or problem that minimally establishes a meaningful purpose for upcoming activities or is confusing.	• Begins the lesson without posing or co-crafting a question or problem for investigation. • Begins the lesson without establishing a meaningful purpose for upcoming activities.
Share initial ideas about the question/problem	• Elicits students' initial explanations (or models) to the problem/question. • Encourages students to draw upon their prior knowledge and experiences. • Asks probing questions to encourage students to explain their reasoning.	• Elicits students' initial explanations (or models) to the problem/question without probing deeper into students' prior knowledge or reasoning.	• Does not elicit students' ideas.
Specific examples, language, or moves the teacher used to support the students in engaging with an investigation question: What is one move in need of revision? How would you revise it?			

1. What feedback did you receive during the peer teaching?

2. What did you learn about science teaching from this peer teaching activity?

3. What would you do differently if you were to teach this lesson again?

4. Any additional thoughts about today's peer teaching activity?

Appendix C. EEE Framework Feedback Form

EEE Framework for Science Teaching and Learning Feedback Form

Intern teaching: ______________________________ Date: ________________

Engage with an investigation question

Likely dimensions of the lesson phase	***Relevant teaching practices***		
	Proficient Performance	*Developing Performance*	*Missed Opportunity Performance*
Establish an investigation question/ problem	• Begins the lesson by posing or co-crafting a question or problem for investigation. • Establishes a meaningful purpose for upcoming activities and generates interest and curiosity among Ss.	• Begins the lesson with a question or problem that minimally establishes a meaningful purpose for upcoming activities or is confusing.	• Begins the lesson without posing or co-crafting a question or problem for investigation. • Begins the lesson without establishing a meaningful purpose for upcoming activities.
Share initial ideas about the question/ problem	• Elicits Ss' initial explanations (or models) to the problem/question. • Encourages Ss to draw upon their prior knowledge and experiences. • Asks probing questions to encourage Ss to explain their reasoning.	• Elicits Ss' initial explanations (or models) to the problem/question without probing deeper into Ss' prior knowledge or reasoning.	• Does not elicit Ss' ideas.

<table>
<tr><th>Observations from Lesson
- specific examples, language, or moves the teacher used to help students establish an investigation question and share initial ideas about the question/ problem.</th><th>Inferences
- How did the teacher support the students in establishing an investigation question/problem?
- How did the teacher elicit students' initial explanations to the problem/question based on their prior knowledge and experiences?</th></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">What is one move in need of revision? How would you revise it?</td></tr>
</table>

Experience the scientific phenomenon to generate evidence to answer the investigation question

	Relevant teaching practices		
Likely dimensions of the lesson phase	*Proficient Performance*	*Developing Performance*	*Missed Opportunity Performance*
Establish data collection for answering the investigation question/ problem	Support Ss in setting up one or more investigations that allow them to gather data that they can use as evidence to answer the IQ question/problem. With varying degrees of guidance, have Ss... - Determine what data will be gathered and how and why it will be collected and recorded - Make reasoned predictions about the outcome of the investigation.	- Supports Ss in setting up one or more investigations, but the investigations may not allow for the collection of sufficient or accurate evidence about the phenomenon. - Tells Ss the procedure for what data will be gathered and how it will be collected and recorded without a discussion that helps Ss understand the underlying rationale. - Helps Ss make predictions, but without eliciting reasons for their predictions.	- Does not provide an opportunity for Ss to collect and record data. - Does not provide an opportunity for Ss to make reasoned predictions about the outcome of the investigation.
Carry out the investigation	- Supports Ss in systematically collecting and recording data (making scientific observations & systematic measurements) to answer the IQ. - Observes and listens to Ss as they interact. - Asks Ss questions to help them begin to make sense of their data rather than "telling" Ss the answer. - Redirects Ss' investigations to be more systematic, precise, and objective when necessary. - Manages the distribution and collection of materials well. - Facilitates productive small group work.	- "Tells" Ss the answer to the investigation. - As Ss interact, focuses mainly on procedural or behavioral issues. - Asks questions not likely to help Ss begin to make sense of what their data mean. - Neglects Ss' work in conducting the investigation. - Haphazardly distributes and collects materials. - Struggles to keep small groups productive.	- Does not provide an opportunity for Ss to carry out an investigation.

Observations from Lesson *- specific examples, language, or moves the teacher used to help students establish data collection and carry out the investigation*	**Inferences** • How did the teacher support the students in setting up an investigation to gather data that they can use as evidence to answer the question/problem? • How did the teacher support the students in carrying out the investigation? • How did the teacher support the students in systematically collecting and recording their observations?
What is one move in need of revision? How would you revise it?	

Explain with Evidence

	Relevant teaching practices		
Likely dimensions of the lesson phase	*Proficient Performance*	*Developing Performance*	*Missed Opportunity Performance*
Identify patterns and trends in the data for answering the investigation question/ problem	Support students in making sense of the data so that they can generate claims with evidence. This includes helping students: - Compile class data, and if relevant, organize/represent the data in meaningful ways (e.g., in graphs, tables). - Attend to particular aspects of the data to help them identify and make meaning of patterns or trends in the data. - Select appropriate and sufficient data to use as evidence to support claims.	- Facilitates a discussion that provides a limited opportunity for students to use the data as evidence to answer the original question/problem. - May not provide an opportunity for students to compile class data, or data compilation is confusing or unorganized. - May not provide an opportunity for students to identify and make meaning of patterns or trends in the data.	- Tells students what their data mean without providing them with an opportunity to make sense of the data. - Tells students how their data answers the original question/problem without providing them with an opportunity to use the data to make sense of the original question/problem.
Generate scientific claims with evidence and reasoning	Facilitate a discussion that enables students to answer the investigation question by using the data to generate evidence-based claims with scaffolds such as "I think ____(*claim*) because I observed ______ (*evidence*)." Provide opportunities for students to share their explanations with others. Help students… - Revisit their initial ideas about the investigation question, expanding upon or developing new evidence-based claims. - Compare their own explanations with explanations reflecting scientific understanding, given via direct instruction, textbooks, models, etc. This includes introducing new terms to students, as appropriate. - Question one another about their explanations.	- Provides a limited opportunity for students to share their explanations with others. (e.g. Students may only share their explanations with the teacher.) - Elicits students' claims but does not encourage them to support their claims with evidence.	- Does not elicit students' claims with evidence about the phenomenon. - Does not provide opportunity for students to share their explanations with others.
Apply knowledge to new problems/ questions	- Support students in applying their knowledge to new learning tasks. - Ask students, "What would happen if…?" to think through and explain their understanding of science concepts.	- Asks questions that focus on re-stating, "what was learned," rather than questions that ask for an application of knowledge.	- Does not provide an opportunity for students to apply their knowledge to new learning tasks.

Observations from Lesson - specific examples, language, or moves the teacher used to help students identify patterns and trends in the data and then use the patterns/trends to generate claims with evidence (and reasoning, if relevant).	**Inferences** • How did the teacher support students in making sense of the data so that they could generate evidence-based claims to answer the IQ? • How did the teacher provide opportunities for students to share their explanations with others? • How did the teacher support students in applying their knowledge?
What is one move in need of revision? How would you revise it?	

Appendix D. Peer Teaching Memo

Reflection Memo on Peer Teaching *Explain* Lesson

Due by Sunday night, January 29, posted to your dropbox in CTools

After you've taught your *Explain* peer teaching lesson, reflect on your lesson enactment and the feedback you received from your colleagues and the teacher educator. Upload your video to the ED528 hard drive on Friday or Monday.

Answer the following questions in your written reflection:

Instructional Learning Goals

1.) Briefly explain your learning goals (content and scientific practices) for this lesson and how your lesson was deliberately designed to address those goals. Did your "students" meet your learning goals in the *Explain* lesson?

Explain Teaching Practices and Enactment

2.) How well did your enactment go with regard to supporting students in making sense of the data (identifying patterns/trends) so that they could generate evidence-based claims to answer the investigation question? What went well? What didn't go well?

- Provide evidence from the video enactment (indicate the timestamp(s) from your video) to support your discussion (of either strengths or missed opportunities).

3.) How well did your enactment go with regard to supporting and responding to students in constructing adequate claims with sufficient evidence? What went well? What didn't go well?

- Provide evidence from the video enactment (indicate the timestamp(s) from your video) to support your discussion (of either strengths or missed opportunities).
- Did you have an opportunity to support students in applying their knowledge to new problems/ questions?

Explain Peer Teaching Enactment and Feedback

4.) What do you think you will take away from the opportunity to peer teach the *Explain* lesson? Why?
5.) What do you think you will take away from the feedback you received during the *Explain* lesson? Why?
(d)

- Did you meet, exceed, or fall short of your own expectations for yourself, including the teaching goal(s) you were focusing on?

- Be specific about what you would do differently or try in the next lesson. For example, what specific questions would you ask? What language would you use? Get to the details to make it do-able, not just talk-able.

EEE Peer Teaching Enactments and Feedback

6.) What do you think you will take away from the three opportunities to peer teach the *Engage*, *Experience*, and *Explain* lessons? Why?
7.) What do you think you will take away from the feedback you received during the *Engage*, *Experience*, and *Explain* lessons? Why?

A word on format and style

- This is intended to be a memo. You may respond to each of the questions above separately. In fact, I'd urge you to focus on preparing thoughtful responses within *2 pages single-spaced* rather than making it a 'school paper' with introductions, transitions, conclusions etc. Please be clear which question you are responding to. Care and accuracy with spelling, word choice, grammar, format etc. are important and will be taken into account as I read your memo.

Appendix E. Survey Questions

Science Teaching Survey

1. How confident are you in your knowledge of science compared to the beginning of the course?

    a. Not confident at all
    b. Not quite confident
    c. Unsure
    d. Confident
    e. Very confident

---

2. How confident are you in your ability to effectively teach elementary science?

    a. Not confident at all
    b. Not quite confident
    c. Unsure
    d. Confident
    e. Very confident

---

3. If you had to choose one word to describe how you feel about teaching elementary science, it would be:

---

4. What remaining concerns, if any, do you have about teaching elementary science?

---

5. What did taking on a student role in the peer teaching lessons help you learn or improve?

---

6. Based on the course experiences, I feel well prepared with regard to….

Appendix F. Interview Questions

Interview Questions

Purpose of interview: First, I'd like to thank you for agreeing to participate in this study! Obviously, there are no right or wrong answers for any of the questions we will talk about; we are just interested in hearing your views. What you share during the discussion will not affect your grade in the science methods course in any way. These interviews will only be available to your instructor after the course has finished. I would like to interview you again (1) after the "Experience" peer teaching, (2) after the "Explain" peer teaching, (3) and again after your Reflective Teaching lesson. If at any point you decide you no longer wish to participate in this study, please let us know—you always have the option to opt out.

Tape recording: I am going to audiotape the interview, because I am interested in your ideas and want to be sure that I have a good record of everything you say.

Do you have any questions before we get started with the interview questions?

A little bit about the structure of the interview: I'll start off by asking you some general questions about yourself and your field placement, as well as your experiences, if any, with teaching science up until now. Then I'll ask some more specific questions that are targeted toward helping me understand your experiences with the peer teaching lessons, the feedback that you received during the peer teaching, and the feedback you offered your colleagues.

Purpose of Question	**Question**	**Notes**
Background Questions to ask during the first interview. Establishing a background for use, teaching, & science experiences	• Tell me your name, your major & minor in the School of Education, and a little bit about your field placement (which grade, which school, are you seeing science being taught, how often?) • Before starting the ELMAC program, what sorts of teaching experiences did you have? • Have you had opportunities to teach science before? If so, can you describe those for me? o What do you like most about science?	

What interns specifically attend to in recounting their lesson.	1. Tell me about your peer teaching lesson today.
	    a. What did you do in your lesson?
	    b. What do you think you did well? What could you have revised?
	    c. *Interviews 2-4*: How did the feedback from previous peer teaching lessons influence your lesson today?	

Specific feedback the interns noticed that they received during & following the approximation.
 	
How interns are making sense of the specific feedback.
	2. What feedback did you receive from the teacher educator in your group?
	    a. When was this feedback offered? (i.e., in the middle or following the approximation)
	    b. Which feedback stood out to you? Why? Reactions to it? How did it feel? Helpful? Not helpful
	3. What feedback did you receive from the other interns in your group?
	    a. Which feedback stood out to you? Why? Reactions to it? How did it feel? Helpful? Not helpful?	

Feedback the interns offered during the approximation, and what influences the feedback they offer.
4b elicits info about why they *may not* have offered certain feedback--social pressures; didn't feel comfortable offering critical feedback, etc.
	4. Let's talk about your colleagues' peer teaching lessons. What feedback did you offer your colleagues?
	    a. Why do you think you noticed that?
	    b. Did you notice anything else, but didn't bring it up? Why?	

Knowledge of student understanding, curriculum, instructional strategies, purposes of teaching	a. What do you think you will take away from the experience you had today in <u>terms of the peer teaching</u>? **Why**? b. What do you think you will take away from the experience you had today <u>in terms of the feedback</u>? **Why?** c. Can you think of an instance of when you might use it (the takeaway)?	

Appendix G. EDUC 528 Syllabus

Teaching Elementary Science

Education 528 Winter 2012

Course Information

Instructor:	Mandy Benedict-Chambers
Office:	1228M SEB (inside Teacher Ed suite)
Mailbox:	Teacher Education Suite
Phone:	
Email:	mbenedi@umich.edu
Classroom:	2241 SEB
Office hours:	Easily arranged by email

Course Objectives and Organization[10]

In Elementary Science Methods, we will build on current research and best practice to prepare you to foster science learning in elementary school students. Our main goals are for you to:

- describe the four strands of science learning—understanding scientific explanations (content), generating scientific evidence (through scientific practice), reflecting on scientific knowledge (and the nature of science), and participating productively in science
- incorporate the four strands of science learning into effective elementary science teaching to support students as they *engage, experience*, and *explain with evidence*
- identify and enact instructional strategies that make science accessible to *all* students, including through connecting it to their lives
- learn how to prepare, teach, and analytically reflect on elementary school science investigation lessons

Throughout the course, we will work on the goals listed above. We'll read relevant chapters and articles that can help us unpack the ideas related to these, and we'll also use other records of practice (video, student work, etc.) to help bring some of the ideas to life. In each class, we'll be working on some key teaching practices, and you'll be practicing those practices in our ED528 class, in the field, or both. By the end of the course, you should feel better prepared to put the pieces together to teach science effectively as a beginning teacher.

We've structured the class to allow for a focus on the elements of science lessons. Many science lessons can be broken down into three basic phases: *engage*, *experience*, and *explain with evidence*. Sometimes, these phases will span across a unit, rather than a lesson. We'll work

[10] This syllabus has been adapted from Dr. Betsy Davis's EDUC 421 syllabus

through different teaching strategies associated with each phase, focusing on using investigations to help students learn science content and scientific practices.

What are possible ways to engage, experience, and explain with evidence in science lessons? Watch for these elements when you observe science teaching. For example, you might see a teacher use a KWL or journal writing to *engage* students by eliciting their ideas at the beginning of a lesson, and/or the teacher might review previous lessons. For the *experience* phase, a teacher might provide students multiple opportunities to interact with scientific phenomena and concepts. For example, the teacher could have students conduct an investigation, supporting them in collecting and recording data systematically. S/he might also have students read a text, watch a video, or conduct research using the Web. In the *explain with evidence* phase of a lesson, the teacher might have students look for patterns in data, make claims based on evidence, construct a consensus model, or all of the above. Some of these approaches might, in turn, serve as formal or informal assessments.

Course Reading Materials

Required Readings and Other Course Expenditures

> Michaels, S., Shouse, A., & Schweingruber, H. (2007). *Ready, set, science! Putting research to work in K-8 science classrooms*. Washington, DC: The National Academies Press.
>
> *Ready, Set, Science!* (abbreviated in the syllabus as RSS!) presents the most up-to-date discussion of reform-oriented science teaching. The book focuses on how you can incorporate scientific practices, such as scientific inquiry, into your elementary science teaching. Written for practitioners, it includes lots of nice descriptions of effective science teaching at the elementary level. You can purchase *Ready, Set, Science!* at Ulrich's or online at http://www7.nationalacademies.org/bose/TSS_RSS_FAQ.html.

The other required readings are provided on CTools under "Resources" and within the "Weekly Resources" folder, by week.

In addition to the required readings, you should expect to need to spend no more than $25 to cover expenses associated with your science teaching in your elementary classroom.

Additional Resources

You may find some of the following books to be useful, as well. At least portions of these books are available online. Each is linked from the CTools site and from the CASES Resources page.

American Association for the Advancement of Science. (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

> *Benchmarks* "specifies how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach certain grade levels" (AAAS, p. xi). The Benchmarks are available at http://project2061.aaas.org/tools/benchol/bolintro.html. You may want to purchase this book if you are a science major; the URL is http://project2061.aaas.org/tools/bsl/index.html

American Association for the Advancement of Science (AAAS). (2001). *Atlas of science literacy*. Washington, DC: American Association for the Advancement of Science.

The *Atlas* provides a concept map view of the Benchmarks described above, demonstrating how the different concepts are interconnected. Some of the Atlas' maps are available on-line at http://www.project2061.org/tools/atlas/sample/toc.htm. You may want to purchase this book if you are a science major; the URL is http://www.project2061.org/tools/atlas/default.htm

National Research Council (NRC). (1996). *National Science Education Standards (NSES)*. Washington, DC: National Research Council.

National Science Education Standards are another set of national standards for science teaching; though many states have their own standards or frameworks, they are generally in line with the NSES. They are available on-line at http://books.nap.edu/html/nses/html/index.html . Please note that the Next Generation Science Standards are being developed and will replace the NSES soon (see http://www.nap.edu/catalog.php?record_id=13165)

National Research Council (NRC). (2000). *Inquiry and the National Science Education Standards*. Washington, DC: National Academy Press.

This book builds on the NSES and discusses specific ways of incorporating inquiry into your science teaching. See http://www.nap.edu/catalog.php?record_id=9596.

Michigan Department of Education. Michigan Grade Level Content Expectations.

The Michigan Department of Education has developed a set of standards for teaching science in Michigan. These science standards can be found in the Michigan Grade Level Content Expectations (GLCEs), available at www.michigan.gov/documents/mde/Item_C_194161_7.pdf .

CASES

The CASES learning environment is available at: http://cases.soe.umich.edu. CASES is a learning environment we developed to help preservice and new teachers like you as they learn to teach inquiry-oriented science. CASES includes links to many useful science teaching resources, including some inquiry-oriented science units. The project is funded by the National Science Foundation.

Course Requirements and Grading

The percentages listed here are approximate, but will give you a sense of the relative weight of each assignment. Expectations for these assignments will be discussed in more detail in class, and detailed assignment sheets will be provided. All written work, unless otherwise specified, is due by the start of class on the due-date, and should be uploaded to your drop-box on the ED528 CTools site.

Class Attendance and Participation, including Teaching Journal (30%)

"Attendance" means being in class on time and staying till the end. If you must miss class, send an email in advance to your instructor explaining the situation. In keeping with ongoing discussions in the School of Education, three absences—excused or unexcused—will constitute failure of the course. "Participation" means that you need to be in the habit of speaking up and being engaged in whole class and small group discussions and activities, including online opportunities.

You will also be keeping a science teaching journal where you will record your reactions to the readings and responses to the guiding reading questions, as well as notes from the peer teaching lessons. I will collect the teaching journals once near the end of the course.

Peer Teaching in ED528 (three times) (10%, 15%, 15% or 40% total)

Each peer teacher will have a chance to lead their peer "students" through each of the following three phases of a science lesson: *engage with an investigation question*, *experience the scientific phenomenon* associated with the investigation, and *explain the phenomenon with evidence* to his/her peer teaching team. We will refer to the three phases of science teaching as the "*EEE* framework for science teaching".

After each peer teaching lesson, you will submit a short memo where you review your peer teaching lesson video and reflect on your enactment and on the feedback you received to figure out changes to make for the future.

Reflective Teaching Assignment (30%)

You will teach a full science lesson in your practicum classroom. For the reflective teaching (RT) assignment, you will develop a science lesson plan using existing science lessons and other curricular resources, analyze the lesson plan using analysis criteria, teach the lesson to children, reflect on your teaching using your video record, and analyze some student work. You will also have an opportunity to observe a colleague's RT lesson and to review it using the EEE rubric.

Class Policies and Additional Information

Contacting Me

Email is the best way to reach me. You may also call me, come to my office, or leave something in my mailbox in the Teacher Education Suite.

Making up a missed class:

To make up a class that is missed, you will need to do the following. Prepare a short memo in which A) you summarize the main topic(s) of the session; B) you capture 2 to 4 key points about the topic(s); and C) you list any specific questions you have about the content and how you will get answers to them (*e.g.* talk to a classmate, reread the readings, ask me, etc). To do this memo, I expect you do the reading and assignment for the session (this gets at the basic content), then talk to classmates about what you missed (this gets at the process and deepens the content). The memo length is 700 words. Given the intensity of the course, make-up work is due within two days of your absence or before the next class (whichever is longer) in your dropbox on CTools.

e-Etiquette (laptops & cell phones) in class:

Electronics (laptops, cell phones) present a real dilemma in class. Used appropriately, laptops can clearly support what is going on—taking notes, accessing and tracking down information, etc. Used otherwise, they can quickly become distracting both for you and for others around you. And popular notions of multi-tasking as efficient notwithstanding (which brain research is now debunking), using electronics while trying to do other things can and does get in the way of productive interaction. For this reason, we ask the following norm: That cell phones are off and away and laptops stowed while the seminar is in session. During the times that you may want to take notes, we will flag the use of laptops for that period. But otherwise, electronics are not needed.

Grading and Late Work

If you cannot complete an assignment on time, please contact me by email and request an extension. Typically I will give an extension of one week; after that, the work will be counted as late and your grade will be affected.

You may request a re-grade on any assignment. The request must be made via email and you must turn in the revision within one week of the assignment being handed back.

Readings

You are expected to do all the reading in advance of class. Our work in class depends on it.

Written Assignments

For turning in your written assignments, you will use the drop box area in the CTools site.

Accommodations

Please talk with me if you require accommodations due to religious practices, learning disabilities, physical requirements, medical needs, or any other reasons. We will work together to identify resources and make accommodations. As adults, we all have needs and a broad range of responsibilities—it's your job to speak up and talk with me if you need an accommodation of any sort.

Questions, Comments, or Concerns

If you have any questions, comments, or concerns about the class, please do not hesitate to contact me! I am looking forward to working with you throughout the course!

Summary of Assignment Due Dates (see syllabus and handouts for more complete explanations)

Session & Date	**Today's In-Class Topic**	**Readings for Today**	**Assignments due Today**	**Peer teaching today…**
(1) Tues 1/3 1-4	Our visions of science teaching Introducing the EEE framework			
(2) Wed 1/4 9-12	*Engage*: What should be taught and learned in elementary science? Science education standards, scientific practices, scientific vocabulary, and EEE framework	RSS! Skim chapters 1 & 4 Skim the six cases: Pages 9, 11, 22, 66, 72, 79 Read chapter 2 *Guiding reading question*: How do the RSS! Chapters 1, 2, & 4 support, extend, and challenge your thinking about science learners and science teaching? Jot down some examples from the reading and from your experiences in yourscience teaching journal.		
(3) Thurs 1/5 1-4	*Engage*: Students' ideas in science and sharing initial ideas about the question/problem *Experience*: Investigations as learning activities Part I (Establishing data collection for answering the investigation question)	Watson & Konicek Benchmarks Chapter 15 MSTA Misconceptions *Guiding reading question:* As teachers, why do you think it's important to anticipate, elicit, and facilitate students' ideas in science? In what ways might you do these?		
(4) Fri 1/6 9-12 PM	*Experience*: Investigations as learning activities Part II (Carrying out the investigation, fostering students' sense-making with data)	RSS! Chapter 6 & 7 *Guiding reading question:* What struck you about the advantages and challenges in using models, representations, and investigations to promote students' learning of science? As teachers, how might you address some of the challenges?		
Session & Date	**Today's In-Class Topic**	**Readings for Today**	**Assignments due Today**	**Peer teaching today…**
(5) Mon 1/9 9-12	Co-planning for *Engage* peer teaching lesson	Read the Motion or Ecosystems peer teaching lesson plan & students' alternative ideas Review the *EEE* phases in your lesson		Prepare for *Engage* peer teach
(6) Tues 1/10 9-12	*Engage* peer teaching	Skim the other peer teaching unit and students' alternative ideas	Peer teaching lesson plan	*Engage* peer teach: Establish purpose through question or problem; share initial ideas

(7) Thurs 1/12 9-12	*Explain with evidence*: Closing an investigation lesson Part I (Identify patterns and trends in the data for answering the investigation question)	Abell et al. McNeill & Krajcik: ch. 1; excerpts ch. 2 (pp. 18-25; p. 30) *Guiding reading question:* Why is it important to use a sensemaking "Explain with Evidence" discussion to conclude an investigation? How do the elements of a sensemaking discussion (argumentation and explanations) advance students' thinking?	Peer teaching reflection due by Sat., 1/ 14	
(8) Tues 1/17 1-4	Assessment: Constructed response as a form of assessment in science (Assessing students' scientific explanations—claims, evidence, and reasoning) Co-planning for *Experience* peer teaching	McMillan chaps. 8 & 9 *Guiding reading question:* What types of assessments are used in your classroom around learning science? Based on the McMillan chapters, describe two kinds of assessments you will likely use in your science instruction to assess students' learning, explain why you will use them, and give specific examples of when you could utilize them.		Prepare for *Experience* peer teach
(9) Wed 1/18 9-12	*Experience* peer teaching		Peer Teaching lesson plan	*Experience* peer teach: Establish data collection; carry out investigation to support sensemaking
(10) Thurs 1/19 9-12	Co-planning for *Explain* peer teaching *Explain with evidence*: Closing an investigation lesson II (Generating scientific claims with evidence and reasoning)	RSS! Chapter 3 & chapter 5 *Guiding reading question:* What struck you about the advantages and challenges in teaching for conceptual change and encouraging talk and argument in your classroom? As teachers, how might you address some of the challenges?	Peer teaching reflection due by Saturday night, 1/21.	Prepare for *Explain with Evidence* peer teach
(11) Thurs 1/26 9-12	*Explain with Evidence* peer teaching	(e)	Peer teaching lesson plan Peer teaching reflection due by Sunday night, 1/29	*Explain with Evidence* peer teach: Revisit question; identify patterns and trends, support claims with evidence; apply knowledge
(12) Thurs 2/2 9-12	Putting it all together: Final synthesis and reflections on course	Review the two lesson plans through a EEE lens	The Reflective Teaching assignment with peer observation is due by Sunday 2/19	

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