IMPROVING PRE-SERVICE TEACHERS' NOTICING WHILE LEARNING TO LAUNCH

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Effectively launching a task involves surfacing and addressing misconceptions so that students can make progress on the task. Launching a task is supported by teachers' noticing (interpreting and responding to students' thinking). We investigated the degree to which an intervention supported improvements in pre-service secondary teachers' (PSTs') abilities to notice when launching a rich proportional reasoning task. Through the use of representations of practice and an intervention consisting of opportunities to make sense of and discuss multiple choice options for interpreting and responding to students' thinking, we analyzed whether PSTs improved their abilities to notice. After the intervention, PSTs improved in responding to a student's misconception when PSTs concurrently exhibited expertise with interpreting students' thinking.

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Effectively introducing or "launching" rich mathematical tasks is an important teaching skill (Jackson, Garrison, Wilson, Gibbons, & Shahan, 2013; Stein & Lane, 1996). When launching rich tasks, effective teachers support students as they make sense of the context. Effective teachers also clarify the problem to be solved and surface and address misconceptions that obscure core mathematical issues.

Jacobs, Lamb, and Philipp (2010) have identified attending, interpreting and deciding how to respond as three aspects of teacher noticing. To launch a task well, teachers need to *attend* to students' thinking, *interpret* students' thinking, and then *decide how to respond* to students' thinking in ways that support students' sense-making without reducing the cognitive load of the task. In this paper, we report on our efforts using animated representations of teaching in pedagogy courses to improve pre-service teachers' (PSTs') abilities to interpret and respond to student thinking while launching a rich mathematical task.

Perspectives on Teacher Learning

When confronted with complex phenomena, experts rely on *schema* to make sense of situations and inform decision-making (Bransford, Brown, & Cocking, 2000). Given the complexity of noticing, we hypothesize that developing sophisticated schema would enable PSTs to interpret and respond to student thinking during a launch. Their interpretations and responses would then support students' engagement with the task.

There is evidence that PSTs possess naïve schema that interfere with their efforts to engage students in productive mathematical work. When interpreting student thinking, many teachers have two categories: students that "get it" and students that do not (Otero, 2006). Additionally, PSTs often assume that students who perform procedures correctly have conceptual understanding (Bartell, Webel, Bowen, & Dyson, 2013). These schema may make it difficult for PSTs to identify and engage students' prior understandings, an essential element of effective launches in which students make sense of rich problems. Therefore, one of our goals for PSTs' learning was to expand their schema for interpreting student thinking in ways that would lead to improved launches. In particular, we hoped that PSTs would become able to: (a) identify important student misconceptions and (b) differentiate between procedural and conceptual understanding.

When responding to student thinking, PSTs also may create challenges for students based on naïve schema. Given the persistent prevalence of IRE (initiate, respond, evaluate) discourse patterns in American math classrooms (Franke, Kazemi, & Battey, 2007), PSTs might be pre-disposed to

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respond to student thinking dualistically by correcting incorrect responses and praising correct ones. This precludes opportunities for reasoning and elevates correct answers over deeper understanding (Stein, Grover, & Henningsen, 1996). To promote students' opportunities to reason about mathematics, especially in working through misconceptions that could interfere with productive mathematical work, we wanted to expand PSTs' schema for responding to student thinking so that they would: (a) leverage misconceptions to engage the class in reasoning about important mathematics and (b) assert the value of understanding why a solution makes sense when confronted with a procedural response.

The Process of Teacher Learning

"Practice-based" teacher education situates teacher learning in the actual work of teaching (Ball & Cohen, 1999). However, teaching is complex (Lampert, 2001), and novices struggle to make sense of big ideas when confronted with multiple dynamics of real classroom situations. Representations of teaching that retain some of the complexity of practice, while also providing opportunities for novices to focus on specific elements of practice are a valuable tool for teacher educators as they struggle to situate learning in practice while simultaneously focusing on core ideas (Herbst, Chazan, Chen, Chieu, & Weiss, 2011). *LessonSketch* (http://www.lessonsketch.org) is a web-based platform that allows for creating cartoon storyboards of classroom interactions and embedding them in interactive assignments for PSTs. This platform can present complex situations, but focuses PSTs on specific elements of those situations, thus shaping their attention.

Research Questions

We created a *LessonSketch* experience to introduce and expand PSTs' schema for interpreting and responding to typical examples of student thinking in the context of a rich task on proportional reasoning. As a part of the experience, we presented multiple-choice options for how to interpret and respond to students' thinking. We hypothesized that by working to make sense of possibly new categories for interpreting and responding in the context of potentially realistic classroom interactions during a lesson, PSTs could expand their own schema, which could improve their abilities to effectively interpret and respond to student thinking.

Our investigation was guided by these research questions: (a) After completing a task designed to expand schema for interpreting and responding to student thinking, in what ways, if at all, do PSTs show improvement in interpreting and responding to student thinking during the launch of a complex task? (b) In what ways, if at all, do these improvements reflect the options introduced in the multiple-choice task designed to expand PST's schema?

Context and Methods

This study took place in secondary mathematics methods courses in undergraduate teacher preparation programs at two different Mid-Atlantic universities. Both of these courses were connected to field experiences, shared an emphasis on proportional reasoning, and took place near the end of the PSTs' teacher education coursework. Both courses also focused on pedagogical strategies that support students with developing conceptual understanding of important mathematics through problem-solving, including planning and enacting effective lesson launches.

To engage PSTs in thinking through the launch of a rich task, we designed a *LessonSketch* experience which featured the initial reactions of ten different students to the following task:

> At the hardware store they sell 30 pound bags of sand for 6 dollars. At the lumberyard they sell 50 pound bags of sand for 9 dollars. Where should I buy the sand? Which store has the better deal?

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The experience also indicated that the learning goal of the lesson featuring this task was to understand the quantitative relationships in the problem and understand why scale-factor or unit rate strategies would support finding the solution.

We designed two different versions of this *LessonSketch* experience. One version was administered twice and served as a pre- and post-assessment. In this version PSTs worked individually, writing an interpretation of each student's thinking, and a description of what they (the PST) would plan to do in response.

The second version of the experience was the multiple-choice intervention, designed to expand PSTs' schema for interpreting and responding to student thinking. The task and specific examples of student thinking remained the same. For each instance of student thinking, participants were given a series of choices that represented the schema we were trying to introduce about (a) interpreting and (b) responding to students' thinking. For example, choices for interpreting, or "what can you tell about this student's thinking," included (among others):

- This student is thinking about the mathematics of the lesson in a way that will lead to a correct solution
- This student has a misconception that will get in the way of them creating a correct solution
- This student is working to remember and/or apply a procedure <u>without any evidence of understanding</u> the underlying mathematical relationships

Choices for responding ("What would you plan to do?") included (among others):

- Facilitate a discussion during the launch in which students respond to this student's idea; students do most of the talking
- Briefly explain or clarify to the whole class during the launch. You, the teacher, do most of the talking.
- Explain or clarify to individual student during the launch.

PSTs completed this second version in pairs. We hypothesized that the opportunity to discuss with partners would support PSTs in making sense of the multiple-choice options.

Data Analysis

This analysis focuses on PSTs' interpretations and responses to four of the ten items. Two items (1 & 6) represented univariate thinking: a student attended to only one of the quantities in the problem (i.e. only the sand or only the price) rather than a relationship between the amount of sand and the price (Harel, Behr, Lesh, & Post, 1994). The other two questions (2 & 10) represented procedural thinking: the student talked about a rule for solving the problem without evidence of deeper conceptual understanding.

We created codes for determining whether PSTs' answers were at the levels of novice, emerging expert, or expert. These codes were developed through an iterative process that involved identifying key elements of novice and expert answers, coding answers independently, and meeting to revise disagreements or address questions. For the items involving misconceptions (1 & 6), we developed the following criteria for novice, emerging expert and expert.

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Table 1: Codes for Student Misconception Items

	Novice (n)	Emerging Expert (em)	Expert (ex)
Interpret	• PST does not identify paying attention to one quantity as the problem	• PST uses vague language to identify that student has misconception involving attending to both quantities.	• PST clearly identifies that student has attended to only one quantity
Respond	• PST explains or tells student about relationship between quantities • PST tells student what to do • Solves the problem during the launch	• Asks questions that promote reasoning, directed to single student • Asks questions to the whole class, but does not promote reasoning or discussion	• Initiates a discussion with whole class that promotes reasoning about the relationship between the two quantities

For the items involving procedural student thinking (2 & 10), we developed the following criteria for novice, emerging and expert.

Table 2: Codes for Procedural Thinking Items

	Novice (n)	Emerging Expert (em)	Expert (ex)
Interpret	• Assumes conceptual understanding • Assumes procedure will produce correct answer • No mention of understanding • Non-specific descriptions of using prior knowledge	• Assumes that student does not understand • Aware of possible lack of understanding but assumes correct response *Or* • Qualifying language around prior knowledge	• Aware that student may, or may not understand concepts *and* • Aware that student may not get correct answer
Respond	• Amplifies procedure as method without any prompt for sense-making • No redirection to sense-making • Solves the problem during the launch	• Pushes sense-making with individual student • Discourages using formula • Changes task to forbid or discourage formula use	• Clarifies to the whole group that any solution strategy is acceptable as long as you can explain why your strategy works and makes sense

To develop a shared understanding of our refined codes, we each coded a subset of PSTs and met to resolve disagreements. We then coded the rest of the data. As we identified answers that were challenging to code, we conferred and reached agreements.

To determine whether PSTs' answers improved, we looked at whether or not individual PSTs' answers changed from pre- to post-assessment. For each of the items, we classified PSTs as same (no change), improve or decline. Types of improvements were: from novice to expert, from novice to emerging expert, and from emerging expert to expert. Finally, we tabulated the total results for each item to identify overall trends.

Results

Student Misconceptions: PSTs' Interpretations and Responses

For items 1 and 6, designed to assess PSTs' interpretations of and responses to a specific student misconception.

Item 1 depicts a student saying, "He should just buy it at the lumberyard. He gets a whole lot more sand there."

Item 6 depicts a student saying, "Hardware store; it's only six dollars, not nine."

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We hypothesized that there would be consistency among PSTs' answers for these two items due to the similarity of the design of the items.

Table 3: Changes (Pre-Post) - Interpreting and Responding to a Misconception

Item 1: Interpretation	Item 6: Interpretation	Item 1: Response	Item 6: Response
Same (19): 17 (expert-expert) 2 (emerging-emerging) 0 (novice-novice)	**Same (22):** 20 (ex-ex) 0 (em-em) 2 (n-n)	**Same (13):** 2 (ex-ex) 8 (em-em) 3 (n-n)	**Same (13):** 1 (ex-ex) 7 (em-em) 5 (n-n)
Improve (8): 5 (emerging-expert) 0 (novice-emerging) 3 (novice-expert)	**Improve (4):** 4 (em-ex) 0 (n-em) 0 (n-ex)	**Improve (15):** 5 (em-ex) 6 (n-em) 4 (n-ex)	**Improve (16):** 5 (em-ex) 7 (n-em) 4 (n-ex)
Decline (3): 1 (expert-emerging) 2 (emerging-novice) 0 (expert-novice)	**Decline (5):** 2 (ex-em) 1 (em-n) 2 (ex-n)	**Decline (3):** 1 (ex-em) 2 (em-n) 0 (ex-n)	**Decline (2):** 1 (ex-em) 1 (em-n) 0 (ex-n)

Most PSTs were able to clearly identify the misconception. For interpretations on item 1, 83% (25 out of 30) clearly identified the misconception on the post-assessment, noticing that the student engaged in univariate reasoning. Of these, 57% (17 out of 30) did so on the pre-test as well. 27% (8 out of 30) showed improvement from pre to post. Similarly for item 6, 77% (24 out of 31) clearly identified the misconception students were displaying on the post-assessment. Of these 64% (20 of 31) had done so on the pre-assessment; 13% (4 out of 31) showed improvement from pre to post. (Note: The number of total responses differs because some PSTs did not answer every item.)

Approximately half of the PSTs showed improvement in their response to student misconceptions during the launch. PSTs improved their responses in the post-assessment by engaging the whole class in discussion and / or discussing reasoning about the misconception. 48% of PSTs (15 of 31) showed improvement in their responses on item 1. 52% of PSTs (16 of 31) showed improved responses on item 6. Out of these 31 improvements, 24 responses involved facilitating a discussion with the whole class. A typical example in the post-assessment was this PST's answer:

> Before asking for questions, I could pose the question that if you get more sand at the lumberyard then why not just buy it at the lumberyard? Then let the groups of students turn and talk about that before opening it up to the class.

However, only a subset of the PSTs with improved responses newly included addressing the whole class about a misconception during the launch in their post-assessment answer. Eight PSTs, representing twelve instances of improvement, did not mention addressing the whole class at all during their pre-assessment, yet they did mention discussing the misconception with the whole class during the post test. These improved responses reflected an option from the multiple choice assessment: facilitate a discussion.

The rest of the PSTs' responses improved in ways less aligned with the options in the multiple choice assessment. Six PSTs, representing 11 instances of improvement, responded with whole group discussions in both pre- and post-assessments. The nature of the discussion differed, however; in the pre-assessment, PSTs discussed correct solutions or clarified the context, and they discussed a misconception with the whole class in the post-assessment. Other PSTs (six, representing 8 instances) also improved by focusing on addressing the misconception in the post-assessment, but their post-responses still involved addressing an individual rather than the whole class.

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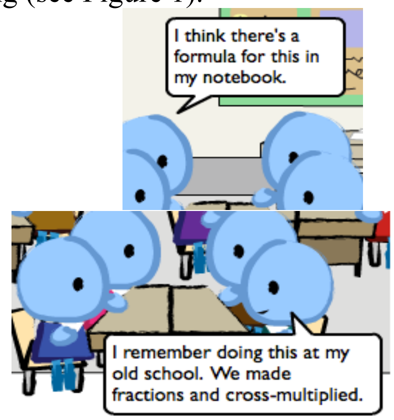
Students' Procedural Thinking: PSTs' Interpretations and Responses

Two items (2 and 10) assessed PSTs' interpretations of and responses to students' procedural thinking (see Figure 1).



Item 2
Item 10
Figure 1. Procedural Student Thinking.

These items did not provide evidence of whether or not students had conceptual understanding. We hypothesized that PSTs would be more likely to interpret procedural thinking in item 10 incorrectly (i.e. as evidence of conceptual understanding) because that item contained more specific details about students' thinking.

Table 4: Changes (Pre-Post) - Interpreting and Responding to Procedural Thinking

Item 2: Interpretation	Item 10: Interpretation	Item 2: Response	Item 10: Response
Same (24):	**Same (23):**	**Same (19):**	**Same (23):**
0 (expert-expert)	0 (ex-ex)	1 (ex-ex)	0 (ex-ex)
16 (emerging-emerging)	5 (em-em)	10 (em-em)	7 (em-em)
8 (novice-novice)	18 (n-n)	8 (n-n)	16 (n-n)
Improve (5):	**Improve (6):**	**Improve (3):**	**Improve (4):**
2 (emerging-expert)	3 (em-ex)	0 (em-ex)	1 (Em-ex)
3 (novice-emerging)	2 (n-em)	2 (n-em)	2 (N-em)
0 (novice-expert)	1 (n-ex)	1 (n-Ex)	1 (N-Ex)
Decline (2):	**Decline (2):**	**Decline (9):**	**Decline (4):**
1 (expert-emerging)	0 (ex-em)	1 (ex-em)	0 (ex-em)
1 (emerging-novice)	0 (em-n)	8 (em-n)	4 (Em-n)
0 (expert-novice)	2 (ex-n)	0 (ex-n)	0 (Ex-N)

Most PSTs did not change their interpretations of students' procedural thinking or their responses to students' procedural thinking. For interpretations on item 2, 77% (24 out of 31) of the participants' answers did not change from pre- to post-assessment (16 were at emerging expertise and 8 were at novice). For responses on item 2, 61% (19 out of 31) of the participants' answers did not change (10 remained at emerging expertise, 8 were at novice and 1 at expert). For interpretations on item 10, 74% (23 out of 31) of the participants did not change (5 remained at emerging experts, 18 at novice and none at expert). For responses on item 10, 74% (23 out of 31) of the participants did not change (7 were at emerging expertise, 16 were at novice and none were at expert).

However, there are some important differences in the overall interpretations for items 2 and 10 that indicate that PSTs' conceptualizations of procedural thinking may be multi-dimensional and nuanced. In particular, on item 2 the majority of PSTs identified problems with procedural

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understanding by the post-test (20 out of 30 were emerging and 2 out of 30 were expert). In contrast 20 out of 31 PSTs failed to identify any problem with the procedural approach taken by the student in Item 10. As an example, for an interpretation for item 10 on the post-assessment, a PST wrote, “The student is aware of a more advanced problem solving method that they learned previously.” This would be a novice interpretation because the PST interpreted the use of cross multiplying as “advanced” without problematizing whether or not there was evidence that the student understood the quantitative relationships in the problem. Also, for a response on item 10, a PST wrote, “I would tell the student to try to solve the problem using what he remembers about cross multiplying. I would then walk away and come back minutes later.” This is a novice response because the teacher does not push the individual student (or the class) to reason about why this strategy makes sense.

These results did not reflect the influence of multiple choice options on PSTs’ adjustments of either their interpretations or their responses on the post-assessment. We expected that introducing PSTs to the following option for interpreting students’ thinking would result in expanding their schema to move toward stronger interpretations of students’ procedural thinking: “The student is working to remember and/or apply a procedure without any evidence of understanding the underlying mathematical relationships.” But PSTs did not change their answers to reflect this choice. By the post-assessment, our PSTs still did not recognize that students’ procedural thinking is not enough information to determine whether the student conceptually understands the quantitative relationships in the task during the launch.

Discussion

Overall, these results illustrate the following: (a) PSTs with expertise in interpreting students’ misconceptions can improve their capabilities with responding to students’ thinking during a launch, possibly after being introduced to and having opportunities to discuss new options for responding. (b) PSTs without expertise in interpreting students’ procedural thinking may not be likely to improve interpreting or responding after being introduced to and discussing multiple choice options. Thus, the multiple choice options appeared to provide some support with expanding PSTs’ schema for responding to a student misconception when PSTs had expertise in interpreting students’ thinking.

Improvements in PSTs’ responses to a student’s misconception (items 1 and 6) are quite pronounced. One potential explanation is that PSTs’ expertise in interpreting students’ thinking on these items supported stronger responses to students’ thinking, as their interpretations to these items were strong. It appeared that, for these PSTs, better understanding of student thinking and how it is connected to the important mathematics supported them with making instructional decisions. Recognizing that students are demonstrating a misconception may motivate PSTs to respond more actively and prompt them to look for possible responses.

A subset of the PSTs that improved responses to a student’s misconception seemed to mirror one of the categories that we used in the multiple choice intervention. It may be that the motivation that PSTs had to respond to a student misconception made them more receptive to the categories introduced in the intervention, and more likely to remember and refer to them later, in the post-assessment.

The possible role of interpretation in motivating improvement in pedagogical responses can also be seen in items 2 and 10. Very few PSTs gave expert interpretations of students’ procedural thinking, and none of them had expert interpretations on the pre-test. Because PSTs failed to identify the full problematic nature of procedural thinking in the context of this launch, they may have been less motivated to look for new ways of improving their responses. This may explain why there was so little improvement in PSTs’ responses for these items.

Additionally, these PSTs performed worse on item 10 than item 2, likely because item 10 was more detailed and specific about students’ procedural thinking. This points to important elements of procedural understanding. One element of understanding procedures consists of understanding why the procedure works, what important mathematical concepts lay beneath it. The continued tendency to ascribe conceptual understanding to the student in item 10 indicates that the PSTs in this study struggled with this idea. A second element of procedural understanding entails recognizing when specific procedures are appropriate, including identifying and remembering specific problem types and larger mathematical relationships. The fact that so many PSTs identified the student in item 10 as having an understanding of the mathematics suggests that they can see this element of procedural fluency (knowing which procedure is appropriate to use in a particular situation) and that they conflate such knowledge with conceptual understanding.

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