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INNOVATIVE RESEARCH APPROACHES TO MATHEMATICS TEACHER NOTICING

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In recent years, teacher noticing has gained prominence as a theoretical construct in mathematics education, highlighting the dynamic, situational aspects of teaching that underlie instructional decisions and actions. This research forum explores innovative research approaches to teacher noticing in mathematics education, focusing on four key areas: theoretical perspectives and conceptualizations of teacher noticing, methodological approaches to the study of teacher noticing, teachers' professional learning of noticing, and new research directions in teacher noticing.

BACKGROUND AND AIMS

In the last two decades, teacher noticing has gained considerable prominence in the education literature (König et al., 2022), especially regarding mathematics education (Dindyal et al., 2021). One reason for this is that it underpins teachers' decision-making, which relies on teachers paying attention to and interpreting instructional details (e.g., students' mathematical thinking, including critical thinking; equity and inclusion) to make informed decisions about how to proceed in their lessons. It is therefore not surprising that teacher noticing is increasingly recognized as a fundamental aspect of teachers' professional competence (Kaiser & König, 2019).

The education field today is shaped by various perspectives, which have diverse implications for how noticing is conceptualized and thus studied (Scheiner, 2021). The study of noticing poses considerable methodological challenges, especially since noticing is difficult to capture and make explicit (Kersting et al., 2016). However, technological advances offer new approaches for accessing and assessing teacher noticing and for developing noticing expertise (Kosko et al., 2022; Weyers et al., 2023). Video has been used extensively to support teachers in developing their noticing skills (Santagata et al., 2021), but alternative and emerging approaches may offer new and different ways of supporting teachers in learning to notice (Amador et al., 2021; Walkoe et al., 2020). Noticing skills are influenced by teachers' knowledge, beliefs, and practices, and are socially and culturally shaped in important ways.

In this research forum, these issues are discussed in detail, focusing on innovative approaches and their potential for development. The research forum is organized around four key areas: (1) theoretical perspectives and conceptualizations of teacher noticing, (2) methodological approaches to the study of teacher noticing,

2023. In M. Ayalon, B. Koichu, R. Leikin, L. Rubel & M. Tabach (Eds.). *Proceedings of the 46th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 103-133). PME 46.

(3) teacher professional learning of noticing, and (4) new research directions in the field. Each of these areas will be discussed by a group of senior and emerging scholars in mathematics education, followed by the discussants' commentary to further stimulate developments in the field.

ESTABLISHED AND EMERGING THEORETICAL PERSPECTIVES ON TEACHER NOTICING

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This paper offers an overview of the theoretical perspectives on and conceptualizations of teacher noticing—a critical and complex activity that is vital for effective teaching. We explore established and emerging cognitive–psychological, expertise-related, discipline-specific, sociocultural, and ecological-embodied perspectives, discussing each perspective in terms of how noticing is conceptualized within that perspective. The paper concludes by recommending a multiperspective approach that may better capture the intricate and nuanced nature of noticing.

INTRODUCTION

Teacher noticing is a complex phenomenon that has been explored from various theoretical perspectives, each of which emphasizes different aspects of this crucial activity for effective teaching. Some scholars regard teacher noticing as a set of interrelated mental processes, while others emphasize the differences between novice and expert teachers' processing of visual information in the classroom. Some researchers highlight discipline-specific practices or socioculturally organized forms of professional vision, with others viewing teacher noticing as an embodied form of exploration that involves interacting with the classroom environment. These diverse perspectives have prompted rich, ongoing discussion about the nature of teacher noticing, what it entails, and how it can be developed and studied. The present paper builds upon a recent literature review and uses a theoretical framework that incorporates an additional perspective on teacher noticing to examine how each perspective defines and conceptualizes this complex activity (König et al., 2022).

Although the following overview of theoretical perspectives is not all-encompassing, it endeavors to present a useful framework for understanding the distinctive characteristics of each perspective and how they enhance our understanding of teacher noticing. Through this exploration, we aim to elucidate the key similarities and differences among various approaches to teacher noticing.

A COGNITIVE–PSYCHOLOGICAL PERSPECTIVE

A cognitive–psychological perspective conceptualizes teacher noticing as a set of perceptual and cognitive processes that teachers use to observe and make sense of

noticeable incidents in the classroom. Scholars who have adopted this perspective have identified various such processes, often drawing on van Es and Sherin's (2002) initial conceptualization of noticing, which includes identifying noteworthy classroom situations, connecting specific classroom interactions to broader teaching and learning principles, and using contextual knowledge to rationalize classroom interactions.

Research that takes this perspective has used various conceptualizations of noticing to distinguish between the different processes that underpin teacher noticing of classroom events, their interpretations of those events, or, in some cases, the decisions that arise from what is attended to and interpreted (Jacobs et al., 2010; Kaiser et al., 2015; Sánchez-Matamoros et al., 2019; Star & Strickland, 2008). Despite these variations, a shared theme among these studies is an interest in how teachers "construct" what they see (Erickson, 2011), linking observed events to abstract categories and characterizing their observations in terms of familiar instructional episodes (Sherin et al., 2011). Many of these studies have been based on information processing models, seeking to uncover the cognitive processes involved in teacher noticing, as well as the knowledge required for teachers to make sense of classroom events (Scheiner, 2016; Sherin & Star, 2011).

AN EXPERTISE-RELATED PERSPECTIVE

An expertise-related perspective on teacher noticing focuses on novice–expert differences in perceiving, processing, and monitoring visual information within the classroom. The roots of this perspective can be traced back to early research by Berliner (1988) and Carter et al. (1988) on differences in experts' and novices' perceptions and understanding of classroom information. These studies were precursors to the more recent discourse on teacher noticing, although they did not explicitly use the noticing construct. This research highlighted that expert teachers possess a more extensive repository of classroom knowledge than novice teachers and that their information processing differs, enabling them to evaluate significant classroom incidents more effectively and establish meaningful connections with their knowledge and practical experience, which in turn allows them to act more adaptively.

Building on this foundation, recent research has focused on the cognitive processes and resources involved in expert teachers' noticing and has identified different noticing profiles among teachers with varying levels of experience (Bastian et al., 2022; Jacobs et al., 2023). In addition, recent conceptualizations, such as the cognitive theory of visual expertise posited by Gegenfurtner et al. (2023), have been employed to model the visual information processing of experts.

A DISCIPLINE-SPECIFIC PERSPECTIVE

Noticing from a discipline-specific perspective involves intentionally directing attention and sensitized awareness toward particular aspects of one's teaching practice. This can be achieved by systematically evaluating one's own teaching

practice, as described by Mason (2002), with the aim of increasing awareness of one's own actions, questioning habitual reactions in specific situations, and sensitizing oneself to future opportunities to act with intentionality rather than automatically out of habit.

Mason's (2002) construal of noticing outlines a set of practices for developing teachers' sensitivity and presence in the classroom based on having "a reason to act" and "a different act in mind" (p. 1). These practices include: (1) systematic reflection based on recording important moments and retrospectively identifying threads, (2) recognizing typical situations and formulating alternatives, (3) preparing and noticing by sensitizing oneself to possibilities for action and enhancing opportunities for noticing, and (4) seeking validation from others by describing moments and refining tasks to highlight important issues or sensitivities (Mason, 2002, p. 95).

The discipline of noticing involves the lived experiences of teachers and is phenomenological in nature (Mason, 2011, p. 231). These four practices bring "the moment of noticing from the retrospective into the spective, into the moment, so that a choice can be made to respond rather than to react habitually" (Mason, 2002, p. 87). By intentionally directing their attention and sensitized awareness, teachers become more methodical and intentional in their practices without becoming mechanical or reactive.

A SOCIOCULTURAL PERSPECTIVE

A sociocultural perspective on teacher noticing highlights that noticing is not solely a psychological process, but also a socially situated activity shaped by discursive practices and sociopolitical contexts. Goodwin (1994) argued that professionals, including teachers, develop "professional vision," meaning socially organized ways of seeing and understanding events that are specific to the teaching profession. Professional vision is shared and negotiated through historically constituted practices that enable professionals to construct "objects of knowledge" based on the phenomena that interest them.

Goodwin (1994) identified three practices involved in the formation and communication of professional vision: coding, highlighting, and producing material representations. Coding involves translating observed phenomena into relevant knowledge objects for a particular profession, highlighting makes specific phenomena more prominent by marking them in some way, while producing material representations involves creating external cognitive artifacts that organize and display relevant knowledge.

Professional vision is perspectival, positional, and ideological, with the authority to organize the field of vision unevenly distributed. Power relations are implicated in professional vision, as certain ways of seeing and understanding are privileged over others (Lefstein & Snell, 2011).

Recent studies on teacher noticing have highlighted the cultural, historical, and ideological contexts in which noticing occurs, as well as its relationship to broader discourses and systems (Dreher et al., 2021; Louie et al., 2021; Shah & Coles, 2020; van Es et al., 2022). However, Goodwin's original approach has been widely disregarded, or even, in some cases, lost (for a discussion, see Louie, 2018).

AN ECOLOGICAL–EMBODIED PERSPECTIVE

An ecological–embodied perspective on teacher noticing considers noticing to be an embodied activity of exploring and engaging with the classroom environment. This approach has been introduced quite recently, expanding upon more established perspectives on teacher noticing (Scheiner, 2021). According to this perspective, teachers gather information through continuous interaction with the material and social aspects of the classroom. This viewpoint is informed by Gibson's (1979) ecological approach to perception, which emphasizes the active role of the perceiver in perception and the fundamental reciprocity between a perceiver and the environment.

Gibson (1979) understood perception as a dynamic process because it involves active exploration of the world; it is "an experiencing of things rather than a having of experiences" (p. 239). Gibson (1979) argued that individuals modify their environment and alter its affordances to better suit their needs or intentions. Similarly, teachers shape the classroom environment to make specific events noticeable, establish particular interpretations, or bring certain events into being.

The ecological–embodied perspective on teacher noticing highlights the interdependence of perceiver and environment, the reciprocity of perception and action, and a form of direct perception. It posits that teachers are active participants in the instructional scene, not just passive observers.

Recent studies on teacher noticing have highlighted the embodied and ecological nature of noticing, providing insights into how teachers gather information by moving their eyes, heads, and bodies to interact with the classroom environment (Jazby, 2021; Kosko et al., 2021; Scheiner, 2021). For example, Scheiner (2021) characterized teacher noticing as "an embodied way of accessing, exploring, and engaging with the world of classroom events" (p. 88), emphasizing its dynamic and immersive nature.

CONCLUSION

Research on teacher noticing has drawn on various theoretical perspectives, including cognitive–psychological, expertise-related, discipline-specific, sociocultural, and ecological–embodied perspectives. Although the cognitive–psychological perspective is the most prevalent in the literature (König et al., 2022), it is crucial to appreciate the contributions of each perspective toward a more comprehensive understanding of how and why teachers notice what they do.

Each of the five perspectives offers a particular definition of noticing. The cognitive–psychological perspective views noticing as a set of mental processes

that individual teachers engage in when observing and making sense of classroom events. The expertise-related perspective explores noticing in terms of changes in visual information processing that lead to more adaptive classroom behavior as teachers gain expertise. The discipline-specific perspective sees noticing as deliberate and systematic attention to one's own teaching practices aimed at increasing sensitivity to future opportunities for intentional rather than automatic action. The sociocultural perspective regards noticing as a socially situated activity shaped by discursive practices and sociopolitical contexts. Finally, the ecological–embodied perspective considers noticing to be an active, embodied process of exploring and engaging with the classroom environment, emphasizing the reciprocity of perception and action.

It is important to recognize that these different perspectives are not mutually exclusive. Instead, they offer complementary lenses through which to examine the complex phenomenon of teacher noticing. For instance, the sociocultural perspective expands the cognitive–psychological perspective by acknowledging the sociocultural influences that shape individual psychological processes. Future research may investigate how the development of individual teacher noticing shapes, and is shaped by, the evolution of professional noticing among the community of practitioners to which they belong. This would deepen our understanding of the sociocultural influences that shape the psychological aspects of noticing, and vice versa.

Similarly, the ecological–embodied perspective can enrich cognitive–psychological and sociocultural perspectives. An ecological approach concentrates on how teachers encounter and act in their environments, revealing the automaticity with which they notice in meaningful ways. This approach necessitates examining not only what is inside teachers' minds but also what their minds are inside of. Noticing is not strictly internal or external but combines aspects of both, reflecting an ecological commitment.

As research on teacher noticing continues to evolve, researchers may study this phenomenon from various theoretical perspectives to develop a comprehensive understanding of the phenomenon. Adopting multiperspective approaches may allow researchers to posit multidimensional explanations of noticing that account for its sensual, positional, relational, and political nature.

METHODOLOGICAL APPROACHES TO THE STUDY OF TEACHER NOTICING

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In this paper, we discuss different methodological approaches to the study of teacher noticing, review established approaches focused on written and spoken noticing, and examine knowledge-based constructs. Additionally, we present new methodological advances, including the use of 360-degree videos and other extended reality technologies. We discuss the challenges and innovations for each approach, emphasizing the need to connect novel methods to established theory for a cohesive understanding of teacher noticing.

OVERVIEW

Noticing is a complex and multifaceted construct that involves differentiating between the incoming visual-auditory input from the classroom environment that is attended to and that which is not. Efforts to examine this complex phenomenon, as well as the factors associated with it, have been predominately qualitative, but quantitative and mixed-methods approaches have become more prevalent in recent years (König et al., 2022). Methodological approaches include the form of data collected and the theoretical aims of examining it. Herein, we discuss different methodological approaches to the study of teacher noticing, focusing on established approaches to examining written and spoken noticing as well as more recent approaches, such as those for examining knowledge-based constructs and incorporating extended reality technologies.

METHODS FOR EXAMINING WRITTEN AND SPOKEN NOTICING

The written or spoken expressions of teacher noticing are commonly examined in an attempt to deal with the complexity the internal and implicit processes underpinning it. Researchers have used diverse data collection and analysis methods in line with their theoretical perspectives and preferred interventions, each with its own merits and limitations in achieving the researchers' goals (Nickerson et al., 2017; Santagata et al., 2021). A common approach to investigating noticing is to provide teachers with a particular artifact (e.g., a written classroom episode, a lesson video, etc.) as a specific context to notice. Using a shared artifact allows for comparisons between teachers. Usually, the activity is accompanied by guiding prompts, either open/general or specific, to which the teachers are asked to respond in writing or orally (individually or as a group) according to the given prompts. Generally, open-ended questions are used to obtain rich responses, but closed online questionnaires facilitate larger-scale data collection. Another method invites teachers to reflect, either in writing or through recorded interviews, on events they have noticed during their own teaching. Although such an approach makes comparison difficult, it more closely simulates teacher noticing in the classroom.

Data collection may be conducted at a single point in time, usually with the aim of exploring teachers' observations in a certain setting. Alternatively, it can be conducted at two or even more different time points to identify changes (or developments) in teacher noticing, such as those fostered by participation in a professional development course.

Along with diverse data collection methods, there are diverse methods of data analysis. Some researchers "openly" search for what the teachers notice in an event. For example, van Es and Sherin (2008) examined what teachers noticed in video segments of lessons in terms of the participants and the content (e.g., mathematics, pedagogy, etc.). Rotem and Ayalon (2022) extended the existing lenses to capture additional (emotional and social) dimensions of an instructional event, as expressed in teacher noticing. Other researchers sought to examine teachers' noticing of a particular aspect of teaching and learning, such as students' mathematical thinking (Jacobs et al., 2010), or a specific mathematical practice, such as argumentation (Ayalon & Hershkowitz, 2017). The analyses in such cases are sometimes based on certain criteria, according to what the researchers would like the teachers to notice in the event. Along with *what* the teachers notice in the event, researchers often also assess *how* they notice, usually using a rubric to help them evaluate the quality of the written or spoken expressions of noticing, such as the extent to which it is evidence based and the level of specificity.

Investigating teachers' written and spoken noticing can be challenging. One of the challenges is that we can only form an approximation of noticing as reflected in the teacher's writing and/or oral communication. Another challenge relates to the generalizability of noticing measurements in a given context. Yet another challenge lies in measuring what the teachers *do not* notice, in addition to what they do notice. Researchers are trying to cope with these challenges by developing innovative methods that will allow them to better understand teacher noticing skills and design interventions for developing these skills.

METHODS FOR EXAMINING KNOWLEDGE-BASED ASPECTS OF NOTICING

Teachers rely on several resources to facilitate their professional noticing, one of which is teacher knowledge, and approaches that examine the knowledge-based aspects of teacher noticing are becoming more prevalent (König et al., 2022). Some scholars have examined the interactions between professional knowledge and teacher noticing based on quantitative approaches (Jong et al., 2021; Yang et al., 2021), but others have incorporated qualitative (Dick, 2017; Kooloos et al., 2021) and various additional approaches that can best be described as "novel" (Cross-Francis et al., 2022; Kersting et al., 2021).

Quantitative approaches typically incorporate formal measures of mathematical knowledge for teaching and employ quantitative indicators of noticing. For example, Yang et al. (2021) used open- and closed-response items to assess 203 Chinese teachers' content and pedagogical content knowledge (PCK), and they

quantitatively scored teachers' written descriptions based on video vignettes to conduct correlational and path analyses. A similar approach was incorporated by others (Jong et al., 2021; König et al., 2014) using data collected through open and closed questions to assess teachers' professional knowledge and specific coding schemes to evaluate their written responses to brief video clips. Qualitative approaches to examining knowledge-based aspects of noticing allow for more detailed analyses of how professional knowledge interacts with and facilitates components of teacher noticing. A common approach involves examining teachers' discourse patterns as they attend to and interpret students' mathematical thinking from either written work or video (Dick, 2007; Kooloos et al., 2022). These approaches provide detailed analyses of how teachers' knowledge is operationalized to notice students' thinking at the expense of smaller details.

Over the past decade, various scholars have attempted to move beyond these established methods to capture additional aspects of teacher noticing. For example, Kersting et al. (2021) examined moment-to-moment noticing, which they "conceptualized as a noticing task that was filtered through teachers' knowledge of their own practice" (p. 110). Analysis of this moment-by-moment noticing of video clips indicated more nuanced aspects than did holistic ratings by teachers of the videos alone. Cross-Francis et al. (2022) examined teachers' stimulated recall based on their own recorded teaching and found that their emotions about and beliefs toward mathematics significantly affected how they operationalized their professional knowledge in the noticing of their own instruction. A third approach was developed by Jacobs and Kruschke (2011), who used Bayesian networks to examine coded elements of teacher knowledge and noticing extracted from written and verbal responses.

METHODS FOR EXAMINING EMBODIED ASPECTS OF NOTICING

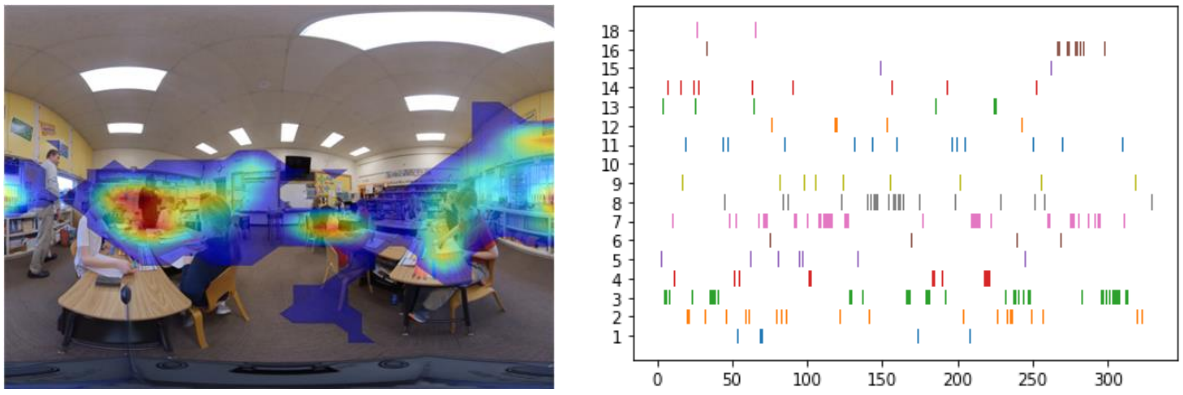
Teacher noticing has been described as teachers making sense of the "blooming, buzzing confusion of sensory data" (Sherin & Star, 2011, p. 69) in the classroom. Teachers perceive much of this sensory information, but noticing involves "selecting stimuli perceived in a scene (Scheiner, 2016, p. 231) and disregarding other aspects perceived in a pedagogical environment (van Es & Sherin, 2021). Because established methodologies for analyzing teacher noticing do not examine physiological factors, many scholars have started incorporating novel technologies to study embodied aspects of teacher noticing, including measurements of physiological data, such as eye and head movement tracking (Huang et al., 2021), and creating immersive contexts for exploring teachers' enacted noticing through virtual reality and 360 video (Kosko et al., 2021; Weston & Amador, 2021).

Methodologies incorporating eye and head tracking make use of the visuospatial system described by Gibson (1966). Most research using eye tracking to study noticing has focused on differences between preservice and in-service teachers, observing that experienced teachers' gaze durations are shorter than those of novice teachers (Huang et al., 2021), but they look at more students in the

classroom and for similar amounts of time (van den Bogert et al., 2014). For example, Huang et al. (2021) found that preservice teachers tended to focus on the students closest to them, and in-service teachers looked at students who were both proximally closer and further away. Extending these findings, Kosko et al. (2023) examined total gaze time and found that preservice teachers with higher assessed PCK gazed for longer at students farther away, while those with lower PCK gazed for shorter periods.

Similar to eye-tracking approaches, scholars have used 360 videos to examine where teachers look (Kosko et al., 2021; Weston & Amador, 2021). Because 360-degree video provides a panoramic recording of the classroom, the viewer must move the camera perspective to focus on certain areas of the classroom. This technological affordance has been used to collect both qualitative and quantitative data on where teachers look. For example, Weston and Amador (2021) had preservice teachers record their mathematics teaching and watch 360 videos with the researcher across multiple teaching sessions. One teacher was initially self-focused, but then turned and looked at what students were doing during the lesson. Similarly, other scholars have examined teachers' fields of view and found that an increased focus on students rather than the classroom teacher coincided with more descriptions of what the mathematics students were learning (Kosko et al., 2022). Such trends can also be examined quantitatively. For example, Gandolfi et al. (2022) prepared count data for the regions of the classroom on which teachers focused in a 360 video. The count data were used to measure unalikeability—a nonparametric indicator of variance for nominal data—which was then employed in a regression model for statistical analysis. Kosko et al. (2023) used a combination of eye-tracking and field-of-view data to record teacher noticing in a 360-degree video (see Figure 1). The total gaze time per student group was then correlated with the participants' PCK scores.

Figure 1. Eye-tracking data from a 360 video presented by Kosko et al. (2023)



The various approaches described here for examining embodied aspects of noticing focus predominantly on the visuospatial system and include both qualitative and quantitative aspects. However, other physiological data can be and has been examined, including auditory (Ferdig et al., in press) and cardiovascular (Huang et al., 2022) data. Common to these approaches is the aim of examining not only the

embodied factors involved in noticing, but also how they correspond with traditionally analyzed data on noticing (i.e., written/spoken data and knowledge-based factors).

CONCLUSION

Our review of methods for examining teacher noticing provides a snapshot of both established and emerging approaches. Some approaches, such as those examining knowledge-based aspects of noticing, have been emerging for some time but continue to attract innovation. Others, such as those focused on the embodied aspects of noticing, are more nascent. In each case, these emerging methods are often used in conjunction with or extended from established approaches to examining written and spoken noticing. Such connections are advantageous for scholars seeking to combine novel and established methods. However, a further advantage is theoretical since each of these approaches relies on different resources that teachers may draw on in the act of noticing (cognitive, embodied, etc.). As noted by Scheiner (2021), these resources are connected, and scholarship that highlights these connections in both theoretical and methodological frameworks may enable researchers to gain a more cohesive understanding of the overarching nature of teacher noticing.

EXPLORING REPRESENTATIONS AND THEIR AFFORDANCES FOR SUPPORTING TEACHERS' LEARNING TO NOTICE

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This paper explores different representations of practice and tools and their affordances in supporting teachers' learning to notice. The paper is divided into three main sections, focusing on vignettes, simulations, and video annotation tools. We discuss the affordances and constraints of these representations and tools and how they can be effectively leveraged to support teachers' learning experiences.

INTRODUCTION

Teacher noticing has been the focus of much work in mathematics education. This previous research has considered noticing processes (attending, interpreting, and deciding how to respond), as well as how these processes can be developed in teacher education programs.

A variety of representations of practice have been used to support the development of teacher noticing and have taken different forms, such as cartoons, videos, depictions, and written case studies (Chazan et al., 2018; Fernández et al., 2018; Ivars et al., 2020). Professional development (PD) experiences that employ these various representations have been investigated, designed, and deployed to support teacher noticing. To this end, tools (including annotation software) have been

combined with representations to enhance teacher learning. For instance, video tagging and annotation tools have allowed teacher educators and researchers to explore the development of teacher noticing over time (Walkoe & Levin, 2018; Walkoe et al., 2020).

In the following, we discuss ways of using various representations and tools to support teacher noticing. In particular, affordances (and limitations) of various representations and platforms and how they can be leveraged to support teacher learning experiences are addressed.

VIGNETTES TO SUPPORT PRESERVICE TEACHERS' NOTICING OF STUDENTS' MATHEMATICAL THINKING

Noticing students' mathematical thinking involves knowledge-based reasoning processes, since preservice teachers must use their knowledge (about mathematics and the teaching and learning of mathematics) to attend to, interpret, and decide. In previous work, we explored the characteristics of learning environments in teacher training programs that can help preservice teachers develop this competence (Fernández et al., 2018; Ivars et al., 2020). The results showed that vignettes of learning environments are potential tools for developing preservice teachers' noticing of students' mathematical thinking. A vignette provides a representation of practice, some questions to guide the analysis of the representation, and an explanation of the theoretical knowledge required to interpret the representation (Ivars et al., 2020).

Representations of practice provide preservice teachers with real contexts and opportunities to relate theoretical ideas to the practice of mathematics teaching. They are understood as depictions of classroom situations (e.g., depicting different students' responses to an activity or illustrating teacher–student interactions when engaged in activities). Guiding questions (prompts) are used to focus preservice teachers' attention on noticing the specific mathematical details of students' answers (selective attention), interpreting students' mathematical thinking based on the identified details, and deciding on a learning objective and activity to help students develop their understanding. Theoretical research on mathematics education related to students' mathematical thinking (acting as a theoretical lens; Fernández & Choy, 2020) provides the required knowledge to attend to, interpret, and decide. In some learning environments, this information follows a learning trajectory. The use of these theoretical lenses is justified since previous research has shown that preservice teachers can learn to attend to important details of students' thinking but may have difficulties in using these details to interpret students' thinking or make specific decisions (Fernández & Choy, 2020). Therefore, the development of teacher noticing in teacher education programs is challenging without a guide to direct teachers' attention to important aspects of the students' answers, provide them with the required knowledge to interpret student's mathematical thinking (such as different levels of students' mathematical understanding, students' difficulties, etc.), and provide them with information to

define specific learning goals and activities to help students advance their understanding of, for example, task variables, levels of difficulties in the activities, and the importance of different activities.

Previous research considered the development of preservice primary and secondary school teachers' noticing of students' thinking in different mathematical domains using learning environment vignettes. In this paper, the characteristics of such learning environments and vignettes that can support preservice teachers' development of noticing students' mathematical thinking are discussed.

REPRESENTATIONS OF PRACTICE: AFFORDANCES AND CONSTRAINTS

For at least the past two decades, video-based technologies have been the predominant technologies used to represent teaching practices and to support teacher noticing in mathematics (Santagata et al., 2021). More recently, researchers have begun using other types of multimedia technologies to represent practices (e.g., animations or lesson sketches) and develop noticing competence (Herbst et al., 2011). However, few researchers have focused specifically on the affordances of different representations of practice for supporting teacher noticing. Affordances refer to specific functions that can be activated based on the properties of a representation (Hatch & Grossman, 2008). The few studies that have examined the affordances of representations have largely focused on video-based representations (Dindyal et al., 2021), and far fewer have focused on the nature of representations in relation to teacher noticing outcomes (Superfine & Bragelman, 2018).

The effectiveness of learning from representations of teaching depends on the affordances of the representations themselves and the settings in which they are analyzed. Representations of practice vary in the granularity of the teaching and learning interactions they make visible. Moreover, learners (e.g., teachers) not only need to analyze teaching and learning in ways that are appropriate for their experience levels but also need to observe what is present—or not present—in the representations (e.g., details that might be obscured; Hatch & Grossman, 2008). Moreover, representations of practice should capture the realities and complexities of teaching and learning interactions. How can accessible and authentic representations of practice be provided to learners?

In our research, we explored the role of different representations of practice in supporting preservice teacher noticing. We borrowed the concept of the "decomposition of practice" from Grossman et al. (2009) and applied it to our work on noticing to decompose noticing practices into their constituent components. To decompose practices and enable novices to "see," how can we leverage the affordances of different representations of practice to support preservice teachers' noticing of students' mathematical thinking in accessible and authentic ways? No single representation can accomplish such goals. Instead, we need a repertoire of different representations of practice with different affordances that can be used to

decompose the practice of noticing. Different representations make students' thinking more or less visible; in other words, they vary in opacity. In our research, we focused on three main categories or types of representations of practice: static representations that capture the "end products" of students' thinking (e.g., student work samples), dynamic representations that illustrate students' thinking processes (e.g., video clips or audio recordings of problem-solving think-aloud sessions), and malleable representations that allow for intentional interactions with a "student" to probe and influence the elicitation of students' thinking in real time (e.g., for teaching simulations, see Shaughnessy & Boerst, 2018). In this paper, we discuss the unique affordances of each category of representations for supporting preservice teacher noticing.

USING VIDEO ANNOTATION TOOLS TO SUPPORT NOTICING IN VIDEO CLUBS

Video clubs are effective professional development interventions to support noticing (Sherin & van Es, 2009). In prior video club work, teachers watched a short classroom video clip together, and a facilitator then led a discussion about the students' thinking they noticed in the video (Sherin & Han, 2004; van Es & Sherin, 2008). A transcript was provided to support the teachers' analysis of the video, and they were allowed to take notes while viewing that they could refer to during the subsequent discussion. In the discussion, the participants primarily relied on their memory of the video and any notes they took as they discussed student's observed thinking.

A few issues arose from this approach. First, as the teachers watched the video, their attention was split between the video and the transcript. When teachers looked at the transcript, they often missed important nonverbal clues to students' thinking in the video. Second, since the participants watched the video synchronously, they could not pause the video or rewind it without the facilitator's intervention, and interesting nonverbal cues could easily be overlooked or forgotten. Given the significance of the nonverbal aspects of students' thinking in cognition (Goldin-Meadow, 2003), we consider it important to provide more support for multimodal teacher noticing in video club PD (Walkoe et al., 2023).

In a current project, in which we are using a video annotation platform (www.anotemos.com) (Herbst et al., 2019) to support multimodal teacher noticing (Walkoe et al., 2023). The platform allows teachers to view and annotate an embedded video clip prior to a video club discussion. We are investigating two types of annotation: (1) a "pin" feature that allows users to mark and comment on a moment of interest, indicated by a pin icon in the video progress bar located at the bottom of the video, and (2) a "draw" feature that allows users to pause the video and draw on the screen. Such annotations are saved in the video and visible for a few seconds before and after the drawing is completed. Both the "pin" and "draw" features allow users to add comments.

Some affordances ask teachers to watch and annotate a clip, unlike previous methods whereby teachers watched a video together and it was only paused or rewound at someone's request. The Anotemos tool gives teachers the ability to watch a video on their computers and pause or replay the video if desired. Another major benefit of watching and annotating video clips is that teachers' full attention is on the clips rather than split between the video and a transcript. We found that teachers are able to pay more attention to nonverbal aspects of students' thinking and discuss them more deeply in video clubs when they use the video annotation tool. This is important because our work indicates that when teachers attend to nonverbal aspects of students' thinking, they also rationalize the students' thinking in more substantive ways using a more resource-based lens (Walkoe et al., 2023).

In addition to allowing teachers to pay attention to nonverbal cues, we have also found ways to use the annotation tool itself to prompt teachers to attend to nonverbal aspects of students' thinking. We found that when teachers used the draw tool to highlight moments they noticed, they only attended to students' nonverbal cues, which contrasted with their behavior when they used "pins" to tag examples of students' thinking when they only attended to verbally expressed ideas. We continue to explore this promising support for video clubs.

DISCUSSION

Central to all three sections is a focus on the role of different tools and representations of practice in supporting teachers' noticing of students' mathematical thinking. Each tool or representation has particular affordances for supporting teacher noticing. For example, a video annotation tool affords opportunities to attend to both students' verbal mathematical thinking and nonverbal mathematical thinking (e.g., gestures and drawings). Using the annotation tool, teachers can interpret students' thinking in substantive ways grounded in evidence. Vignettes, on the other hand, leverage focal questions and information about students' thinking depicted in representations to support teachers in attending to and interpreting student thinking, but also afford opportunities to decide subsequent learning objectives and activities for students based on the mathematical thinking represented. Moreover, representations of practice, such as simulations, afford opportunities for teachers to interpret students' mathematical thinking and to elicit and potentially influence students' thinking by virtue of the questions they pose. Indeed, different tools and representations, and the contexts in which they are used, can be leveraged to support the development of effective noticing processes.

Additionally, the current work raises several issues regarding the use of different tools and representations to support teacher noticing. Although many tools and representations of practice have unique affordances for supporting teacher noticing, they also have some limitations. The affordances of particular tools or representations may not be aligned with the needs of novice learners (i.e., preservice teachers) who have limited knowledge about teaching and learning

interactions. Moreover, the use of different tools and representations requires facilitators/teacher educators to leverage the unique affordances of each tool or representation.

NEW DIRECTIONS IN RESEARCH ON TEACHER NOTICING

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In this paper, we explore new directions in research on teacher noticing, focusing on three aspects: inclusive mathematics education, the relationship between beliefs and teacher noticing, and sociocultural influences on teacher noticing. We highlight the importance of teacher noticing in facilitating inclusive education and student-centered teaching. We also emphasize the relationship between teachers' beliefs and their noticing skills, showing that constructivist beliefs about teaching and learning mathematics positively impact teachers' noticing abilities. Furthermore, we present findings from cross-cultural comparative studies, demonstrating that cultural characteristics influence what teachers notice and how they interpret what they do and make decisions in the classroom.

INTRODUCTION

Over the past decade, teacher noticing has attracted considerable attention from researchers around the world. Recent studies have focused on understanding the underlying principles of and new directions for noticing research, including empirical studies in the field of inclusive education. Furthermore, efforts have been made to investigate the relationship between teacher noticing and teacher beliefs, or the dimensionality of cognitive and situated aspects of teachers' professional competence. Moreover, researchers discuss the cultural characteristics of teacher noticing (Louie, 2018) and investigate its strengths and weaknesses by comparing teacher noticing in different contexts (Yang et al., 2021). In this paper, we explore new directions in research on teacher noticing, focusing on three aspects: inclusive mathematics education, the relationship between beliefs and teacher noticing, and sociocultural influences on teacher noticing.

TEACHER NOTICING IN INCLUSIVE MATHEMATICS EDUCATION

In recent years, inclusive education has been identified as a key challenge for education by policymakers and organizations worldwide (OECD, 2019). It is considered to meet the needs of all students and to take a broader perspective on dealing with heterogeneity. Heterogeneous classes, diverse learners in diverse situations, and the wide variety of subject matter pose specific challenges for teachers, particularly for their diagnostic or formative assessment competencies, their intervention skills, and, thus, their teacher noticing (König et al., 2017; Vantieghem et al., 2020).

Teacher noticing can be understood as an important skill for facilitating inclusive education and student-centered teaching. Teacher noticing is an important component of teachers' professional skill sets and is increasingly included in conceptualizations of teachers' professional competencies for connecting knowledge and other factors, such as beliefs, with teachers' behavior in the classroom. Recent results have emphasized the crucial role of teacher noticing skills in students' learning success and identified it as a characteristic of expert teachers (Blömeke et al., 2022; Jacobs et al., 2010; Lachner et al., 2016). Therefore, understanding and fostering teacher noticing are key for teacher education and professional development, particularly for inclusive education.

Nonetheless, only a few studies have investigated teacher noticing in the context of equity and diversity (König et al., 2022), and even fewer have specifically addressed inclusive (mathematics) education or ways of dealing with heterogeneity. However, there are some exceptions. Keppens et al. (2019) and Roose et al. (2018) developed two video-based instruments—for primary and secondary education, respectively—using comparative judgments and rating scales on general pedagogy to assess preservice and in-service teachers' perceptions and interpretations of positive teacher–student interactions and differentiated instruction as two main aspects of inclusive education. The results revealed connections between beliefs and teacher noticing skills in inclusive education (Keppens et al., 2021) and highlighted some influences at the school level on noticing, stressing the relevance of schoolwide, internal efforts to incorporate inclusive teaching practices (Roose et al., 2019). Moreover, high proficiency in teacher noticing in inclusive education seemed to correspond with the implementation of communication-promoting and differentiating teaching practices (Gheyssens et al., 2019). Beyond these studies, Meadows and Caniglia (2018) analyzed noticing skills in the co-teaching practices of inclusion- and content-specialized teachers. Their results showed that teachers' beliefs about teaching, learning, and collaboration during co-teaching were aligned, whereas the noticing focus (i.e., the topics that were noticed) differed and were connected to the teaching profession (Meadows & Caniglia, 2018). Besides studies specifically addressing inclusive education, some works have focused on equity, investigating noticing in the context of sociopolitical diversity dimensions, such as culture, ethnicity, or socioeconomic background (Louie, 2018; Shah & Coles, 2020), as a way of examining inclusive education practices.

However, to our knowledge, no studies have investigated how teachers' noticing skills can be developed to support inclusive education or what knowledge might be necessary to facilitate this. In addition, domain-specific perspectives appear to be missing from the discussion. These desiderata are addressed by the *Teacher Education and Development Study – Inclusive Mathematics Education* (TEDS-IME) project, the participants of which have created a professional development program for inclusive mathematics education that is currently being implemented. Accompanying pre–post design evaluations using newly developed video-based

teacher noticing instruments based on existing instruments (Kaiser et al., 2015) and knowledge tests for inclusive education have provided promising insights concerning the mentioned research desiderata.

RELATIONSHIP BETWEEN BELIEFS AND TEACHER NOTICING

There is great interest in noticing research on the features that influence teacher noticing ability and development, such as sociocultural aspects, cognitive dimensions, and affective and motivational components. Teachers' beliefs are a crucial facet of the affective–emotional domain (Blömeke & Kaiser, 2017). Studies incorporating situation-specific skills (i.e., perception, interpretation, and decision-making) into their analyses have found connections between these skills and teachers' beliefs for different teacher groups and in various settings; for example, preschool teachers (Dunekacke et al., 2015), primary school teachers (Larrain & Kaiser, 2022), secondary school teachers (Griful-Freixenet et al., 2020), and inclusive settings (Keppens et al., 2021; Roose et al., 2019).

In a large-scale study in Germany involving 131 primary school teachers (a follow-up study to the International Teacher Education and Development Study; TEDS Follow-Up), researchers analyzed the interrelations between teacher noticing skills, their subject-specific knowledge, and beliefs about the teaching and learning of mathematics. They assessed teacher noticing (perception, interpretation, and decision-making skills) using three short video clips from primary school mathematics teaching and corresponding questions. In addition, they assessed teachers' mathematics and pedagogical content knowledge, as well as their constructivist beliefs. Analyses revealed that teacher noticing was significantly correlated with their beliefs and subject-specific knowledge, indicating that teachers holding constructivist beliefs about the teaching and learning of mathematics perceived opportunities that provided insights into students' thinking more precisely and analyzed them more competently (Hoth et al., 2022). A multi-regression analysis showed that these beliefs had a greater influence on teacher noticing than their professional subject-specific knowledge (Hoth et al., 2022). They also showed, again, the great influence of beliefs on the teaching and learning of mathematics and teacher noticing in particular.

How exactly this interconnection between teachers' beliefs and noticing ability occurs and what role beliefs play in the development of teachers' professional competence are crucial issues for the education field and should be the focus of further research. Such research may provide deeper insights into how teachers' professional competence is formed and how it influences their performance in the classroom.

SOCIOCULTURAL INFLUENCES ON TEACHER NOTICING

As mentioned previously, teacher noticing has been accepted as a socially and culturally shaped construct (Louie, 2018). Therefore, mathematics teachers working in different sociocultural contexts may notice differently in practice. In

recent years, in a few cross-cultural comparative studies, researchers have compared the similarities and differences in mathematics teacher noticing between the West and the East. For example, Yang et al. (2019) carried out a comparative study in China and Germany that involved a large sample of in-service mathematics teachers. The findings of this study showed that compared with in-service German mathematics teachers, in-service Chinese teachers performed significantly worse on general pedagogy-related aspects but much more strongly on mathematics instruction-related aspects. Further differential item functioning (DIF) analysis results revealed that German teachers demonstrated specific strengths in aspects of the perception process, such as classroom management and the behaviors of students and teachers. In contrast, Chinese teachers demonstrated specific strengths in aspects of interpretation and decision-making processes, such as using knowledge to analyze and reason about incidents. For noticing in mathematics instruction, DIF results showed that German in-service mathematics teachers were better at noticing aspects such as mathematical modeling and visual approaches to teaching. In contrast, Chinese in-service mathematics teachers demonstrated specific strengths in using knowledge to make judgments about students' work, evaluate students' mathematics mistakes, and develop alternative lesson plans.

Similarly, Ding et al. (2023) compared the similarities and differences in teacher noticing between expert elementary school mathematics teachers in China and the United States. They found that at the macro level, the expert mathematics teachers from both countries paid great attention to the teaching domain, such as by using representations, deep questions, and classroom communications. However, the researchers identified differences at the micro level; for example, American mathematics teachers noticed more about concrete representations, whereas Chinese expert teachers noticed more about the sequence of representations (e.g., from concrete to abstract). In addition, the comments made by American teachers contained less reasoning than those made by Chinese teachers.

In summary, the findings of cross-cultural comparative studies on mathematics teacher noticing have provided empirical evidence that teachers in different sociocultural contexts tend to perceive different aspects of mathematics teaching and interpret their perceptions differently; correspondingly, they also make different decisions. Generally speaking, Chinese mathematics in-service teachers tend to pay more attention to teaching content and demonstrate specific strengths in knowledge-based reasoning. In contrast, teachers in Western countries, such as Germany and the United States, tend to perceive more general pedagogy-related issues (Yang et al., 2019).

CONCLUSIONS AND RECOMMENDATIONS

To understand teacher noticing and decode its development and impact as a crucial part of teachers' professional competencies, various aspects should be considered. Not only are inter- and intrapersonal aspects important, but also the context and

environment in which teacher noticing takes place. Studies have suggested that teacher noticing is shaped by individual beliefs and shared contextual conditions. Teachers' constructivist beliefs about mathematics teaching and learning have a positive effect on their noticing skills. In addition, cultural characteristics crucially influence what teachers notice, their interpretations of classroom situations, and the decisions they make. Moreover, additional but critical contextual aspects, such as heterogeneous settings, seem to shape teacher noticing. Nevertheless, how these different elements interact and how each influences the development of teacher noticing remains unclear.

Therefore, future research on teacher noticing should consider both its intrapersonal and contextual aspects in relation to theoretical frameworks and empirical methods. Interactions between intrapersonal factors, such as knowledge, skills, and beliefs, and between intrapersonal aspects and contextual factors should be further studied to enrich our understanding of teacher noticing in the classroom. In addition, the characteristics of teacher noticing in different areas of teaching and their dependence on these areas need to be considered. Studying similarities and differences in teacher noticing in inclusive settings or in different areas of mathematics teaching and learning would provide further insights into the construct, its development, and its impact on students' learning.

TEACHER NOTICING: A PASSING FAD OR HERE TO STAY?

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It is clear from the contributions to this research forum that there have been many innovative research approaches to studying teacher noticing in various contexts. As the authors of the various contributions have claimed, research on teacher noticing may be at a critical point in its development trajectory. Will such research continue on an upward trajectory, or will it dwindle and come to the end of its innovation cycle? In this commentary, I argue that research on teacher noticing may continue to grow if our research continues to strengthen the different "powers" of teacher noticing as a foundational construct to explain, model, and develop different aspects of mathematics teaching across various contexts.

MANY INNOVATIONS, BUT …

There have been many innovative research approaches to studying teacher noticing in various contexts, as highlighted by all the authors participating in this research forum. Important aspects of this development are the different theoretical perspectives that underpin studies of teacher noticing. As Scheiner and Kaiser (included herein) explained, noticing has been conceptualized from at least five perspectives—cognitive–psychological, expertise-related, discipline-specific, sociocultural, and ecological-embodied. They recommend using a multiperspective approach to provide a more comprehensive view of teacher

noticing, because each of these perspectives has afforded different nuanced explanations and models of teacher noticing.

The proliferation of these different perspectives has been complemented by a corresponding development in the methods used to examine teacher noticing. To this end, Ayalon et al. (included herein) reviewed both established and emerging methods and highlighted some recent innovations, such as eye-tracking technology and 360 videos, that can be used to capture the complexities of what teachers notice. More importantly, they argued that these innovations not only contribute to our repository of methodological tools but also to a more connected and cohesive view of the different theoretical perspectives on noticing. Correspondingly, the same repository of methodological tools provides mathematics educators with the means to develop tools and representations to support teachers' learning to notice. As presented by Fernandez et al. (included herein), representations of practice, such as animations and lesson sketches, together with annotations of video-based tools, have unique affordances for supporting teachers' development of effective noticing competencies. It is also crucial to note, as pointed out by Bastian et al. (included herein), that teacher noticing is influenced by contextual factors (e.g., sociocultural influences) and intrapersonal factors (e.g., beliefs about teaching and learning in a variety of contexts). Therefore, they argued that it is time for researchers studying teacher noticing to investigate the interactions between these influences and factors.

Despite these innovations in the study of teacher noticing, several significant concerns have been raised. For example, Fernandez et al. (included herein) questioned the particular affordances of different tools and representations in relation to the different needs of novice teachers and the role of facilitators/teacher educators in harnessing these affordances. Bastian et al. (included herein) also highlighted that how contextual factors and intrapersonal factors interact to influence the development of teacher noticing remains unclear. Furthermore, although the different perspectives on noticing may complement and deepen our understanding of teacher noticing, these perspectives have different epistemological foundations. These issues suggest that the trajectory of research on teacher noticing may have reached a critical point. Innovations as a proxy for growth may not always result in sustained and impactful research. Furthermore, novelty alone is a weak basis for sustained research. These issues beg the following question: Will research on teacher noticing continue its upward trajectory, or will it dwindle as a passing fad and come to the end of its innovation cycle?

TEACHER NOTICING: A FOUNDATIONAL CONSTRUCT?

With the aim of addressing these issues, it is crucial for us, as a research community, to carefully consider why teacher noticing is *foundationally* important in mathematics education—"to what extent will research on noticing help us better understand teacher practice and/or daily issues of teachers in the classroom?" (Dindyal et al., 2021, p. 11). To this end, it is useful to consider the explanatory,

modeling, and generative powers of teacher noticing as a construct for understanding teaching. This follows from one of the key motivations behind the study of teacher noticing: "teachers' changing practices are accompanied by new and enhanced teacher noticing" (Sherin et al., 2011, p. 11). In other words, teacher noticing is consequential. Hence, critically, the construct of teacher noticing can help explain what teachers can or cannot do in their classrooms. Conversely, closely associated with its explanatory power is its power to model a teacher's decisions and actions in different teaching contexts according to what has been noticed—or not (Choy, 2016).

It is clear that teacher noticing must continue to be a generative construct for the purpose of understanding mathematics teaching. There are at least two generative aspects to consider. First, research in teacher noticing should continue to generate relevant characterizations of noticing to provide impactful insights into the different aspects of mathematics teaching, such as task design (Choy, 2016) and argumentation (Ayalon & Hershkowitz, 2017), among others. Second, research on teacher noticing should focus on generating new tools and methods to access, assess, and support the development of this component of teaching expertise. Moreover, there is a need to expand the terrain of teacher noticing research in terms of its ability to account for differences in culture, contexts, and practices (Dindyal et al., 2021).

Is teacher noticing a foundational construct for understanding mathematics teaching? I think the answer is potentially affirmative when we examine state-of-the-art teacher noticing research as shared in this research forum. A possible hindrance, however, could be the lack of clarity in the conceptualization of noticing. Although Sherin et al. (2011) believed that research on teacher noticing "is too young to benefit from a single definition" (p. 10), they acknowledged that it is important for researchers to clarify their conceptualizations of teacher noticing for the field to move forward. Echoing similar views, Dindyal et al. (2021) highlighted that it is useful for researchers to make their conceptualizations of noticing clear to fully realize the explanatory and analytical power of noticing as a construct. Scheiner and Kaiser's (included herein) explication of the five theoretical perspectives on noticing is certainly a positive step toward unpacking the "black box" of noticing (Scheiner, 2016, p. 231) and clarifying the conceptualizations of noticing for use in future studies.

Enhanced clarity, facilitated by explication of theoretical perspectives, would also support researchers in explicitly connecting their conceptualizations of teacher noticing with the methodological commitments made in their studies, which is necessary for furthering "our understanding of the affordances and constraints that are linked to various conceptualizations of noticing" (Sherin et al., 2011, p. 10). As Ayalon et al. (included herein) claimed, there is a greater awareness among researchers of the need for explicit alignment between the methodological approaches used and theoretical stances on noticing. This alignment is key to

ensuring that our findings harness the full explanatory and analytical powers of teacher noticing as a construct for understanding mathematics teaching. More importantly, current perspectives on noticing, especially the embodied perspective on noticing, have generated novel approaches to the collection of eye-tracking and head-movement data (Huang et al., 2021; Stahnke & Blömeke, 2021), and researchers are increasingly using virtual reality and 360 video to explore teachers' enacted noticing (Kosko et al., 2021). In addition to video-based methods, these advances in methodologies will certainly contribute to more varied and robust approaches to developing teacher noticing expertise throughout teachers' teaching careers.

This brings us to an important question concerning the relationship between the conceptualization of noticing and the generative aspects of noticing as a foundational construct: How do new tools and ways of developing teacher noticing expertise relate to our understanding of noticing as a construct? The different tools and representations described by Fernandez et al. (included herein) for decomposing teaching practices suggest a strong leaning toward cognitive–psychological and expertise-related conceptions of noticing. This is not surprising because these conceptions offer relatively straightforward explanations and models of how expertise in noticing may be developed to train teachers with different backgrounds in different contexts.

MOVING FORWARD: ISSUES AND POSSIBLE DIRECTIONS?

In summary, teacher noticing can be seen as a foundational construct to explain and model mathematics teaching, potentially generating new tools, representations, and approaches to capturing and assessing expertise in teaching. However, whether the trajectory of teacher noticing research can continue its upward trend depends on our collective efforts to build on and expand mathematics teacher noticing research. The move toward studying teacher noticing in other academic, social, and cultural contexts is another positive step. As highlighted by Bastian et al. (included herein), there have been some encouraging shifts toward understanding noticing in the contexts of inclusive mathematics education and different cultural backgrounds. There is a need to continue pursuing the study of noticing across more varied contexts and to be open to the possibility that expertise in noticing can be perceived differently from currently dominant thinking. Much more work is required. For instance, the links between knowledge, beliefs, contexts, physiological data (e.g., gaze patterns), and teachers' noticing expertise are rather tenuous. For research on teacher noticing to strengthen and grow, we need to be able to give an *account of* and *account for* (Mason, 2002) the interactions between teachers' knowledge, beliefs, and practices in relation to what they notice. This may also require extending the examination of noticing beyond in-the-moment noticing to include the whole gamut of teaching activities (e.g., lesson planning and reflection) and corresponding representations of practice, focusing on pre-teaching and post-teaching noticing (Choy, 2016). This research forum offers an

exciting opportunity for us to critique and co-construct our understanding of teacher noticing as a foundational construct so that its explanatory, modeling, and generative powers can be fully harnessed in future research.

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