TOWARDS EXPERT CURRICULUM USE: DEVELOPING A MEASURE OF PRE-SERVICE TEACHERS' CURRICULAR KNOWLEDGE

Tonia Land
Drake University
tonia.land@drake.edu

Corey Drake
Michigan State University
cdrake@msu.edu

The overall purpose of this study is to develop a measure of elementary mathematics teachers' curricular knowledge (Shulman, 1986) and curriculum use practices. In this paper, we present the first step in this larger effort—the piloting of one set of questions that document pre-service teachers' (PSTs') knowledge and practices for reading, evaluating, and adapting a Standards-based curriculum lesson. We present the range of responses elicited from 34 PSTs related to the goals and purposes of the lesson, the strengths and weaknesses of the lesson, and possible changes to the lesson. These survey questions and our findings about the range of PSTs' responses to the questions are intended to help researchers further develop the constructs of curriculum use and curricular knowledge.

Keywords: Curriculum; Elementary School Education, Teacher Education–Preservice, Teacher Knowledge

Introduction

The overall purpose of this study is to develop a measure of elementary mathematics teachers' curricular knowledge (Shulman, 1986) in order to document the development of this knowledge as PSTs move through elementary mathematics methods and then into student and novice teaching. Mathematics curriculum materials are ubiquitous and often mandated in elementary classrooms, yet the field of mathematics education has few tools for developing and measuring teachers' knowledge related to using these materials in productive ways. In this paper, we present the first step in this larger effort—the piloting of one set of questions that document PSTs' knowledge and practices for reading, evaluating, and adapting a *Standards*-based curriculum lesson.

Theoretical Framework

We understand these practices—reading, evaluating, and adapting curriculum materials—to be part of a larger construct of expert curriculum use that incorporates many of the aspects of curricular knowledge described by Shulman (1986). In our work, we have begun to develop a conjectured learning trajectory describing teachers' curriculum use practices from initial curriculum use (beginning of the methods course) to expert curriculum use. Our definition of expert curriculum use draws from a substantial body of work that has been conducted in the past several years, including the work of Remillard (2005; Remillard and Bryans, 2004), Brown (2009), Sherin and Drake (2009), and Taylor (2010).

Taken as a set, this work suggests that the teachers' curriculum use is a dynamic, interpretive, and interactive process in which both teachers and materials contribute resources in the design and enactment of instruction. "Expert" curriculum users seem to have (1) curriculum vision—an understanding of the goals of the curriculum, as well as strategies for using the curriculum materials to reach those goals (Cirillo & Drake, in revision); (2) particular strategies for reading, evaluating, and adapting curriculum materials in productive ways (Sherin & Drake, 2009); (3) practices for using curriculum materials to accomplish instructional goals (Brown, 2009); and (4) strategies for "systematically" adapting curriculum materials to meet the needs of students (Taylor, 2010). The portion of the curriculum use survey that we describe in this paper focuses on the second set of practices—reading, evaluating, and adapting curriculum materials. Our ultimate goal is to develop a measure that reflects all of these components of expert curriculum use, as well as additional features of curricular knowledge as described by Shulman (1986).

Methods and Data Sources

Participants

We piloted the survey with 34 PSTs enrolled in a small liberal arts university located in the Mid-West. Thirty-one participants were female; three were male. Seven took the survey at the beginning of a semester-long elementary mathematics methods course that included a focus on the use of *Standards*-based curriculum materials, and the remaining PSTs took the survey at the end of the course. For this study, responses from the beginning and end of the semester were combined into a single set of responses in order to identify and describe the range of PST responses.

Description of Lesson

The curriculum use questions focus on a first-grade lesson from *Math Trailblazers* (University of Illinois at Chicago, 2008a). The lesson begins by presenting several numbers (e.g., 125) to students and asking them what those numbers mean. In the materials, anticipated student responses are listed (e.g., 5 groups of 25, 12 groups of 10 with 5 left over). During student exploration time, students consider the number 172 and represent it in any way they choose. Next, they share their representations with a partner, and then a whole group discussion occurs.

Data Collection and Analysis

The survey consists of 18 questions. For the purposes of this study, we selected six questions:

<u>Reading</u>

1. As a teacher, what would be your specific goal(s) for your students' learning with this lesson?
2. On page 37 in the first bullet point under the assessment heading, the lesson plan states, "Even though counting by ones is an inefficient strategy, it works if done carefully." What does that mean?

<u>Evaluating</u>

3. Does this lesson have multiple entry points? In other words, is the task accessible to a wide-range of learners? Explain.
4. When thinking about student learning, what are the strengths and weaknesses of this lesson?

<u>Adapting</u>

5. If you would make changes to this lesson, what would they be?
6. Another pair of students represented 172 with 6 groups of 25 and had 22 left over. What would you say to or ask these students after they have shared their solution?

The first two questions were designed to measure PSTs' *reading* of the curriculum materials by asking them to explain the learning goals and meaning of a selected phrase from the materials. The third and fourth questions addressed PSTs' *evaluation* of the materials by asking them to assess the lesson against the concept of "multiple entry points" discussed in class and determine the strengths and weaknesses of the lesson. The last two questions allowed PSTs to describe the ways in which they might *adapt* the lesson after having read and evaluated the curriculum materials and respond to a particular solution strategy.

Each survey question was analyzed separately through a process of open and emergent coding (Strauss & Corbin, 1998). For each question, a set of codes was generated that illustrated the type of survey responses. Codes will be presented in our results section. Our goal at this point in the development of the survey is to capture the range of possible PST responses to each item in order to further refine the survey.

Results

In this section, we present results from the six survey questions in sections related to each of reading, evaluating, and adapting curriculum materials.

Reading Curriculum Materials

PSTs' goals (Question 1) for teaching the 172 Lesson were categorized using three primary codes. Responses were categorized as *procedural* if they focused on counting/grouping; as *conceptual* if they focused on the understanding/meaning of number and/or place value; and as with *connections* if there was explicit mention of making connections across multiple strategies and/or representations. Responses could be any combination or all of the above three codes, which led to six types of goal responses. Table 1 summarizes the response to Question 1.

Table 1: Responses to Question 1 (Goal Question)

Number of PSTs	Type of Response	Example
7	Procedural	Counting and grouping objects that are greater than 100.
11	Procedural with Connections	Students will be able to represent numbers greater then 100 using manipulatives and words. Students will be able to group objects by ones, tens, and hundreds.
3	Conceptual	My goals for this lesson would be for the students to understand what 3 digit numbers mean and to be able to talk about and explain them.
1	Conceptual with Connections	To have students talk about the meaning of a number, represent a number by a picture, and use different objects to represent a number.
5	Procedural and Conceptual	As the teacher, my specific goal for this lesson would be that the students group numbers between 101 and 199 in a way that shows that they understand place value.
6	Procedural and Conceptual with Connections	Understanding place value, hundreds, tens, and ones. Being able to break numbers into parts and recognize they belong to a whole representing numbers with pictures or symbols grouping and counting objects by ones, tens and hundreds.

In the curriculum materials, the goals were listed as the following:

- Representing numbers greater than 100 using manipulatives, pictures, symbols, and words
- Grouping and counting objects by ones, tens, and hundreds. (University of Illinois at Chicago, 2008b, p. 33)

Using our coding scheme, the above goals would be categorized as procedural with connections, which makes these results particularly interesting to us. We conjecture that the curriculum authors had a conceptual purpose in mind when writing these goals, but that purpose was not explicit in the materials. Identifying a conceptual goal for the lesson required a significant amount of interpretive work while reading the lesson, and we found that many of the PSTs (15/33) did engage in that work.

For Question 2, PSTs were asked to interpret the following statement: *Even though counting by ones is an inefficient strategy, it works if done carefully,* there was a wide range of responses. Each response was coded with one or more of the following codes—*better ways* if the PST stated there were "better ways" to count or represent 172 than counting by ones; *specific limitation(s)* if the PST stated one or more limitations of counting by ones; *another strategy* if the PST suggested another strategy that students should use; *it works if careful* if the PST stated the strategy works, but students need to be careful; *count by ones* if the PST discussed that it is expected that some students will counts by ones to represent 172; and *acceptable strategy* if the PST seemingly took a stance for students who wanted to use that strategy. Table 2, along with some text after the table, summarizes the responses to this question.

Van Zoest, L. R., Lo, J.-J., & Kratky, J. L. (Eds.). (2012). *Proceedings of the 34th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Kalamazoo, MI: Western Michigan University.

Table 2: Responses to Question 2 (Interpreting a Phrase)

Number of PSTs	Type of Response	Example
16	Specific Limitations	This means that it takes longer to count three digit numbers by ones, and is more prone to mistakes because of the tediousness of the strategy.
7	Better Ways	Counting by ones is not the quickest way to assess a large number of items. It does work, but there are better ways to do it.
6	Counts by ones	It is expected that some students will count by ones even though the number is so large. When it states, "it works if done carefully," I think they are saying that if is ok that students do that.
4	Acceptable Strategy	The purpose of this lesson is counting 172, not grouping 172. If the student's method is counting by ones and they are getting the correct answer, then they are completing the lesson. From this foundation, you can build with them an understanding of grouping and they may change their method of counting as they grow older.

Of the 16 PSTs who stated one or more specific limitations of the counting by one strategy, five mentioned another strategy (e.g., grouping larger numbers) students could use and six mentioned that the strategy works if it is done carefully. Of the seven PSTs who stated that there are better ways to count 172, three also mentioned specific limitations of the strategy while another mentioned the strategy was OK to use. Of the six PSTs who thought it would be expected for students to count by ones, one PST also said that it was okay to do. In this set of findings, the role of PSTs' beliefs is clear, particularly their beliefs about how children learn mathematics. Many PSTs elaborated the aspect of the statement that counting by ones is an inefficient strategy by describing in one or more ways how counting by ones is inefficient. Others perceived the statement as saying that some students will need to count by ones to solve the problem and/or that strategy is acceptable.

Evaluating Curriculum Materials

Responses to the third question about whether or not the 172 Lesson had multiple entry points were first sorted into yes or no categories. Eight PSTs did not think the lesson had multiple entry points and all eight stated that this was because only one number was given for students, although some of the eight noted that this number could be adjusted by the teacher, as in the example response in Table 3. Twenty-six of the 34 PSTs thought that the lesson *did* have multiple entry points. For those 26 responses, a set of codes was developed to describe PSTs' reasoning. A response was coded as *student develops/uses own strategy* if the PSTs discussed that the students could develop or use their own strategy to represent 172; *number can be changed* if the PST thought the number could be changed to meet the range of learners in the classroom; and *count by ones* if the PSTs discussed the idea that if students could count by ones to represent 172, then the lesson had multiple entry points. Table 3 summarizes these responses.

Table 3: Responses to Question 3 (Multiple Entry Points)

Number of PSTs	Y/N	Type of Response	Example
8	No	Only one number choice	There is only one number choice provided for the students to work with and it is in the high range of the 100's. Thus, I would provide additional number choices of one slightly above 100 like 112 and another number choice in the middle (e.g.132) to provide access to a greater range of ability levels.
14	Yes	Student develops/uses own strategy	There are multiple ways to draw 172 beans, but there really isn't a clear "solution." They already know there are 172 beans and have to draw them. The only different will be how they drew it.
4	Yes	Number can be changed	For slower or higher learners, you could adjust the number of beans to an easier or more difficult number, and give more or less support to the students as needed.
3	Yes	Students develops/uses own strategy and Number can be changed	I think the lesson has multiple entry points. The lesson doesn't specifically give a way to illustrate the number. I think students could represent it in a lot of different ways. Because of the number, the lesson may be harder for lower level students. I would adjust the number for a different range of learners.
2	Yes	Count by Ones	As long as students know the number about 100 and can count by ones, then yes it is accessible to wide-range learners.

All but three responses could be sorted into our above codes. Of those three responses, one talked about targeting multiple learning styles, another mentioned the teacher being able to ask students to count in a certain way, and the third suggested that the lesson did a good job of providing manipulatives. Another noteworthy finding was that four PSTs suggested alternative number choices as in the first example above. Many PSTs focused on the idea of offering multiple choices as a way to provide multiple entry points for students, or PSTs focused on the idea that students could develop their own strategies. Three PSTs thought a combination of those two ideas provided multiple entry points.

PSTs were asked to list the strengths and weaknesses of the 172 Lesson in Question 4. For this response, we developed a set of 12 codes that categorized ideas listed as strengths or weaknesses. In Table 4, we list the code and how many times it was mentioned as a strength and weakness.

Although the PSTs listed a wide range of strengths and weaknesses, we can identify some important themes in looking across their evaluations of the lesson. First, the PSTs focused a great deal on the students' role in the lesson, with "Student-directed" and "Multiple Strategies" as the most common strengths. The most commonly noted weaknesses were in the structure of the lesson (e.g., the lack of an opening routine, the use of worksheets) and that the lesson was perceived as too challenging for some students and not challenging enough for others. Finally, many aspects of the lesson that were viewed as a strength by some PSTs were also viewed as a weakness by other PSTs, suggesting that PSTs vary widely in their evaluations of lessons.

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Table 4: Responses to Question 4 (Strengths and Weaknesses)

Code	Frequency as Strength	Frequency as Weakness
Student-directed	14	4
Multiple Strategies	15	1
Lesson Structure	3	10
Interactions	10	2
Too challenging or not challenging enough	0	11
Concrete	8	1 (Abstract)
Differentiation – lack of/can be/cannot be	7	2
Assessment	4	4
Number Choice	1	3
Teacher-directed	2	2 (lack of)
Affective (e.g., enjoyable, comfortable)	3	0
Connection to real-life	1	2 (lack of)
Connection to more advanced mathematics	1	0

Adapting Curriculum Materials

Eleven PSTs would not make any changes to the given lesson. The remaining PST responses fell into three categories—would provide multiple number choices, would change aspects of the lesson that did not affect the overall approach in lesson, and would practice a model beforehand or give example. Table 5 summarizes responses to Question 5.

Table 5: Responses to Question 5 (What changes would you make?)

Number of PSTs	Type of Response
11	Would make no changes
11	Would provide multiple number choices
7	Would change aspects of the lesson (e.g., add opening routine, count something more meaningful to students) that did not affect overall approach in the lesson
4	Would practice a model beforehand or give example

It was not surprising to us that the most frequent adaptation ($N = 11$) was to provide multiple number choices. The result can be explained, in part, by the fact that these PSTs were in a methods course in which they had many opportunities to observe and reflect on lessons that provided multiple number choices for students. Seven other PSTs thought they would change aspects of the lesson that did not affect the overall approach in the lesson and four wanted to provide a model or example before the students began to work.

Question six pertained to how PSTs might question students as they engaged with the 172 Lesson: *Another pair of students represented 172 with 6 groups of 25 and had 22 left over*. *What would you say to or ask these students after they have shared their solution?* Responses were categorized according to which aspect of the solution PSTs questioned. In a few instances, a PST questioned multiple aspects of the solution. Table 6 summarizes the foci of PSTs questions.

Table 6: Responses to Question 6 (Questioning students about solution strategy)

Number of PSTs	Foci of Question
8	Questioned if there was another way to group or represent the leftover 22.
7	Questioned students as to why they used groups of 25.
4	Questioned if there was another way to group or represent 172 due to having 22 leftover.
4	Asked another type of question about the strategy (e.g., any patterns)
3	Questioned students as to why they used groups of 25 and if there is another way to group or represent the leftover 22.
2	Questioned if there was another way to group or represent 172.
2	Questioned if there was a way to consolidate the groups of 25.
3	Other

Most interesting to us was how PSTs reacted to the leftover 22 given that the curriculum materials listed the grouping by 25 strategy as an anticipated student response and the connection to money. Nine PSTs (second and sixth rows) asked if there was another way to group or represent the leftover 22 even with the other groups of 25 as in this response: "I would say, "how can we group the leftover 22 in an organized way? How could we split those 22 beans into 5 groups?" Another four PSTs wanted students to regroup the 172 entirely due to the leftover 22 as in the following response: "Could you have made less groups of more beans in order to not have so many left over?" Two others wanted students to consolidate their groups of 25.

Quite opposite from the disdain for the grouping by 25 strategy, was the response from one PST, who fell in the other category, as he/she made the connection (not the students) to money in their response. That response is given below:

> That's another great idea as we know that just like in a dollar there are 4 quarters (25), right? (relating it to a real life situation) then break it down further like 2 quarters in 50 cents, so there would be 22 ones left over (if you are thinking in those terms).

The other responses seemed not to value or dis-value the grouping of 25 strategy, as PSTs are just asking students to explain why they grouped by 25 or if there was another way to group or represent 172. The intent of these responses may be to support or extend student thinking.

Implications

This study is a step towards understanding expert curriculum use. These survey questions and our findings about the range of PSTs' responses to the questions can help researchers further develop the constructs of curriculum use and curricular knowledge, through an understanding of ways in which PSTs read, evaluate, and adapt curriculum materials. At the same time, these findings might support mathematics teacher educators in designing learning experiences for PSTs that contribute to the development of PSTs' curriculum use practices. This study also contributes to the field by providing a measure for documenting growth in teachers' curricular knowledge—an important knowledge base for teaching first identified by Shulman (1986). Ultimately, this measure, and others like it, can be used to understand PSTs' growth in knowledge and practices as they progress through teacher education courses and programs.

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References

Brown, M. W. (2009). The teacher-tool relationship: Theorizing the design and use of curriculum materials. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 17–36). New York: Routledge.

Cirillo, M., & Drake, C. (in revision). Curriculum vision in school mathematics: Understanding and navigating the curricular landscape.

Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research, 75*(2), 211–216.

Remillard, J. T., & Bryans, M. (2004). Teachers' orientations toward mathematics curriculum materials: Implications for teacher learning. *Journal for Research in Mathematics Education, 35*(5), 352–388.

Sherin, M., & Drake, C. (2009). Developing curricular trust: Changes in teachers' curriculum strategies. In J. Remillard, G. Lloyd, & B. Herbel-Eisenmann (Eds.), *Teachers' use of mathematics curriculum materials: Research perspectives on relationships between teachers and curriculum*.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Taylor, M. W. (2010). *Replacing the "teacher-proof" curriculum with the "curriculum-proof" teacher: Toward a more systematic way for mathematics teachers to interact with their textbooks* (Unpublished doctoral dissertation). Palo Alto, CA, Stanford University.

University of Illinois at Chicago. (2008a). *Math Trailblazers* (3rd ed.). Dubuque, IA: Kendall Hunt.

University of Illinois at Chicago. (2008b). *Math Trailblazers* (3rd ed.). Grade 1, Unit 17. Dubuque, IA: Kendall Hunt.