THE EFFECTS OF FRAMING ON MATHEMATICS STUDENT TEACHER NOTICING

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Teacher education programs have increasingly incorporated activities to support novice teachers in learning to attend to student ideas that surface during mathematics instruction. These efforts have been found to be effective at the end of a particular course, but less is known about their longer-term effects on teaching practice. A related study of the noticing of prospective mathematics teachers who had engaged in such activities found that they demonstrated a focus on students during their own instruction; however, this focus was not always on student ideas. Here, the cases of two of these prospective teachers are used to explore the nuances of their noticing of students, and how the ways in which they framed their instruction—in terms of their knowledge of students and their own expectations of students—affected this noticing. Implications for teacher education programs are discussed.

Keywords: Teacher Education-Preservice, High School Education

Teacher noticing (e.g., Sherin, Jacobs, & Philipp, 2011) has emerged as central to student-centered mathematics instruction (e.g., National Council of Teachers of Mathematics, 2000). Typically defined to include three interrelated skills—identifying important events during instruction, reasoning about them, and making connections between them and broader educational principles (e.g., Sherin & van Es, 2005)—the importance of this construct stems from the fact that teachers cannot intentionally act upon that which they do not notice (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008; Sherin & van Es, 2005). In fact, a major difference between expert and novice teachers' practice is their ability to recognize and respond to important instructional events (Berliner, 2001; Hogan, Rabinowitz, & Craven, 2003). Often, novices fail to act upon student-generated instructional instances to which experienced educators intuitively recognize and productively respond (Peterson & Leatham, 2010).

Many teacher education programs have begun to incorporate activities intended to help prospective teachers develop the skills and dispositions necessary to notice important student-generated instances that arise during instruction (e.g. Stockero, 2008; Leatham & Peterson, 2010; Santagata & Guarino, 2011). Some of these activities have been found to be effective in the short term, that is, at the conclusion of a particular teacher education course. Analyses of the outcomes of using video-based activities in mathematics methods courses, for example, have documented that prospective teachers developed a focus on making sense of student thinking (Stockero, 2008), as well as on the teacher moves that help make such thinking visible (Santagata & Guarino, 2011). The latter study also found that prospective teachers began to consider the relationship between teacher moves and student learning. Less is known, however, about the longer-term effects of such activities—what teachers who have engaged in coursework focused on noticing and making sense of student ideas attend to during their own instruction.

This paper focuses on the cases of two novice mathematics teachers who had engaged in such activities during their teacher education coursework. It builds on the results of a prior analysis of the in-the-moment noticing of six teachers during their student teaching experience.

This analysis documented a strong focus on students, with 87.5% of the participants' self-documented instances of noticing having some focus on students (Stockero, 2013). Although this result was encouraging, the analysis also revealed that only 25% of the documented instances were focused on students' thinking, with 15% focused on making sense of an individual student's mathematical thinking—a focus of the student teachers' mathematics methods course. This finding prompted further analysis of the data to better understand the nuances of the participants' student-centered noticing, and what barriers might be preventing them from carefully attending to students' ideas. The cases discussed here highlight how the frame or lens through which the student teachers noticed influenced what they did or did not document as important during the act of teaching. The findings are used to highlight potential implications for teacher education programs.

Theoretical Perspectives

The work is grounded in a vision of teaching where teachers continuously build on student thinking in ways that are responsive to their current mathematical understanding (e.g., NCTM, 2000). This requires that teachers maintain a strong student focus during the act of teaching; specifically, it requires teachers to *notice* (e.g., Sherin et. al, 2011) student mathematical ideas.

Ideas from the psychology literature provide a foundation for the construct of teacher noticing and may help to explain novice teachers' lower level of responsiveness to student ideas. One cause may be *inattentional blindness* (Simons, 2000), defined as a failure to recognize unexpected events. In the context of a mathematics classroom, such blindness may result, for example, in a teacher failing to recognize that an incomplete student idea might be mathematically important because they may not be aware that this could be the case. A lack of responsiveness could also be related to *situational awareness*, defined to go beyond mere awareness of a phenomenon, to include sense-making ability (Endsley, 1995). During a classroom lesson, if a teacher cannot make sense of what a student is saying or how it might relate to the goals of the lesson, they will likely be less inclined to take up the student's idea. Teacher noticing during instruction requires both awareness and sense-making.

This research focuses on understanding a specific type of teacher noticing, *mathematical noticing*. Mathematical noticing focuses on attending to student ideas that surface during instruction that include important mathematics and have the potential to support students' understanding of the mathematical goals for the classroom (e.g., Leatham, Peterson, Stockero, & Van Zoest, 2011). Although a range of instances of student thinking occur during instruction, not all of these instances are equally important to notice in terms of their potential to help achieve the goal of supporting students' mathematical learning. While some instances of student thinking might be important for affective or pedagogical reasons, teachers need to be clear about which instances are important mathematically.

Context and Methodology

The case participants, Adam and Ally, were prospective mathematics teachers completing a semester-long student teaching experience during the final semester of a secondary-school level teacher education program. The teacher education program focused on developing student-centered instruction grounded in inquiry and sense-making. The participants had completed a mathematics methods course with a strong focus on listening to, making sense of, and considering how to use student thinking during instruction. In the course, they had studied Smith and Stein's (2011) *5 Practices for Orchestrating Productive Mathematics Discussions*. They had also analyzed student thinking in written and video cases of instruction, and worked with small groups of secondary school students on tasks to elicit and build on their thinking to support their mathematical understanding (see Van Zoest & Stockero, 2008 for a description of a course after which this was modeled).

Adam and Ally were typical, or even slightly above average, prospective teachers in the teacher education program. In the mathematics methods course, each had demonstrated an ability to make sense of student thinking in cases of practice and when analyzing their own or peers' work with small groups of students in a local classroom. Both were also able to accurately reflect on their work with students, using classroom-based evidence to highlight ways in which they both helped and hindered student learning.

Each participant was observed and video-recorded teaching three mathematics lessons during their 15-week student teaching experience, early- mid- and late-semester. During each observation, the participant was asked to document important instances that they noticed while teaching by wearing a self-mounted camera that allowed them to capture a 30-second segment of video when they felt an important instance had occurred. The definition of what might constitute an important instance was left open-ended to allow the researcher to understand what participants viewed as important during their teaching. Following each lesson, the participant engaged in an interview focused on discussing self-documented instances, undocumented instances that were deemed to be mathematically important by the researcher/observer, and the participants' general ideas about what might be important to notice during a lesson.

Data included the lesson video recordings, the participants' documentation of important instances they had noticed, and video recordings of the post-lesson interviews. The interview video was segmented into conversations about instances discussed in the classroom video and general ideas about noticing. Building on a framework used in prior work (e.g., Stockero, 2008), each conversation about an instance was coded for agent (Who was the noticing focus?) and topic (What was the noticing focus?). Discussions of undocumented instances were coded for participant-identified barriers to noticing. During the coding process, it became apparent that some participants, including Adam and Ally, seemed to have a particular frame through which they viewed their practice; additional coding was added to document when these frames were apparent. In this work, a frame is defined as a lens through which a participant seemed to make sense of what was important in their classroom.

The Cases of Adam and Ally

Adam and Ally were selected as cases for this study because the way they talked about their self-documented instances of noticing and their general ideas about what is important to notice while teaching highlight two different noticing frames that were evident among the larger group of participants—*knowledge of students* (four participants) and *expectations of students* (five participants). Data from Adam and Ally's post-observation interviews are used to help the reader understand these frames and to highlight how they affected the participants' noticing.

Adam: Knowledge of Students Frame

During the three observed lessons, Adam self-documented a total of 16 instances. Of these, 12 (75%) included some student focus, with individual or groups of students being the primary focus in 7 instances. In the post observation interviews, it became evident that Adam's knowledge of students significantly affected what he deemed important to notice during his instruction. Although Adam's overall noticing shifted across the three observed lessons, he consistently framed the discussion of his documented instances in terms of what he knew about the particular students who were central to the instance.

In the first classroom observation, the instances Adam documented as important mainly focused on his own use of questioning. Even in this early observation, he noted that he felt like he had a good understanding of the needs of individual students in his classroom and was able to tailor his questioning to those needs. It was typical for Adam to frame his noticing both in terms of the 'level' of the class, and his perceptions of the particular student's needs. This framing is evident in the following dialogue, where Adam discussed the importance of an instance in which he scaffolded a student's thinking:

> This class has probably one high achiever and then a lot of pretty okay students and then a couple not-as-good-at-math students, and [Student] is one of those students that is not as good at math and also has like an attention disorder or something. So I try to ask him questions because it keeps him on track and it keeps him working and when I can get him to give me a correct answer, he's actually a lot smarter than he gives himself credit for, so I try to keep working with him until he can give me the correct answer. I keep asking questions and sometimes I have to, I try to start with hard questions because I don't want to give him like dog treats. I don't want to do that. Sometimes I have to work him down that far, most of the time, and actually in this instance he was able to figure out that this [face of a figure] is a rectangle.

During the second observation, Adam shifted to documenting instances in which he facilitated small group interactions, but still framed the importance of each documented instance in terms of the needs of the students in the group. In some cases, he explained how he intervened with a group, while in others he noted how he helped particular students become involved with their group, or why he was able to let students work out difficulties on their own, as in the following:

> This group, in particular, is a very good group because [Student 1] is a very high achiever, [Student 2] and [Student 3] are both hard working students that are okay at math. [Student 4] is, I think, very smart at math but doesn't really try that hard…So I think their group is nicely balanced where they have kind of different levels of motivation as well as achievement. And I think that that discussion is very telling of each of their level of achievement, where [Student 3] wants a lot of, she wants to achieve well, or she wants to do well even though she is not that great at math. So she is always like asking for the clearest clarification she can get or multiple explanations….And then [Student 2] who actually gives the explanation at the end I think has, I don't want to say the lowest understanding, but she's, I mean they're all really pretty good, so of the four she's probably the lowest understanding but her explanations and writing skills are very good, so she gives the explanation to [Student 3] at the end. I don't know, I think that dynamic is very interesting.

After the interviewer pushed Adam to articulate why he had marked the instance as important to notice, he stated that it was the interaction among the students that was important, and concluded by saying, "I didn't do anything good there. I was just listening."

In the third observation, a stronger focus on individual student's thinking started to become apparent in Adam's noticing. In one instance, he described a student as having an attention disorder and then discussed a moment when he was "inspired" by this student's thinking:

> So he is actually very, very bright but he gets confused in the middle of his problems and I think that I found this to be almost like an inspiring moment for me, like [I] let [Student 5] do it. [Student 6] was trying to help him, she actually gave him the answer but we worked to make sure that he knew the process to get to the answer, and he didn't actually give the answer [Student 6] said of 1000…So I don't know, I just thought it was powerful to see

> someone's thoughts happen, like what's happening in their brain happened out loud. He was literally thinking through the problem and I don't know if he knew the answer when I called on him but he definitely, at least I feel like he knew the answer by the time it was done.

Across the three interviews, Adam consistently framed his noticing in terms of his knowledge of students, providing detailed accounts of students' strengths, weaknesses and individual needs to explain why a particular documented instance was important for him to notice. This framing was clearly evident in 11 of his 16 documented instances (4 out of 5 in the first observation, 4 of 7 in the second, and 3 of 4 in the third). Although he showed a strong focus on students, he was not always focused on students' mathematics. Instead, he was often focused on more general needs of the students in his class, such as what kind of support they might need to complete a problem or how they were interacting within a small group. In fact, his knowledge of students caused him not to document student ideas as important on at least two occasions, once because the student was strong mathematically and frequently approached problems differently and the other because he was unsure whether he should put the student on the spot to discuss his idea. In these cases, his perceptions of students caused him not to note the importance of students' mathematical thinking that might have been used to help other students make sense of the mathematics in the lesson.

Ally: Expectations of Students Frame

Ally documented a total of 12 instances as important to notice during the three observed lessons. Her total number of student-focused instances was similar to Adam, with 9 instances (75%) including some focus on students and 7 (58%) with students as the primary focus. Unlike Adam, what Ally considered important to notice was fairly consistent across the three observed lessons and was grounded in students' work on mathematical tasks. A clear frame for noticing also became apparent in Ally's post-observation interviews; she viewed the classroom through a lens of her expectations of students.

In all three of her observed lessons, Ally documented instances that provided evidence of whether students were making the "connections" that she wanted them to make; most often, these were instances when she felt connections were not being made. She often noticed how students were approaching a task or thinking about a problem in comparison to what she expected, using the words "rather than" and "instead of" to contrast the two. An example of this occurred in the first post-observation interview when she discussed an instance she had documented as important while observing the work of a small group of students. They were working on a task related to developing a function to model magazine sales. Here, she explained how the students had used an unsimplified form of a function to answer a question rather than using the simplied form that she had prompted them to find in a previous part of the problem:

> I actually saw in their work, because a lot of them, on number two, when they were putting in 72 individual magazines into their function, they didn't use their simplified function. They went back to [the unsimplified form of the function] and only did .55 times the individual magazines. So they didn't connect with the significance of taking the individual magazines away from them, too…I was trying to prompt them into looking at number one and making the connection, what's the difference, and what function could be [used] for number three.

In this instance, the students' use of the unsimplified function may have eventually resulted in a correct solution, but was not what Ally expected or wanted them to do. Thus, she documented the instance as an example of students not making a connection that she wanted them to make during the lesson.

Another example of an instance in which Ally framed her noticing in terms of her expectations of students occurred in the third interview. She documented this instance as important because an individual student did not respond to her questioning about long division of polynomials with the answer that she expected, which she interpreted as a lack of understanding.

Ally: So, maybe he identified that constant, but that wasn't, and I just swept over it because that wasn't what I was thinking in my head. I was looking for...ahhh!

Interviewer: Well, OK, so you were looking for what?

Ally: I was looking for the $0x^4$, $0x^3$ because [those terms] are not there. So, and then my, the way I was explaining that was not clear at all: "They don't exist but we need them to exist so they probably", it wasn't clear to them.

Interviewer: So what do you think was important about this [instance]? Do you think that it was the way you explained it or didn't explain it as well as you wanted, or was it [the student] not understanding?

Ally: I think it was important that I didn't really approach it, I approached it looking just for what was in my head, what I wanted the answer to be, instead of actually drawing out of him what his thoughts were, what his thinking was to approach the problem. So doing that doesn't help either of us, it's just putting an answer on the board. So it is not clearing anything up in his head, cause I am not addressing what he first said, just probably right where his thinking was going. I could have done that in a different way.

In this exchange, Ally again framed her noticing in terms of what she expected the student to say, and interpreted his comment though this frame, initially noticing only that his response did not align with her expectation. It is important to note, however, that there was evidence in this dialogue that Ally was beginning to realize how her expectations were limiting what she noticed as important during her instruction. In fact, at the end of this same interview, Ally discussed this limitation, saying, "I can predict, anticipate what they are going to say, but sometimes, they just, I didn't expect that so much. So then, I don't always have a high level or good question to ask them, so I don't actually focus on it." She later added, "I think my brain is going another way, and so I'm not, I'm like, OK, this is going to happen, they're going to not realize this, so I'm not thinking about handling or noticing [something else]."

Across the three observed lessons, Ally framed her noticing of important instances in her instruction through the lens of expectations of students in 7 of 12 documented instance (5 out of 7 in the first video, 1 of 2 in the second, 1 of 3 in the third). As seen in the dialogue above, this frame often caused her to dismiss the value of student ideas, rather than viewing them in terms of the important mathematics within them. In both of the above episodes, the students were not incorrect, but rather, were not thinking about the problem in the way Ally expected; her frame allowed her to only notice the inconsistency.

Discussion and Conclusion

The data in this study showed that both Adam and Ally had a strong focus on students in their in-the-moment noticing during instruction. In general, this is an encouraging finding; it indicates that the teacher education activities in which they had engaged may have been effective in moderating the tendency to focus on their own teaching actions, rather than on their students, which is often the case with novice teachers (e.g., Berliner, 2001). The cases of Adam and Ally also highlight, however, that developing an ability to notice and make sense of student thinking in teacher education coursework may provide a foundation for attending to students during instruction, but may not be enough. Although both Adam and Ally noticed students, their focus was not on making sense of student ideas in order to build on them during instruction. Instead, Adam focused on meeting students' general learning and affective needs, while Ally focused on whether students approached tasks or answered questions as she expected.

The data suggests that the frames through which Adam and Ally viewed their instruction strongly influenced what they noticed as important in their teaching. Because Adam framed his noticing in terms of his knowledge of students, he often only viewed instances as important when they gave him a sense of whether students' specific needs were or were not being met. For example, he noticed the importance of one student's thinking because the student often did not display good mathematical thinking and the instance was a chance to let him do so. In another case, however, he dismissed a student's unique approach because this student often approached problems differently than other students. Ally's frame of her expectations of students often constrained her noticing to student ideas, approaches or answers that did not align with what she wanted to hear. Although this type of noticing has the potential to be productive—if the teacher considers the mathematics behind the student thinking and how that thinking might be built on—Ally's frame caused her to instead interpret these instances as cases where students were not making desired "connections". Thus, Ally's focus in these instances was on how to correct the student's thinking, rather than how to productively use their ideas to develop a better understanding of the mathematics. These results closely align with Levin, Hammer and Coffey's (2009) findings about novice science teachers' noticing. In their work, they concluded that, "whether and how novice teachers attend to student thinking depends significantly on how they frame what is taking place" (p. 146). This was clearly the case for Adam and Ally.

This work suggests that helping novice teachers move beyond noticing students, to noticing the nuances of students' mathematical thinking, during instruction may require rethinking teacher education experiences. Although video cases have effectively developed noticing skills in the context of a particular course, this noticing might be connected to specific analysis frameworks or questions that are used to prompt such noticing. It is not guaranteed that teachers will adopt the same frames when not required to do so. Moreover, the context of a course provides the luxury of time to analyze and reflect on practice that is not available in the act of teaching. One potential solution is to scaffold prospective teacher noticing in coursework by first helping them learn to notice student thinking in a context that is "slowed down", gradually moving toward situations that more closely simulate in-the-moment noticing. It may also be essential to push prospective teachers to frame instructional instances in multiple ways to prevent them from adopting one particular lens. Yet another solution might be to provide different kinds of support and opportunities to engage in structured noticing activities during the student teaching experience; these could focus on both helping novice teachers continue to develop their noticing skills in a new context and pushing them to frame instances of practice in multiple ways. This would require either training classroom teachers to support novice teacher noticing or more substantial engagement between student teachers and university teacher educators. The outcomes of some of these efforts are being investigated in the author's ongoing work.
"[W]hat and how teachers teach depends on the knowledge, skills, and commitments they bring to their teaching and the opportunities they have to continue to learn in and from practice" (Feiman-Nemser, 2001, p. 1013). Given this understanding, the mathematics teacher education community must not only consider ways to develop essential knowledge, skills and dispositions in teacher education coursework, but to study the extent to which the results of this work are evident in teachers' practice—what is taken up, adapted, or dismissed. This study highlights the need to consider what types of ongoing support might be necessary to help prospective teachers build on what was learned in their coursework to notice what is important during instruction—

their students' mathematics. Providing such support has the potential to improve mathematics education by better enabling teachers to implement instruction that is responsive to student thinking even at the start of their teaching career.

Acknowledgements

This material is based upon work supported by the U.S. National Science Foundation under Grant No. 1052958. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Foundation. The author acknowledges Erin Thomas, Michigan Technological University, and Raymond Gant, Ferris State University, for their contributions to the work.

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