EXAMINING K-12 PROSPECTIVE TEACHERS' CURRICULAR NOTICING

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This paper explores the construct of curricular noticing, defined as the act of teachers making sense of the complexity of content and pedagogical opportunities in written or digital curricular materials (Dietiker, Amador, Earnest, Males, & Stohlmann, 2014), and reports the results of four exploratory studies aimed to examine the Curricular Noticing framework. Taken together, these studies capture work done with 62 PSTs in elementary and secondary mathematics methods courses at four universities. Findings illuminate what PSTs attend to in curriculum materials and how they interpret and respond to these materials. Irrespective of level (i.e., elementary, secondary) and materials, PSTs can learn to notice aspects of curriculum materials in order to make decisions about what to do and how to do it, and activities within methods courses can facilitate this development.

Keywords: Curriculum; Teacher Education-Preservice; Teacher Knowledge; Instructional Activities and Practices

Curriculum materials are integral to mathematics instruction. In fact, more than 80% of K- 12 teachers use a textbook or curricular program for mathematics instruction (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013), though such materials greatly vary in design and philosophy. According to Brown and Edelson (2003), curriculum materials have the most direct influence on what teachers actually plan for and enact in their classrooms and, although research does describe what teachers do with materials, we do not necessarily know the process of how teachers make decisions about what to do and how to do it (Stein, Remillard, & Smith, 2007), and we know even less about how prospective teachers make sense of curriculum materials or use them when enacting instruction.

In this paper, we consider how to make such work explicit through curricular noticing. We define curricular noticing as the process through which teachers make sense of the complexity of content and pedagogical opportunities in written or digital curricular materials. In the following sections we briefly present what researchers have learned thus far about teachers' interactions with curriculum materials, describe our framework and how this contributes to this literature, and present a snapshot of this framework in use by describing four individual studies. We conclude with implications.

Teachers' Use of Curriculum Materials

Research on teachers' use of curriculum materials has presented us with a foundation for describing what teachers do with materials. In the midst of planning and enacting instruction, teachers engage in a variety of activities with curriculum. Remillard (2005) describes the teacher-curriculum relationship as a dynamic transaction in which teachers "participate with" the materials. The socio-cultural conception of this relationship emphasizes the fact that both the teacher and the curriculum influences what and how curriculum materials are used. Using this conception, researchers have outlined ways in which teachers participate with curriculum. This includes the activities teachers engage in such as "reading, evaluating, and adapting" (Drake & Sherin, 2009) and what Brown (2009) describes as "offloading, adapting, and improvising." This research has provided us with a sense of what teachers do with curriculum materials, but we still know little about the process of how teachers make decisions about what to do. To understand how teachers make these decisions we turn to describe the Curricular Noticing Framework.

Theoretical Framing of Curricular Noticing for Mathematics Teaching

Curricular noticing (CN) draws upon the extensive work in professional noticing of children's mathematical thinking (PNCMT), a core instructional activity that is integral to ambitious teaching (Philipp, 2014). PNCMT describes a three-part process of making decisions based on student thinking: *attending to*, *interpreting*, and *responding* to children's mathematical thinking (Jacobs, Lamb, & Philipp, 2010). This process illuminates the phases of work involved in how teachers may leverage children's mathematical thinking. Unless teachers can recognize the complexity of students' mathematical thinking (which includes the diverse strategies and rationales of student ideas), they cannot use this information to inform their decisions.

We argue that this noticing framework may be productively applied to yet another dimension of classroom instruction, the use of curriculum materials. Unlike PNCMT, which focuses on student thinking, CN focuses on curriculum materials. Like PNCMT, we draw upon constructs that illuminate aspects of the work of teaching with curriculum materials: attending, interpreting, and responding. We define each of these aspects in the context of curriculum below.

Attending. Looking at, reading, and recognizing aspects of curricular materials

Interpreting. Making sense of that to which the teacher attended

Responding. Making curricular decisions based on the interpretation (e.g., generating a lesson plan, a visualization, or enactment)

Figure 1 further depicts some of the activities in which teachers might engage in each of the phases of CN.

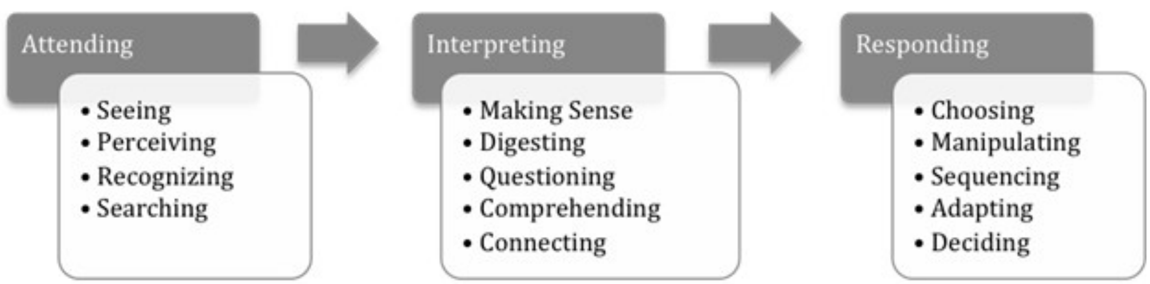

Figure 1. Activities embedded within each of the dimensions of Curricular Noticing.

CN and PNCMT have important commonalities, two of which we highlight here related to (1) the role of tasks and (2) supporting PSTs. First, both CN and PNCMT treat task selection as a necessary and critical component of ambitious teaching. While there have been varied empirical techniques in research on PNCMT, much of this underscores the role of teachers' attending to the mathematics of the present task and interpreting how students interact with the mathematics of that task, and in some cases how to then strategically respond with a new problem, task, or lesson. We see tasks as a critical component of CN as well. Second, both constructs allow the field to consider methods to support PSTs. Cultivating PNCMT practices has been identified as a mechanism to provide PSTs with opportunities to understand student-centered teaching and develop the pedagogical content knowledge necessary for effective and high-leverage instruction (Hill, Ball, & Schilling, 2008; Jacobs et al., 2010). Similarly, we see CN as inextricably linked to these efforts to support PSTs. As teachers make decisions in order to support children's mathematical thinking, curricular materials – specifically teachers' interaction and understanding of the complexity and opportunities reflected in such materials – influence their decisions. In practice, teachers participate or collaborate with curricular materials (Remillard, 2005). Noticing, therefore, is related to both the teacher-student dimension and teacher-curriculum dimension of instructional practices.

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We see the CN framework providing a lens for examining not only what teachers do with curriculum materials, but how they do it. Specifically, how may we describe the mechanisms that determine how teachers make particular decisions in their practice? For example, we know some teachers adapt curriculum materials (Brown, 2009; Drake & Sherin, 2011); at the same time, we do not yet know how teachers come to such decisions to adapt. The CN framework allows us describe how teachers make the decision to adapt by considering how teachers' attention and interpretation may lead to such adaptations. We see these actions instead highlighting, more specifically, how teachers are interacting with the text when engaging in the reading and evaluating process, which in turn impacts the responses they make. As described below in our work with PSTs, we argue the phases of CN provide a useful framework for empowering teachers' decision-making, as each phase can be an explicit object of inquiry and development and productive engagement in the phases can help teachers make more informed decisions about how to use their curriculum materials.

Four Studies Aimed at Examining PSTs' Curricular Noticing

Here we present the methods and findings from four independent and exploratory studies, each of which examined CN. The first two studies focused on mathematical tasks and what PSTs can *attend* to in the tasks in order to grapple with identifying affordances and constraints based on the characteristics of these tasks. The second two studies focus on PSTs' *attention to* and *interpretation of* multiple sets of curriculum materials in order to make decisions (or, *respond*) about adoption and lesson planning. Each methods course supported PSTs in inquiry-oriented and student centered mathematics instruction. Studies explored the character of the three phases of noticing, and how these manifest in the context of curricular materials.

Study 1: Noticing Curricular Task Design Features

In Study 1 the task design features to which secondary mathematics PSTs attend to was explored. PSTs (n = 8) in two groups were given one of two versions of the same challenging optimization task, with each version reflecting common presentations in textbooks. One version was open-strategy, prompting students to make a prediction, work together as a group to find a solution, and justify that the result was indeed the optimal solution. The other version was closed-strategy, prompting students to test two possible solutions and use the results of those tests to choose new possible values to test. After each group worked together for 10 minutes on their version of the task, the whole class discussed what mathematical challenges they encountered and what strategies they had used. When the different versions were revealed, they had another five minutes with their group to read through the other version and consider the differences it would have had on their experience solving the tasks.

The comparison of tasks afforded reflections on the interpretation of task design. The whole class held a discussion about what differences they noticed between the two versions of the task. While the mathematical goal of the task (solving for an optimal value) and the context (locating a stereo on a cabinet) were the same, the way the task prompted students to engage resulted in different experiences. Overall, five themes of task design were noticed and mentioned: (1) students pointed out the way in which the design enables or prevents students from following "gut reactions," affecting how the students may engage with the mathematical content of the task. The open-strategy prompt enabled these gut reactions to be followed-up while the given-strategy version encouraged abandonment of potentially fruitful reactions. A teacher with the closed-strategy task commented: "Something interesting was when we were first starting the task, I felt like my gut reaction was to write an equation and graph it to find a minimum, but we were like, 'that's not what we were supposed to do.'" (2) The PSTs pointed to what they called the "heart of the problem," which was taken as the core mathematical point of the task. Fundamentally, the two versions provided different glimpses of what mathematical ideas were in play. Several prospective teachers were disturbed how the design of the task could "obscure" important mathematical ideas. (3) The PSTs explained how

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the purpose of their work depended on the version they used. The groups that started with the open-strategy task reported testing a point to see what it would tell them, while the closed-strategy group limited to a purpose of following directions. (4) The PSTs noticed the degree to which the task held students accountable for the mathematics. For example, one task explicitly asked "how can you be sure you found the best answer?" while the other just asked for the answer. (5) Several PSTs noted the design constrains what mathematical ideas there is to talk about. They noted that when a strategy is given, the group works in parallel and limited discussion to the verification of answers or how to perform a procedure. They also noted that the opportunity for discussion as a whole class was greatly enhanced when multiple strategies were supported. Findings indicate that such a comparison of tasks afforded interpretations of task design. Next steps will explore how to leverage such interpretations to support teacher decision-making.

Study 2: Noticing Mathematical and Pedagogical Opportunities in Curricular Tasks

The focus of Study 2 was on elementary PSTs' noticing in the context of fractions, an area of mathematics that is notoriously hard-to-learn and hard-to-teach (Lamon, 1996; Saxe, et al., 2005). In order to empower a teacher to make productive choices in implementing a fractions task, that teacher needs to know something about mathematical properties embedded in—and often hidden in—traditional task design. For example, consider an area model for ¼. The canonical representation features a rectangle or circle divided into four equal sections with one of the four equal parts shaded. Such routine design may obscure two important properties in determining fractional quantities: the role of equal parts and the role of defining the unit (or whole). Study 2 explored how to support PSTs' *interpretations* of such mathematical properties in routine tasks through the use of nonroutine tasks in the methods course. A premise was that sustained discussion involving a nonroutine task may thereby support teachers' noticing of—in particular, interpreting—a routine task in terms of core mathematical properties that typically remain hidden.

PSTs (n = 18) were administered a pretest one month prior to and a posttest one month after intervention, each featuring routine and nonroutine fractions representations. In the intervention, all PSTs were asked to identify mathematical properties of two tasks with area models. Task A featured a routine, equally partitioned model with 1/6 shaded. Task B featured a nonroutine, unequally partitioned model with ⅛ shaded. In class, PSTs were asked to analyze each task and anticipate student responses. Results of activities using both routine and nonroutine tasks indicated the vast majority of PSTs did not originally identify *equal parts* or *defining the unit* as mathematical properties of the routine task, yet the majority did so with the nonroutine task.

While a pre-test showed PSTs did not identify equal parts or defining the whole as important mathematical components, a pre-post comparison confirmed PSTs interpreted both routine and nonroutine routine tasks according to these mathematical ideas after intervention. Results of this exploratory study suggest that nonroutine tasks may support PSTs' interpretations of important underlying mathematical properties of tasks they are likely to encounter in curricular materials.

Study 3: Using a Tool to Examine PSTs Attention to and Interpretation of Curriculum Materials

Within the context of the second of two secondary mathematics methods course, Study 3 examined how PSTs (n=17) evaluated content related to quadratics in three different textbooks. In the first few weeks of a 15-week semester, PSTs were asked to examine the teachers' guides from Algebra I textbooks in three curricular series: Prentice Hall (PH), The CME Project (CME), and The College Preparatory Mathematics Program (CPM). PSTs were asked first to determine what was similar and different between the three sets of curriculum materials and then to determine which text, if given the option, they would choose to use in their classroom and why. Each PST turned in a written response to these questions. For the next eight weeks PSTs used the CCSSM Curriculum

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Analysis Tool (CCCAT, Bush, 2011) to analyze the materials with respect to 1) content, 2) practices, and 3) equity, special needs, and technology. The tool required PSTs to use a rubric to rate each text and to provide qualitative descriptions. Following this analysis, PSTs responded to the same questions from the beginning of the semester. Each pre- and post-tool response was read multiple times to generate initial codes. Each response was then read again and codes were assigned to these responses.

The post-tool responses indicated that, if given the chance, 76% would choose to adopt CPM (compared to 72% before using the CCCAT), 6% would choose CME (no change), and 18% would choose PH (compared to 22%). One important note is that students engaged in this assignment in the second methods course and in the first methods course had engaged in cursory examinations of curriculum materials (without attention to particular content) and also taught from reform-oriented materials in a micro-teaching setting. It is likely that these previous experiences impacted students' choices of materials.

Although there was not much of a difference regarding which text PSTs chose to adopt after engaging with the CCCAT, there was a shift in the reasoning used by PSTs when discussing their choice. In their pre-tool responses, PSTs' responses were quite general in nature and included the general approach of the materials, whether the materials had good or bad teacher resources, the tools included in the materials such as calculator and manipulatives, and the clarity of layout for students. After using the CCCAT, their evaluations were more detailed and they described different aspects of the materials. On average, PSTs wrote 32% more (as measured by number of sentences) in their post-tool response and included more examples from the materials (mostly to illustrate features that they liked). Six out of the 10 most frequent reasons were explicitly aligned to aspects that PSTs were asked to use when evaluating texts using the CCCAT. PSTs made reference to the CCSS Mathematical Practices and the balance between procedural and conceptual opportunities and when referring to the teacher resources described in detail the supports for assessment, differentiated instruction and working with ELL students.

They also commented more on the ways in which technology was integrated, meaning whether it seemed to be an integral part of the text rather than just naming what tools were used in the text. All of these aspects were explicitly addressed by the CCCAT. In addition, however, PSTs also discussed aspects that were not an explicit object of analysis in the CCCAT. PSTs discussed the types of participation structures that were emphasized in the materials, whether detailed lesson plans or suggestions were provided to teachers, the cognitive demand or richness of the tasks, the flexibility (or often lack of flexibility) of the text and the level of planning needed in order to be successful in using the textbook. Although potentially helpful in being able to apply the CCCAT, these aspects were not explicitly addressed, meaning that PSTs were not asked to attend to these aspects in the same ways they were the others. Results indicate that the CCCAT may have aided in shifting what curricular features PSTs attended to and how they then interpreted those features.

Study 4: Responding with Curricular Materials

This study focused on understanding how elementary PSTs made decisions about intended lesson plans as they interacted with multiple curricular resources to further understand the reasons behind their instructional decisions. In this process, close attention was given to what (i.e., the content) the PSTs *attended* to, how they attended to this content (e.g., the degree to which they selected to include in the content in their lesson design), and how they *interpreted* this content with respect to teaching the intended learning outcomes. Finally, there was a focus on how the PSTs *responded* to the selected curricular components to create a plan for teaching with an emphasis on PSTs' decision-making process.

PSTs (n=19) were provided with Grade 6 teacher materials for a lesson on the division of fractions from four curricular programs. PSTs were tasked with using components of any of the resources to write out a detailed lesson plan that would address the following standard: "Apply and extend previous understanding of multiplication and division to divide fractions by fractions" (CCSSM, 2010, p. 42). PSTs were required to provide rationale for their decisions regarding including or excluding particular curricular resources. Following the design of their lesson plan, PSTs were prompted to respond to questions about their use of the resources, motivation for using particular materials, reasons for not including particular materials, and an overall rationale for their decision-making with respect to curricular materials. Often, the PSTs cited their own experiences, belief, and knowledge for their rationale.

Findings indicated that the PSTs noticed curricular components that aligned with their personal conceptualizations about effective mathematics teaching. PSTs considered problems with authentic contexts and problems that involved students through some tangible manipulative to be exemplary components that aligned with effective pedagogical practices. In addition, PSTs based their selections on preconceived notions of what a lesson on the division of fractions should include. For many, they considered how they personally learned the division of fractions and then searched through the materials until they found something closely aligned with their preconceived method of how a lesson on this topic would be taught. In this case, the Curricular Noticing Framework afforded opportunities for understanding how PSTs conceptualized division of fractions after reading multiple curricular resources. Following this, the decisions the PSTs made about how they would respond, or teach the lesson, became transparent. Consequently, past prior experience with the specific content influenced their decision-making process. In contrast, many PSTs documented that the mathematics content was advanced and they had to grapple with the concept of division of fractions before they were able to consider how they would plan a lesson on the topic for sixth grade students.

Implications

Use of the CN Framework identifies the conceptual work involved in translating curricular materials to classroom practice. Our studies offered glimpses of the character of the phases of curricular noticing. We reflect here on both the individual studies described above and what looking across the set of studies as a whole helps us understand about CN.

First, in Study 1, the analysis of different versions of the same mathematical task enabled PSTs to recognize design features of mathematical tasks and connect them to the potential affordances and constraints of teaching with the tasks. PSTs developed a potential lens to critique the tasks of their mathematical curriculum materials. That is, by attending to one aspect of a mathematical task (e.g., how students are held accountable for reasoning), teachers can scrutinize that dimension of the task design (i.e., define how and to what degree students are accountable for mathematical reasoning) and can decide to adapt their task to enhance this quality (i.e., add "Explain how you know" to a task statement).

Second, involving the use of routine and nonroutine problems to support noticing of mathematical and pedagogical opportunities, Study 2 indicated that PSTs may benefit from task exploration that problematizes the big mathematical ideas (in this case involving fractions) embedded in the routine tasks they are likely to encounter in curricular materials. Furthermore, exploration of such tasks may highlight (Goodwin, 1994) the mathematical aspects that are indeed critical to notice in order to choose tasks that anticipate and respond to student thinking.

Third, in Study 3, there was a shift in the reasoning used by PSTs when discussing their choice. This shift suggests that the tool supported PSTs in being able to attend to and interpret curricular features in order to articulate reasons for curriculum evaluations.

Finally, Study 4 indicated that PSTs noticed opportunities that aligned with their concepts about effective mathematics teaching. Many PSTs had some idea of what the target lesson should include and then wrote a lesson plan irrespective of the relation to materials. Findings suggest that PSTs may benefit from further instruction on how to use curricular materials.

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These studies are not without limitations. First, the studies were humble in scope, both in terms of working with a single mathematics methods course and without consideration the multiple dimensions involved with CN. As a result, we do not yet fully understand how to support each element of noticing - attending to, interpreting, responding- for PSTs. Second, the contexts for each of the methods courses is varied in terms of level (i.e., elementary, secondary), number of PSTs, and grain-size of materials (i.e., tasks, lessons, units), thereby limiting our capacity to compare across studies.

Despite these limitations, however, the four studies offer a glimpse into the work involved in CN and identify an exciting and important arena in the work of teaching. As mentioned, we do not and cannot know the materials to which PSTs will have access once they have jobs. Yet, we can be confident that most will have some form of curricular materials. Our goal is to understand how to enable PSTs to become strategic and productive users of curricular materials regardless of what those materials are, thereby supporting them to make informed curricular decisions as they teach their students. The first two studies show that by focusing on aspects of tasks that PSTs learned to attend to the mathematics and pedagogical opportunities afforded by or constrained by the tasks. The second two studies indicated that providing PSTs with different curriculum materials and focusing either on lessons or units not only provided PSTs with the opportunity to attend to various mathematical and pedagogical opportunities within the materials, but also required them to interpret the materials in order to respond in some way to a particular question (i.e., What materials would you adopt?) or take a particular action (i.e., plan a lesson).

Taken together these studies indicate that, irrespective of level (i.e., elementary, secondary) and materials, that PSTs can learn to notice aspects of curriculum materials in order to make decisions about what to do and how to do it and that activities within methods courses can facilitate this development. In future research, we hope to further reveal how our framework may be strategically implemented in methods coursework or professional development to support teacher decision-making.

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References

Banilower, E. R, Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research, Inc.

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.

Brown, M., & Edelson, D. (2003). *Teaching as design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice?* (Design Brief). Evanston, IL: Center for Learning Technologies in Urban Schools.

Bush, B. (2011). *CCSSM Curriculum Analysis Tool*. Retrieved from: http://www.mathedleadership.org/ccss/ materials.html.

Common Core State Standards for Mathematics (CCSSM). (2010, June).Retrieved from Common Core State Standards: http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

Dietiker, L., Amador, J., Earnest, D., Males, L. M., & Stohlmann, M. (2014, April). Fostering K-12 prospective teachers' curricular noticing. Research symposium at the National Council of Teachers of Mathematics Research Conference, New Orleans, LA.

Drake, C., & Sherin, M. G. (2009). Developing curriculum vision and trust: Changes in teachers' curriculum strategies. In J. T. Remillard, B. A. Herbel-Eisenmann & G. M. Lloyd (Eds.), *Teachers at work: Connecting curriculum materials and classroom instruction* (pp. 321-337). New York: Routledge Taylor, and Francis.

Goodwin, C. (1994). Professional vision. *American Anthropologist, 96*, 606-63.

Hill, H. C., Ball, D. L., Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education, 39*, 372-400.
Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional Noticing of Children's Mathematical Thinking. *Journal for Research in Mathematics Education, 41*, 169–202.
Lamon, S. J. (1996). The development of unitizing: Its role in children's partitioning strategies. *Journal for Research in Mathematics Education, 27*, 170-193.
Philipp, R. (2014, April). *Using representations of practice in survey research with mathematics teachers.* Symposium conducted at the National Council of Teachers of Mathematics Research Conference, New Orleans, LA.
Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research, 75*, 211-246.
Saxe, G. B., Taylor, E. V., McIntosh, C., & Gearhart, M. (2005). Representing fractions with standard notation: A developmental analysis. J*ournal for Research in Mathematics Education, 36*, 137-157.
Stein, M. K., Remillard, J., & Smith, M. S. (2007). How curriculum influences student learning. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 319-369). Reston, VA: National Council of Teachers of Mathematics.