NCSM Journal

of Mathematics Education Leadership

FALL 2015 VOL. 16, NO. 2

National Council of Supervisors of Mathematics www.mathedleadership.org

Table of Contents

Framing Professional Conversations with Teachers: Developing Administrators' Professional Noticing of Students' Mathematical Thinking

Cory A. Bennett, *Idaho State University*
Julie M. Amador, *University of Idaho*
Christine Avila, *Idaho State Department of Education*

Abstract

In this paper we share the first phase of an on-going professional development project for administrators aimed at helping them facilitate non-evaluative professional conversations with mathematics teachers. School administrators have the ability to support teachers' instructional practice, however, administrators' ability to notice pivotal moments in students' mathematical thinking greatly influences the quality of support they can provide. Findings indicated that administrators were initially not specific about noticing students' mathematical thinking when observing lessons, but their ability to notice and plan for conversations about students' mathematical thinking developed over time.

Introduction

The Conference Board of the Mathematical Sciences' release of the *Mathematical Education of Teachers II* (CBMS, 2012) highlighted the complex interdisciplinary enterprise of mathematics teaching, demanding teachers have knowledge of instructional practices as well as mathematics content. The National Council of Teachers of Mathematics' (2014) *Principles to Actions: Ensuring Mathematical Success for All* further emphasized key teaching practices necessary to effectively support students' learning of mathematics as well as a call to action for administrators to help teachers create and sustain meaningful opportunities to learn mathematics. In essence, a primary focus of administrators and other school and district leaders is to create opportunities for teachers to understand and reflect on student-centered teaching and develop the pedagogical content knowledge necessary for effective instruction (Fernandez & Zilliox, 2011; Hill, Ball, & Schilling, 2008).

One way to support teachers' development in both content and pedagogy is by helping them focus on student-centered and evidence-based learning environments. This means closely examining the practices of teachers. From a teaching perspective, to engage in instruction that foregrounds student thinking, teachers need to be able to first *professionally notice* the thinking of students. Professional noticing, hereafter referred to as noticing, involves attending to, interpreting, and responding to students based on their thinking (Jacobs, Lamb, & Philipp, 2010). Two prominent researchers in the field of noticing, van Es and Sherin (2008), have used this construct to refer to the identification of what is important about a classroom situation, the ability to make connections between classroom interactions and principles of teaching and learning, and the ability to use what is known about the context to reason about classroom events. Such practices allow for more responsive teaching, teaching that deliberately connects pedagogical moves to specifics of students' understanding (Thomas et al., 2014). For the purposes of this paper, noticing will be understood to be the interconnected process of attending, interpreting, and responding to students based on specific evidence of their thinking and reasoning. Although previous research has focused on various aspects of teachers' noticing (e.g., Jacobs et al., 2010; Sherin, Jacobs, & Philipp, 2011; Star & Strickland, 2008; van Es & Sherin, 2002), very little has focused on the administrators' noticing of students' mathematical thinking as a means of supporting mathematics teachers' instructional practices.

In transforming learning across a school, the role, importance, and impact of the administrator as an instructional leader cannot be emphasized enough (Zepeda, 2013). However, in order for long-lasting and systematic change to occur in instructional practices across classrooms and schools, school administrators need to reorganize the setting and nature of instructional support provided (Cobb & Jackson, 2011). Clarke and Hollingsworth (2002) stated that professional growth, which includes improvements in instructional practices, occurs in a dynamic and interrelated process situated within a multi-faceted environment dealing with the teacher's personal beliefs, experimentation in their practice, and feedback or information from external sources. This means that administrators, acting as an external source, can situate feedback and initiate non-evaluative professional conversations to support teachers' instructional practices (Feiman-Nemser, 1996). Based on the construct of noticing, the nature of these conversations should be grounded in specific evidence of students' mathematical thinking and reasoning. Thus, the capacity and level of understanding needed to effectively notice is a critical component in providing focused instructional support.

Administrators often set school-wide priorities and provide support based on what they understand (Price, Ball, & Luks, 1995). Yet, many administrators do not fully understand the type of mathematical learning that should occur in classrooms (Buschman, 2004) or they may believe that, because they do not understand mathematics content well enough, they are less able to provide the focused instructional support required to ensure rigorous content standards are met. As a result, administrators often shift their focus to other content areas instead of providing content-based support or are not specific about the mathematics they observe (Nelson & Sassi, 2000). Such beliefs are further amplified in secondary schools wherein the mathematics courses offered include more advanced mathematics not well understood by administrators. Burch and Spillane (2003) found that administrators need to account for the role of mathematics content knowledge and teachers' epistemological beliefs about learning mathematics as they continue to lead school reform in mathematics. This further highlights the need to notice students' mathematical thinking as administrators work with their mathematics teachers to improve learning.

Although supporting teachers of mathematics from an instructional standpoint may seem challenging because administrators may lack content knowledge, the nature and focus of the support can begin by focusing on students' mathematical thinking. A tremendous body of research (e.g., Ball, 1995, 1998; Boaler & Staples, 2008; CBMS, 2012; Grossman, Schoenfeld, & Lee, 2005; Ma, 2010; National Research Council, 2001; Schifter, 2001) has indicated that teachers need to shift their understanding of teaching as an independent pursuit to an interactional social endeavor that helps students make sense of the mathematics under study. As such, the role of the administrator as an instructional leader also needs to shift to help teachers recognize their classrooms as sense-making environments (Burch & Spillane, 2003). This requires attending to, and appropriately interpreting, key mathematical moments during the class, which are fundamental elements of noticing.

As such, specific attention to help administrators understand the essence and nature of effective instruction is imperative to them providing the instructional guidance they are often expected to provide regardless of their school context (Hallinger & Murphy, 1985). That is, without focused support on understanding effective mathematics instruction, specifically designed for school administrators, school-wide efforts to improve the teaching and learning of mathematics will be left to the interpretation of individual or small groups of teachers and may lack a cohesive and concerted effort. Although it is unreasonable for instructional leaders to be experts in all content areas, it is reasonable to expect them to have professional conversations with teachers centered on specific evidence of student learning within the classroom. The effectiveness of these non-evaluative professional conversations is greatly dependent upon the specific evidence gained from noticing students' thinking, as evident in their conversations or work. In doing so, the professional practice of administrators can be further developed and strengthened to provide specific and focused support to their teachers to improve instruction (van Es & Sherin, 2008). Therefore, the researchers initiated a project to answer the following questions: How do administrators notice students' mathematical thinking when observing mathematics teaching and how does their noticing shift as a result of focused professional development on noticing?

Project Overview

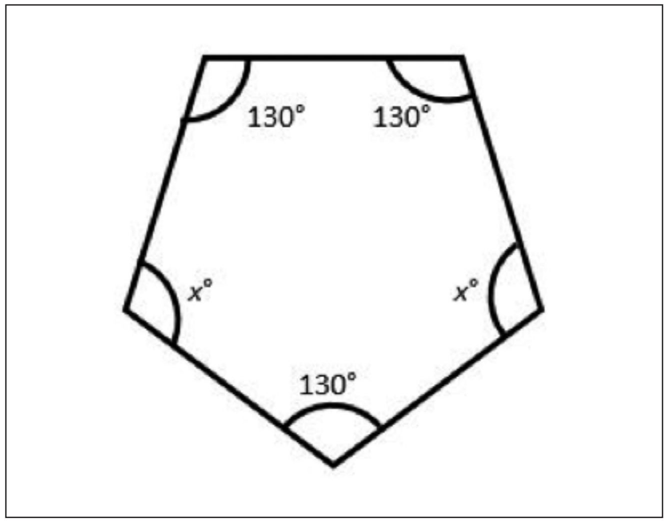
The purpose of this project was to understand and increase administrators' abilities to notice key mathematical moments of students' thinking and reasoning so they would be better able to support teachers (van Es, 2011). This qualitative study focused on K-12 administrators' attending, interpreting, and responding during a two-day professional development session. This context allowed researchers to better understand, and describe, nuances in participants' ability to notice.

Participants included 23 principals, assistant principals, and other district leaders such as superintendents and curriculum specialists, from elementary, middle, and high schools from one small, semi-rural school district. During this two-day professional development session, participants focused on learning the structures of noticing by studying and analyzing four videos of K-12 mathematics teaching from their own school district (Kisa & Stein, 2015). This paper focuses on one portion of the professional development session: a two-part project that was generated around one of those four videos that will be referred to as the *Case of Ms. Hemingway*.

Case of Ms. Hemingway

One module in the professional development session, the Case of Ms. Hemingway, was divided into two parts. Part One of the module was completed during the professional development session and Part Two of the module was completed independently after the conclusion of the workshop. Each part of the module featured video that was situated in Ms. Hemingway's ninth grade integrated mathematics classroom wherein students were to determine the missing angle measures shown in Figure 1. In this classroom, students were placed in heterogeneously mixed groups with three to five students per group. The videos for Part One and Part Two of the Case of Ms. Hemingway were based on this same geometry problem within the same class period but showcased different students presenting their conjectures, justifying their thinking, and responding to questions and comments posed by other students and the teacher.

FIGURE 1.
Missing angle problem.



Part One. For the first part of the module, all participants watched Part One of the video of Ms. Hemingway's lesson and then collaborated within a small group to identify three pieces of evidence of students' mathematical thinking. Participants then recorded this evidence on a poster along with interpretive comments and possible follow-up questions. This occurred prior to learning about the noticing framework (van Es, 2011). Essentially, Part One of the Case of Ms. Hemingway served as a pre-assessment of the participants' noticing.

Introducing the noticing framework. After the participants wrote about and discussed their initial noticing comments, the facilitator asked them to look at their notes and identify specific students and the mathematics in their notes. Some participants were able to recall some of the students' names, but none of the participants had written down, or could identify, the specific mathematics in the video, just general concepts such as, "they were working with triangles and a pentagon" or "students were trying to find a missing angle." They expressed difficulty with more advanced noticing as they were used to paying attention to other contextual classroom features.

The workshop facilitator then provided the participants with the van Es (2011) noticing framework, stressing that this framework was non-evaluative by design and should not be used for teacher evaluations. Participants were reminded again that the importance of their noticing was to be better able to facilitate a professional conversation, focused on the learning of the students, to support and help improve teachers' instructional practices. Next, using the framework, participants were asked to discuss and describe the notable differences between the various levels on the framework. Quickly, the participants recognized that their noticing had been focused more on Level 1 type actions. When framed within the context of using their notes to guide a professional conversation with teachers, participants recognized that the lack of specificity in what they noticed not only impacted how they interpreted the students' learning, but also failed to provide them with any concrete evidence of student learning. In essence, there would have been nothing of significance for the participant and the teacher to discuss that could have influenced future pedagogical moves for mathematics teaching beyond general environmental and behavioral issues.

Part Two. In the second part of the module, participants watched Part Two of the video of Ms. Hemingway's lesson independently. Then, participants answered questions about their noticing of student thinking, Ms. Hemingway's noticing of student thinking, and possible ideas for supporting Ms. Hemingway with her mathematics teaching. Part Two served as the post-assessment to understand the extent to which the professional development session influenced their ability to notice as a means of facilitating professional conversations with teachers around teaching.

Analyzing Responses

Data were collected from Part One and Part Two of the module. For Part One, all written records of what participants had noticed were collected, including individual records and group posters of what was noticed. For Part Two, responses analyzed included participants' individual typed responses based on their viewing of Ms. Hemingway's lesson. This included responses to six prompting questions (see Appendix A).

To analyze the data, the two researchers independently began with a preliminary exploratory analysis (Creswell, 2012) using the van Es (2011) *Framework for Learning to Notice Student Mathematical Thinking* (see Appendix B) to code responses. Examples of these codes included environment, focus on teacher, pedagogy, and interpretive, which are all descriptors within the framework. Next, the different levels of noticing (i.e., Leve1- Baseline, Level 2- Mixed, Level 3- Focused, and Level 4- Extended) were used as predetermined categories (McMillan & Schumacher, 2006) and participants were then assigned to one level of noticing based on the extent to which the codes from their documents aligned with the noticing categories. In instances when the researchers did not agree, they discussed all data points for a given participant and came to a consensus as to which category they belonged.

Findings

The following describes the participants' noticing of students' mathematical thinking. The findings from Part One of the Case of Ms. Hemingway are organized according to Jacobs et al. (2010) processes of attending, interpreting, and responding, though responding was not explicitly addressed. That is, only the initial stages of noticing were analyzed and thus reported. Following this, results from Part Two of the Case of Ms. Hemingway are presented as a contrast with the initial noticing.

Part One: Initial Group Noticing

Attending. The participants primarily focused on the teacher's actions or comments with little to no specific evidence of students' mathematical thinking (see Appendix C). That is, participants tended to notice what the teacher said and whom she called on. In addition, they referenced statements made by the teacher about the general learning context.

Although most small groups of participants indicated that students made an erroneous assumption, this statement came directly from a statement that the teacher made and not from their *own* noticing of student thinking. Other pieces of evidence identified by the participants included such comments as "Mike shows his work" and "students had different responses," but these were merely observations. Again, the nature of their noticing seemed to be on classroom moments that did not pertain to specific mathematical ideas. Other identified moments included statements such as, "[The teacher] paired both groups' strategies close together to 'drill down' to the misconception." In this comment, the participant did not attend to visible or audible evidence of students' mathematical thinking, but made inferences without citing specific student words or actions. Statements of this nature were interpretive, that is, participants imposed meaning on the teachers' actions, but the only real evidence would be that two strategies were presented one after the other. The purpose or intended outcome of sequencing these two strategies may have been to highlight the group's misconception but without more specific evidence from the video, or a conversation with the teacher, such a statement was marginally supported, at best.

Only one statement out of all statements submitted by the participants included any reference to mathematics: "Students knew the properties of triangles." Even so, this statement was ambiguous about the specific properties students used or how those properties were being applied to solve the problem. Despite being asked to identify and record three pieces of evidence of students' mathematical thinking, all participants' noticing aligned with Level 1 in the noticing framework (van Es, 2011). Specifically, the participants attended to the teachers' pedagogy and impressions of whole-class learning; they focused on — general impressions within the classroom and included evaluative comments with few details or specific evidence.

Interpreting. As with the participants' attention to evidence, their interpretive comments also lacked in-depth noticing (see Appendix C). This was due, in large part, to the fact that the evidence provided was unspecific and vague. For example, when discussing evidence of students' mathematical thinking, Group 1 stated, "[The teacher] acknowledged that there were four possible approaches" and then interpreted this to mean that students utilized "multiple strategies." However, simply acknowledging the fact that the teacher identified four different approaches in the students' work did not imply that the students understood the meaning or structure of the strategies used. Furthermore, both of these statements could be understood to mean the same thing, making both more general observations of student learning and not an internalization of the evidence and interpretation of what this specific incident might have implied about students' understanding of the mathematics.

Another small group, Group 4, also had an indistinct interpretation of students' thinking as they recorded the fact that the teacher "invited a group to show one solution" as evidence and then wrote that the "teacher knew what the students were thinking" as the interpretation of this evidence. Again, and partly due to the fact that the evidence was ill-defined, participants' interpretations lacked substance, especially if one were to use these notes as a means to facilitate a professional conversation with the teacher about student learning. In fact, all of the listed interpretive comments failed to adequately synthesize or illuminate the possible implications nuanced in students' thinking. As such, the noticing of these participants provided little to no foundation upon which they could provide any meaningful instructional support, guidance, or leadership for this teacher. The statements were lacking specificity with respect to attending to the relationship between particular students' mathematical thinking and between teaching strategies and student mathematical thinking because they were not articulating the students' mathematical thinking. This reduced their ability to then make connections between how the students were thinking and effective pedagogical strategies and thus appropriately frame a focused professional conversation around the teaching and learning of mathematics.

Reflective statements. Throughout much of the workshop, the participants expressed that the process of noticing was rather difficult for them. Many indicated that they had been trained to look for environmental evidence such as *I can* statements on the board and student work on the walls. They also looked for students' behaviors as quantified by the amount of non-academic talking occurring or raising of hands to speak, and other safety issues, such as ease of access between desks or the use of extension cords for multiple electrical items. All of these items matter and are worthy of attention but they are of little to no assistance in helping teachers improve their instruction or the mathematical learning experiences of students. The participants' struggles seemed to be in simultaneously paying attention to things that might be part of an evaluative teacher observation as well as noticing specific evidence of student thinking. One participant commented, "We know we are supposed to be the instructional leaders in our schools, but [we] have just not been trained to think this way."

Part Two: Individual Noticing

Attending and interpreting. Each participant had a final project to complete wherein they were asked to independently watch Part Two of the Case of Ms. Hemingway, record their noticing, and then develop questions they would ask the teacher to better understand the mathematical thinking of the students in the video. This was done outside of the time allocated for the professional development workshop. Baseline categories for each individual were based on their group codes from the Initial Group Noticing phase. Based on analysis using the van Es (2011) framework, of the 23 participants, 16 moved from a *Baseline* (Level 1) level to either a *Mixed* (Level 2) or a *Focused* (Level 3) level of noticing (eight moved to a *Mixed* and eight moved to a *Focused* level) with some comments extending into the *Extended* (Level 4) level of noticing. Seven participants remained at a *Baseline* level of noticing.

For those who moved from a *Baseline* to a *Mixed* or *Focused* level of noticing, the attending, or what they noticed, aspect of their noticing was much more detailed but often lacked sufficient specificity or centered primarily on evaluative an interpretive comments with few details. In the first *Mixed* example, the participant paid specific attention to angle measures but also made an evaluative comment about the student's (Emily) understanding that was not supported in specific evidence. Robert wrote,

> I noticed Emily split the trapezoid into two Isosceles triangles. Emily knew total angles equaled 540 and that the triangles needed to equal 360. That allowed her to determine the unknown angles. I think it suggests that [she] understood the process but I think she may still have confusion about the other team's process.

Another example of a response coded as Mixed, similarly noticed the student's mathematical thinking. This participant, Sue, wrote,

> They knew to break the trapezoid into parts (isosceles triangle and trapezoid, then trapezoid into triangles) to find angles that were usable. They seemed willing to take steps to problem solve, but [were] unaware of the impact one step had on the outcome of solving the problem. They seemed to understand that angles divided helped them solve, but weren't quite able to accomplish the larger task.

Again, the attention and reference to specific and noteworthy events about students' thinking, along with focused interpretive comments, provided a basis from which the participant could facilitate a professional conversation with this teacher. In this case, Sue grouped the students together and referred to them collectively, which was not as specific as the aforementioned example about Emily provided by Robert. However, Sue noticed key mathematical components of the thinking, such as the outcome of breaking a trapezoid into triangular regions but because it was unspecific to one student's thinking, it was coded as *Mixed*.

An example of a *Focused* noticing comment included specific details about a particular student along with more evaluative aspects. This participant, Mr. Kay, wrote,

> Emily split the figure into two trapezoids, it appears, but she didn't need to draw the extra line to create the triangle. In her mathematical thinking, she appears to have a misunderstanding of the theorem about isosceles trapezoids, and that she could use it (with the congruent angles) to determine the missing angles.

This example provided details about Emily's thinking that would be specific enough for the participant to generate a conversation with Ms. Hemingway about Emily's possible misconceptions. However, the evaluative nature of the comment still contains an evaluative aspect.

The greatest difference between the *Mixed* and *Focused* comments was in the nature of the interpretive comments. Those in the *Mixed* level were evaluative in nature, not based on specific evidence in *what* they noticed, or were still focused on the teachers' pedagogy. Whereas *Focused* comments were interpretive in nature, participants were making meaning about student learning based on the evidence and centered on specific and important mathematical comments or written work. For example, several interpretive comments included statements such as, "Nick used an unusual method but was able to explain his thinking," or "Nick has a unique outlook on this problem" wherein the choice of the word "unusual" and "unique" were evaluative in nature. Another participant commented that "[Emily] does not have a clear understanding that she could use the congruent angles of the isosceles trapezoids to solve, and not add the additional step of drawing the triangle." Although this statement might be an appropriate interpretive comment, there was no specific evidence in the participants' attending from which to make such a claim. It is as though he recognized there was evidence to make the statement, but without being able to refer back to this evidence, this interpretive statement would not be useful in facilitating a professional conversation; it lacked the substance necessary to initiate such a conversation.

There were also seven participants whose final project showed no growth in their ability to notice students' mathematical thinking. These participants' comments focused on broad and vaguely supported *Baseline* statements such as "all three [students] thought well mathematically," "the class demonstrated an understanding of an isosceles trapezoid," and "I noticed the students also had the critical thinking skills needed." Furthermore, their interpretive comments were inconsistent, general, and typically evaluative, which suggested they were still struggling with noticing specific evidence of students' mathematical thinking. Statements such as, "Emily's group struggled with applying specific concepts to this problem" and "the students have a fair understanding of geometric principles and can apply those principles to the material" again, provided little evidence or interpretation of students' mathematical thinking for the participants to facilitate a meaningful and focused professional conversation with the teacher. Some of the comments implied observed evidence, such as "I notice that they all have an understanding of the sum of interior angles," but it would be difficult to use such a comment as a reference when talking with the teacher about the students' understanding of the mathematics.

Implications and Next Steps

Although the majority of the participants improved in their ability to notice students' mathematical thinking and reasoning, there are two primary areas to highlight based on the findings from this project: 1) recognizing the nature of evidence needed in order to meaningfully facilitate a professional conversation with their teachers, and 2) the continued support needed for administrators to develop their noticing.

Necessary Evidence

The purpose of the professional development session was to understand and increase administrators' abilities to notice key mathematical moments of students' thinking and reasoning, so they would be better able to support teachers' instructional practices. In the Case of Ms. Hemingway, the intent was that an administrator could observe such a lesson, notice specific elements of students' mathematical thinking, and then meet with Ms. Hemingway and facilitate a conversation about students' thinking. Essentially, for the administrator to be able to develop noticing in teachers, he or she must have the necessary noticing skills and be able to interpret the complex interdisciplinary enterprise of mathematics teaching (CBMS, 2012). Since administrators often make instructional decisions based on their understandings, supporting them in noticing key elements in a mathematics classroom is essential for them to make decisions or encourage classroom-based and school-wide actions that reflect students' thinking (Price et al., 1995).

Findings from this study highlighted the importance of administrators recognizing the nature of evidence that is necessary for meaningfully supporting teachers and for engaging in professional conversations with teachers to transform schools (Zepeda, 2013). As seen in Part One of this project, the participants were not specific with their evidence and the noticing did not generate talking points that included student evidence. In contrast, as the participants engaged in Part Two of the project, they were able to begin to notice at more advanced levels. This suggested that the professional development session on noticing may have afforded opportunities for the development of noticing among the participants wherein they could reconsider the nature of their instructional support (Cobb & Jackson, 2011). These findings are promising because they indicate that noticing may be developed among administrators when they engage in activities that encourage and scaffold their development. In addition, these findings represented a shift from only evaluating teachers to also facilitating professional conversations about students' learning of mathematics.

The structure of the professional development session, based on a group setting and collaborative opportunities to discuss noticing, provided the participants with opportunities to work with others as their noticing was scaffolded (Clarke & Hollingsworth, 2002). In Part One, the participants were in groups and had the opportunity to share their ideas and observations with peers. In contrast, in Part Two the participants worked individually to notice students' mathematical thinking. There are possible explanations for their shift in noticing from Part One to Part Two.

One possible explanation for the shift in noticing is that the group structure of the setting for Part One provided the participants with opportunities to engage with others and hear varying perspectives. As the professional development progressed, the participants expressed their ideas with others and they were scaffolded with prompts and protocols to encourage their noticing. A second explanation about the shift in noticing relates to the timing of the introduction of the Learning to Notice Framework (van Es, 2011). During Part One, the participants were not aware of the framework and only gained awareness about the role of noticing and the framework after they had engaged in the initial activity. It is plausible that orientation with the framework, viewing classroom videos, and maintaining cognizance about the framework may have encouraged the participants to improve their level of specificity with regard to students' thinking in their noticing.

Another possible reason for the shift could be the scaffolding supports that continued during Part Two. Specifically, the participants all had their own individual copies of the Case of Ms. Hemingway and had specific prompting questions to answer after watching the video. Having a week to view, reflect on, and process Part Two of the video permitted them the opportunity to view the video repeatedly, which could have created an opportunity for continued recurring focus on students' thinking. If the participant did not fully understand how a student was thinking in the video initially, he or she could re-watch the video. With that said, researchers did not collect information on the number of times participants viewed the video in Part Two.

Although the video structure removed the authentic context of observing a teacher, these findings show further promise for the role of video in developing noticing (Star, Lynch, & Perova, 2011). By watching the video repeatedly during the workshop, the participants began to realize where they needed to focus their attention and they gained understanding about the mathematics content and what was important to notice (Price et al., 1995). Likewise, the questions the participants were required to answer in Part Two further encouraged noticing of students' mathematical thinking because the questions specifically prompted participants about exact students and their thinking. For example, question one stated, "What do you notice about Emily, Nathan, and Karrie's mathematical thinking?" To answer this question, the participants had to rely on specific notes and write explicitly about how Emily was thinking, how Nathan was thinking, and how Karrie was thinking. The questioning on this form forced the participants to be intentional about individual students, which further scaffolded their noticing and their specificity about mathematical content. The important concept from these findings is that with support, administrators can develop their ability to notice students' mathematical thinking and improve their competence with understanding the type of mathematical learning that occurs in classrooms (Buschman, 2004).

Continued Support

For administrators to fully realize their role as instructional leaders within schools, continued work on their ability to notice needs to occur. While many participants learned to more precisely notice students' mathematical thinking, one third did not shift in this ability. One reason for this, which the participants discussed during the workshop, was the reported lack of formal training they received in their administrative credentialing programs related to noticing. Participants frequently stated, "We have not been trained to do this, to notice." For these participants, creating a non-evaluative instructional support schema relating to their observations within classrooms seemed difficult to create as their noticing focused on environment, pedagogy, and evaluating the teaching. Realizing administrators' role of an instructional leader seems increasingly difficult to achieve if non-evaluative professional conversations cannot be meaningfully created. Again, the need for focused and on-going support in instructional leadership for administrators should be considered.

As evidenced with these findings, the professional development session resulted in an increased ability to notice for nearly two-thirds of the participants. However, as noted by a lack of research literature on administrators and noticing, little work is being done to specifically address the noticing needs of administrators. Therefore, we call for an increased emphasis on professional development support for administrators to learn and develop their abilities to notice. As evidenced by these data, Part One and Part Two provided necessary scaffolds to administrators to orient them to the process of noticing and the importance of noticing students' mathematical thinking. On-going professional development supports with included scaffolds, such as those used in this project, are necessary for growing and developing administrators' capacities to notice.

It should be noted that it is unclear how the change in participants' noticing skills might have been influenced by the pointed questions in the Part Two module. That is, the increase in noticing might have been a result of the lack of similar questions in part one or the lack of the option of reviewing the video in Part One. Furthermore, for this part of the project, the researchers did not follow the participants into an actual setting so it is unclear whether these skills would transfer into an authentic observational setting. A follow-up project is currently in its second year examining this aspect in further detail. Regardless, as — supported by Hallinger and Murphy (1985), administrators must be able to notice how students are reasoning mathematically if they are going to effectively facilitate professional conversations and support teachers in creating rich mathematical learning environments. ✪

References

Ball, D. L. (1995). Transforming pedagogy: Classrooms as mathematical communities. A response to Timothy Lensmire and John Pryor. *Harvard Educational Review, 65*, 670-677.

Ball, D. L. (1998). Unlearning to teach mathematics. *For the Learning of Mathematics, 8*(1), 40-48.

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of Railside School. *Teachers College Record, 110*, 608-645.

Burch, P., & Spillane, J. P. (2003). Elementary school leadership strategies and subject matter: Reforming mathematics and literacy instruction. *The Elementary School Journal, 103*, 519-535.

Buschman, L. (2004). Teaching problem solving in mathematics. *Teaching Children Mathematics, 10*, 302-309.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*, 947-967.

Cobb, P., & Jackson, K. (2011). Towards and empirically grounded theory of action for improving the quality of mathematics teaching at scale. *Mathematics Teacher Education and Development, 13*(1), 6-33.

Conference Board of the Mathematical Sciences. (2012). *The Mathematical Education of Teachers II*. Providence, RI and Washington DC: American Mathematical Society and Mathematical Association of America.

Creswell, J. W. (2012). *Educational Research* (5th ed.). Boston, MA: Pearson.

Feiman-Nemser, S. (1996). *Teacher mentoring: A critical review*. ERIC Digest. Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education.

Fernandez, M. L., & Zilliox, J. (2011). Investigating approaches to lesson study in prospective mathematics teacher education. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 85-102). New York, NY: Springer.

Grossman, P., Schoenfeld, A., & Lee, C. (2005). Teaching subject matter. In L. Darling-Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world* (pp. 201-231). San Francisco, CA: Jossey-Bass.

Hallinger, P., & Murphy, J. (1985). Assessing the instructional management behavior of principals. *The Elementary School Journal*, 217-247.

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., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education, 41*, 169-202.

Kisa, M. T., & Stein, M. K. (2015). Learning to see teaching in new ways a foundation for maintaining cognitive demand. *American Educational Research Journal, 52*(1), 105-136.

Ma, L. (2010). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States* (2nd ed.). New York, NY: Routledge.

McMillan, J. H., & Schumacher, S. (2006). *Research in education: Evidence-based inquiry* (6th ed.). Boston, MA: Pearson.

National Council of Teachers of Mathematics. (2014). *Principles to action: Ensuring mathematical success for all.* Reston, VA: Author.

National Research Council. (2001). *Adding it up: Helping children learn mathematics.* J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Nelson, B. S., & Sassi, A. (2000). Shifting approaches to supervision: The case of mathematics supervision. *Educational Administration Quarterly, 36*, 553-584.

Price, J. N., Ball, D. L., & Luks, S. (1995). *Marshalling resources for reform: District administrators and the case of mathematics.* East Lansing, MI: National Center for Research on Teacher Learning.

Schifter, D. (2001). Learning to see the invisible: What skills and knowledge are needed to engage with students' ideas? In T. Wood, B. S. Nelson, & J. Warfield (Eds.). *Beyond classical pedagogy: Teaching elementary school mathematics* (pp. 109-134). Mahwah, NJ: Erlbaum.

Sherin, M. G., Jacobs, V. & Philipp, R. (2011). Situating the study of teacher noticing. In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing* (pp. 3–14). New York, NY: Routledge.

Star, J. R., Lynch, K., & Perova, N. (2011). Using video to improve preservice mathematics teachers' abilities to attend to classroom features: A replication study. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing* (pp. 117-133). New York, NY: Routledge.

Star, J., & Strickland, S. (2008). Learning to observe: Using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education, 11*, 107–125.

Thomas, J. N., Eisenhardt, S., Fisher, M. H., Schack, E. O., Tassell, J., & Yoder, M. (2014). Professional noticing: Developing responsive mathematics teaching. *Teaching Children Mathematics, 21*, 294-3003.

van Es, E. A. (2011). A framework for learning to notice student thinking. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing* (pp. 134-151). New York, NY: Routledge.

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*, 571-596.

van Es, E., & Sherin, M. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education, 24*, 244-276.

Zepeda, S. J. (2013). *The principal as instructional leader: A handbook for supervisors* (2nd ed.). New York, NY: Routledge

APPENDIX A.

Part Two — Prompting Questions

ANALYSIS QUESTIONS

Your noticing of student thinking

1. What do you notice about Emily, Nathan, and Karrie's mathematical thinking?
RESPONSE:

2. What might this suggest about Emily, Nathan, and Karrie's understanding?
RESPONSE:

Teacher's noticing of student thinking

3. Describe the teacher's responsiveness to Emily, Nathan, and Karrie's mathematical thinking.
RESPONSE:

4. Describe the extent to which you feel the teacher has the same understandings of Emily, Nathan, and Karrie's mathematical thinking as you.
RESPONSE:

Your plan of support for the teacher

5. What questions would you ask this teacher to better understand their understanding of Emily, Nathan, and Karrie's mathematical thinking? What do you intend to learn from these questions?
RESPONSE:

6. How would you support this teacher in the future to make pedagogical decisions that support the development of all students' mathematical thinking?
RESPONSE:

APPENDIX B.

van Es (2011) Framework for Learning to Notice Student Mathematical Thinking

	Level 1 Baseline	**Level 2 Mixed**	**Level 3 Focused**	**Level 4 Extended**
What Teachers Notice	Attend to whole class environment, behavior, and learning and to teacher pedagogy	Primarily attend to teacher Pedagogy Begin to attend to particular students' mathematical thinking and behaviors	Attend to particular students' mathematical thinking	Attend to the relationship between particular students' mathematical thinking and between teaching strategies and student mathematical thinking
How Teachers Notice	Form general impressions of what occurred Provide descriptive and evaluative comments Provide little or no evidence to support analysis	Form general impressions and highlight noteworthy events Provide primarily evaluative with some interpretive comments Begin to refer to specific events and interactions as evidence	Highlight noteworthy events Provide interpretive comments Refer to specific events and interactions as evidence Elaborate on events and interactions	Highlight noteworthy events Provide interpretive comments Refer to specific events and interactions as evidence Elaborate on events and interactions Make connect ions between events and principles of teaching and learning On the basis of interpretations propose alternative pedagogical solutions

APPENDIX C.

Administrator Noticing of Part One Video

	Evidence	Interpretative Comments	Follow-up Questions
Group 1	Acknowledge that there were 4 possible approaches	Students utilize multiple strategies	
	"Mike's group figured it out in a way that a lot of students have figured out that we determined doesn't quite work"	Teacher allowed productive struggle	How did the students resolve the inaccuracies/misconceptions pre-sented by Mike's group?
	Mike's group did it this way but made a bit of an assumption	Students possess foundational knowledge that helps them problem solve and analyze	How did you know that all the students understood the learning goal?
Group 2	Multiple strategies for solv-ing-shared 1 with whole class	Value in showing exemplars	How do you know if students under-stand the difference between the methods and their usage?
	Noticed the assumption Mike's group made	Aware of math thinking of students	
	Mike shows his work	Value of process after product	Does Mike know why it didn't work?
Group 3	Noticed an erroneous assumption		
	Teacher pointed out/evaluated error	Teacher stated these things rather than allowing them to discover mis-takes on their time	How could you have facilitated the lesson rather than directing?
	Teacher corrected [students'] subtraction		
Group 4	Invited a group to show one solu-tion	Teacher knew what the students were thinking	How did the erroneous assumption impact the course of the lesson?
	All students worked together to develop a shared understanding	Allowed for informal assessment and higher engagement	
	Students knew the properties of triangles	Students could apply their knowl-edge	
Group 5	[Teacher] highlighted one groups logic of "assumptions"		How did involving Mike's group's solution build a deeper conceptual understanding?
	Paired both groups strategies close together to "drill down" to the misconception	Helps keep track of what you are doing	
Group 6	Students had different responses	Mike's group made some assump-tions	How will you help Mike's group learn the correct method?
	Both strategies were displayed with an explanation by students	Elaborate 4 ways to solve	