ELEMENTARY PRESERVICE TEACHERS' CRITIQUES, COMPARISONS, AND PREFERENCES IN EXAMINING STANDARDS-BASED CURRICULAR MATERIALS

Andrew M. Tyminski
Clemson University
amt23@clemson.edu

Tonia J. Land
Drake University
Tonia.Land@drake.edu

Cory Drake
Iowa State University
cdrake@iastate.edu

Shulman's (1986) curricular knowledge includes knowledge of the variety of curricular materials and the ability to evaluate, compare and justify curricular choices. To meet this need we have engaged our pre-service teachers (PSTs) in a comparison activity of two Standards-based lessons. We present PSTs' perceptions of the affordances and constraints within each lesson, interpret these results and present implications for further research.

Because *Standards*-based curriculum materials are becoming ubiquitous in schools (Archer, 2005; Remillard, 2005), there is a need for teacher education programs to prepare PSTs to be able to perceive the intended meaning of, mobilize the potential of, and continually develop their pedagogy through curricular resources. Our overarching research concerns the design of research-based activities for the elementary mathematics methods course that will allow pre-service teachers (PSTs) to learn about- and from- *Standards*-based curricular materials. We posit these types of activities can enable PSTs to move along a trajectory towards expert curriculum use. Our conceptualization of expert curriculum use can be associated with Taylor's (2010) notion of the "curriculum-proof teacher"; a teacher "who can use any given curriculum in highly-effective ways" (p. 152). This paper presents our findings related to PSTs' critiques and perceptions of two *Standards*-based lessons.

Theoretical Frame

Framing our examination of PSTs' perceptions and preferences in working with materials from *Everyday Mathematics* and *Investigations* is the research around teacher learning about and from curriculum materials and PSTs' capacities to evaluate curriculum materials. We also considered research that provides some insight into the relationship between teacher capacity, curricular use, and instruction involving *Standards*-based curriculum materials.

Learning about and from Curriculum Materials

To frame our use of curricular materials and to inform our examination of what PSTs learn about and from *Standards*-based curricular materials, we employ Shulman's (1986) construct of curricular knowledge:

> The curriculum is represented by the full range of programs designed for the teaching of particular subjects and topics at, a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances. (p. 10)

The learning activity reported on in this study addresses PSTs' curricular knowledge by introducing examples of available materials and asking PSTs to evaluate, compare, consider and justify a curricular choice.

Several studies have examined how teachers use *Standards*-based curriculum materials and the impact those materials have had on teacher learning (e.g. Collopy, 2003; Nicol & Crespo, 2006; Remillard & Bryans, 2004). Some of those studies (e.g. Collopy, 2003; Remillard &

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Bryans, 2004) have shown that external resources (e.g., curriculum materials, professional development) that have prompted some teachers to use and learn from curriculum materials in reform-oriented ways do not prompt *all* teachers with those same resources to learn or teach in similar ways. For example, Collopy (2003) reported the stark contrast between two teachers in their learning from the use of the same curriculum series with the same professional development opportunities. One teacher (Ms. Ross) developed a new teaching practice by using the materials as her primary source of professional development. Ms. Clark, however, did not change her practice and continued to emphasize memorization and the use of standard algorithms. Collopy (2003) contends that the two teachers differed in their "opportunities to learn" because of the ways in which they read and enacted the curriculum along with how they used the materials when collaborating with colleagues. We posit Collopy's (2003) findings on how teachers read curriculum may allow us to explain the PSTs' critiques and perceptions of the two lessons.

PSTs' Capacity to Evaluate Curriculum Materials

Studies in science and mathematics education (e.g. Beyer & Davis, 2009; Davis, 2006; Lloyd & Behm, 2005, and Nicol& Crepo, 2006) have found that 1) PSTs need continuous supports available in order to evaluate curriculum materials in reform-oriented ways, and that 2) PSTs can misinterpret lessons when they look for aspects of lessons that are familiar to them. In one study, PSTs were asked to complete three science lesson plan analyses using a narrative that provided a description and rationale for an important "principle of practice" (Beyer & Davis, 2009, p. 6). The majority of PSTs used the educative support in their analysis and made adaptations that better supported key principles in science teaching, but did not make similar analyses and adaptations when the support was not available (Beyer & Davis, 2009). Lloyd & Behm (2005) investigated the ways in which PSTs compared and contrasted two textbook lessons (one traditional and one reform-oriented). The researchers found that PSTs looked for aspects of the lessons that were familiar to them. Thus, the lessons they preferred were more traditional. Furthermore, the researchers concluded that PSTs' fondness for traditional lessons led the PSTs to misinterpret those lessons.

Capacity and Mobilization of Standards-based Curriculum

Stein and Kaufman (2010) investigated how teacher capacity and teachers' mobilizations of curriculum materials influenced instruction. They found that teachers implementing *Investigations in Number, Data, and Space* (*Investigations*) had higher-quality lessons (measured by maintaining high levels of cognitive demand, attending to student thinking and vesting intellectual authority in mathematical reasoning) than those implementing *Everyday Mathematics* (*EM*). The researchers attribute this finding to that fact that *Investigations* (TERC, 2008) provided more support to teachers for "locating and understanding the big mathematical ideas within lessons compared to *Everyday Mathematics*" (Stein & Kaufman, 2010, p. 663). After examining levels of cognitive demand and supports for teachers in both series however, the researchers branded *Everyday Mathematics* as a low demand/low support curriculum and *Investigations* as high demand/high support.

Methods

The Developing Addition Strategies module asks PSTs to examine and engage in two addition lessons from *Standards*-based curricula. "Addition Starter Sentences" is a third grade lesson from *Investigations* (TERC, 2008) and "A Shopping Activity" is a second grade lesson from *EM* (USCMP, 2007). Both lessons are designed to provide opportunities for children to develop alternate addition strategies for multi-digit addition. Over the course of two 75-minute class sessions, the first author used the Developing Addition Strategies Module within two sections of an elementary mathematics methods course. He engaged PSTs in the examination of the curricular materials and also in completing the learning tasks from each lesson. The researchers had several goals for this module, including affording PSTs an opportunity to develop knowledge of alternative addition strategies as well as how children develop, make sense of, and use alternative addition strategies (Tyminski, et al., 2010). Another aim, and the focus of this paper, was to give PSTs an opportunity to critique and compare the two lessons, culminating with the PSTs choosing and defending their preference for one of the two lessons. In order to support PSTs in critically examining curricular materials, the first author had introduced, implemented and discussed constructs and tools for analyzing tasks earlier in the semester. These supports included activities involving: levels of cognitive demand (Schwan-Smith & Stein, 1998); availability of multiple access points; whether solution strategies are teacher/textbook- or student-generated; the degree to which lessons support teaching through problem solving; and whether/how lessons address the essential skills and content in state Standards. The comparison activity was posed as follows:

> First, describe, in a bulleted list the strengths and weaknesses of these two lessons as written. Be sure to comment on:
>
> - What you think students will know or understand by the end of the lesson
> - Cognitive demand of the tasks
> - Whether strategies are teacher/textbook-generated or student-generated
> - Whether the tasks include multiple access points for different students
> - Whether/how this lesson reflects teaching through problem-solving
> - Whether/how this lesson addresses essential skills/content in your state Standards
> - Your overall impression of the lesson's strengths and weaknesses
>
> Second, write a short paragraph (4-6 sentences) telling which lesson materials you would rather teach from, why you feel that way, and what goals you would have for your students in using this lesson. Please use evidence from the materials and/or from your own experiences to support your choice.

This paper focuses on the results of the final paragraph in which PSTs selected the lesson they would prefer to teach from and justified their choice based on their perceived strengths and weaknesses of the curricular materials. We collected responses from 45 PSTs at a large, Midwestern university during the spring semester of 2010.

Addition Starter Sentences (TERC, 2008) begins by asking children to decide which of the following "addition starter problems" is easier for them to solve and why: 100 + 200 = ______, 136 + 200 = ______, 136 + 4 = ______. Next, children are asked to choose a starter sentence to solve 136 + 227 and explain why that would be a good start. After children solve 136 + 227, they share their solution paths. Children then complete a worksheet with five more "sets" of tasks, three starter problems matched to a final problem. In the methods course, we enact the lesson as written with PSTs participating as students. We then ask PSTs to read the curriculum materials and discuss the educative features (Davis & Krajcik, 2005). One educative feature we focus on is the information about alternate addition strategies that align with the starter problems: breaking apart by place; adding one number in parts; and changing a number, then adjusting (TERC, 2008). We then ask PSTs to analyze ten examples of children's mathematical thinking for the problem 249 + 175. The PSTs are to make sense of the strategies, determine if the approaches are mathematically valid, and categorize them according to the three strategies. We finish the

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module with a discussion of how teachers can support students in using these three strategies (see Tyminski, et al., 2010).

A Shopping Activity (UCSMP, 2007) also allows opportunity for students to develop invented strategies for multi-digit addition. According to the curriculum materials, "The main objective of this lesson is to develop and practice strategies for mental addition of 2-digit numbers" (UCSMP, 2007, p. 254). The lesson begins with some mental math exercises and a contextual task designed for students to use the "count up" strategy for subtraction. The lesson then moves into an activity in which the teacher selects two items from a list of eight, to "purchase". Each of the prices for the items is less than $50. The teacher selects two items, for example a telephone ($46) and a toaster ($29) and asks the children how they might find the total cost. In discussing the students' solutions the lesson reads:

> You or the children might suggest the following strategies:
> **Strategy 1:** Start with the larger addend, 46. To add 29, note that there are 2 tens in 29. Count up by 10s. Then add 9. The total cost is $75.
> **Strategy 2:** Think of $10 bills and $1 bills. Add the $10 bills. Add the $1 bills. Add the tens and the ones.
> **Strategy 3:** 29 is 1 less than 30. Add 30 to 46. Then subtract 1 to make up for the extra 1.
> **Strategy 4:** 29 is 1 less than 30 and 46 is 4 less than 50. Add 30 and 50. Then subtract the extra 1 and the extra 4. (UCSMP, 2007, p.253)

The lesson asks the teacher to pose more examples and discuss students' solutions. It explicitly tells teachers not to introduce a traditional pencil and paper algorithm for addition at this point. The students are then put into pairs to complete the next activity, "Playing Shopping", which uses the same eight items and prices. One child is the clerk and the other child the customer. The customer selects two items randomly and finds the total amount of the two items using a "part-part-total diagram", but without using a calculator. The clerk then checks the total amount using a calculator. The children then switch roles. The lesson concludes with children completing a handout of shopping problems similar to the lesson tasks. In a similar manner to the Starter Sentences Lesson, we engage the PSTs in the main learning tasks as if they were students in the elementary classroom, followed by a reading of the materials and a discussion of its educative features (Davis & Krajcik, 2005).

Both lessons afford students opportunity to develop alternative addition strategies. The three strategies in both curricula are research-based student approaches to these types of problems. What differentiates the two lessons for us is in the amount of support given to students and the teacher in this process. The starter sentences are presented as a potential first step in a solution path and suggest one of the three solution strategies. The students however choose how to use the starter sentence to complete the problem and there are a myriad of ways to apply the strategies, especially within the "change the numbers" approach. Further, the Starter Sentences teaching materials include supports for the teacher in terms of student strategies ("Often the numbers in a problem will suggest one strategy more than another; for example, students may be more likely to add on to the next hundred if one number is close to a multiple of 100, such as 199" (TERC, 2008, p. 92)); questioning ("How did the Starter Problem you chose help you know what to do next?" (p. 92)); and for observation ("Do students choose one of the starts to solve the final problem? Which one? Can they follow though with the solution and keep track of the steps?" (p. 92).

Although the solutions included within the *EM* lesson are descriptions of the three strategies in *Investigations* (Strategy 1 is "add one number in parts", Strategy 2 is "break apart by place", Strategy 3 and 4 involve "changing the numbers"), similar scaffolds are not found within the *EM* lesson, leaving it up to the student to decide how to begin the task. In terms of teacher supports, the inclusion of the phrase "You or the students might suggest the following strategies" (UCSMP, 2007, p. 253) concerned us as it implicitly suggests to the teacher that it is acceptable to directly teach or introduce the strategies. We also identified a lack of teacher support in helping students begin to engage with the tasks. *EM* does include some instructions for supporting Strategy 2 with physical models, ("Use play money to illustrate Strategy 2. Put four $10 bills and six $1 bills on one stack and two $10 bills and nine $1 bills in a second stack. Combine the bills as indicated" (p. 253). This scaffold is more of a demonstration than an approach to help students think about the strategies, but at least it offers some pedagogical support. The lack of suggestions for the other strategies leaves it on the shoulders of the teacher to develop scaffolds for students.

Data Analysis

From two methods course sections, we collected 45 responses. These were first sorted according to their final curricular preference. Next, each justification paragraph was analyzed independently at the two university sites through a process of open and emergent coding (Strauss & Corbin, 1998), using a framework of PSTs' perceived affordances and constraints as a lens. Through an inductive analysis process, a series of codes for four categories: student affordance, student constraint, teacher affordance, teacher constraint, emerged from the data. As codes emerged from the PSTs' perceptions of the strengths and weaknesses of the materials, they were shared across university sites and refined. There were 18 codes established for student affordance, 5 for student constraint, 5 for teacher affordance, and 3 for teacher constraint.

Results

Of the 45 responses, 30 PSTs stated their preference for the *Everyday Mathematics* materials, while 13 PSTs selected *Investigations*. One PST did not include a final paragraph, and the other suggested using parts of both lessons in her teaching. We present data from the 43 responses in this section, broken down by the viewpoint of the student and the teacher.

Student Affordances and Constraints

In justifying their choice of lesson, many PSTs commented on features pertaining to the interactions and opportunities students would have in learning from the materials. A vast majority of the PSTs who preferred "A Shopping Activity" justified their choice with examples of student affordances (SA) of the materials. Twenty-seven of the 30 PSTs included an SA in their justification, and many students (22 of 27) included more than one SA in their justification. In all, 70 comments were coded as SA-EM (student affordance within *EM*). Table 1 presents the affordances that appeared in at least 15% of the PSTs' responses (N=30). None of the 30 responses included text coded as a student constraint (SC-EM) of the *EM* lesson. Three PSTs focused on student constraints within *Investigations* (SC-IN) as opposed to the affordances of *EM*. One PST felt that the *Investigations* lesson lacked student autonomy; two others described the solution strategies as being teacher/textbook generated. One of the PSTs who selected *EM* nonetheless mentioned that the *Investigations* lesson afforded students opportunities to make connections.

The majority of PSTs who had a preference for *EM* viewed "A Shopping Activity" as a familiar context, hands-on, and fun. These responses seem to focus on the interest of the activity rather than the interesting mathematics. Other, less reported reasons for preferring *EM* focused more on the mathematics – opportunities for practice, student-generated solutions, multiple solution strategies, student autonomy, and learning from peers.

Of the 13 PSTs who selected "Addition Starter Sentences" from *Investigations*, 7 included student affordances in their justification. Across these seven responses, twenty-two comments were coded as SA-IN. Table 2 presents the affordances appearing in at least 2 of the PSTs' responses (N=13). One of the 13 PSTs who selected the *Investigations* lesson cited the lack of contextual tasks as a weakness of the materials; we coded this as a student constraint of *Investigations* (SC-IN). Three of the 13 PSTs focused on the student constraints of *EM*, two on "lack of student autonomy", the other on a perceived "lack of goal". Comparatively, the reasons PSTs gave for preferring *Investigations* tended to focus more on the mathematics: student autonomy, student generated solutions, and multiple solution paths.

SA Code	#	%
Contextual tasks	12	40%
Hands on tasks	9	30%
Fun	8	27%
Opportunities for practice	7	23%
Student generated solutions	7	23%
Multiple solution strategies	6	20%
Student autonomy	5	17%
Learn from peers	5	17%

Table 1: PSTs' Perceptions of Student Affordances in EM Lesson

SA Code	#	%
Student autonomy	7	54%
Student generated solutions	4	31%
Multiple student strategies	2	15%
Scaffolding	2	15%

Table 2: PSTs' Perceptions of Student Affordances in Investigations Lesson

Teacher Affordances and Constraints

PSTs also commented on their analysis of the curricular materials from a teacher's perspective. Of the 30 who preferred the *EM* lesson, 13 used justifications we coded as TA-EM (teacher affordance within *EM*), 5 of these included more than one affordance for a total of 18 comments: 8 PSTs cited the materials for including "differentiation"; 7 comments indicated "ease of use (implementation)", 2 PSTs noticed "possible student solutions" included in the materials; and 1 viewed the materials as giving the "teacher control" of the lesson. Only 1 PST who selected the *EM* lesson included a comment coded as TC-EM (teacher constraint within *EM*), it was coded as "difficult to understand". We take this comment to mean the PST had difficulty in making sense of the organization of the curricular materials. A total of three PSTs included commentary from a teaching perspective on the *Investigations* materials within their *EM* justification. One commented on the "ease of use" of the *Investigations* materials (TA-IN: teacher affordance within *Investigations*). Two PSTs' comments were coded TC-IN (teacher constraint within *Investigations*): one was coded "difficult to understand"; the other was coded as "difficult to use (implement)". We specifically differentiated between difficulties PSTs perceived in *reading* the materials and *using* the materials, although we posit the two ideas are strongly connected.

Seven of the 13 PSTs' justifications that selected *Investigations* materials included comments coded as TA-IN (teacher affordance within *Investigations*); only 2 made more than one such comment in their paragraph. There were a total of 11 comments coded as teacher affordances: 7 indicated "ease of use"; 2 indicated the inclusion of "differentiation" for students; 1 PST cited the inclusion of "examples of teacher talk"; and 1 noticed "possible student solutions" included in the materials. Two PSTs indicated teacher constraints within the *Investigations* materials (TC-IN): 1 response was coded as "needs to be adapted", the other as "difficult to use (implement)". One PST, who commented on the ease of use of the *Investigations* lesson, also cited the *EM* lesson as "difficult to use" (TC-EM).

We were surprised by the marked difference in the number of comments coded as student affordance or constraint and the number of comments coded as teacher affordances or constraints. There were 99 comments that addressed the materials from a student point of view and 38 from a teaching point of view. One interpretation of these results is that PSTs were more attuned to the potential experience of learning from these materials, rather than teaching with the materials. The comments that were made however, provided interesting evidence of PSTs' critiques of the lessons. The theme of differentiation was evident within many of the PSTs' comments on both sets of curricular materials, demonstrating to us they were aware of the importance of addressing the needs of individual learners, and noticing the supports within the materials designed to aid teachers in doing so. What was interesting to us about these results is the assignment did not specifically ask them to comment on this facet of the lessons. Fourteen PST commented on the ease of use of the materials, 7 for *EM* and 7 for *Investigations*. This data raised a new question for us to consider as researchers, what was it specifically about the materials that PSTs were referring to when citing their ease of use?

Conclusions and Implications

We agree with Stein and Kaufman's (2010) assessment that *Investigations* is stronger than *EM* in terms of cognitive demand, and in the amount and quality of teacher support. Yet, our PSTs overwhelmingly picked *EM* as the curricular materials they would rather teach from. Why was what was clear to us, not evident to the PSTs? We conclude with three possible explanations and implications for future research.

First, we agree with Collopy's (2003) notion that the manner in which PSTs read the materials, with a viewpoint of a learner, may have caused them to miss out on some of the opportunities to learn *about* the curricular materials. We base this upon their comparative lack of attention to teacher affordances and supports; particularly lack of attention to supports within both curricular materials in terms of presenting possible student solutions. Our future research needs to specifically address how PSTs view teacher supports. Do PSTs believe they can learn from the curricular materials? Should we include a non-*Standards*-based example lesson in the comparison in order to help them notice when supports are not available?

A second explanation also pertains to PSTs' tendency to evaluate the materials from a student's point of view. By selecting the *EM* lesson and focusing on aspects of the lesson such as hands on materials, real world contexts and being "fun", PSTs are trying to ensure that the *activity* involved in the lesson is interesting. From a teaching point of view, we would hope they would try to ensure that the *mathematics* involved in the lesson is interesting. Most PSTs perceive mathematics as a discipline of discrete facts and procedures to be memorized rather than a discipline of interconnected concepts (Thompson, 1992). In other words, mathematics is not meant to be interesting. To make mathematics interesting, the activity needs to be interesting. Thus, the "shopping activity" is preferred.

A third explanation is the PSTs were drawn to *EM* as a result of their teacher capacity. Teacher capacity, including a teacher's education, experience, and mathematical knowledge is a measure of ability needed to implement curriculum (Stein & Kaufman, 2010). At the PSTs' current stage of development (first semester seniors), it is fair to classify them as having comparably low teaching capacity in terms of education and experience. Although they did not clearly state this in their paragraphs, perhaps given their experience and knowledge, the PSTs perceived that *Investigations* could be difficult to teach from, leading them to prefer the lower demand in *EM*. Stein and Kaufman (2010) talked about this notion – some believe that "even among standards-based curricula, some are more difficult for teachers to implement than are others" (p. 664). Our PSTs, and others, are not noticing the supports provided in *Investigations* to help implement the high-demand tasks.

Finally, it is evident that through this activity, PSTs are learning about the curricular materials, developing curricular knowledge, and are able to use educative supports in their critique and analysis of *Standards*-based curricular materials. While many PSTs did not view the materials in the same manner an expert might, we are encouraged that with further experiences, PSTs will continue to develop in their ability to do so.

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