FRAMEWORKS FOR NOTICING IN MATHEMATICS EDUCATION RESEARCH

Dominique Banner
Boise State University
dominiquebanner@u.boisestate.edu

Eliciting student thinking and using what is learned of student understanding to inform instruction is critical to effective mathematics teaching. Professional noticing skills assist teachers in identifying, interpreting and responding appropriately to student thinking. Therefore, the development of professional noticing skills in teacher candidates has become a goal of some mathematics teacher education programs. For the purpose of determining whether instruction is assisting in the development of these skills, it is necessary to have a way to measure these skills. This paper is a brief review of how professional noticing has been operationalized in mathematics teacher education research. A search of the ERIC data bases resulted in 405 studies, 89 of which met the criteria for the review. The following results contain a representative subsample of the 89 studies due to space limitations.

Keywords: Teacher Educators, Teacher Education – Preservice, Teacher Education – Inservice/Professional Development, Research Methods

In recent years, there has been an increased focus on using evidence of student thinking to inform and support instruction. In fact, the 2014 National Council of Teachers of Mathematics (NCTM) publication "Principles to Action: Ensuring Mathematical Success for All," recommended "eliciting and using evidence of student thinking" as a mathematics teaching practices to support student learning (NCTM, 2014). As the focus of professional noticing, in general, is to recognize, interpret, and respond to student thinking, noticing aligns well with the aforementioned NCTM mathematics teaching practice. Therefore, the development of professional noticing skills in teachers support student thinking, learning and understanding.

Theoretical Framework

Within recent research, there are three commonly cited definitions of professional noticing. First, van Es and Sherin (2002) define noticing as consisting of "three components: identifying what is important in a teaching situation; making connections between specific events and broader principles of teaching and learning; and using what one knows about the context to reason about a situation". Second, Jacobs, Lamb and Philipp (2010) define noticing as consisting of "three interrelated skills: attending to children's strategies, interpreting children's understandings, and deciding how to respond on the basis of children's understandings". Finally, Mason (2002) describes the "discipline of noticing" as consisting of the following techniques: keeping and using a record; developing sensitivities; recognizing choices; preparing to notice at the right moment; and validating with others.

Professional noticing, or simply noticing, has been the focus of much research in the past two decades. Berliner (2001) found well developed noticing skills to be a feature of an expert teacher. Researchers have also stated, novice teachers do not naturally notice important events in a classroom (Jacobs et. al, 2010; van Es and Sherin, 2002; Star and Strickland, 2008). However, research had found noticing skills can be learned (Jacobs et. al, 2010; van Es and Sherin, 2002; Star and Strickland, 2008). There is also evidence to support the development of noticing skills has improved field experiences (Star and Strickland, 2008; Stockero, Rupnow, and Pascoe, 2017).

Structures (e.g. frameworks, scaffolds) can support teachers in the development of noticing skills. The purpose of this paper is to examine noticing frameworks used in mathematics education research to support and measure teacher noticing. The research questions which guided the analysis are: What

In: Sacristán, A.I., Cortés-Zavala, J.C. & Ruiz-Arias, P.M. (Eds.). (2020). *Mathematics Education Across Cultures: Proceedings of the 42nd Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, Mexico. Cinvestav / AMIUTEM / PME-NA. https:/doi.org/10.51272/pmena.42.2020

type of frameworks exist to measure professional noticing skills in mathematics teacher education research? How are these frameworks applied (e.g. for measurement, instruction, or both) in mathematics teacher education research?

Methods

I searched ERIC data bases using the search criterion of (notic* AND mathematics) OR ('professional vision' AND mathematics) yielding 405 results. Titles, keywords, and abstracts of the resulting articles were scanned and excluded using the following exclusion criteria (EC). EC 1: The focus of the article was not mathematics. EC 2: The article was not research concerning professional noticing. EC 3: The article was not published in a research journal. EC 4: The article was not regarding K-12 teacher education. EC 5: The article was not a research study. EC 6: The framework in the article was too specific (e.g. Fernandez et. al., 2011 framework for noticing a students' additive/multiplicative thinking in proportional reasoning). Although articles with a specific noticing purpose are important to developing noticing skills in specific instructional areas, these articles were excluded from this paper in the interest of space.

Results

After review, 89 articles were included for analysis. Thirty-two were excluded due to a focus other than mathematics, 224 of the remaining articles were not on professional noticing, 29 were excluded because the article was not published in a research journal, 6 were not K-12 education, 4 articles were not experimental studies, and 21 were excluded for having too specific a focus.

Many researchers use, or adapt, an existing framework to fit their research purposes, although some developed independent frameworks. Researchers used these frameworks in a variety of methods (e.g. to provide to candidates for instructions; to inform the creation of pre and post assessments; to create a coding scheme for qualitative data). Frameworks were used for either instruction, measurement, or both. If a researcher used a framework for both instruction and measurement, sometimes the same framework, occasionally different frameworks. Due to limited space, the following is an abbreviated representative sample of the 89 articles reviewed.

Frameworks

Leatham, Peterson, Stockero and Van Zoest (2015) describes the development of Mathematically Significant Pedagogical Opportunities to Build on Student Thinking (MOST) Framework. MOST is a linear framework developed through an iterative process in mathematics teacher education courses over a four-year period. The framework was developed to identify MOSTs in video captured lessons for analysis. Researchers found the framework to be applicable for instruction and measurement as well. The framework begins with Student Mathematical Thinking: can student mathematics be identified, if so, is there a mathematical point? The second part of the framework involves Mathematical Significance: is the mathematics appropriate, if so, is it central? The final part of the framework is Pedagogical Opportunity: opening, timing? (Leatham et. al., 2015; Stockero et. al., 2014; Stockero et. al., 2017). If the answer to each of the six questions is yes, the interaction is a MOST.

Star and Strickland (2008) developed the 5 Category Observation Framework to identify what teacher candidates noticed from watching a classroom lesson. Star and Strickland created a pre/post assessment consisting of questions related to items and actions in a video the teacher candidates watched. The pre/post assessment was designed to represent each of the five categories and question types evenly. The five categories of the framework include: classroom environment, classroom management, tasks, mathematical content, and communication. The researchers were able to show significant gains in all areas, with the exception of classroom management (which was higher on the pre assessment).

Santagata and colleagues (2007, 2010, 2016) developed and used the Lesson Analysis Framework (LAF). One version of the LAF consisted of three parts: goals/parts of the lesson, student learning, and teaching alternatives; another version of the LAF consisted of four parts: learning goals, analysis of student thinking, effects of teaching, and propose improvements in teaching (Santagata and Yeh, 2016). Researchers use the framework to guide teacher candidate analysis of video.

van Es (2011) introduced the Learning to Notice Framework. The framework consisted of two categories: what teachers notice and how teachers notice. Data in each of these categories are then assigned one of four levels: baseline, mixed, focused, and extended. Statements made concerning some overall aspect of the classroom aspects or interactions, and are evaluative in nature, represent baseline level statements. Mixed level statements are primarily focused on the teacher but begin to mention student thinking and start showing some interpretive qualities. Focused statements primarily concern specific instances of student thinking and began to predict student actions. Finally, the extended level statements began to make connections between teacher response and student thinking.

Sherin and van Es (2009) introduced the Professional Vision Coding Scheme based on their definition of professional vision. The coding scheme consisted of two components: selective attention and knowledge-based reasoning. Selective attention consisted of two dimensions of analysis: actor (student, teacher, other) and topic (management, climate, pedagogy, mathematical thinking). Knowledge-based Reasoning also has two dimensions of analysis: stance (describe, evaluate, interpret) and strategy (restate student ideas, investigate meaning of student idea, generalize and synthesize across student ideas).

Mitchell and Marin (2015) introduced the Structured Analysis Framework based on Mathematical Quality Instruction (MQI). A subset of MQI codes relevant to noticing were chosen to create the framework. Five areas of codes were chosen: lesson or segment structure; teacher mathematical error or imprecision, use of mathematics with students, cognitive demand of task, and student work with mathematics.

Applications of Noticing Frameworks

Noticing frameworks are applied within mathematics teacher education research in a variety of ways. Frameworks are applied in the areas of instruction, measurement, or both. In addition, researchers may use one existing framework for the purpose of instructions and another for measurement. The following are examples of each of these applications of noticing frameworks in mathematics teacher education research.

Instruction. Definitions of noticing (Mason, 2002; Jacobs et. al., 2010; van Es & Sherin, 2002) were the most common influence for instructional design. In fact, Fisher and colleagues (2019) provide an overview of their 3 meeting instructional model which shows alignment with the Jacobs and colleagues (2010) definition of noticing.

Measuring noticing. Jacobs and colleagues (2010) described three skills necessary for the "expertise" of professional noticing: attending to children's strategies, interpreting children's understanding, and responding on the basis of children's understanding. In their research, Jacobs and colleagues developed a coding structure for each of these skills: attending (1) evidence (0) lack of evidence; interpreting and responding (2) robust evidence (1) limited evidence (0) lack of evidence (Jacobs et. al., 2010). This coding structure was then used in their research to code writing prompts to compare the noticing skills of teachers at various levels in their careers (prospective teachers, initial participants, advancing participants and emerging teacher leaders). Many other researchers have adopted this method of measuring noticing skills in their own research (e.g. La Rochelle, Nickerson, and Lamb (2019); Fisher, Thomas, Schack and colleagues (2013, 2018, 2019)).

Another framework found often in mathematics teacher education research on noticing was the learning to notice framework (van Es, 2011). As previously described, the learning to notice framework consists of two categories, with four levels to each category. In the van Es, 2011 study, the researcher employed the framework to measure video club discussions, as a whole, and provide one level for each meeting. It was found the progression through the levels was not linear, especially in levels 2 and 3: meeting 3 was at level 2, meeting 4 was at level 3, meeting 5 was back at 2, meetings 6 and 7 were back at 3, and meeting 8 was back at 2 before jumping to level 4 in meetings 9 and 10. Amador and colleagues (2015, 2016, 2018) modified the learning to notice framework and used it extensively in their work.

Applying multiple frameworks. Amador, Carter and Hudson (2016) is an example applying multiple frameworks. Both Jacobs et. al. (2010) and van Es (2011) are applied in their noticing research. The learning to noticing framework was expanded to include a total of 9 levels: 2 sublevels for each level 1, 2, and 4; and 3 sublevels for level 3. In addition, researchers created a 9 level learning trajectory based on the Jacobs et. al. (2010) definition of noticing: 2 codes for attending, 5 codes for interpreting, and 2 codes for responding. This expansion of their coding scheme also shows influences of the Sherin and van Es (2009) professional vision framework.

Discussion

This paper reported on a small representative subset of the 89 results of a systematic review of the literature regarding operationalizing noticing. As can be seen from the results, the majority of the research on operationalizing professional noticing focuses on measuring noticing employing the Jacobs and colleagues (2010) definition or the van Es (2011) learning to notice framework. In addition, researchers are able to modify these frameworks to suit their research needs.

Of course, whenever a review of the literature is conducted, there are limitations. It is difficult to know, using the search criteria previously mentioned, whether all studies were identified. In addition, due to space limitations, it was not possible to include all studies. For example, in this review studies with specific foci were not included (e. g. curricular noticing).

The main purpose of the paper was to provide researchers and mathematics teacher educators with a summary of frameworks employed to inform instruction and the measurement of noticing. The goal was to assist in mathematics teacher researchers and educators who would like to begin research in professional noticing or developing an instructional unit on professional noticing with a list of common ways to operationalize noticing. Further research to summarize the theory which informed the development of these frameworks is still necessary.

Acknowledgments

The larger study referenced is supported by the National Science Foundation (Award No. 1726543).

References

Amador, J. (2016). Professional noticing practices of novice mathematics teacher educators. *International Journal of Science and Mathematics Education*, *14*(1), 217-241.

Amador, J. M., & Carter, I. S. (2018). Audible conversational affordances and constraints of verbalizing professional noticing during prospective teacher lesson study. *Journal of Mathematics Teacher Education*, *21*(1), 5-34.

Amador, J. M., Carter, I., & Hudson, R. A. (2016). Analyzing preservice mathematics teachers' professional noticing. *Action in Teacher Education*, *38*(4), 371-383.

Amador, J., & Weiland, I. (2015). What preservice teachers and knowledgeable others professionally notice during lesson study. *The Teacher Educator*, *50*(2), 109-126.

Amador, J., Weston, T., Estapa, A., Kosko, K., & De Araujo, Z. (2016). Animations as a transformational approximation of practice for preservice teachers to communicate professional noticing. *Journal of Technology and Teacher Education*, *24*(2), 127-151.

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International journal of educational research*, *35*(5), 463-482.

Ding, L., & Domínguez, H. (2016). Opportunities to notice: Chinese prospective teachers noticing students' ideas in a distance formula lesson. *Journal of Mathematics Teacher Education*, *19*(4), 325-347.

Estapa, A. T., Amador, J., Kosko, K. W., Weston, T., de Araujo, Z., & Aming-Attai, R. (2018). Preservice teachers' articulated noticing through pedagogies of practice. *Journal of Mathematics Teacher Education*, *21*(4), 387-415.

Fisher, M. H., Thomas, J., Jong, C., Schack, E. O., & Dueber, D. (2019). Comparing preservice teachers' professional noticing skills in elementary mathematics classrooms. *School Science and Mathematics*, *119*(3), 142-149.

Fisher, M. H., Thomas, J., Schack, E. O., Jong, C., & Tassell, J. (2018). Noticing numeracy now! Examining changes in preservice teachers' noticing, knowledge, and attitudes. *Mathematics Education Research Journal*, *30*(2), 209-232.

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for research in mathematics education*, 169-202.

LaRochelle, R., Nickerson, S. D., Lamb, L. C., Hawthorne, C., Philipp, R. A., & Ross, D. L. (2019). Secondary Practising Teachers' Professional Noticing of Students' Thinking about Pattern Generalisation. *Mathematics Teacher Education and Development*, *21*(1), 4-27.

Leatham, K. R., Peterson, B. E., Stockero, S. L., & Van Zoest, L. R. (2015). Conceptualizing mathematically significant pedagogical opportunities to build on student thinking. *Journal for Research in Mathematics Education*, *46*(1), 88-124.

Llinares, S., & Valls, J. (2010). Prospective primary mathematics teachers' learning from on-line discussions in a virtual video-based environment. *Journal of Mathematics Teacher Education*, *13*(2), 177-196.

Mitchell, R. N., & Marin, K. A. (2015). Examining the use of a structured analysis framework to support prospective teacher noticing. *Journal of Mathematics Teacher Education*, *18*(6), 551-575.

National Council of Teachers of Mathematics (NCTM). (2014). Principles to actions: Ensuring mathematical success for all.

Santagata, R., & Angelici, G. (2010). Studying the impact of the lesson analysis framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of teacher education*, *61*(4), 339-349.

Santagata, R., & Yeh, C. (2016). The role of perception, interpretation, and decision making in the development of beginning teachers' competence. *ZDM*, *48*(1-2), 153-165.

Santagata, R., Zannoni, C., & Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of mathematics teacher education*, *10*(2), 123-140.

Schack, E. O., Fisher, M. H., Thomas, J. N., Eisenhardt, S., Tassell, J., & Yoder, M. (2013). Prospective elementary school teachers' professional noticing of children's early numeracy. *Journal of Mathematics Teacher Education*, *16*(5), 379-397.

Sherin, M. G., & Van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of teacher education*, *60*(1), 20-37.

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice mathematics teachers' ability to notice. *Journal of mathematics teacher education*, *11*(2), 107-125.

Stockero, S. L., Rupnow, R. L., & Pascoe, A. E. (2017). Learning to notice important student mathematical thinking in complex classroom interactions. *Teaching and Teacher Education*, *63*, 384-395.

Taylan, R. D. (2017). Characterizing a highly accomplished teacher's noticing of third-grade students' mathematical thinking. *Journal of Mathematics Teacher Education*, *20*(3), 259-280.

van Es, E. A. (2011). A framework for learning to notice student thinking. In *Mathematics teacher noticing* (pp. 164-181). 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*(4), 571-596.