Examining Student Thinking Through Teacher Noticing: Commentary

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Abstract With the growing research base on teacher noticing has come a similar expansion of methodologies used to measure teacher noticing. The six chapters in this section reflect a range of methodologies, and this commentary is organized around three methodological considerations showcased in the chapters: (a) adoption of a conception of teacher noticing, (b) design of data-collection tools, and (c) choice of data-analysis lenses.

Keywords Teacher noticing · Professional noticing · Teachers' knowledge · Preservice teachers · In-service teachers

Classrooms are highly complex environments, and for teachers to create and nurture rich and supportive learning environments for all their students, they must learn to focus their attention among the "blooming, buzzing confusion of sensory data" (Sherin & Star, 2011). One approach teacher educators and professional developers have taken is to decompose the practice of teaching into specific components that might be studied and learned (Grossman et al., 2009), and the practice of noticing has emerged as a growing area of inquiry among researchers in their study of teaching practices (e.g., see Sherin, Jacobs, & Philipp, 2011). This book extends our understandings of teacher noticing, and the authors of the four papers in this section examine *student thinking* through teacher noticing. After addressing one commonly applied noticing framework, we describe contributions from each of the four papers, identifying major questions raised, and finally turn to

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recent work by two of the authors of this commentary (Fredenberg, 2015; Hawthorne, 2016) to consider the knowledge associated with engaging in the practice of noticing of students' mathematical thinking.

Professional Noticing of Students' Mathematical Thinking

Authors of the four papers in this section draw upon frameworks for noticing, mathematical content, and learning, as we mention when discussing each paper, but because the framework *Professional Noticing of Students' Mathematical Thinking* (Jacobs, Lamb, & Philipp, 2010) (hereafter *Professional Noticing*) plays a central role in all four papers, we first describe *Professional Noticing*. *Noticing* is a teaching practice, something one *does*. The construct of *Professional Noticing* is comprised of three practices: *attending* to students' strategies and their mathematical thinking, *interpreting* students' understandings, and *deciding how to respond* on the basis of students' understandings. We highlight two key aspects of this conceptualization. First, the three components are highly interrelated and often occur seemingly simultaneously. For example, when a student responds in a manner that indicates to the teacher an unforeseen conception, the teacher might pose a follow-up question to that student or to other students, and on the basis of additional information, the teacher might modify the lesson. In this example, attending to and interpreting the first student's thinking were virtually inseparable, and the teacher began to formulate a response while interpreting the students' thinking. Furthermore, although these three components of *Professional Noticing* are highly interrelated, for purposes of studying teacher noticing, researchers often isolate the components, an isolation we consider useful for the early development of the construct. The second aspect we highlight relates to the fact that teachers constantly engage in multiple types of noticing. For example, teachers notice whether a small group is working productively or if a student who seems troubled might need medical attention. Although these examples of teacher noticing have clear and direct implications for students' learning, *Professional Noticing* is a particular and explicit focus on the mathematical thinking of students.

The Four Studies

In the chapter by Lee and Choy, they studied preservice teachers from the United States and in-service teachers from Singapore to investigate the role noticing plays in teachers' learning from Lesson Study. They drew upon van Es's (2011) work to consider both what and how teachers notice during two components of a Lesson Study cycle, specifically while planning the lessons and while reviewing and discussing the lessons. They also drew upon the *Professional Noticing* framework (Jacobs et al., 2010) to investigate the extent to which the preservice U.S. teachers and in-service Singaporean teachers attended to, interpreted, and decided how to respond when discussing significant mathematical aspects during lesson-study discussions. Further, they applied a 3-Points framework (Yang & Ricks, 2013) to consider how teachers focus on the mathematical concept or big idea (the *Key Point*), the cognitive obstacle students face when grappling with the main idea (the *Difficult Point*), and the teacher's approach for supporting students while they get at the heart of the lesson (the *Critical Point*). The study showed that during the initial class observations, both groups of teachers found focusing on significant mathematical aspects challenging. For example, the U.S. preservice teachers focused on such nonmathematical issues as management and organization. However, by the final lesson-study discussion, both the preservice and in-service teachers began to notice specific episodes of student thinking. The researchers attributed the increased attention to students' thinking to a concentration during the lesson-study cycle on the 3-Points framework: the preservice and in-service teachers' discussion of the Key Point, the Difficult Point, and the Critical Point. The authors also found that neither the preservice nor the in-service teachers reached the level of noticing such that they engaged in deciding how to respond to students' mathematical thinking. Finally, although they noted that supporting teachers in adopting the 3-Points framework is nontrivial, they concluded that Lesson Study focused on such a framework can be a means to develop noticing expertise.

One noteworthy feature of the study by Lee and Choy is that although they studied two very different groups, U.S. preservice teachers and Singaporean in-service teachers, the results of their study were similar for the two groups. A second noteworthy feature is their infusion of the 3-Points framework, which was designed to focus attention among the participants on the mathematical details. Although such a focus supported the participants in developing noticing skills, none of the teachers engaged in the highest level of *Professional Noticing*. This result provides additional evidence for the challenge of supporting even experienced teachers in learning to respond to students' mathematical thinking.

van den Kieboom, Magiera, and Moyer studied prospective teachers' noticing in the context of one-on-one clinical interviewing taking place as part of a two-course integrated mathematics/field-experience sequence. Unlike the other authors of this section, van den Kieboom et al. situated their study within a well-defined mathematical content domain, the meaning of the equal sign, and they presented a four-category hierarchical framework of student thinking about the equal sign. Their overall goal was to engage prospective teachers in opportunities to rehearse and, subsequently, improve their noticing skills. They found that the prospective teachers' noticing skills improved, with 19 of the 32 prospective teachers showing improvement in attending to and further exploring student thinking about the equal sign; however, the improvement was not statistically significant. They also found that the prospective teachers noticed predominantly the strategies students used to solve a task without focusing on the details of the students' thinking about the equal sign. The authors concluded with two suggestions for improving the focus on the prospective teachers' noticing skills: (a) Use more examples and counterexamples of interviewers attending to and further exploring student thinking about the equal sign, and (b) incorporate "missed opportunities," whereby prospective teachers watch an interview that might seem similar to one that they conducted and then reflect on how the interviewer might have taken a different direction to explore student thinking concerning the equal sign.

A noteworthy feature of the study by van den Kieboom et al. is their focus on a well-defined mathematical content domain that includes details about students' mathematical thinking, creating opportunities for prospective teachers to grapple with the mathematical details of the students' thinking. We see this approach as holding much promise for supporting the development of professional noticing of students' mathematical thinking.

Amador, Weiland, Hudson, Galindo, and Rogers, drawing upon frameworks of van Es (2011) and Jacobs et al. (2010), carried out a longitudinal study of six prospective elementary school teachers and then focused on one, Mikayla, over three phases: enrollment in a field experience during her junior year (Phase 1), student teaching during her senior year (Phase 2), and her first year of teaching (Phase 3). The authors studied Makayla's noticing in the context of mathematics and science, and a Lesson Study approach was used during Phases 1 and 2 when the six prospective teachers were paired during cycles of Lesson Study. Extensive data were collected, including written lesson plans, videotapes of lessons, field notes and observation, and post-teaching interviews. Two major themes emerged from the study. First, Mikayla emphasized students' mathematics understanding by attending to and interpreting students' thinking in all three phrases, with the greatest changes to her attending and interpreting being measured as the difference between her junior year and senior year. Second, the extent to which Mikayla adapted or modified her teaching in the moment, also grew, with marked changes being measured as the difference between her senior year and her first year of teaching. Also noteworthy, although Makayla's noticing improved in both mathematics and science, her deciding how to respond to students' thinking was evident more in mathematics than in science. Amador et al. theorized that Mikayla may have been limited in her scientific content knowledge vis-à-vis her mathematical content knowledge, accounting for the difference.

Amador et al. followed teachers over 3 years, an ambitious yet powerful means of learning about the development of teacher noticing. Furthermore, by observing Mikayla in two subject areas, the researchers were able to tease out the role that her content understanding played in her deciding how to respond in the moment. In particular, the authors noted that for prospective teachers to respond to content-specific instruction, they must be supported in developing the rich content knowledge needed to do so.

Wells extended the construct of professional noticing of students' mathematical thinking (Jacobs et al., 2010) to incorporate observable gestures, body language, and audible indicators of student thinking, most notably in students' conversations. Data were videotapes of weekly lessons in a fifth-grade class considered to reflect the teacher's normal teaching practices, transcribed with gesture mark-up to indicate the temporal aspect of each gesture. Wells examined common features to which a teacher might attend during group work. Major study results indicate that the manner in which a group engages in conversation is more important than what is said. For example, Wells posited that for a group to progress satisfactorily toward a solution path, the group must first embrace a cooperative demeanor and that an increase in gesture size seemed to indicate progress toward a solution, as did *posture echoing*–group members' adopting a common posture when working and conversing.

By attending to student conversations, including student gestures, to investigate the relationships between group conversations and progress toward a solution strategy, Wells has added another layer to the study of teacher noticing. For example, Wells offered a set of group dynamics that a teacher might find valuable for deciding whether to intervene in classroom group work. In addition, the finding that successful groups appear to immediately establish a supportive conversational atmosphere underscores a key noticeable aspect of group work. We suggest that some of these group dynamics seem to be more easily attended to than others. For instance, a teacher can observe posture echoing from across a classroom, but conversational shifts in a group's discourse requires a more intimate degree of observation. Moreover, noticing initial group dynamics requires a specific focus on each group's opening conversational tones and inflections, and such centered attention might be difficult to achieve across multiple groups. Finally, the results of Wells' work raise for us a question relating to the most efficient use of a teacher's attention: Of the group dynamics that Wells presents, which most contribute to the *Professional Noticing* of students' mathematical thinking?

The Role of Knowledge in Deciding How to Respond to Students' Thinking

The four papers in this section highlight the challenges involved with preparing prospective teachers, and even practicing teachers, to decide how to respond to students' thinking. We are not surprised that this practice is difficult for teachers. Tyminski and colleagues (2014) highlighted the coordinated and integrated manner in which teachers' specialized content knowledge, knowledge of content and students, and knowledge of content and teaching (Ball, Thames, & Phelps, 2008; Hill, Ball, & Schilling, 2008) must be held for teachers to engage in deciding how to respond to students' thinking. Perhaps an important issue is understanding not just the type of knowledge needed but also the constellation of knowledge and practice held by teachers and how it supports their in-the-moment decision making. Two recent studies of teacher noticing shed light on this question.

Fredenberg (2015) studied three primary-grade teachers who had more than 13 years of experience teaching mathematics using the principles of Cognitively Guided Instruction (CGI) and more than 6 years of professional development centered on children's mathematical thinking. Fredenberg applied a methodology whereby, in addition to conducting a series of structured clinical interviews and classroom observations, he (politely, with the teacher's preapproval) interrupted immediately after a teacher modified a task for a student and asked the teacher to explain her reasoning for the decision. Combined with semi-structured stimulated-recall interviews, these interruptions enabled Fredenberg to unpack the teachers' knowledge, noticing, and other practices and begin to understand the relationships among these.

Fredenberg (2015) posited that for these teachers the practice of noticing children's mathematical thinking was inextricable from the teaching practices of lesson planning and task design. He argued that when these teachers designed a task, they manufactured within the task architecture frameworks for, first, noticing their respective students' thinking and, second, leveraging their students' thinking to meet specific learning objectives. For example, Fredenberg found that during the task-design process the teachers often anticipated how specific students might react to a problem, and they made precise number choices to provide themselves opportunities for scaffolding moves across the wide range of their students' mathematical knowledge and understandings. Essentially, the teachers appeared to premeditate instructional responses applicable to the various strategies that their students would in all likelihood employ. Fredenberg concluded that for these exemplary teachers, *Professional Noticing* was woven across the domains of lesson planning and lesson enactment, and, hence, for them *Professional Noticing* was not exclusive to classroom teacher-student interactions. On the basis of this finding, we ask: How does *Professional Noticing* become integrated across the practices of exemplary teachers? And what knowledge is required for such integration, or degrees of, to be an attainable outcome of teacher preparation or professional development?

Hawthorne (2016) presented another study of exemplary teachers, but unlike Fredenberg's study in which all three teachers displayed expert noticing, Hawthorne's study showed that although two middle school teachers possessed similar knowledge structures, only one of the two effectively engaged in deciding how to respond on the basis of the students' understandings. Furthermore, the differing degrees of professional noticing correlated with the teachers' respective lesson-planning practices. For example, Jack, who expertly incorporated student thinking into his in-the-moment pedagogical decisions, premeditated his noticing in the lesson-planning process. Jack was deliberate and meticulous in designing his lesson plans, all of which included the nature of the student thinking that he wanted to stimulate and build upon during the lesson. Furthermore, Jack's precise organization of his lesson plans enabled him to anticipate and sequence students' emergent ideas while enacting the lessons. Thus, Jack, like the teachers in Fredenberg's study, actively premeditated his noticing of students' thinking when he proactively attended to specific instances of mathematical concepts and ideas of his students' thinking that he believed would emerge during a lesson.

In contrast, Clara, the second teacher in Hawthorne's study, did not exhibit organization and detail in the lesson-planning process similar to Jack's. Clara did not actively anticipate student thinking when planning a lesson, and, as such, she did not plan instructional strategies to meet specific instances of student thinking.

Consequently, Clara's professional noticing seemed to be much more reactive to student thinking than Jack's, which did not afford her the same opportunities to build on and extend her students' emergent ideas. Particularly noteworthy in Hawthorne's (2016) study is that the two teachers were engaged in the same long-termed professional development, and they both displayed similar mathematical content knowledge of algebraic generalization, the topic they were teaching. Hawthorne argued that the differences in the teachers' noticing could not be explained by their mathematical content knowledge and instead related to the manner in which they anticipated and thought through details of students' mathematical thinking vis-à-vis the generalization process.

Final Comments

In any classroom, one might direct one's attention in seemingly infinite ways, and the study of teacher noticing in general and professional noticing of students' mathematical thinking in particular have helped us understand where teachers place their focus. But understanding *what* teachers do (and do not) notice in mathematics classrooms, as important as it is, leaves those of us charged with preparing new teachers or providing professional development to experienced teachers posing another question: How might we leverage these constructs in our work with prospective or practicing teachers? By focusing the teachers' noticing on students' mathematical thinking, we emphasize this central feature of the mathematics teaching enterprise, and, further, we elevate not just the mathematics and not just the students' thinking, but the important space that lies at the intersection of these critical areas. And in this space we still have much to learn about how the mathematics must be understood for a teacher to effectively engage in professional noticing of students' mathematical thinking or how a focus on students' mathematical thinking leads to teachers' deeper learning of the mathematics. These questions seem to us to be both important and rich, and the papers in this section provide additional examples of how researchers are pursuing the study of student thinking through teacher noticing.

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