The Lesson Play Experience: Professional Development of a Teacher

Rebekah Stenner
Simon Fraser University

Rina Zazkis
Simon Fraser University

Received: December 2020 Accepted: July 2021

In this study we introduce "lesson play experience" (LPE) for implementation as professional development for in-service teachers. LPE is an extension of the "lesson play" notion, which refers to a script for an imagined lesson, written by a teacher, presented as dialogue of teacher-student(s) interaction. In mathematics teacher education, lesson play has been used primarily with prospective teachers as a complement to traditional lesson planning. The LPE includes, in addition to a script for (part of) a lesson, observations of the actual taught lesson, and interviews with the teacher-playwriter in which the script and the lesson are discussed. We report on two rounds of one teacher LPE and the resulting modification. The investigation has shown that the LPE can be an effective tool for in-service teacher professional development.

Keywords · lesson play · in-service teachers · representation of practice · teacher noticing · professional development

Introduction

Mathematics teacher educators are in an ongoing search for effective professional development of mathematics teachers. Significant research efforts have been devoted to the issue (e.g., Even & Ball, 2009; Bednarz, et. al., 2011; Borko, et. al., 2014) exploring a variety of ways to support and enhance teacher knowledge and teaching practice. Scher and O'Reilly (2009) suggested that a more successful professional development is that which happens over time and is most closely tied to classroom practice. One way to ensure that classroom practice remains at the forefront, is by designing professional development that involves participants analysing or creating *representations of practice* (e.g., Buchbinder, & Kuntze, 2018). For the purpose of this study, we adopt a view of a representation of practice offered by Zazkis (2018):

> Practice is the practice of teaching and it is represented by a variety of artifacts, such as videos, animations, comic strips, vignettes, scripted interactions, or excerpts of student work. Some of the artifacts are carefully chosen excerpts of actual teaching practice, while others are imagined, designed and simulated. (p. 155)

A representation of practice then, could be anything from a video taken during a mathematics lesson, to a comic written by a teacher. A representation of practice on which this study is based is a *lesson play* (Zazkis et al., 2009, 2013). In the next section we focus on the notion of lesson

play and briefly describe what guided its development. We then outline the theoretical underpinnings of our study. Subsequently we elaborate upon the study detail and introduce our extension, namely the *lesson play experience* (LPE).

On lesson play

The notion of "lesson play" uses the theatrical interpretation of the word "play". As such, a lesson play is a script written by a teacher for a part of an imagined lesson that contains student-teacher dialogue about a potentially problematic area of a mathematics lesson. According to Zazkis et al. (2009), the notion of lesson play was developed as these researchers and teacher educators were dissatisfied with the traditional "lesson plan" as a way of preparing for instruction. They noted that the formats of presenting lessons plans, albeit their variety, did not allow for sufficient attention to exploring students' potential difficulties, or to possible pedagogical responses to students' ideas.

One of the salient features of lesson play is how it leads the playwright to focus on the specific details of a mathematical concept, how that concept is communicated to the student(s), and how the student(s) might respond. This is significant, as it has been shown that teachers tend to focus on general strategies rather than attending to the specifics of student mathematical thinking (e.g., Jacobs et al., 2011). Zazkis et al. (2013) observed a similar tendency when they compared what they noticed about a prospective teacher's lesson play with what a group of in-service teachers noticed about it:

> Most of the teachers' comments were of general nature. For example, they acknowledged the general strategy of re-voicing students' ideas and focusing on mathematical terminology, rather than attending to the specifics of the definitions... They also focused on the general desirable strategy of reviewing basic ideas, rather than on the appropriateness of the specific choices. Finally, they focused on the general idea of drawing connections, rather than on the particular connections that were (or were not) drawn. (p. 208)

When writing a lesson play, the teacher *must* focus on details, attend to the specific language, and consider students' interactions with mathematical content. In addition, a playwright should attend to specific pedagogical responses to student thinking.

Since its introduction, and through several iterations, lesson play has evolved significantly, and has been used extensively in research related to preservice teacher education (e.g., Crespo et al., 2011; Koichu & Zazkis, 2013; Mamolo, 2018, Zazkis & D. Zazkis, 2014;), and mathematics education at the undergraduate level (e.g., Brown, 2018, D. Zazkis, 2014). Researchers described multiple affordances of lesson plays for teachers-play-writers, as well as for teacher educators and researchers. Engaging in playwright forces teachers to look at and imagine different scenarios and how they might play out; in other words, to some degree lesson play is training in improvisation, which we believe is an essential skill for handling the messiness and unpredictability of teaching. For researchers and teacher educators, the plays written by prospective teachers provide a window into the writer's pedagogical dispositions and mathematical understanding. As such, the lesson plays provided data for researchers and avenues for further instruction for teacher educators (Zazkis & Marmur, 2018).

However, research has not yet attended to the kind of impact lesson play might have on *in-service* teachers; specifically, in what way lesson play could relate to or influence teacher practice, as well as how lesson play might be a useful professional development tool for

teachers. As such, this case study is a first step towards exploring how lesson play can be used with in-service teachers. Our purpose is two-fold: first, to examine how writing a lesson play may influence what teachers attend to, and second, to explore how lesson play may be used as a professional development tool for teachers. We offer an in-depth look at one teacher's scripts, how they relate to her corresponding lessons, as well as a more general discussion about her *lesson play experience* and the impact it had on her orientation as a teacher. What became particularly relevant throughout this study was where the teacher placed her attention; in other words, what she noticed and how she responded to what she noticed.

Theoretical underpinning: Noticing and attention

The construct of mathematics teacher *noticing* has attracted increased attention in mathematics education research community in the past several decades. Acknowledging the crucial importance of noticing in teacher practice, Dindyal, et al. (2021) provided a detailed summary of the literature, synthesizing different conceptualisations of noticing and related research approaches. In our brief overview we highlight several constructs that informed our investigation: noticing as a professional discipline (Mason, 2002, 2011, 2021), learning to notice framework (Van Es & Sherin, 2002, 2021), the construct professional noticing of children's mathematical thinking (Jacobs, et al., 2010) and situating noticing as part of teachers' decision making (Schoenfeld, 2011a, 2011b).

Much of Mason's work (2002, 2011) has been around recasting noticing as an intentional act. In doing so, he developed a *discipline of noticing* – a framework designed to help teachers break free of their habitual behaviours and act freshly in the moment. However, in order to act freshly in the moment, one must be able to notice an opportunity to do so. This framework therefore consisted of a collection of techniques designed to help teachers notice these opportunities. Specifically, Mason (2002) recognised that three things had to happen in order for someone to notice an opportunity to act: "being present and sensitive in the moment, having a reason to act, and having a different act come to mind" (p. 1). Furthermore, Mason (2011) referred to noticing as "disciplined inquiry" which guides teachers' actions. Mason's work linked the notion of noticing to shifts of attention, in particular, for teachers, "becoming aware of the shifts of their own attention can alert teachers to worthwhile shifts in learner attention, opening up possibilities for pedagogical actions to bring these about." (Mason, 2021, p.239).

Van Es and Sherin (2002) introduced a learning to notice framework which consisted of *attending* and *interpreting*. Attending related to identifying noteworthy aspects of a classroom situation, whereas interpreting included making connections between the classroom interactions and the broader principles of teaching and learning and using what one knows about the context to reason about what is observed. The authors claimed that how we interpret what we notice matters as much as what we notice.

More recently, the construct of *professional noticing of children's mathematical thinking* was introduced (Jacobs et al., 2010). The authors introduced a three-part framework, one that was more specific to noticing student thinking. It included attending, interpreting, and responding to children's strategies and understandings. The authors extended this work to look more closely at the third component – deciding how to respond on the basis of children's understanding. Jacobs et. al. (2010) concluded that developing expertise in this area is

challenging and that long-term professional development is needed. In accord with this theoretical development, Van Es and Sherin (2021) extended their previous conceptualisation of noticing by adding a third component, *shaping*. Shaping is construed as constructing "interactions and contexts that provide access to additional information" (p.19), which also extends the notion of responding and decision making from prior research (Jacobs et. al., 2010, Blomeke, et. al., 2015).

Schoenfeld (2011a) presented yet another perspective on noticing. He observed that teacher noticing is a function of their orientation. Thompson, et. al., (1994) also considered the influence that a teacher's orientation towards mathematics teaching has on their practice. They observed "two sharply contrasting orientations towards mathematics teaching" (p. 1), that they referred to as calculational and conceptual.

In providing some concluding remarks on the literature on noticing, Schoenfeld (2011a) wrote:

> But what teachers notice, and how they act on it, is a function of the teachers' knowledge and resources, goals, and orientations. Hence the study of noticing must be situated within the larger picture of teacher decision making. (p. 233).

So, going forward, if we accept that "[e]very act of teaching depends on noticing" (Mason, 2002, p. 7), then the question becomes, how can teacher noticing be developed and refined? How can we support practicing teachers in learning to notice in a way that will maximise student learning of and engagement in mathematics?

Method

In this report we spotlight the case of Samantha (pseudonym), who was one of nine participants in a larger study. We focus on Samantha because she was involved in two rounds of the study and her experience in the first round contributed to the design of the second. At the time of this study Samantha was in her ninth year of teaching. She had a combined grade 5-6 class at a school with a vulnerable student population.

Lesson play extended

While the notion of a lesson play formed the basis of this work, the process in which we invited Samantha to participate extended the writing of a lesson play; other elements related to professional development became a significant part of the experience. For this reason, we introduce a framework to which we refer as "lesson play experience" (LPE) to describe the process that Samantha engaged in. Specifically, the LPE consists of the following:

1. Writing and submitting a play/script
2. Participating in a pre-lesson interview (this step was added after the first round of implementation)
3. Teaching the planned lesson
4. Participating in a post-lesson interview

Step 1: Writing the Play

To support Samantha with the process of writing the script and to help her develop a better understanding of lesson play, she was given an article introducing lesson play (Zazkis et al., 2009) and a book that provided more detail and several examples of scripts (Zazkis et al., 2013). Once the notion of a lesson play was familiar, Samantha wrote a script based on part of a mathematics lesson or task that she anticipated would be problematic for her students. The particular mathematical topic was chosen by the teacher based on her knowledge of students and the curriculum.

Step 2: The Pre-lesson Interview

This step was added in the second round of the study (the need for including this step is explained following the description of Round 1 of the study). After submitting the script, Samantha met with the interviewer to discuss it. One of the affordances of this interview, which lasted about 30 minutes, was that it provided a natural opportunity for mentorship. The interviewer asked questions about the script and offered feedback. Typically, the interviewer attended to three aspects of the script: relevant mathematics, how the teacher responded to the students' mathematical thinking, and how the teacher was managing the class.

Step 3: The Lesson

Once Samantha had written her script and discussed it with the interviewer, she taught the lesson that she addressed in her script. The entire lesson was observed by the interviewer who took field notes, focusing on how Samantha interacted with the students. As students worked in small groups, part of the interaction between the teacher and students was audio-recorded.

Step 4: The Debrief Post-lesson Interview

During the post-lesson interview, which lasted about 60 minutes, the teacher and interviewer were able to look back, reflect on the experience and draw some conclusions. The focus of discussion was on what happened during the lesson, as well as what influence lesson play may have had in how the lesson unfolded. This interview also provided an opportunity for mentorship, considering some aspects of the lesson that may not have gone as well as was hoped, and possible alternative actions to try in the future.

Research Questions

As mentioned above, the influence that lesson play could have on in-service teachers has not yet been explored. To contribute in this area, we aim to address the following research questions:

1. How does engaging in the LPE influence what a teacher attends to, and what could the implications be of that shift in attention?
2. How might LPE be useful as a professional development tool for in-service teachers?

Data collection and analysis

Data were collected in three forms: a script submitted by the teacher, fieldnotes taken during observations of the lesson (supplemented with an audio recording), and two audio-recorded interviews.

In order to analyse the data, we transcribed the audio recordings from the lessons and interviews. We then implemented inductive content analysis (Hsieh & Shannon, 2005; Weber, 1990) considering patterns and trends in all the components of data. We looked closely at the construct of teacher noticing and how lesson play might be a tool that could influence what teachers attend to. We identified common themes that were addressed (a) in the script and in the lesson; (b) in the script and the pre-lesson interview, (c) in the lesson and the post-lesson interview, and (d) in the two lessons. Our report of the results is organised according to several of these themes, chosen for their potential impact in teacher professional development.

Results and Analysis

The following analysis has excerpts from scripts for a lesson play, from lessons, and from the interviews. As all these excerpts are presented as an interaction between interlocutors, for the ease of distinction, 'S' before the talk-turn number refers to *script*, to indicate that the excerpt is taken directly from a participant's lesson play script. An 'L' refers to *lesson*, indicating the excerpt is taken from audio of the lesson, and an 'I' refers to *interview*, to indicate that the excerpt was taken from the audio of an interview. In some longer excerpts "S" or "L" is followed by a number for the ease of reference. Furthermore, we refer to Samantha as 'teacher' when interacting with her students in a lesson or in a script, and by her pseudonym when interacting with the interviewer. In what follows, we present the results from the two rounds of Samantha's LPE. In each round we focus on several themes and describe episodes contributing for a professional development of the teacher.

Round 1: Pumpkin farm

Samantha wrote her first lesson play around a task that was presented in Zazkis et. al (2013), although she modified it slightly. The task was initially presented as follows:

> Once upon a time there were two melon farmers; John and Bill. John's farm was 200 by 600 m and Bill's farm was 100 by 700 m. Who grew the most melons? (Zazkis et. al, 2013, p. 161).

In her script Samantha adapted the task, as she was concerned many of her students would not know how to multiply larger numbers. She presented the following version of the task to her students:

> Once upon a time there were 2 pumpkin farmers; Bill and John. John's farm was 20 × 60 m and Bill's farm was 10 × 70 m. Who could grow the most pumpkins?

Theme 1: Using diagrams

In what follows we present a part of the lesson play script written by Samantha; this is Samantha's imagined interaction with students working on the pumpkin farm problem. We note Samantha's attention to the expected difficulties her students may face and their approaches.

S-John: What farmer can grow the most pumpkins. I guess I could draw the farms.
S-Teacher: Great! Show me what you'd draw on the whiteboard.
S-Maria: We can add the sides to see what farm is biggest.
S-Teacher: Okay so you're going to find the perimeter?
S-Maria: Yes.
S-Teacher: Think back to Wednesday, when we worked on this as a class. What does perimeter tell us again? What was the strategy we used when remembering perimeter?

In her script, Samantha imagined that some students would decide to draw a diagram as a strategy. Samantha also predicted that some groups would calculate perimeter instead of area. In such a case her planned approach was to refer to a previous lesson in which the concepts of perimeter and area were revisited. This would help students remember why calculating perimeter might not be an appropriate strategy. What she perceived to be an appropriate solution is presented in Figure 1.

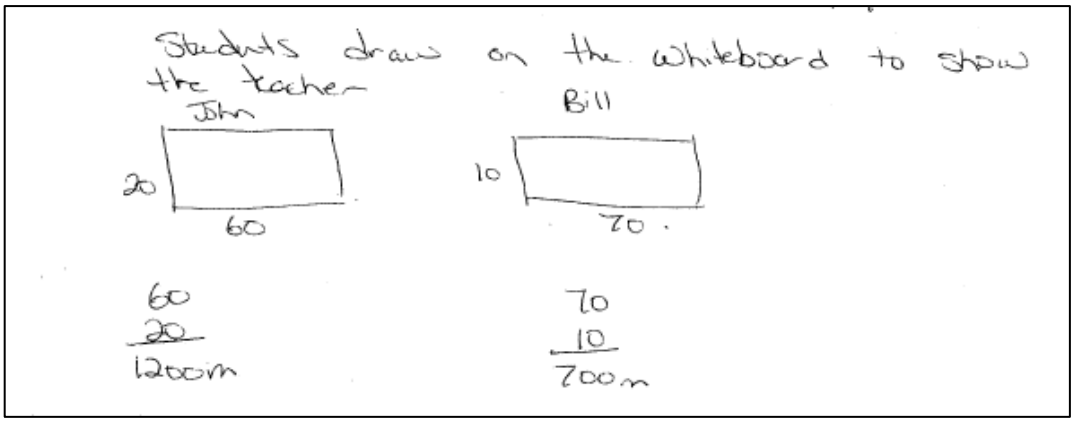

Figure 1. Excerpt from Samantha's script: area calculations, incorrect units (m instead of m^2)

Overall, Samantha was surprised and disappointed that so few of the students were able to make sense of this problem. She shared this during the debrief interview afterwards:

I-Samantha I was hoping somebody would have remembered the lesson... but nobody remembered. So like, then I was thinking okay how do I get them to remember things in the future so you're not constantly reviewing the same thing all the time? You know what I mean? Like every single person at first was like, "I don't understand." ...Like I thought you would have learned area and perimeter in lower grades. But they just, like they lose it – the second they walk out the door it's out of their brains.

It was evident that many students did not understand the problem or know what to do to solve it, but Samantha's ideas about why were different from ours. She understood the issue to be that students did not remember the difference between area and perimeter, whereas it seemed to us that the issue was around application – students did not recognise that the problem was about area.

Van Es and Sherin (2002) observed the importance of how teachers interpret events: "In defining what it means to notice, we want to highlight the importance of *interpreting* classroom interactions. Thus, how individuals analyse what they notice is as important as what they notice" (p. 575). Based on Samantha's understanding of what happened, her concern was with helping students retain what they learn about area and perimeter. That is where the notion of interpreting an event leads to a particular *shaping* of interactions. However, the focus of the post-lesson interview was on how to help the students learn to apply the ideas, and how to decide which is appropriate in a given scenario, potentially leading to an alternative shaping.

Theme 2: On square units

The following exchange about square units was observed in the lesson as Samantha responded to the solution of one group of students.

> L-Teacher: The only thing you're missing is the unit of measurement. Remember, with the little two above it for metres squared? So whenever you're doing area it's length times width. So this is all I'm asking you to include, m for metres, squared 'cos it's area.

From this interaction, it is evident that Samantha attended to an incomplete student answer, but her interpretation of student work related to incomplete memory of how to record the result. It appeared that Samantha herself may have been unsure about the meaning of a square unit (see Figure 1). This was discussed during the post-lesson interview, as the interviewer asked Samantha to comment on her directions to students cited above, and in particular on the use of "metres squared":

> I-Samantha I mean I don't know why it's like that. Like I just learned it and it is and I hadn't looked at that further, so I was like I didn't have your answer, right now. But then I'm like maybe I should have said, "well I don't know – we will find out or I will find out and get back to you" or something instead of just saying I don't know. I didn't give her any closure or an answer for her. I just was like I don't know.

We noticed after this interview that Samantha's script for a play had provided some foreshadowing into her possible misunderstanding of square units. In the script Samantha had offered what is shown in Figure 1 as an anticipated correct student solution to the problem. Note that the numerical result is correct, (event though the multiplication is not explicitly indicated by a symbol) but the unit attached to the numerical solution is m (metres) rather than m^2 (square metres). Had this issue been attended to and discussed before the lesson, Samantha would have had an opportunity to develop an understanding of what a square unit is and hence, would have been better equipped to handle the related student questions. The professional

development should have happened, at least in part, *before* the lesson rather than after. This realisation was the most significant take-away from the first round as it changed how the study proceeded and how the data were collected for the remainder of the study.

Round 1 – Overall reflection

Although Samantha was disappointed with how much her students struggled with this problem, she did express an overall appreciation for writing a lesson play during the debrief interview:

> I-Interviewer: So for the whole process, did you find that any of it could be helpful to you as a teacher, like what particular aspect do you find, if any, that made it easier?
>
> I-Samantha: Well I did like the anticipating what the potential problems could be in the beginning and thinking about that before you deliver the lesson, like that did help me kind of figure out how I wanted to do it or… you had to think ahead, which I think was really helpful. I find with this demographic too, you have to really spell everything out I find. You can't leave a lot for them to figure out on their own, so having me think about that in the beginning helped me then teach it later.

Samantha appreciated the opportunity to slow down and think carefully about what she wanted to do, and potential problems that could arise. Yet, she had not anticipated how much trouble the students would have, or that students might have difficulty with units.

Although Samantha did not realise how difficult the task she chose would be for her students or herself regarding answering her students' questions, these difficulties are well-documented. Zazkis et al. (2013) summarised the literature and concluded that not only do children often confuse the concepts of area and perimeter, but also that the concept of area is often not well understood by elementary school teachers. Perhaps this explains why Samantha struggled to guide her students with this task, and why she focused on procedural explanations. This is consistent with the statement Samantha made during our final interview about how when she was in school, she "didn't get to know the why".

As a result of the first round of the study the LPE sequence was extended.

Towards Round 2– Extending Lesson Play Experience

As mentioned above, we realised after the post-lesson interview that it would have been helpful to have talked with Samantha about her script before she taught the lesson, as some of the challenges that occurred during the lesson could have been predicted from the script. From this realisation it was decided that in going forward, one more point of contact with the teacher would be added: there would be a brief interview about the script *before* the teacher taught the corresponding lesson. That is, after reading the script, the interviewer and Samantha discussed it, as well as the potential pedagogical and mathematical implications of teaching the lesson as imagined in the script. Samantha then had the option of refining her preparation for the lesson.

Round 2: Multiplication algorithm

Samantha's second LPE took place five months later, in the following school year. Her script was written on multiplication of two-digit by one-digit numbers. She planned to teach the lesson using the standard algorithm, but with a focus on understanding why the algorithm works. Specifically, Samantha wanted to introduce the algorithm as a compact form of multiplication by first having students explore multiplication by calculating two easier products, implicitly referring to the distributive property. For example, she wanted students to notice that 42 multiplied by 3 could be thought of as three 40s and three 2s. Samantha's plan was to use this opening exercise to get a sense of what her students knew, as well as what strategies they might use to determine the product.

Theme 3: On "the Why" and on "adding zeros"

In the script, Samantha anticipated students' difficulty and described a possible intervention. She wrote:

S1-Teacher:	Can we split the 42 to make it easier? What about looking at it like 40 + 2 = 42. Splitting it up into two parts.
S2-John:	Okay but I'm not sure why.
S3-Teacher:	What is 4 x 3?
S4-John:	12
S5-Teacher:	Right, so if you know 4 x 3 = 12, what would 40 x 3 equal?
S6-John:	I could just add a zero so 40 x 3 = 120.
S7-Teacher:	Yes 40 x 3 = 120 which means 4 tens x 3 = 12 tens.
S8-John:	So the answer is 120!
S9-Teacher:	Not quite. What part of the question did we not include yet? 40 x 3 = 120 but the original question is 42 x 3 =___. We need to now multiply 2 x 3.
S10-John:	6
S11-	Right so 120 + 6 = 126
S12-John:	So the answer is 126.
S13-Teacher:	Breaking the question down into two easier problems can make it easier to solve. 40 x 3 and 2 x 3 is easier than doing one big question or drawing a large array which can be confusing and time consuming.
S14-John:	I think I get it now.

We talked about this excerpt during the pre-lesson interview for a few reasons. First, because when John expressed that he did not know *why* he should "split the 42" [S1-S2], rather than clarifying why, Samantha's explanation seemed to be about *how* to carry out the calculation.

I-Interviewer: John says okay but I'm not sure why. So you kind of showed what to do –
I-Samantha: I didn't tell him why.
I-Interviewer: Yeah. I think the why is because it's three forties and three twos.
I-Samantha: Okay I will add that part.

Interestingly, with the declared focus on understanding of the standard algorithm, there was no explanation provided or even sought in Samantha's script. However, during the pre-lesson interview she noticed it herself and decided to modify her script.

Another notable feature of this excerpt was the conversation about "adding a zero" [S5-S8]. John suggested "adding a zero" as a strategy for determining 40×3 from 4×3, and Samantha affirmed John's idea and explained why. While we could have responded to John differently, for example by questioning his understanding of "adding zeros", we see Samantha's response as a significant pedagogical shift. This is because in the first round of the study a similar situation arose and Samantha did *not* explain why; rather, she reminded students to "just add the zeros". Below is an excerpt from a conversation she had with a group of students around the pumpkin problem. Students were trying to multiply 20 by 60 to determine the area of John's farm.

L-Teacher: So can you do that multiplication? What's two times six? You know this. Yes, so write twelve. And how many zeros are there? Just add the two zeros.

Because of her change in response to students regarding "adding the zeros", it appeared that Samantha had moved away from a follow-the-rule orientation and was now on a path to more of a sense-making orientation (Schoenfeld, 2011a). She had shifted her attention to helping students understand the mathematics behind the procedures. In terms of VanEs and Sherin's revised framework (2021), we suggest that *shaping* interactions as a result of shift of attention can be implemented not only in a classroom, but also in an imaginary scripted lesson.

Theme 4: Responding to a student error

In the next part of the script, Samantha wrote about intervening in a group that was working on calculating 63×3. The error that Samantha anticipated was that the students would misalign the digits:

S-Teacher: Let's have a look at how your group is doing.
S-Katie: We are doing what you said and breaking the question into two easier questions. We broke it down like this:

$$\begin{array}{r} 63 \\ \underline{\times\ 3} \\ 3\times3 = \quad 9 \\ 60\times3 = \underline{+180} \\ \quad\quad 270 \end{array}$$

So the answer is 270.

S-Teacher: Do you see anything in your problem solving that doesn't seem quite right?
S-Katie: What do you mean?
S-Teacher: Have a closer look at your number alignment. Are all the numbers in their proper place value as you were working through the question?
S-Katie: Let me look. Oh I see. When I line the numbers up I get 189 not 270. I have to make sure I watch that the numbers are in the proper place first.
S-Teacher: Yes because if you don't the answer will be incorrect.

In reading this, the interviewer noticed that Samantha asked a question about Katie's answer rather than immediately saying it was wrong. This was a change from how she might have responded previously. She was able to notice and act on an opportunity to do something different. In her exchange with the student, Samantha focused on number alignment. During the discussion afterwards, the interviewer suggested alternatives for how to respond to this type of error, and to students' errors in general.

While no one misaligned digits during the lesson, we note some influence in how Samantha responded to students' work. The following conversation took place as Samantha attended to a student who was working on 58×5.

L-Teacher: Okay so tell me, you think it's two hundred fifty – how are you doing it?
L-Carmen: I haven't done this in a long time. Can you please tell me how to do this?
L-Teacher: Okay well you've done this [points to 8x5]. You've got forty. What do you think you should do next?
L-Carmen: Add the four to the tens.
L-Teacher: So what do you think? So four times five times five?
L-Carmen: Yeah.
L-Teacher: And what would that equal? So four times five is…
L-Carmen: Twenty.
L-Teacher: times five is one hundred. So you think we're gonna go like this now? [writing 100 beside the zero that was already below to give a final answer of 1000]
L-Carmen: No.
L-Teacher: Is five groups of fifty-eight close to one thousand? Would that make sense?

L-Carmen: No.

It seemed that the student was on the right track except she had not added the 40 (note 4 in the tens place) after multiplying 50 by 5 (see below). She had 250 as the answer and it should have been 290:

$$\begin{array}{r} {}^{4}58 \\ \underline{\times\ 5} \\ 250 \end{array}$$

It appeared the student did not know how to include the 40 that had been obtained from 8 x 5. In her next attempt, she multiplied the 4 by the 5 in 58, and then multiplied that answer by 5. This was discussed at length during the post-lesson interview; specifically, the interviewer focused on the way in which Samantha interacted with the student.

I-Samantha:	Well at first I was like I don't even really understand your thinking so I really needed her to like lay it out for me and then when she said it I'm like oh you're gonna get a number that's way wrong.
I-Interviewer:	But you let her do it.
I-Samantha:	Yeah because at first I'm like I don't understand what she's trying to tell me. And then I just thought like I'm gonna play this out a little bit 'cos I was confused and then it ended up working that then once she did it I got what she was trying to do.

Again, we saw this as evidence that a shift had taken place in Samantha's attention and how the instruction was shaped. From the way she was communicating with this student and others, it was evident that her focus was much more on trying to understand her students' mathematical thinking than it had been during the first round of the study. This points to Schoenfeld's (2011b) notion of diagnostic teaching:

> In diagnostic teaching …the teacher recognises that students have varied understandings of the mathematics under discussion. He or she probes for what the students know and then responds in ways that address errors and misconceptions, and that builds on student understanding, to move the students toward the instructional goals. (p. 463)

Samantha was trying to figure out what strategies her students were using, why they were using them, and what difficulties they were having. Her attention was on student learning, and as such, she identified a need to talk with students and really listen in order to figure out how they are thinking about a problem.

Theme 5: Student explanation

In the final portion of Samantha's lesson play, she wrote about bringing the class over to one group's whiteboard and introducing the standard algorithm for multiplication as a compact way to multiply – a way that "saves time and space" in her words. She did bring the class to one group's whiteboard, but the conversation did not take place the way she had planned.

L-Teacher:	Okay, you guys I want you to come over to Tom's group. Come closer [class standing]. Okay so this was the question that Jake was working on. I hear people talking. Shh. It was this one right Jake? Fifty-eight times five? No fifty-three times three.
L-Jake:	Yes.

Teacher:	So Jake had an interesting thing to share. Can you show us your way of thinking on this question?
L-Jake:	Alright so um a lesson that Ms Owen recently teached was pretty much you take this number and look at these, so pretty much what you're doing is just counting say you wanna do this number first you just have to count by fifty three times.
L-Teacher:	So write that down.
L-Jake:	So that would be one hundred fifty.
L-Teacher:	So you did fifty, so he goes fifty plus fifty plus fifty. Kay what's the next part?
L-Jake:	And then you just look at your last number and then what's three times three which would be nine so you scratch that out and put a nine here.
L-Teacher:	So good – see? He broke the question down into two simpler numbers that he could do quickly so he broke it down to fifty and three. Kay 'cos then we can add this quickly to be one hundred fifty and we can do this to equal nine and then we can add these together one hundred fifty nine.

Samantha had planned to offer a similar explanation earlier on in the lesson, but in the script, there was nothing written about her having a student explain it. The interviewer learned during the post-lesson interview that after Samantha had submitted the script, she changed her plan slightly, and hoped that rather than her introducing this method, that a student would come up with it. Because she had changed her plans, she was *actively looking for someone to do this*, and was quite happy that during the lesson, a group did in fact use this method. Samantha was also surprised and excited as the student who explained this strategy rarely talks in class:

I-Interviewer	So what are some of the things you noticed from the lesson?
I-Samantha:	Well they were more engaged than I had anticipated. They knew more than I thought they were going to know - well some of them did. And then like Jake speaking up – that was really cool because he doesn't say anything ever, and I don't ever think he's listening. So he was listening even to something, so that's cool.
I-Interviewer	He was really proud.
I-Samantha:	Oh yeah he was so that's awesome too – just maybe boost some confidence there in him. 'Cos I don't think he's the most confident person so that's helpful.

After elaboration on the strategy presented by Jake, Samantha gave the class a few more problems and invited them to try using Jake's strategy. She spent some time circulating – helping groups and giving bonuses, and then wrapped up the lesson.

Round 2 – Overall reflection

How Samantha had taught during her nine years as a practicing teacher reflected how she had been taught mathematics. This came up several times in conversation, but most notably, during a discussion about the "why":

I-Samantha:	And I think just like when I went to school you didn't get to know the why – you just had to memorise the how, so it's hard to for me now to teach the why because I'm like well I have to really think about it myself because before it was just like memorise this, do this and so then when I'm teaching it I'm like well what is the reason, like there was something else I was doing the other day, I'm like let me just look at this for a minute … it took me a minute to even realise 'cos I can do the multiplication and it's just that the why is still difficult for me to teach too.
I-Interviewer	So what's making you look for that now? The why?
I-Samantha:	Well probably because of that.
I-Interviewer	Because of lesson play?
I-Samantha:	Yeah.

It was this experience of lesson play that finally allowed Samantha to see that there is another way to teach mathematics. It is interesting that at no point during the interviews did she mention her teacher training as having any impact or influence on how she taught; rather, it was her own experience as a student that had informed her practice.

During the post-lesson interview, Samantha and the interviewer were discussing another shift in orientation that she had experienced through this process: from focusing on covering content to focusing on student learning. This was an inevitable result of her more foundational shift to a conceptual orientation, as a focus on student learning requires noticing and responding to student thinking and discourse; in other words, the students are involved – participants in the improvisation as King says (2001). We talked about how teaching this way necessarily involves a letting go of some control regarding how much one "covers":

I-Samantha:	Well it just makes it, and to not rush it as much anymore, like let it go.
I-Interviewer	Let it go.
I-Samantha:	So I mean we're not as far as maybe I'd wanna be but like I just have to even let that go, like it just has to kind of go the way they lead it and stop where you need to stop so…

As King (2001) observed, "in a classroom where conceptually oriented mathematics teaching is being enacted the students are a part of the improvisation, not passive receivers of knowledge" (p. 11). As such, it would be impossible for a teacher to predict in advance either how long the lesson would take, or in what direction it might go. It should be noted here, that alignment between what the teacher imagines might happen and what actually happens in the lesson is

not the goal of lesson play. What is of interest is the degree of alignment between the teacher's imagined and actual reactions to students' incorrect answers or ideas. The goal of lesson play is for a teacher to reconsider her reaction to what students do and what mathematical ideas they present, and therefore to develop an expanded repertoire of possible responses. An exercise in interpreting a potential situation and shaping a follow up instructional interaction equips teachers with resources to turn to in actual teaching. We note that in the second round both the script and the actual lesson were more responsive to students' mathematics, which we consider a contribution of the LPE.

To us, this is the essence of diagnostic teaching: teaching in response to student mathematical thinking and understanding, as evidenced by their conversations, questions, and mathematics presented on the whiteboards. Samantha was now spending much more of her time engaging in diagnostic teaching, whereas previously she rarely did so as she was primarily concerned with teaching procedures and covering content.

Samantha's LPE reinforced the finding repeatedly acknowledged in prior research, which is is how much our own experiences as students of mathematics can influence us as teachers (e.g., Ball, 1988; Cheek & Castle, 1981; Oleson & Hora, 2014). It seems the norms we learn as children can become so deeply entrenched, that we do not even realise that there might be other ways to do things. In Samantha's case, these beliefs prevailed, even over more effective strategies she may have learned during her teacher education program. This points to the need for teachers to receive consistent, research-based professional development and to be able to explore and work with it in a supportive collaborative setting, as one cannot act differently unless they have both a reason to do so, and an alternative action in mind (Mason, 2002, 2021).

Discussion

Until now, lesson play has been used primarily as a tool to help prospective teachers both imagine and deal with potentially problematic issues in teaching. Addressing the research questions could inform possible ways of introducing LPE as a professional development tool for in-service teachers.

How does engaging in the LPE influence what a teacher attends to, and what could the implications be of that shift in attention?

As Schoenfeld (2011a) pointed out, teacher noticing is a function of their orientation. That orientation can be limited, especially for novice teachers; it might be comprised of a collection of their own memories of being a student, along with what they learned about what it means to teach. And after some time in the classroom, they would also likely begin to adopt a way of seeing based on the institutional or cultural norms in which they work.

Samantha seemed to epitomise the fact that teacher noticing is influenced by cultural and institutional norms. As a result of her experience as a student of mathematics, and through interactions with administrators and colleagues, as well as a general cultural acceptance of this norm, Samantha had come to value covering content. Covering content was an integral part of her orientation, and as a result the majority of what she attended to was focused on and interpreted in terms of that outcome.

If, however, teachers are somehow able to shift or expand their orientation, as was the case in this study, they can awaken to an entirely new way of seeing, after which they will likely begin noticing and attending to things that had previously been completely overlooked. Samantha shifted from focusing on procedures and covering content, to a more conceptual orientation. As a result, she started attending to strategies students were using, errors in their reasoning, and ways of productive intervention. This shift in attention led her to notice specific aspects of her students' mathematical reasoning that were likely either invisible or very much in the background to her before, and consequently shape her instruction.

A shift in orientation is like looking at the same thing through new eyes and can bring about new worlds of noticing – worlds that once seen, cannot be unseen. So how did such a change come about for Samantha?

Writing a lesson play requires the playwright to slow down and carefully consider the mathematics, the students, and the ways in which the students might interact with the mathematics. The need to actually write down imagined conversations demands consideration of the details of mathematical language as well as possible student responses. This shift in attention from content to student thinking was one of the initial goals of lesson play: "The idea of a lesson play was introduced to… engage prospective teachers in the process of seeing what learners might be attending to— and not just what they, as teachers, plan to instruct" (Zazkis et al., 2013, p. 22). Samantha's experience demonstrates possible advantages of implementation with in-service teachers.

How might LPE be useful as a professional development tool for in-service teachers?

What occurred to us early in this study, was that writing lesson play on its own may be limited as a professional development tool. There seemed to be a necessary element of mentorship. For prospective teachers this element is achieved when lesson plays are brought to discussion and critique in class, as students may revise and rewrite following class discussion and exposure to additional research literature. In-service teachers usually do not have access to such a community. For this reason, we introduced LPE, the notion of a *lesson play experience,* that has mentorship built into its structure. A significant feature of the LPE is that it combines a representation of practice, in a form of writing a script for a play, with the actual practice of teaching. Our study demonstrates that this combination can be a powerful tool for professional development.

Conclusion

The primary strength of this study is that Samantha's experience can be seen as a "proof of concept". That is, we demonstrated how the notion of lesson play can be extended to professional development settings with practicing teachers. We extended it by introducing the notion of a *lesson play experience* (LPE), where teachers write and submit a script, participate in a pre-lesson interview, teach the lesson that corresponds with the script, and participate in a post-lesson interview. Extending research that involved participants in writing lesson plays or other imagined scripted interactions, carried out mostly with prospective teachers, our study

was conducted in an actual teaching environment. In a way, the LPE provides a bridge between a representation of practice with actual practice.

Another strength is that Samantha learned a lot, both about herself and about how she relates to her students and their mathematical thinking. Perhaps this is because the LPE requires several points of contact with the teacher, which allowed Samantha and the interviewer the opportunity to explore teaching together.

A limitation of this study is that writing a lesson play is not easy. It is time-consuming and difficult and for this reason, we may have attracted a teacher who is particularly passionate or ambitious. Furthermore, the study relied on a collegial relationship of trust developed between Samantha and the interviewer, which could have influenced the results. Perhaps it was the combination of multiple touch points, and direct involvement in authentic classroom experiences that resulted in such a bond.

However, rather than a limitation, a professional bond could potentially be an affordance of the LPE, where the relationships forged during the experience endure to become long-term professional collaborative communities of teachers. An interesting question to explore then, would be what the LPE might look like if we introduce a collaboration component: perhaps a mentor along with two or three teachers who write a script together. The teachers could then teach the lesson separately and reflect together afterwards. In an overview written about professional development and teacher learning, Borko (2004) concluded that, "strong professional development communities are important contributors to instructional improvement and school reform" (p. 6). Borko added that the development of such teacher communities is not easy and noted the importance of a critiquing component. These elements of collaboration with critique could potentially become part of the LPE and may in fact be a natural extension, that we intend to explore in the future.

Overall, we suggest that the LPE has the potential to shape teachers' practice. As a tool that directs teachers' attention to specific aspects of student mathematics, the LPE can support teachers in their practice of noticing and responding to student mathematics. Moreover, because of the structure of the experience, there is a mentorship component which supports teachers as they go through this process.

References

Ball, D. L. (1988). Unlearning to teach mathematics. *For the learning of mathematics*, *8*(1), 40-48.

Bednarz, N., Fiorentini, D., & Huang, R. (Eds.). (2011). *International approaches to professional development for mathematics teachers*. University of Ottawa Press.

Blomeke, S., Gustafsson, J., & Shavelson, R. (2015). Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie, 223*(1), 3–13.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*, 3-15. https://doi.org/10.3102/0013189X033008003

Borko, H., Koellner, K., & Jacobs, J. (2014). Examining novice teacher leaders' facilitation of mathematics professional development. *The Journal of Mathematical Behavior*, *33*, 149-167. https://doi.org/10.1016/j.jmathb.2013.11.003

Brown, S. (2018). Difficult dialogs about degenerate cases: A proof script study. *The Journal of Mathematical Behavior*, *52*, 61-76. https://doi.org/10.1016/j.jmathb.2018.02.002

Buchbinder, & S. Kuntze (Eds.) (2018). *Mathematics teachers engaging with representations of practice: A dynamically evolving field*. Springer.

Cheek, H. N., & Castle, K. (1981). The effects of back-to-basics on mathematics education. *Contemporary Educational Psychology, 6*(3), 263-277.

Crespo, S., Oslund, J. A., & Parks, A. N. (2011). Imagining mathematics teaching practice: Prospective teachers generate representations of a class discussion. *ZDM Mathematics Education*, *43*(1), 119-131. https://doi.org/10.1007/s11858-010-0296-z

Dindyal, J., Schack, E.O., Choy, B.H. & Sherin, M. G. (2021). Exploring the terrains of mathematics teacher noticing. *ZDM Mathematics Education, 53*(1), 1–16. https://doi.org/10.1007/s11858-021-01249-y

Even, R., & Ball, D. L. (2009). The professional education and development of teachers of mathematics. Springer.

Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169-202. https://doi.org/10.5951/jresematheduc.41.2.0169

Jacobs, V. R., Lamb, L. L., Philipp, R. A., & Schappelle, B. P. (2011). Deciding how to respond on the basis of children's understandings. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing* (pp. 97-116). Routledge.

King, K. D. (2001). Conceptually-oriented mathematics teacher development: Improvisation as a metaphor. *For the Learning of Mathematics*, *21*(3), 9-15.

Koichu, B., & Zazkis, R. (2013). Decoding a proof of Fermat's Little Theorem via script writing.*The Journal of Mathematical Behavior, 32*(3), 364-376.

Mamolo, A. (2018). Eyes, ears, and expectations: Scripting as a multi-lens tool. In R. Zazkis & P. Herbst (Eds.), *Scripting approaches in mathematics education: Mathematical dialogues in research and practice* (pp. 229-248). Springer.

Mason, J. (2002). *Researching your own practice: The discipline of noticing.* Routledge Falmer.

Mason, J. (2011). Noticing: Roots and branches. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers'* eyes (pp. 35–50). Routledge.

Mason, J. (2021). Learning about noticing, by, and through, noticing. *ZDM Mathematics Education, 53*(1), 231-243. https://doi.org/10.1007/s11858-020-01192-4

Oleson, A., & Hora, M. T. (2014). Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices. *Higher education, 68*(1), 29-45. https://doi.org/10.1007/s10734-013-9678-9

Scher, L., & O'Reilly, F. (2009). Professional development for K-12 math and science teachers: What do we really know? *Journal of Research on Educational Effectiveness, 2*(3), 209-249. https://doi.org/10.1080/19345740802641527

Schoenfeld, A. H. (2011a). Noticing matters. A lot. Now what? In M. G. Sherin, V. R. Jacobs, & R. A. Philipp, *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 223-238). Routledge.

Schoenfeld, A. H. (2011b). Toward professional development for teachers grounded in a theory of decision making. *ZDM Mathematics Education*, *43*(4), 457-469. https://doi.org/10.1007/s11858-011-0307-8

Thompson, A. G., Philipp, R. A., Thompson, P. W., & Boyd, B. A. (1994). Calculational and conceptual orientations in teaching mathematics. In A. Coxford (Ed.), *1994 Yearbook of the NCTM* (pp. 79-92). NCTM.

Van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4),571-596.

Van Es, E. A., & Sherin, M. G. (2021). Expanding on prior conceptualizations of teacher noticing. *ZDM Mathematics Education, 53*(1), 17-27. https://doi.org/10.1007/s11858-020-01211-4

Weber, R. P. (1990). *Basic content analysis* (2nd ed.). SAGE Publications.

Zazkis, D. (2014). Proof-scripts as a lens for exploring students' understanding of odd/even functions. *The Journal of Mathematical Behavior*, *35*, 31-43. https://doi.org/10.1016/j.jmathb.2014.04.001

Zazkis, R., & Zazkis, D. (2014). Script writing in the mathematics classroom: Imaginary conversations on the structure of numbers. Research in mathematics education, 16(1), 54-70. https://doi.org/10.1080/14794802.2013.876157

Zazkis, R. (2018). Ceci n'est pas une Pratique:. In O. Buchbinder, & S. Kuntze (Eds.), *Mathematics Teachers Engaging with Representations of Practice: A Dynamically Evolving Field* (pp. 155-161). Springer.

Zazkis, R., Liljedahl, P., & Sinclair, N. (2009). Lesson Plays: Planning Teaching Versus Teaching Planning. *For the Learning of Mathematics, 29*(1), 39-46.

Zazkis, R., & Marmur, O. (2018). Scripting tasks as a springboard for extending prospective teachers' example spaces: A case of generating functions. *Canadian Journal of Science, Mathematics and Technology Education, 18*(4), 291-312.

Zazkis, R., Sinclair, N., & Liljedahl, P. (2013). *Lesson Play in Mathematics Education: A Tool for Research and Professional Development.* Springer.

Authors

Rebekaah Stenner
Simon Fraser University
email: rebekaah_stenner@sfu.ca

Rina Zazkis
Simon Fraser University
email: zazkis@sfu.ca