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The Relationship between Pre-service Mathematics Teachers' Focus on Student Thinking in Lesson Analysis and Lesson Planning Tasks

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Abstract This study explored whether pre-service teachers' (PSTs') lesson analysis skills during a teacher education course in the country of Turkey were related to their skills of lesson planning. PSTs' lesson analysis skills during fieldwork were assessed by their attention to and interpretation of student thinking and learning, and how it is influenced by the teachers' instructional decisions. The PSTs' lesson analysis scores were significantly and positively correlated with scores in lesson planning task focusing on student thinking. The findings contribute to the literature on whether PSTs' lesson analysis skills may be transferred to one of the core activities of teaching.

Keywords Lesson analysis · Lesson plan · Pre-service teacher noticing · Teacher preparation

Introduction

The need for an advanced knowledge base on preparing effective teachers (Floden & Meniketti, 2005; Grossman & McDonald, 2008), specifically, for the subject of mathematics (Hiebert, Morris & Glass, 2003) has been acknowledged. In a review of studies on teacher preparation with an aim to find evidence for building teacher education policies, the National Research Council (2010) recommends that effective teachers need preparation, not only in knowledge of mathematics but also with how students learn the mathematics and mathematical pedagogies recommended by the researchers and professional societies. Recent recommendations suggest that teacher education programs should be planned around the core activities of teaching, such as working with students, observing lessons, conducting lesson analysis by identifying

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significant aspects of lessons, preparing lesson planning, and rehearsing teaching (Grossman & McDonald, 2008; Hiebert, Morris, Berk & Jansen, 2007; Lampert, Beasley, Ghousseini, Kazemi & Franke, 2010; Lampert et al., 2013). Learning from core activities of teaching mentioned above may better prepare teachers and help them make more meaningful connections between their teacher education program experiences and teaching and learning in schools.

In Turkey, disconnectedness between field experience and teacher education classes (Çakıroğlu & Çakıroğlu, 2003; Özcan, 2013) is a well-known problem. Although preservice teachers (PSTs) spend structured time observing other teachers' practices, it is not obvious what they learn from these experiences and whether their observation skills translate to other practices important in teaching. What PSTs pay attention to during the field experience may determine what they learn as future teachers and, as such, requires that teacher educators assess what PSTs attend to. In this paper, I explore a possible relationship between lesson analysis skills in the context of teacher noticing and an important aspect of teaching: lesson planning. The next sections provide an overview of the constructs of teacher noticing and lesson analysis, and lesson planning practices.

Literature Review

Teacher Noticing

Learning to notice important aspects of classroom instruction is considered an important area of expertise for teachers (Jacobs, Lamb & Philipp, 2010). In their Learning to Notice Framework, van Es and Sherin (2002) describe three significant aspects of noticing that constitute a basis for the conception of teacher noticing in this study:

> (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 one's context to reason about noteworthy events. (p. 573)

In this study, I use noticing to describe attention to important events during teaching and interpretation, which includes how PSTs make sense of noteworthy events in their reflections on fieldwork observations. Developing lesson analysis skills in PSTs by facilitating what they attend to and how they interpret events may help with their professional development (Jacobs et al., 2010).

The construct of "lesson analysis skills" in this paper is situated in the teacher education and noticing literature where teacher candidates observe teaching in the context of fieldwork or by incorporating videos and report their observations. Use of lesson observation reports is a frequently used tool to gauge PSTs' lesson analysis skills, which are closely related to teacher noticing skills, such as attending to and making sense of significant events during teaching (Levin, Hammer & Coffey, 2009; Santagata & Angelici, 2010; Star & Strickland, 2008).

With respect to novice teachers' observations of teaching, a literature review suggests that inexperienced teachers tend to focus on teachers' actions rather than student thinking or learning and fail to notice important aspects of instruction related to

student learning of the content. For instance, Berliner (1988) found that inexperienced teachers were able to notice static features of the classroom, such as classroom materials or number of students, but had difficulty in noticing more significant aspects of instruction. Similarly, Kagan (1992) argued that novice teachers were likely to focus on classroom management rather than significant aspects of teaching. Star and Strickland (2008) analyzed what pre-service teachers learned to notice over a methods course. Similar to what Berliner (1988) found, PSTs in Star and Strickland's study did not demonstrate strong observation skills during the initial phases of the teacher education program, although they were able to improve in noticing skills during the course under investigation. The results of these studies indicate that teacher educators need to find ways to improve PST observation skills.

In a comparative study by Santagata and Angelici (2010), the authors found that using the Lesson Analysis Framework prompted PSTs to provide higher quality reflections on teaching compared to using other frameworks. The Lesson Analysis Framework facilitated use of evidence in arguments, prompted PSTs to focus on student learning in relation to instructional decisions, and provide alternative strategies to what is observed in teaching. This finding was consistent with other studies conducted by Levin et al. (2009), Sun & van Es, (2015), and Barnhart and van Es (2015), who argued that novice teachers could attend to student thinking when their professional environments emphasize and encourage novices with regards to paying attention to student thinking. A study by Barnhart and van Es (2015) revealed that attending to student thinking was a critical skill in being able to analyze and respond to student thinking among pre-service science teachers. On the other hand, attending to student thinking did not automatically lead to more sophisticated analyses of student thinking or responding to student thinking. In contrast, Sun and van Es (2015) found that when PSTs had better lesson analysis skills and focused on student thinking in their reflections on teaching, they also tended to perform better in focusing on student thinking during teaching. These studies provide an important basis for my study by evidencing that lesson analysis skills could be improved in PSTs and that they are important skills in the sense that they may influence the nature of teaching.

Different than the study by Sun and van Es (2015), which investigates how PSTs learn from analyzing exemplary practices ("ambitious pedagogy", p. 1) of teaching by using video, I investigate how PSTs observe and analyze *authentic* classroom practices during fieldwork and have different opportunities to learn from lesson analysis. Lesson analysis within the authentic context of field experience could inform PSTs about the state of teaching and learning in the classroom they visit regularly, which could facilitate focusing on significant aspects of teaching and learning. In contrast, when PSTs are asked to analyze video-taped lessons from unfamiliar classrooms, the information available from video viewing is much more limited than the dynamic nature of classroom teaching, and it is based on a particular focus of the camera (Krammer et al., 2006; Sherin, 2004; van Es & Sherin, 2002). When viewing video, PSTs may not be able to offer insightful reflections due to their limited knowledge about the classroom context. Additionally, incorporating cases of problematic instead of exemplary classroom practices in teacher education classes have a better potential to provide teacher candidates rich lenses for reflection and opportunities of inquiry into teaching and learning (Sherin, Linsenmeier & van Es, 2009). Consequently, investigating the relationship between PSTs' lesson analysis skills and focusing on student thinking in lesson

planning in the context of a fieldwork course contributes to the field of teacher education by way of analyzing and understanding strengths and weaknesses of using different approaches in PST learning.

Lesson Planning

Lesson planning involves teachers' decisions related to lesson preparation. Fennema and Franke (1992) provide a rationale for preparing lesson plans in the following way: "During the planning phase, teachers make decisions that affect instruction dramatically. They decide what to teach, how they are going to teach, how to organize the classroom, what routines to use, and how to adapt instruction for individuals" (p. 156).

It is expected that, compared to experienced teachers, PSTs may have difficulties in incorporating student thinking in both their planning and teaching practices. National Council of Teachers of Mathematics (2000) emphasizes the importance of consideration of student thinking in lesson planning in the following way: "Planning needs to reflect a deep and thorough consideration of the mathematical content of a lesson and of students' thinking and learning." (p. 424) Despite such recommendations, research results reveal that PSTs tend to focus on organization of teaching, and ignore student thinking during their lesson planning, which fails to prepare them to facilitate student understanding during instruction (Grossman & McDonald, 2008; Stein, Engle, Smith & Hughes, 2008). In a study by Hughes and Smith (2004), teachers were asked to prepare lesson plans by using *Thinking Through a Lesson Protocol*, which included questions to prompt PSTs to consider student conceptions, misconceptions, and prior knowledge in preparing a lesson plan focused on conceptual understanding. The findings revealed that using the lesson protocol as a tool helped teachers in considering student thinking in their planning, and the results persisted after the study was conducted. Considering previous literature on how PSTs struggle with focusing on student thinking during instruction, it may be argued that learning to focus on student thinking during lesson planning as preparation might be helpful for PSTs' professional development.

Research Question

Although PSTs could grow professionally during a teacher education course, it is difficult to determine whether these skills, beliefs, or types of knowledge may transfer to other important practices of teaching. In this paper, developing noticing skills of prospective teachers was not an end to itself. The specific research question that guided this study was the following:

> Is there a relationship between pre-service teachers' lesson analysis skills and their lesson planning skills?

In this study, PSTs' lesson analysis skills were assessed by their attention and making sense of significant events of teaching, more specifically, to student learning and its relation to teachers' instructional decisions. It may be hypothesized that when teachers learn to attend to student thinking in their fieldwork observations, they may be more likely to attend to student thinking in their lesson planning which may

consequently lead to a focus on student thinking in their teaching. Results of this study have the potential to help teacher educators design activities to support prospective teachers in both their lesson analysis and lesson planning skills.

Methods

This study emerged as a result of an inquiry into my own and PSTs' learning experiences throughout the course. During the course, I, the author of this paper, assumed the dual role of the teacher educator and researcher. Therefore this study can be considered as an example of "practitioner research." Practitioner researchers use data to make inferences about the relationship between their teaching and students' learning (Price, 2001; Simms, 2013). Although practitioner research studies may stem from one individual teacher educator's inquiry situated in a particular context, the results can be extended to the larger contexts of educational research and implications may become valuable for the larger teacher education communities (Loughran, 2007).

This study explored PSTs' lesson analysis and lesson planning skills by mainly using qualitative methods, namely, through content analysis (Stemler, 2001) and use of conceptual frameworks (or a priori coding) (Miles & Huberman, 1994). The qualitative analyses were supplemented by quantitizing qualitative assessment of PSTs' performance, which involved "transformation of qualitative data to numerical form." (Onwuegbuzie & Leech, 2004, p. 783). Subsequently, quantitative scores were analyzed by correlation analyses and an independent *t* test.

Participants

This study investigated senior PSTs' noticing and lesson analysis skills in their observation reports and their focus on student thinking as they engaged in writing lesson plans during a course on school experience in a public university in a large city in Turkey. The class consisted of 34 prospective teachers. At the end of the semester, the prospective teachers were advised that, if they provided written informed consent to the instructor of the class, their anonymous observation reports and lesson plan homework would be used for this study. The ethical research committee of the institution approved the study. Being both the instructor of the class and the practitioner researcher, I included PSTs' work in data analysis procedures only under the condition that they provided a written consent document. The participants in this research study were 26 of the PSTs in the class, each of whom completed lesson analysis reports and lesson plan homework and provided an informed written consent document to the instructor. Out of 26 PSTs, 3 were male and 23 were female.

Data Collection, Context, and Procedures

The course "School Experience in Teaching Mathematics" investigated in this study aimed to improve lesson analysis and observational skills of PSTs, such that they could learn more from their respective field experiences and be better prepared for teaching activities. During this course, PSTs observed a mathematics teacher for a total of 30 h

and gained school experience prior to teaching. This course, and all PST teacher education courses, were in English, not Turkish, the PSTs' native language. The observations took place in middle school mathematics classes with Turkish language instruction. Throughout the semester the PSTs were asked to write several "lesson analysis reports" recording their fieldwork observations, and focusing on student thinking and influence of teachers' instructional decisions. Their final assignment was writing a lesson plan protocol considering student thinking.

In line with mentioned research, PSTs in this course initially struggled to focus on student learning in their reflections. Most frequently, PSTs focused on issues of classroom management (i.e. "the teacher could not establish authority over the class"), their judgment of teacher personality (i.e. "the teacher was very strict and never smiled"), or physical aspects of classroom environment (i.e. "the classroom was very small"). During classroom discussions, PSTs professed a disconnection between their fieldwork and teacher education courses. In general, the PSTs did not observe exemplary teaching and rarely witnessed teachers who were successful in building on student thinking. I provided examples from PSTs' reflections and initiated discussions on how they could learn from reflecting on their observations. The PSTs admitted to difficulties in writing lesson analysis reports and learning from observations.

After a few weeks of observing PSTs' problems in writing lesson analysis reports, I introduced examples of *productive reflections* (Davis, 2006; Santagata & Angelici, 2010) and provided readings to help PSTs focus on important aspects of the classroom environment. Typically, a *productive reflection* includes not only description or judgment of events, but reasoning between events, and focuses on significant aspects of teaching, mainly student learning. The PSTs were provided with a reading about writing observations of mathematics lessons: the Lesson Analysis Framework (Santagata & Angelici, 2010). After completing the reading, PSTs started to become aware of how their initial reflections were not productive because they had not focused on student learning or how teacher decisions could influence student learning. During the semester, the PSTs were asked to submit their observation reports by no guidance first and using the Lesson Analysis Framework (Santagata & Angelici, 2010) later. The Lesson Analysis Framework encouraged PSTs to focus on the *learning goal*, *relationships between student learning and teacher practices*, and *suggestion of alternative strategies* based on observations. Using the Lesson Analysis Framework instigated more thoughtful classroom discussions because PSTs were asked to focus on more significant aspects of classroom instruction.

In order to facilitate PSTs' focus on student thinking, I also assigned tasks emphasizing various student strategies in a specific topic and provided examples of how teachers can build on student thinking. I chose the topic of division because most PSTs observed 5th and 6th graders; division is a common topic across 5th, 6th, and 7th grades curricula; and PSTs mentioned division in their observation reports. During the course, PSTs worked on analyzing real student work in division, and they read about students' conceptions of division (Keiser, 2012).

Through the above-mentioned activities, a common understanding of division was established such that all PSTs were familiar with division. Although the PSTs considered division as an "easy" topic, in general, they demonstrated difficulties in understanding student work. The PSTs also read about selecting tasks (Stein et al., 2008), managing classroom discussion (Stein & Smith, 2011), and most importantly, preparing

lesson plans with a focus on student thinking (Smith, Bill & Hughes, 2008). At the end of the course, the PSTs were asked to complete two tasks: a final observation reflection by using the Lesson Analysis Framework, and preparing a lesson plan protocol on the topic of divisions in teaching 5th grade based on the Smith et al. (2008) reading. It was hypothesized that as prospective teachers learned to focus on student thinking in their reports, they might find it easier to prepare lesson plans based on student thinking. Although the teacher candidates were familiar with the protocol from Hughes and Smith (2004) and were engaged with activities related to different aspects of preparing lesson plan protocols (i.e. asking questions, anticipating student answers, engaging in mathematical discussions), their final project was the first time the PSTs used the lesson planning protocol. The data sources analyzed in this study consisted of the initial lesson analysis reports, the final lesson analysis reports, and the lesson plan protocol based on the topic of division. The initial lesson analysis reports were submitted at the beginning of the semester, after the initial school observation experience. Both the final lesson analysis reports and the lesson plan protocol homework were submitted at the end of the semester.

Data Analysis

A combination of qualitative and quantitative methods were used in order to assess PSTs' lesson analysis skills and lesson planning skills focused on student thinking. Conceptual frameworks from the previous literature (Hughes & Smith, 2004; Santagata & Angelici, 2010; Smith et al., 2008)—which were also used during the instruction of the course—and content analysis guided the qualitative data analysis procedures (Stemler, 2001). As a first step, both initial and final lesson analysis reflections and lesson plan protocols were analyzed qualitatively by using conceptual frameworks from previous studies, which were then converted to quantitative scores. Below, coding and transforming qualitative codes to number scores for both lesson analysis and lesson planning skills are explained in detail. Each lesson analysis report and lesson plan was analyzed based on the frameworks, individually, by the author and an independent researcher who was knowledgeable in conducting qualitative analyses and familiar with teacher education literature. Interrater reliability was tested using the Miles and Huberman (1994) formula for each analysis (comparison percentage = [agreement / (agreement + disagreement)] × 100) and conflicts were resolved accordingly.

Comparing the initial and the final lesson analysis reports, I recognized the quality of reports in focusing on student thinking improved for some PSTs and remained similar for others. Although the qualitative analyses revealed that PSTs' performance in focusing on student thinking in the final lesson analysis reports and their lesson planning skills appeared similar to one other, quantitative analyses were needed in order to enhance interpretation of qualitative data (Onwuegbuzie & Leech, 2004). The next step was to conduct correlation analyses between PSTs' final lesson analysis reports and lesson plan scores. Conducting correlation analyses was needed in order to determine whether there was a relationship between final lesson analysis report scores and lesson plan scores. Following correlation analysis, an independent *t* test was also conducted to investigate differences between lesson plan scores among two groups of PSTs: PSTs whose analysis skills remained at a low level from initial to final lesson analysis reports, and PSTs whose lesson analysis skills improved from the initial to the

final lesson analysis reports and demonstrated attention to student thinking (at medium or advanced levels). An independent *t* test across lesson plan scores of these groups was needed in order to explore whether the difference in quality of tasks was also manifested quantitatively.

Qualitative Data Analysis

Lesson Analysis Framework (Santagata & Angelici, 2010). Lesson Analysis Framework focused on classroom lessons as a unit of analysis. The lesson goals were used as the guiding criteria to analyze each lesson. Student learning and how it is affected by teaching practices were emphasized as an important part of the analysis. Additionally, PSTs were also required to provide and justify alternative strategies to what they observed in order to enhance student learning.

The initial and the final lesson analysis reports were evaluated according to the extent the PSTs provided productive interpretations of the lesson. When the reflections included merely factual information or judgment of what happened in the class without providing reasoning, then the reflection was considered unproductive. These reflections were superficial in their analysis of classroom events and were scored as 1, representing low levels in lesson analysis skills. A reflection was scored a value of 2 when the student elaborated on the lesson beyond what happened and provided reasoning across significant elements of classroom learning. A score of 2 was considered the medium level. When the productive reflections additionally provided alternative strategies to what the teacher did in a meaningful way, the reflections were scored with the value of 3, representing advanced levels in lesson analysis skills.

Sample reflection scored 1. In the excerpt below, the PST only provided a description of the events and failed to provide any reasoning regarding how teaching might influence student learning. Consequently, the reflection was scored as 1, demonstrating low-level lesson analysis skills. Below is a representative excerpt from her report:

> The teacher gave a short introduction about what students would learn in the lesson and which steps they would follow during the activity. He said to the students that they would be able to multiply two first order algebraic expressions together by using a mathematical modeling. He drew a table on the board to describe the modeling method that would be used for multiplication of algebraic expressions and gave some verbal explanation about the modeling. After giving the description and the explanation, he gave some blocks to each group. The blocks are composed of cubes and represent x, $-x$, 1, -1. All this took 15 min.

Sample reflection scored 2. The excerpt below is a typical excerpt from another PST's reflection report. She was able to extend her description of the classroom events to include reasoning between teaching and student learning. In this case she argued that students learned in a more effective way with the help of daily life examples the teacher provided. On the other

hand, she did not include any alternative strategies throughout her reflection and therefore her reflection was scored as 2.

Teacher gave examples from real life such as probability of a soccer team's winning the Team A vs. Team B match and the probability of weather being sunny tomorrow. Through these examples, both attracting students' attention and connection between mathematics in the lesson and life experiences were provided so students learned more effectively.

Sample reflection scored 3. The excerpt below is a typical example of a reflection coded at the advanced level and scored as 3:

The topic covered during the lesson that I observed was the probability of occurrence of independent events. At the beginning of the lesson, the teacher explained what they will cover in this lesson and he started to lecture. Firstly, he wrote the related formula that is P (A and B) = P (A∩B) = P (A). P (B) and then asked the students how they will find the probability of occurrence of independent events. At this point, the teacher wanted students to answer the question by reading the formula on the board. He waited for a short time and no response came from students. Then, the teacher said "we will multiply, don't you see" and the students said "we could not see the point (multiplication symbol) and so we could not understand what we will do". As it is understood from the story above, the lesson was centered on improving students' procedural skills and it had no implications on conceptual learning and students' construction of their own meaning about concepts. At the very beginning of the lesson, without mentioning about what is "independent events" and without making students understand the concept, the teacher jumped to the way of finding probability of occurrence of independent events. When it comes to what can be an alternative for this kind of lesson structure, I think there are some activities other than this teacher used. For instance; at the beginning of the lesson, the teacher can make students understand the concept of independent events by showing occurrence of simple independent events like taking one pencil two times from a bag by putting the first one back. Then, the teacher can ask students to give other examples of this type of events. I think this showing and then making students think on the subject will make them construct their own knowledge and will prevent possible misconceptions about the conditions in which the events are independent.

As observed in the long excerpt, the PST first described the classroom events and extended the description by reasoning how she thought the teaching was related to student learning. In this case, she reasoned that students had difficulty of understanding how to solve a problem because the teacher focused on using a formula and not on conceptual understanding. If this reflection ended after the first paragraph, then the reflection would be scored as a 2. Instead, she continued to provide an alternative strategy in the second paragraph that the teacher could have implemented to facilitate

student understanding in better ways, such as sharing probability of occurrence of simple events and asking students to provide other examples.

With regards to interrater reliability of analyses related to initial and final lesson analysis reports, the agreement between the researcher and the independent coder was 94 and 88 %, respectively. The conflicts were resolved using examples from the literature.

Analysis of Focusing on Student Thinking Through Lesson Protocol (Hughes, 2006; Hughes & Smith, 2004; Smith et al., 2008). At the end of the course, students' lesson plan protocols in teaching the subject of division were assessed according to the extent to which they focused on student thinking. Different than the typical format of a lesson plan, the lesson protocol (Hughes & Smith, 2004) provided questions for the PSTs in order to help them focus on student thinking: *What do students already know? What will they learn? What misconceptions might students have?* The prompts also encouraged them to think of ways to facilitate student learning such as: *What questions will you ask to focus students' thinking, assess students' understanding, and advance students' understanding of the mathematical ideas?* It was expected that PSTs answered each question on the Lesson Plan Protocol. In other words, the PSTs were required to consider what students already knew, what they were going to learn, the strategies students may have or misconceptions about the topic of divisions, and what questions to ask in order to help students extend their understanding.

The lesson plans were analyzed by using conceptual framework developed by Hughes (2006). The dimensions of the framework were the following: *identifying mathematical goals of the lesson*, *anticipating student thinking of the topic*, *identifying specific questions teachers can ask to extend student thinking*, and *discussions*. The last dimension in the framework, *discussions*, was dropped from the analysis in this study because originally *discussion* dimension was used to analyze one task, while in my study the lesson plan included more than one task and considered one lesson rather than a task as the unit of analysis. Dimensions in the framework were used to analyze the lesson plans in terms of attending to student thinking both qualitatively and quantitatively. The lesson plan score of each PST was determined by adding PSTs' scores associated with each dimension of the framework. I provide details on analysis and scoring of each dimension in the paragraphs that follow.

Identifying the Mathematical Goal of the Lesson. When the lesson plan did not include a goal, this dimension in the lesson plan protocol report was scored as 0. It was scored 1 when the goal was not specific enough or it was focused on skills rather than conceptual understanding. If the lesson goal was focused on understanding of a specific concept, then the score was 2. Each lesson plan was analyzed and coded for *identifying the lesson goal* individually by two independent researchers. The agreement between the researcher and the independent coder was 96 %. The conflicts were resolved by attending to the specificity of the lesson goal.

Anticipating Student Thinking About the Lesson Topic. This dimension included two different aspects of anticipating student thinking: (1) anticipating students' correct thinking about the topic, (2) anticipating students' misconceptions about the topic. "Anticipating students' correct thinking" meant that the PSTs provided possible

examples to students' thinking, which were correct about the lesson topic and could be considered as strength in understanding. For example, in planning to teach division, the PSTs may anticipate that students can do division by using repeated subtraction because they are familiar with the concept of subtraction (i.e. in order to divide 20 by 10, anticipating that students can use the repeated subtraction strategy: 20 – 10 = 10, 10 – 10 = 0). In the category of "anticipating students' misconceptions," the PSTs provided examples of difficulties in students' understanding, which could be considered as incorrect or erroneous thinking. For instance, it is an example of anticipating a student misconception that some students may ignore place value of numbers when doing division (i.e. anticipating an erroneous answer: 180 ÷ 3 = 6). The PSTs may be familiar with different aspects of student thinking based on readings, field experiences, or their experiences as learners.

For both categories, the lesson plan was scored a 0 if the plan did not include an example of anticipating student thinking. The lesson plan was coded as 1 when it included an aspect of student thinking that was not elaborated on. The lesson plan was coded as 2 when correct or incorrect student thinking was described in an elaborated way. Each lesson plan was analyzed and coded for *anticipating students' correct thinking* and *anticipating students' misconceptions* individually by two independent researchers. The agreement between the researcher and the independent coder was 88 and 92 %, respectively. The conflicts in levels of elaboration of examples were resolved by discussing whether such examples could be helpful for teaching.

Questions to Extend Students' Mathematical Thinking. The lesson plan was scored as 0 when it did not include any question. The lesson plan was scored as 1 when it included a question but the question did not have the potential to extend student thinking because it was mostly a factual question or sought for basic information (Cengiz, Kline & Grant, 2011). The lesson plan was scored as 2 when the question had the potential to elicit and extend student thinking and was based on student thinking. Each lesson plan was analyzed and coded for *questions to extend students' mathematical thinking* individually by two independent researchers. The agreement between the researcher and the independent coder was 92 %. The conflicts regarding classification of questions were resolved using examples from literature (Cengiz et al., 2011).

Results

Results of Qualitative Analyses

Lesson Analysis Skills of PSTs. In the beginning of the teacher education course, the PSTs generally focused on classroom management issues and tended to ignore student thinking in their lesson analysis reports. Out of 26 PSTs, only 1 PST's initial lesson analysis report was scored as 2 while the rest of the initial lesson analysis reports were scored as 1. As PSTs got familiar with the Lesson Analysis Framework and importance of the connection between student thinking and teaching practices, some PSTs demonstrated growth in their lesson analysis skills and shifted their focus to student understanding and its relationship with teacher decisions as shown in Table 1.

Table 1 PSTs' scores on the initial and the final lesson analysis reports, and lesson plan

PSTs	Initial lesson analysis score	Final lesson analysis score	Lesson plan total score
PST 1	1	1	3
PST 2	*1*	*2*	*4*
PST 3	*1*	*3*	*8*
PST 4	*1*	*2*	*8*
PST 5	*1*	*3*	*7*
PST 6	*1*	*3*	*5*
PST 7	1	1	1
PST 8	*1*	*2*	*5*
PST 9	*1*	*2*	*3*
PST 10	*1*	*2*	*4*
PST 11	1	1	3
PST 12	*1*	*3*	*8*
PST 13	*1*	*2*	*3*
PST 14	1	1	5
PST 15	*1*	*3*	*7*
PST 16	1	1	3
PST 17	1	1	4
PST 18	1	1	4
PST 19	1	1	2
PST 20	1	1	3
PST 21	1	1	3
PST 22	1	1	2
PST 23	*1*	*2*	*2*
PST 24	1	1	2
PST 25	1	1	2
PST 26	*2*	*3*	*7*
Average	1.04	1.73	4.15

The Initial and the Final Lesson Analysis Scores and Total Lesson Plan Scores are presented. PSTs are listed randomly. The PSTs who demonstrated improvement in their lesson analysis scores are presented in italics. Rows with items in upright position indicated a PST was in group 1 and rows with items in italics indicated a PST was in group 2

The analyses of reflections revealed that at the end of semester 13 PSTs' lesson analysis reports were scored as 1. Seven reports were scored as 2 and six were scored as 3. In summary, out of 26 PSTs, 13 did not show much improvement in lesson analysis skills based on the framework used and 13 demonstrated some type of improvement: 6 at the advanced level and 7 at a medium level.

Seven PSTs whose reflections were scored as 2 improved in their analyses compared to the beginning of the semester and were able to provide meaningful interpretations focused on student thinking. Six PSTs identified at advanced levels of lesson analysis skills were not only able to make meaningful interpretations of student learning in the

classrooms they observed, but also provided alternative strategies as they reflected on how they would teach the same class.

Using Student Thinking in Lesson Protocol

Identifying Lesson Goal. Out of 26 pre-service teachers, 10 were able to write a lesson goal that considered student understanding rather than skills, and which was not superficial. A typical example that was scored as 2, indicating more advanced learning goals than others was the following:

> The aim of this lesson is to help students understand the division concept as multiple subtractions. To reach this understanding, students may consider equal sharing or distribution, then they may find a solution by subtracting the divisor from the dividend repeatedly.

Thirteen pre-service teachers were able to write a goal for the lesson. However, the goal was mostly concerned with demonstrating certain computing skills and was not detailed. An example of a goal scored as 1 was the following: "My goal for this lesson is that students can solve basic division operations. As a result of this lesson, students have logic of division and they know how division problems are solved." Three PSTs did not write a goal even though they were prompted. Two of these PSTs demonstrated low levels of lesson analysis skills, and one of them was at a medium level. The average score for this dimension of lesson protocol was 1.27 out of 2, indicating that the average PST was able to write a goal even though it was not at a high quality. The average score associated with this dimension was higher than the other dimensions in the framework.

Anticipating Students' Correct Thinking. This dimension was the most difficult dimension to observe among the PSTs' lesson plans. The average score on this dimension was 0.58, and the maximum score was 2. Only 6 of the 26 PSTs' lesson plans were scored as 2, which indicated they included a specific example of *anticipating students' correct thinking. Anticipating students' correct thinking* included anticipating student strategies and anticipating their strengths in understanding the division concept. Three of the PSTs were able to anticipate student thinking vaguely; that is, they did not refer to details of students' possible ways of correct thinking. The following were two contrasting examples to anticipating student thinking. The first example was scored as 2 and represented more specificity with anticipating student thinking, in a problem situation representing division of 110 by 5.

> Students may solve this question by using pictures. For example, some students may draw 5 sticks for each group until they reach 110, some may count rhythmically by fives with fingers, or some may subtract 5s from 110 at each step until the difference is zero or less than 5 and then count how many steps they subtract. Also, some may separate 110 to 100 and 10, which are more obviously divided by 5.

The second example represented a vague way of anticipating student thinking and was scored as 1:"Students may already know the division of 2 digit numbers by one

digit numbers and how the base ten blocks can be used." Seventeen PSTs did not have any example of *anticipation of students' correct thinking* although they were prompted for examples in the lesson plan protocol.

Anticipating Students' Incorrect Thinking. Ten PSTs anticipated students' incorrect thinking in a detailed and meaningful way. Nine PSTs provided rather vague examples, which did not appear to be helpful for instruction. Seven PSTs made no effort to anticipate incorrect student thinking. The average score for this dimension was 1.11. The following were two examples of anticipating incorrect student thinking. The following paragraph was scored as 2 because it was specific to a given situation:

> Students may generally think that the unknown in the division problems is the number of groups. However, students also need to realize the unknown may be the group size, in other words, for this problem, the divisor with teacher's early moneybox example.

On the other hand, the following example was scored as 1 because it did not represent a specific student difficulty:

> In this lesson plan students may have difficulty in finding mathematical strategy to do division without using manipulatives at first. Teachers need to orient students to think on traditional division methods.

The findings revealed that, in general, PSTs were better at providing examples of incorrect student thinking as compared to anticipating correct student thinking.

Questions to Extend Student Thinking. Eleven PSTs were able to provide at least one question based on student understanding in a meaningful way. Nine PSTs provided questions that were too general and not based on student thinking, or did not have the potential to extend student thinking because they were focused on basic information and skills (Cengiz et al., 2011). Six PSTs did not provide any questions, although they were prompted. The average score for this dimension was 1.19. The following example represented a PST's questions that were based on students' thinking in a given situation in a meaningful way. The questions had a potential to extend students' thinking. Consequently, this dimension was coded as 2 for this PST's lesson plan. The PST decided to direct the following question to a student who demonstrated a misconception of finding 11 as a result of dividing 333 by 3. In this case, the PST appeared to understand that the root of the problem was a lack of understanding of place value:

> Let's represent 333 in a different way. How many hundreds, tens and ones are there? Let's convert hundreds to tens, how many tens do you have after converting?

Conversely, another PST wrote one possible question to ask without providing a context or circumstance under which it would be meaningful: "Can you explain the division in terms of multiplication?" The question was very broad

and did not seem to have potential to extend student thinking in a given situation. Therefore, it was scored as 1.

Results of Quantitative Analyses

Lesson plan scores were calculated as shown in Table 2. Quantitative analyses involved both correlation and the independent t test. The results indicated that there was a positive and statistically significant correlation between the final lesson analysis scores and total lesson plan scores of PSTs with Spearman's rho coefficient at $r = 0.708$, $p < 0.01$. When PSTs scored high in the final lesson analysis task, they were also likely to score high in the lesson plan task. This finding implied that lesson analysis and lesson planning skills were positively related to one another. This is an important contribution to literature in the sense that developing analysis skills of PSTs is not an end to itself. Rather, it is related to other important aspects of teacher learning and practices, namely, planning, which may influence teacher practices and student learning.

PSTs were grouped according to their final lesson analysis report scores (as seen in Table 1). PSTs who improved in lesson analysis skills and observations (whose final lesson analysis reports were scored as 2 or 3, indicated by gray rows in Table 1) received higher scores in lesson plans ($M = 5.46$, SD = 2.14) as compared to their peers who scored 1 in the lesson analysis skills report ($M = 2.85$, SD = 1.07). Table 3 demonstrates different means in lesson plan scores across two groups of PSTs.

An independent-samples t test was conducted to compare the Lesson Plan scores for PSTs Average Group 1 Lesson Analysis Low Final Report Scores and Average Group 2 Lesson Analysis Improved Final Report Scores. There was a statistically significant difference in Lesson Plan scores for Average Group 1 ($M = 2.85$, SD = 1.06) to Average Group 2 ($M = 5.46$, SD = 2.14); $t(17.60) = -3.93$, $p = .001$ (two-tailed). The magnitude of the differences in the means (the mean difference = −2.61, 95 % CI −4.01 to −1.21) was large (eta squared $\eta^2 = 0.29$). This indicated that 29 % of the variance in lesson plan performance could be explained by lesson analysis skills observed in the final lesson analysis reports. The results indicated that PSTs with intermediate and advanced lesson analysis skills in focusing on student thinking also performed better than their classmates in preparing lesson plan protocol with a focus on student thinking.

Summary

Viewed together, PSTs' lesson analysis skills were not productive at the beginning of the course. The fieldwork reports were mostly focused on classroom management or judgment of teacher behaviors and did not mention the student learning that took place during classroom observations. At the end of the semester, 13 PSTs demonstrated some type of improvement (Table 1, comparing the initial and final lesson analysis reports), whereas the other 13 participants were at still low levels. Preparing a lesson plan by considering student thinking was a challenging task for the majority of the PSTs. In general, as observed in Table 2, PSTs demonstrated most competence in the dimension

Table 2 Details of PSTs' lesson plan scores

PSTs	Lesson plan dimensions				Lesson plan Total score
	Identifying mathematical goals	Anticipating student correct thinking	Anticipating student incorrect thinking	Questions to extend students' thinking	
PST 1	2	0	1	0	3
PST 2	2	1	1	0	4
PST 3	2	2	2	2	8
PST 4	2	2	2	2	8
PST 5	1	2	2	2	7
PST 6	2	0	1	2	5
PST 7	0	0	0	1	1
PST 8	1	0	2	2	5
PST 9	1	0	1	1	3
PST 10	1	0	1	2	4
PST 11	1	0	2	0	3
PST 12	2	2	2	2	8
PST 13	1	0	2	0	3
PST 14	2	0	2	1	5
PST 15	2	2	1	2	7
PST 16	1	0	1	1	3
PST 17	1	2	0	1	4
PST 18	1	0	2	1	4
PST 19	1	0	0	1	2
PST 20	2	0	0	1	3
PST 21	1	1	1	0	3
PST 22	1	0	0	1	2
PST 23	0	0	0	2	2
PST 24	1	0	1	0	2
PST 25	0	0	0	2	2
PST 26	2	1	2	2	7
Average	1.27	0.58	1.11	1.19	4.15

Details on Lesson Plan Scores are presented here. Lesson Plan Total Score is calculated by adding scores related to four different skills: identifying mathematical goals, anticipating student correct thinking, anticipating student incorrect thinking, and questions to extend students' thinking

of *identifying a lesson goal*. On the other hand, *anticipating students' correct thinking* appeared to be the most difficult dimension in the lesson protocol task for the PSTs.

The quantitative analyses following the qualitative coding allowed me as a practitioner researcher to identify some patterns between two important skills for teacher candidates: lesson planning by taking into account student thinking and lesson analysis skills. This implies that PSTs who noticed student thinking in their fieldwork reports in more sophisticated ways compared to their peers were also better at considering student thinking in their lesson plans.

Table 3 Comparing PSTs' lesson analysis and lesson plan scores

PSTs grouped according to improvement in final lesson analysis scores	PSTs' lesson plan scores
Group 1: PSTs whose final lesson analysis report scores were 1 (no improvement comparing between the initial and the final lesson reports) ($N = 13$)	$M = 2.85$ SD = 1.07
Group 2: PSTs whose final lesson analysis report scores were 2 or 3 (demonstrating improvement comparing the initial and the final lesson reports) ($N = 13$)	$M = 5.46$ SD = 2.14

Table 3 shows two groups of PSTs and mean and standard deviation of their total lesson plan scores. There was a statistically significant difference in Lesson Plan scores for Average Group 1 ($M = 2.85$, SD = 1.06) to Average Group 2 ($M = 5.46$, SD = 2.14); $t(17.60) = -3.93$, $p = 0.001$ (two-tailed)

Discussion and Conclusion

Conducting this practitioner research study helped me become aware of both the strengths and limitations of my own teaching as well as the problems of teacher learning. The insights gained from this experience may help improve other teacher educators' practices. Although some of the PSTs' lesson analysis skills improved during the course under investigation in this study, the growth of lesson analysis and noticing skills across participants was not as obvious as mentioned in previous studies using the same reflection framework. In previously conducted studies (Barnhart & van Es, 2015; Santagata & Angelici, 2010; Sun and van Es, 2015), PSTs' lesson analysis skills were analyzed through the reflections on video clips of teaching, which may create differences in noticing compared to observations of fieldwork. Although viewing video also has limitations as mentioned in the literature review (Krammer et al., 2006; Sherin, 2004), video use may have facilitated improvement in lesson analysis in other studies. It is also probable that the lesson analysis skills of some PSTs did not improve because the field observation hours were limited. The teacher education course within the university and the internship experience in the middle schools was not coordinated such that mentor teachers and the teacher educators were familiar with each other's practices. There is a need for future studies to compare effectiveness of teaching lesson analysis using different tools in a variety of contexts.

Preparing lesson plans by considering student thinking was also challenging for the PSTs. The findings suggested that PSTs experienced difficulties in core activities of teaching. Some PSTs did not write a lesson goal, include potential questions to ask students, or provide examples of anticipation of student responses even though they were prompted to do so in lesson plan preparation. Specifically, the PSTs appeared to struggle in anticipating students' correct thinking about a given topic. One reason for this result may be because the PSTs, in general, may have observed student difficulties in their fieldwork placements and were not familiar with strengths in student understanding. The general difficulties about anticipating student thinking are almost certainly fueled by the PSTs' having no field experience, until this course in the teacher education program. This finding confirms a need to improve teacher education quality in Turkey by increasing the duration and quality of field experience (Özcan, 2013). Perhaps, if preparing lesson plans focused on student thinking was a practice that PSTs

were engaged in early in their fieldwork, PSTs' planning skills would have improved. Future studies may investigate whether improving analysis skills and collaborating with mentor teachers help PSTs improve their lesson planning skills and nature of their teaching.

One implication of this finding is that PSTs need to be more informed in student thinking via student records, readings, and concrete experiences in working with children. Also, use of a lesson plan protocol focusing on student thinking could be a more frequently used tool within other teacher education courses such that PSTs are familiar with the idea of focusing on student thinking in their lesson plans. In this study, the lesson analysis skills and practicing noticing of student thinking seemed to help PSTs focus on student thinking in lesson planning. The main finding of PSTs' noticing of significant events of a lesson being positively related to their lesson planning skills is compelling. Lesson planning experiences focusing on student thinking can, potentially, help teachers build instruction on student thinking in a meaningful way.

The results have implications for teacher education practices as well as research in teacher education. Use of lesson analysis frameworks *and* video technologies should be explored, and productive reflections should be facilitated by discussions such that PSTs may be more competent in their lesson analysis skills and noticing student thinking. It may be beneficial to PST learning for lesson analysis frameworks to be introduced early in the teacher education program and used consistently throughout. Furthermore, fieldwork practices could be supported by video technologies. Future research is needed to explore how teacher candidates' lesson analysis skills may be different if video is used or not in teacher education.

The differences between PSTs' performance with regards to both lesson analysis and lesson planning tasks could perhaps be explained by the differences in their mentor teachers. It is probable that some PSTs could improve professionally with the help of their mentor teachers who were more approachable and knowledgeable than others. Another possible explanation may be related to the fact that some PSTs may have more advanced levels of content knowledge than others, which could influence their noticing and lesson analysis skills as well as lesson planning (Dunekacke, Jenßen & Blömeke, 2015; Kersting, Givvin, Sotelo & Stigler, 2010). Future studies could investigate how PSTs' nature of content knowledge and their relationships with the mentor teachers could influence their lesson analysis and lesson planning skills.

One limitation of the study was that it was conducted in English, which was not the native language of the PSTs. Although English language proficiency was a course requirement, and their classes were conducted 100 % in English, the PSTs expressed difficulty in writing rich English language reflections on their fieldwork and detailed lesson plans. Consequently, PSTs' difficulties in using English language may be another reason for their low performance involving both tasks. Another limitation was that the study was conducted among a small group of PSTs. It needs to be determined whether the relationship between lesson analysis and lesson planning skills established in this paper could be replicated in other contexts, in other public and private institutions of teacher education. Future studies may investigate PSTs' lesson analysis skills and lesson planning skills together with instructional practices, and specifically, determine the extent they build on student thinking during instruction.

References

Barnhart, T. & van Es, E. A. (2015). Studying teacher noticing: Examining the relationship among pre-service science teachers' ability to attend, analyze and respond to student thinking. *Teaching and Teacher Education, 45*, 83–93.

Berliner, D. (1988). *The development of expertise in pedagogy*. Washington, D.C: American Association of Colleges for Teacher Education.

Cengiz, N., Kline, K. & Grant, T. (2011). Extending students' mathematical thinking during whole-group discussions. *Journal of Mathematics Teacher Education, 15*(5), 1–20.

Çakıroğlu, E. & Çakıroğlu, J. (2003). Reflections on teacher education in Turkey. *European Journal of Teacher Education, 26*(2), 253–264.

Davis, E. A. (2006). Characterizing productive reflection among preservice elementary teachers: Seeing what matters. *Teaching and Teacher Education, 22*, 281–301.

Dunekacke, S., Jenßen, L. & Blömeke, S. (2015). Effects of mathematics content knowledge on pre-school teachers' performance: A video-based assessment of perception and planning abilities in informal learning situations. *International Journal of Science and Mathematics Education, 13*(2), 267–286.

Fennema, E. & Franke, M. L. (1992). Teachers' knowledge and its impact. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 147–164). New York, NY: Macmillan.

Floden, R. & Meniketti, M. (2005). Research on the effects of coursework in the arts and sciences and in the foundations of education. In M. Cochran-Smith & K. M. Zeichner (Eds.), *Studying teacher education: The report of the AERA panel on research and teacher education* (pp. 261–308). Mahwah, NJ: Lawrence Erlbaum.

Grossman, P. & McDonald, M. (2008). Back to the future: Directions for research in teaching and teacher education. *American Educational Research Association, 45*(1), 184–205.

Hiebert, J., Morris, A. K. & Glass, B. (2003). Learning to learn to teach: An "experiment" model for teaching and teacher preparation in mathematics. *Journal of Mathematics Teacher Education, 66*, 201–222.

Hiebert, J., Morris, A. K., Berk, D. & Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education, 58*, 47–61.

Hughes, E. K. (2006). *Lesson planning as a vehicle for developing pre-service secondary teachers' capacity to focus on students' mathematical thinking* (Unpublished doctoral dissertation). Pittsburgh, PA: University of Pittsburgh.

Hughes, E. K., & Smith, M. S. (2004). *Thinking through a lesson: Lesson planning as evidence of and a vehicle for teacher learning*. Poster presented at the *Annual Meeting of the American Educational Research Association*, San Diego, CA.

Jacobs, V. R., Lamb, L. C. & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education, 41*, 169–202.

Kagan, D. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research, 62*(2), 129–169.

Keiser, J. M. (2012). Students' strategies can take us off guard. *Mathematics Teaching in the Middle School, 17*(7), 418–425.

Kersting, N. B., Givvin, K., Sotelo, F. & Stigler, J. W. (2010). Teacher's analysis of classroom video predicts student learning of mathematics: Further explorations of a novel measure of teacher knowledge. *Journal of Teacher Education, 61*, 172–181.

Krammer, K., Ratzka, N., Klieme, E., Lipowsky, F., Pauli, C. & Reusser, K. (2006). Learning with classroom videos: Conception and first results of an online teacher- training program. *Zeitschrift für Didaktik der Mathematik, 38*(5), 422–432.

Lampert, M., Beasley, H., Ghousseini, H., Kazemi, E. & Franke, M. (2010). Using designed instructional activities to enable novices to manage ambitious mathematics teaching. In M. K. Stein & L. Kucan (Eds.), *Instructional explanations in the disciplines* (pp. 129–141). New York, NY: Springer.

Lampert, M., Franke, M. L., Kazemi, E., Franke, M. L., Ghousseini, H., Turrou, A. C. & Crowe, K. (2013). Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of Teacher Education, 64*(3), 226–243.

Levin, D. M., Hammer, D. & Coffey, J. E. (2009). Novice teacher's attention to student thinking. *Journal of Teacher Education, 60*, 142–154.

Loughran, J. (2007). Researching teacher education practices: Responding to the challenges, demands, and expectations of self-study. *Journal of Teacher Education, 58*(1), 12–20.

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Research Council (2010). *Preparing teachers: Building evidence for sound policy*. Committee on the Study of Teacher Preparation Programs in the United States, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Onwuegbuzie, A. J. & Leech, N. L. (2004). Enhancing the interpretation of significant findings: The role of mixed methods research. *The Qualitative Report, 9*(4), 770–797.

Özcan, M. (2013). *University within school: A model to re-structure teacher education in Turkey*. İstanbul, Turkey: TÜSİAD Publications.

Price, J. N. (2001). Action research, pedagogy and change: The transformative potential of action research in pre-service teacher education. *Journal of Curriculum Studies, 33*(1), 43–74.

Santagata, R. & Angelici, G. (2010). Studying the impact of Lesson Analysis Framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education, 61*(4), 339–349.

Sherin, M. G. (2004). New perspectives on the role of video in teacher education. In J. Brophy (Ed.), *Using video in teacher education* (pp. 1–28). Amsterdam, Netherlands: Elsevier.

Sherin, M. G., Linsenmeier, K. A. & van Es, E. A. (2009). Selecting video clips to promote mathematics teachers' discussion of student thinking. *Journal of Teacher Education, 60*(3), 213–230.

Simms, M. (2013). A teacher-educator uses action research to develop culturally conscious curriculum planners. *Democracy and Education, 21*(2), Article 3.

Smith, M. S., Bill, V. & Hughes, E. K. (2008). Thinking through a lesson: Successfully implementing a high level task. *Mathematics Teaching in the Middle School, 14*(3), 132–138.

Star, J. R. & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education, 11*, 107–125.

Stein, M. K., & Smith, M. S. (2011). *Five practices for orchestrating mathematics discussions*. Reston, VA: National Council of Teachers of Mathematics.

Stein, M. K., Engle, R. A., Smith, M. S. & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning, 10*(4), 313–340.

Stemler, S. (2001). An overview of content analysis. *Practical Assessment Research and Evaluation, 7*(17), 137–146.

Sun, J. & van Es, E. A. (2015). An exploratory study of the influence that analyzing teaching has on preservice teachers' classroom practice. *Journal of Teacher Education, 66*(3), 201–214.

van Es, E. A. & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, 571–596.