



Teacher noticing: A systematic literature review of conceptualizations, research designs, and findings on learning to notice

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ABSTRACT

Teacher noticing has become a prominent construct in research on teacher education and professional development; however, the current state of research is quite diverse, with different theoretical foundations and a variety of research designs. The study described in this paper provides a systematic review of the literature on teacher noticing published over the past two decades. Based on a full-text analysis of 182 articles published in renowned databases and peer-reviewed Englishscholarly journals, the study reveals the dominance of a cognitive-psychological perspective of teacher noticing, especially in combination with qualitative studies. Although teacher noticing has been described as a holistic concept in many earlier articles, more recent studies from the last decade tend to differentiate teacher noticing into different facets. Overall, qualitative studies with small sample sizes are prevalent, which allows for fine-grained analysis but limits the generalizability of findings. This study highlights the limitations of the current discussion, such as the prevalence of teacher noticing mainly in the field of mathematics education and the low representation of work from parts of the world other than North America and Europe. In addition, the studies under consideration in this literature review are examined in depth in terms of their findings on improving teachers' noticing through interventions and on comparisons between experts and novices, which allows for a discussion of the implications of learning to notice for teacher education and professional development.

Teacher noticing has come to the forefront of discussions about teachers' professional competencies and professional development. On the one hand, [Jacobs, Philipp, and Sherin \(2018\)](#) defined noticing as “a term used in everyday language to indicate the act of observing or recognizing something” (p. 1). On the other hand, specific forms of noticing characterize a profession and describe the “ability to notice features of a practice that are valued by a particular social group” ([van Es & Sherin, 2008](#), p. 244). In his socio-cultural

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work, Goodwin (1994) discussed these forms of noticing as professional vision. Teacher noticing plays an important role in teachers' professional lives, as teachers have been described as being in a maelstrom, often confronted with a "blooming, buzzing confusion of sensory data" (B. Sherin & Star, 2011, p. 69). Therefore, teachers need to make sense of what they perceive, act accordingly, and make quick decisions. Sherin, Jacobs, and Philipp (2011a) pointed out that activities related to teacher noticing and their underlying meanings have been discussed for decades, but the more constructivist focus of these approaches, centered on student thinking and strategies, has led to a new wave of empirical studies. With a focus on cognitive psychology, such approaches can be related to the expertise approach proposed by Berliner (2001, 2004), according to which teachers' noticing is commonly accepted as a component of their expertise. Teachers' expertise—and thus their noticing—develops over different stages through cognition and reflection related to teaching practices and experiences. Given the increasing interest in noticing, it is timely to survey the existing literature, summarize key findings, and provide directions for future research.

In the literature, teacher noticing is conceptualized in a variety of ways. Often, scholars identify multiple facets or processes involved in noticing, such as identifying important and noteworthy classroom incidents, making connections between these incidents and broader principles of teaching and learning, and reasoning about classroom interactions (van Es & Sherin, 2002). Other conceptualizations include in their definition deciding how to respond (Jacobs, Lamb, & Philipp, 2010), or focus on the construct of attention raising teachers' awareness of students and their understanding of the subject (Mason, 2002, 2009).

To provide an overview of the research field of teacher noticing and given the low number of systematic literature reviews on teacher noticing (for exceptions, see Amador, Bragelman, & Castro Superfine, 2021; Santagata et al., 2021; Stahnke, Schueler, & Roesken-Winter 2016), we conducted a systematic review of publications that focus on studies of noticing of pre- and in-service teachers. Despite the apparent increase in research on teacher noticing that demonstrates the relevance of this area of research, the research field appears to be blurred; different terms are used to refer to similar concepts or construct facets, and there is no clear definition of the concept of noticing itself. Overall, the field is characterized by paradigmatically different theoretical approaches, leading to wide variation in the conceptualization of central constructs and the empirical methods used. Currently, it is even questioned whether "the theoretical framework is pushed *too* far, then it might become so diluted that it loses the very power that makes it attractive" (Sherin, 2017, p. 401).

Drawing on the collective knowledge of the field, as reflected in entries in encyclopedias (Choy & Dindyal, 2020; Jacobs et al., 2018; Philipp, Jacobs, & Sherin, 2014), existing reviews (e.g., Stahnke et al., 2016), and our own work in the field (Kaiser & König, 2019; Santagata, 2010; Scheiner, 2016), we aim to provide a global overview of the current state of research on teacher noticing. In doing so, we focus on three aims that guided our review process: First, at a general level, we analyzed conceptualizations of teacher noticing in the literature, including their development over time. Second, we examined the research designs associated with these conceptualizations. Finally, using a specific selection of publications, we asked what evidence exists about how teachers learn to notice, first by looking at the effects of intervention studies and second by comparing expert and novice teachers on noticing skills.

In the following, we briefly describe the different theoretical roots of noticing and the different conceptualizations that have been developed and that serve as the theoretical framework for our systematic review.

1. Theoretical framework as the basis of the analysis

Based on recent survey papers, we identified four major perspectives that have strongly shaped research on teacher noticing over the past two decades:

- a **cognitive-psychological perspective** of teacher noticing that defines noticing as what teachers attend to and make sense of focusing on the according mental processes (van Es & Sherin, 2002);
- a **socio-cultural perspective** of teacher noticing that focuses on the social and situated nature of teacher noticing and is often mentioned in conjunction with the term 'professional vision' (Goodwin, 1994);
- a **discipline-specific perspective of teacher noticing** as practices for raising teacher awareness (Mason, 2002); and
- an **expertise-related perspective of teacher noticing** that focuses on the differences between experts and novices (Berliner, 2001).

The works that introduced these perspectives are extremely frequently cited, with more than 1,000 Google Scholar citations each as of March 2022: 1,388 citations for van Es and Sherin (2002), 4,913 for Goodwin (1994), 1,853 for Mason (2002), and 1,590 for Berliner (2001). Although several of these perspectives overlap in multiple ways, we distinguish these four perspectives for theoretical clarity. Despite this extensive empirical and theoretical work, no common understanding of the construct of noticing can be found in the literature, nor can it be identified unequivocally how the different perspectives of noticing relate to each other. In the following, we briefly describe the different theoretical roots of noticing and the different perspectives that guided us in preparing and conducting this literature review taking into account these ambiguities.

1.1. Cognitive-psychological perspective of teacher noticing

The cognitive-psychological perspective of teacher noticing characterizes noticing as a set of cognitive processes or processes that take place in the minds of individual teachers, such as perceiving salient incidents in a classroom and interpreting and making sense of those incidents (Sherin, Jacobs, & Philipp, 2011; B. Sherin & Star, 2011).

Based on reform movements that call for student thinking as central to teaching, this perspective of teacher noticing developed in

the context of teacher education or teacher professional development programs that focused on the analysis of video excerpts from participating teachers' lessons (e.g., van Es & Sherin, 2002, 2007). In their seminal work, van Es and Sherin (2002) conceptualized teacher noticing as follows: "(a) identifying what is important or noteworthy about a classroom situation; (b) making connections between the specifics of classroom interactions and the broader principles of teaching and learning they represent; and (c) using what one knows about the context to reason about classroom interactions" (p. 573).

Although this early conceptualization of teacher noticing by van Es and Sherin (2002) is still frequently cited and forms the theoretical basis for many empirical studies, no consensus has yet been reached on the different facets of noticing. Sherin, Jacobs, and Philipp (2011), in their introduction to an edited volume on teacher noticing, summarized the following two processes as central to noticing in many existing approaches: "attending to particular events in an instructional setting", meaning teachers must deliberately focus their perception, and "making sense of events in an instructional setting", meaning teachers must actively interpret what they see and interpret these events through relations to abstract knowledge (p. 5). However, they also point out that there are differences in how scholars understand the conceptualization of 'making sense' (Sherin, Jacobs, & Philipp, 2011, p. 9). Making sense is either limited to interpretation (e.g., van Es, 2011) or further differentiated. For example, Jacobs et al. (2010) developed a three facet approach that explicitly focuses on children's thinking, namely: attending to the details in children's strategies, interpreting children's understanding reflected in their strategies, and deciding how to respond based on children's understandings. Other approaches proposed similar distinctions, for example, Kaiser, Busse, Hoth, König, and Blömeke (2015) identified perception, interpretation, and decision making as facets of noticing and conceptualized decision making as anticipating a response to students' activities or proposing alternative instructional strategies. Furthermore, approaches can be identified, which go beyond student thinking and focus on the entire lesson and/or a variety of instructional aspects (Choy, 2016; Yang, Kaiser, König, & Blömeke, 2020).

A notable aspect of the cognitive-psychological perspective on teacher noticing is the recognition that human perception is limited and that teachers must learn to pay attention to certain instructional aspects while disregarding other aspects. These considerations take up central aspects of the socio-cultural perspective as discussed by Goodwin (1994) in his conceptualization of professional vision. Dependent on the relevance of these aspects, the approach on professional vision is either explicitly taken up in publications or is only mentioned (Sherin, 2001; van Es & Sherin, 2006), which makes the distinction between these two perspectives partly demanding.

1.2. Socio-cultural perspective of teacher noticing

The socio-cultural perspective of teacher noticing draws on the socio-cultural and practice-based construct of professional vision developed by Goodwin (1994) in the field of linguistic anthropology. Underlying this approach is the conviction that "the ability to see a meaningful event is not a transparent, psychological process, but instead a socially situated activity" (Goodwin, 1994, p. 606) developed through the discursive practices of professionals demonstrating their expertise. Goodwin (1994) asserted that the effective use of discursive practices enables professionals to construct 'objects of knowledge' based on the phenomena of interest to them in their profession. According to Goodwin (1994), "discursive practices are used by members of a profession to shape events in the domains subject to their professional scrutiny. The shaping process creates the objects of knowledge that become the insignia of a profession's craft: the theories, artifacts, and bodies of expertise that distinguish it from other professions." (p. 606).

Goodwin (1994) distinguished central discursive practices (coding, highlighting, articulating), on the basis of which "participants build and contest *professional vision*, which consists of socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular group" (p. 606). This means that professional vision is characterized as 'perspectival' within the specific social group and that the understanding of experts in the field is different from that of laypersons.

This socio-cultural view of professional vision, which was not originally related to the teaching profession, was incorporated into the discussion of teacher noticing described above in order to enrich the cognitive-psychological approach with socio-cultural aspects. Although many authors refer to professional vision in their work on teacher noticing (e.g., Jacobs et al., 2010; Sherin & van Es, 2009), the references are not consistent as most scholars mainly consider social practices and disregard other aspects. The political dimension of the work by Goodwin (1994) on professional vision "has largely dropped out of the concept in its recontextualisations," although "power relations are necessarily implicated in the development of professional vision as a social activity that involves privileging certain practices of seeing and understanding" (Lefstein & Snell, 2011, p. 505–506). Furthermore, Louie (2018) noted that not only has the political understanding of Goodwin's (1994) approach been overlooked, even though it is "key for understanding the challenges of learning to notice for reform and equity" (p. 61), but also the cultural dimension of what and how teachers notice has been ignored. More recently, equity-oriented, socio-political approaches have emerged that call for anti-deficit noticing and emphasize the need for noticing practices that value the abilities of underprivileged students and reciprocate student and teacher noticing (Dominguez, 2019; Louie, Adiredja, & Jessup, 2021). The newly developed framework on Multidimensional noticing for equity by van Es, Hand, Agarwal, and Sandoval (2022) puts equity in the foreground and proposes new facets of noticing with a focus on equity by including the historical and culturally bound development of students' learning and teachers' noticing of it. Although this approach emphasizes socio-cultural aspects in noticing, no reference to Goodwin's (1994) approach on professional vision is made.

To sum up, the consideration of socio-cultural aspects in noticing is not restricted to the approach by professional vision (Goodwin, 1994), which poses the question, whether this approach is a theoretically independent approach. This is an open question, however, due to its importance for the current discourse and empirical studies on noticing, we distinguished this perspective from the other perspectives considering the fuzziness of the distinction.

1.3. Discipline-specific perspective of teacher noticing

The discipline-specific perspective of teacher noticing was developed by [Mason \(2002\)](#) in the context of mathematics education. Although it is a general perspective, developing the discipline of noticing, the examples used by [Mason \(2002\)](#) are mathematical in nature, so the influence of this perspective has been taken up primarily by scholars of mathematics education. This practice-oriented approach provides recommendations for research on one's own practice: "At the heart of all practices lies noticing: noticing an opportunity to act appropriately. To notice an opportunity to act requires three things: being present and sensitive in the moment, having a reason to act, and having a different act come to mind" ([Mason, 2002](#), p. 1). [Mason \(2002\)](#) developed a set of practices for teacher professional development that constitute the discipline of noticing when done systematically in the context of action research. Overall, the discipline of noticing is characterized by four interrelated actions that aim to bring "the moment of noticing from the retrospective into the present, into the moment, so that a choice can be made to respond rather than to react habitually" ([Mason, 2002](#), p. 87). These actions are as follows: (1) systematic reflection, which involves keeping accounts by noticing and recording important moments and retrospectively identifying threads; (2) recognizing, which is based on the interrelated processes of identifying and labelling typical situations, distinguishing choices, and accumulating alternatives; (3) preparing and noticing, which consists of the sensitizing processes of imagining possibilities and enhancing the opportunities for noticing; and (4) validating with others, which is based on describing moments and refining task exercises to highlight important issues or sensitivities ([Mason, 2002](#), p. 95). Although the focus of this approach is to raise the awareness and sensitivity of individuals, the aspect of validation with others implies a social practice by bringing together three different worlds, namely the world of one's own personal experience, the world of one's colleagues' experience (where support, challenge, and recognition are provided), and the world of observations and theories ([Mason, 2002](#), p. 93–94). In the context of teaching, these are referred to as 'awareness-in-action' (improving the awareness of teachers and their students), 'awareness-in-discipline' (sensitizing teachers mathematically to work with students in mathematically informed ways), and 'awareness-in-counsel' (working with colleagues to educate each other) (see [Mason, 1998](#)).

This perspective shares commonalities with the previous two perspectives; however, we distinguish it from the other perspectives, which are focusing internal processes and take place during the moment of noticing, as it focuses on teachers' practices of how to prepare for noticing, the act of noticing, and reflection on noticing.

1.4. Expertise-related perspective of teacher noticing

The fourth and final perspective relevant to the study of teacher noticing was developed in the field of expertise research through the pioneering work of [Berliner \(1988, 2001, 2004\)](#) and the empirical studies of his research group (e.g., [Carter, Cushing, Stein, & Berliner, 1988](#); [Sabers, Cushing, & Berliner, 1991](#)), which applied expertise research to the target group of teachers. As a research paradigm related to teacher professionalization, teaching, and teacher education, teacher expertise research is neither exclusively nor directly linked to teacher noticing. Instead, expertise and its development are, to varying degrees, a central point of reference for the conceptualizations of the aforementioned perspectives and thus can be seen "as precursors" to research on teacher noticing ([Lachner, Jarodzka, & Nückles, 2016](#), p. 198).

In his description of the development of teaching expertise, [Berliner \(1988\)](#) distinguished between different stages of skill development, ranging from novice to expert teacher. Although the notion of noticing is not used in describing or differentiating these stages, connections to the construct of teacher noticing can be seen in areas where the behavior and performance of novice and expert teachers differ. For example, in interpreting classroom phenomena, novices had difficulty interpreting their classroom observations and developing explanations for what was happening in the classroom. Other differences exist in predicting classroom phenomena, such as the ability to make assumptions and hypotheses about classroom phenomena and student behavior, particularly in relation to student errors and the use of incorrect algorithms.

Other empirical studies within expertise research show even stronger links to the construct of teacher noticing. For example, [Sabers et al. \(1991\)](#) report differences between novice and expert teachers in their perception, observation, and monitoring of classroom events, as well as their understanding and interpretation, providing insight into classroom events.

Overall, the processes of interpreting classroom situations, making sense of important events, and developing connections are described in this perspective as individual cognitive mental processes carried out by teachers, revealing connections to the discourse of teacher noticing.

To sum up, the four perspectives share various commonalities and differences. The cognitive-psychological, discipline-specific, and expertise-related perspectives focus on the individual teacher and conceptualize noticing primarily as a function of the individual mind whereas noticing or professional vision in the socio-cultural perspective is a function of society. Thus, the focus is not on the individual teacher, but on cultural and historical ways of thinking and speaking, and thus of culturally influenced ways of seeing. This does not mean, however, that the mind (in the cognitive-psychological, discipline-specific, and expertise-related perspectives) is necessarily separate from or opposed to society.

2. The present study

Overall, the different perspectives on teacher noticing share many commonalities, but also strong differences. It remains to be clarified how these different perspectives have been empirically operationalized in the current discussion of teacher noticing and have yielded findings about learning to notice. The different theoretical underpinnings have led to differences in the starting points and development of empirical research, particularly in terms of the research designs used. One main approach, particularly in the context

of teacher education and teacher professional development (see Gaudin & Chaliès, 2015), engages teachers with artifacts of practice, such as student written work or videos of their own teaching or the teaching of others (for a literature review of video-based programs focused on teacher noticing in mathematics, see Santagata et al., 2021). In other approaches, teachers reflect retrospectively on their noticing by referring to diaries or other observational work. More recent approaches attempt to capture teachers' noticing in the moment using portable cameras (Jacobs & Spangler, 2017). Less common are standardized tests of teachers' noticing, particularly video-based methods that use staged or natural video vignettes as stimuli for assessing teachers' noticing (e.g., Kaiser et al., 2015; Seidel, Stürmer, Blomberg, Kobarg, & Schwindt, 2011; for a brief overview, see; Jacobs et al., 2018; for more details, see; Dindyal, Schack, Choy, & Sherin, 2021; Schack, Fisher, & Wilhelm, 2017).

In summary, building upon theoretical frameworks and insights into how researchers have employed various methodologies to investigate teacher noticing in empirical research may reveal how cumulative progress has been made in research over the past decades. In our study, we systematically review the existing literature in the field of teacher noticing to answer the following research questions:

1. How have researchers conceptualized teacher noticing over time (i.e., the past two decades)? Are the theoretical perspectives identified and described in the theoretical framework also reflected in the existing empirical research? Is noticing viewed as a holistic construct or is it further differentiated in various facets?
2. How have researchers studied teacher noticing over time (i.e., the past two decades)? What types of designs have been used, what data collection methods, what groups were targeted, and what was the sample size?
3. What insights have researchers gained over time (i.e., the past two decades) on learning to notice, indicated by the impact of interventions and comparisons between experts and novices in noticing skills?

3. Methods

3.1. Literature search

A thorough and systematic search was conducted for terms related to teacher noticing, with teacher professional vision included as a separate search term due to its use in many papers. To maintain a balance between identifying as many potentially relevant publications as possible and ensuring that these publications were actually relevant, searches were conducted for both 'teacher* AND notic*' and 'teacher* AND professional vision*'.¹ The search was conducted using titles, abstracts, and keywords in five online databases: ERIC, PsycINFO, ScienceDirect, Scopus, and Web of Science. No restrictions were placed on the type of publication or year of publication. In total, these database searches, conducted in June 2019, yielded 7,205 publications after duplicates were removed. The references retrieved were exported to EndNote version X9.

3.2. Inclusion and exclusion criteria

Publications had to meet the following four criteria to be included in the literature review: (1) the publication appeared in a peer-reviewed journal; (2) the publication was written in English language; (3) the publication explicitly addressed teacher noticing or teacher professional vision; and (4) the content of the publication was evaluated as relevant to the discourse on teacher noticing.

Criterion 1 ensured that only high-quality publications were included. Publications ($n = 2,831$) that did not appear in a journal article, including books, book chapters, conference proceedings, dissertations, and (technical) reports, were excluded in this selection step because it was unclear whether they had undergone peer review, which is a generally accepted criterion for ensuring scientific quality. Criterion 2 was used to identify publications that had a high degree of accessibility. Publications ($n = 962$) that were not written in English language were excluded. Criterion 3 was used to ensure that only publications that were relevant for the purposes of this literature review were selected. This selection step excluded publications ($n = 3,186$) that did not explicitly address teacher noticing. In addition to empirical studies on teacher noticing, theoretical and conceptual analyses of the construct of teacher noticing were included. Book reviews, commentaries, and editorial notes published in journals were excluded. A total of 226 publications retrieved from the literature search appeared to meet the selection criteria based on their titles, abstracts, and keywords.

Criterion 4 was then applied to assess the relevance of the 226 publications. The author group retrieved and reviewed the full-text versions of each article and collectively and consensually determined whether 'teacher noticing' or 'teacher professional vision' were used as constructs or phenomena of interest. To make this determination, we developed and used the following exclusion criteria: (4.1) teacher noticing or teacher professional vision was not the primary focus in the full-text version of the article; and/or (4.2) the description of teacher noticing or teacher professional vision was not sufficiently detailed in the full-text version of the article to be described as a construct or phenomenon of interest.

These two criteria were used to exclude publications that merely mentioned teacher noticing or teacher professional vision or addressed the constructs in a superficial, marginal, or overly generalized manner. Several of the selected publications ($n = 44$) mentioned teacher noticing or teacher professional vision only in passing in the full-text version and therefore did not use teacher

¹ The use of a truncation symbol at the end of the search terms (*) allowed the databases' search algorithms to include all possible word endings, especially plural forms or gerunds (e.g., notice or noticing and teacher or teachers). The term 'professional vision' was chosen instead of 'vision' because the term 'vision' was too broad and returned too many references, especially those that were not relevant to this review.

noticing or teacher professional vision as a construct or phenomenon of interest. A final database of 182 articles was included in this systematic literature review (see Table A.6 in Appendix A). Fig. 1 summarizes the search and selection process and indicates the number of publications that were excluded based on each criterion.

Review papers were not excluded as there is no clear position on this type of work, but they need to be mentioned in the database according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) (Page et al., 2021). Three review papers are included in our study, but only one of them provides a systematic literature review (Stahnke et al., 2016), the other two describe the discourse in a more general way (Kaiser & König, 2019; Scheiner, 2016).

3.3. Information retrieval process

As a first step, we coded basic information about the articles in the database, such as the author(s), year of publication, title, and

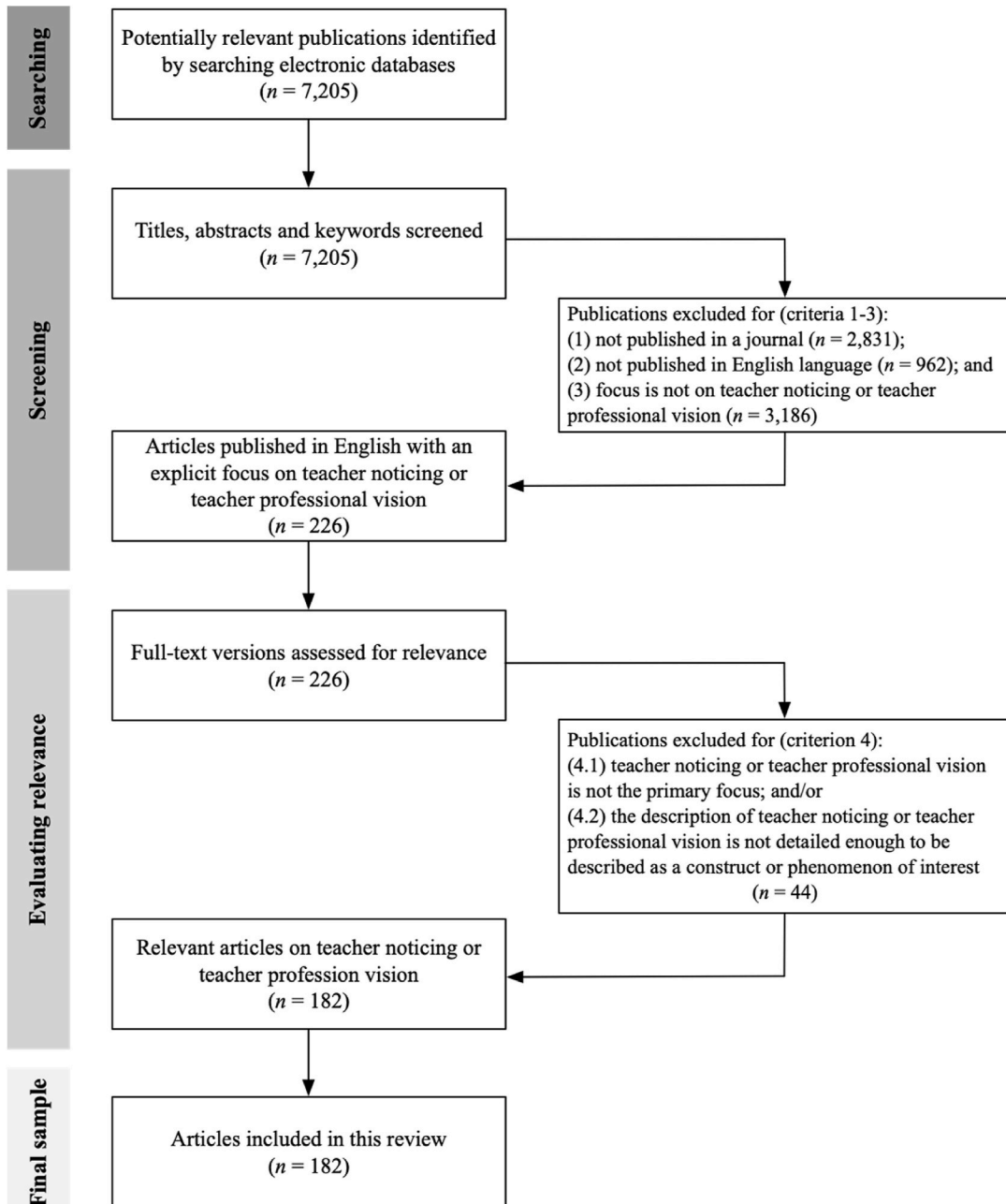


Fig. 1. Flowchart of search and selection process of publications.

continent where the author(s) or co-author(s) reside. We also used codes to classify each article as a theoretical, empirical, or review paper. Empirical papers were further classified as qualitative, quantitative, or qualitative–quantitative papers. We deliberately did not use the term ‘mixed-methods’ since hardly any of the studies met the mixed-methods criteria, for example referring to the same sample or applying triangulating methods in order to answer the common research question (see Johnson, Onwuegbuzie, & Turner, 2007). This initial coding step served to describe the papers included in our database. Descriptive results are presented in Section 4.1. In the second step, we coded specific information for all articles that related to our research questions presented in Section 2.

3.4. Development of coding schemes and coding

For the theoretical conceptualizations, methodological approaches, and findings about learning to notice, we first developed preliminary coding schemes comprising drafts of categories and codes. We then employed an iterative refinement process, in which we independently coded a randomly selected article, discussed the article in pairs (i.e., with one member of the author group), performed the coding, and made adjustments to the coding schemes before proceeding with the second and third articles. Second, from the list of all 182 articles, we coded the first 20 articles to further refine the coding schemes. The refinement process took into account the complexity of the articles and characteristics that had not previously been considered, such as the focus of the different perspectives on noticing, the study design, and the data collection method. This iterative refinement process led to the creation of coding schemes with multiple categories and codes. Discrepancies in this phase were considered as resolved when all raters agreed with the classification of information in the article and the sufficiency and accuracy with which the coding scheme captured that information. Due to space limitations, we do not describe the complex coding categories in detail here, but refer to them in the results section. The complete coding manual can be found in Appendix A.

Finally, coding was done by four members of the research team. Double coding was performed for 20% of the papers. The interrater reliability of the codes assigned by independent raters was analyzed. Cohen’s Kappa was calculated for each of the 58 codes (see Appendix A and Tables A.1, A.2, A.3, and A.4). However, Kappa statistics were available for only 41 codes due to the non-applicability of the other codes in the sub-sample of papers. With a mean of $M_{\text{Kappa}} = .72$ ($\text{min} = .35$, $\text{max} = 1.0$, $SD = .19$), the reliability of the coding can be regarded as good. For the remaining 17 codes, all raters agreed on their non-applicability. After this reliability check, all other papers were subjected to single coding, with negotiations between raters as needed. Examples of coding for two papers central to our review (Jacobs et al., 2010; van Es & Sherin, 2002) are provided in Table B.6 (Appendix).

3.5. Coding schemes and categories

In order to obtain basic statistical descriptions in addition to year and continent(s) of origin (Appendix A, Table A1), we classified papers into theoretical, empirical, review, or other papers. Empirical papers were classified according to the description of the research design provided by the according author(s). If the author(s) did not explicitly state a research design, categorization was based on the type of data collected (i.e., qualitative, quantitative, or qualitative–quantitative).

To answer the first research question, we detailed the theoretical grounding and terminology used, the facets of noticing, domain-specific and content focus, and the relationship to other facets of competence in conceptualizing teacher noticing (see Appendix A, Table A.2). The theoretical grounding of each study described in the paper was coded based on its general framing, its theoretical framework and the method and results sections of the paper. The literature review section was explicitly not taken into account as the majority of papers tended to refer to most of the four theoretical perspectives described above to provide an adequate background for the research field. Instead, we decided to primarily rely on what authors themselves declared as being their framework in a relatively concrete sense. This coding procedure included interpretive parts, especially since the socio-cultural approach referring to Goodwin (1994) has been taken up by different groups of scholars in different ways, not always maintaining the original socio-cultural intentions and/or not always using consistently the constructs or terminology. This interpretive approach, which contains hermeneutic elements, can hardly be avoided when analyzing complex theoretical frameworks.

To answer the second research question, we documented the research and study designs used in the articles, as well as the data collection methods and sample characteristics (see Appendix A, Table A.3). To answer the third research question, we first identified intervention studies. This set of intervention studies on teacher noticing ($n = 71$) was then coded in terms of reported outcomes and how the authors interpreted their findings on learning to notice as an outcome of the specific intervention (see Appendix A; Table A.4). That is, the findings and discussion sections of the publications were reviewed to determine whether the programs had meaningful or significant impact on various aspects of teacher noticing using low-inferent codes, which increased inter-rater reliability. In a second step, we identified the studies that made expert-novice comparisons related to noticing skills as another subset ($n = 11$). Although the distinction of experts and novices by their length of practical experience is seen as critical, it is a very common approach as there are despite the critique hardly convincing better approaches (Stigler & Miller, 2018). Because this subset of publications was very small (approximately 6% of our database), we decided to use a hermeneutic content analysis, which resulted in the documentation in Table B.6 (Appendix B), which made constructing and conducting technical coding expendable.

4. Results

4.1. Basic characteristics of the articles

Of the 182 papers included in this review (Table A.6 in Appendix A), six were classified as theoretical papers (Cowie, Harrison, &

Willis, 2018; Gibson & Ross, 2016; Mason, 2015; Mason & Davis, 2013; Scholten, Höttecke, & Sprenger, 2018; Thomas, Jong, Fisher, & Schack, 2017). Three additional papers were identified as reviews (Kaiser & König, 2019; Scheiner, 2016; Stahnke et al., 2016). One paper could not be clearly classified as a theoretical, empirical, or review paper (Fernández, Sánchez-Matamoros, Valls, & Callejo, 2018). The majority of papers (172) were empirical in nature, describing the results of empirical studies based on different theoretical approaches. These 172 empirical papers were classified according to their general approach: qualitative, quantitative, or qualitative–quantitative. Overall, 82 papers (47.7%) used a qualitative approach, 29 papers (16.9%) used a quantitative approach, and 61 papers (35.5%) applied both methods. In the following, we refer to papers that used an empirical approach as studies.

It is worth noting how the use of different research designs in different studies has evolved over time. As can be seen in Fig. 2, empirical research on teacher noticing has proliferated over the past decade, with the majority of studies (i.e., 34 studies) published in 2018. Since our database was created in June 2019, it underestimates the total number of papers published in 2019. Regarding the distribution of studies using the three different research designs, the number of qualitative studies and studies using qualitative and quantitative methods has increased, whereas the number of studies deploying quantitative methods only has not increased since 2015. As can be seen in Table B.1 (Appendix B), the non-empirical papers included in our study were published during the period (2013–2019) when at the same time the number of empirical studies increased. Obviously, the central concepts and constructs shaping the four perspectives on noticing described at the beginning were developed by 2012, and since then the field has broadened its theoretical scope. For example, curricular aspects, instructional practices, or lesson studies were included. The field has also expanded to include school subjects other than mathematics and has been enriched by other frameworks, such as those on teacher knowledge. This growing number of studies has led to the publication of summary papers such as that of Thomas et al. (2017).

Most of the articles (170) were written by authors or teams of authors belonging to only one continent, eleven were the result of collaboration between authors from two continents, and one article was written in collaboration between authors from three continents. In total, our database of 182 articles contains 195 references to authors' continents of origin: 103 (53%) of the authors are from North America, 70 (36%) from Europe, 13 (7%) from Asia, 7 (4%) from Oceania, and 2 (1%) from South America. We did not find any articles authored by scholars from Africa.

4.2. Conceptualizations of teacher noticing (research question 1)

4.2.1. Approaches to teacher noticing and theoretical grounding

To explore the theoretical underpinnings of the studies described in the papers, we coded the influential perspectives (cognitive-psychological, socio-cultural, discipline-specific, expertise-related; see our theoretical framework in Section 1 for details). In addition, we coded other subject-related references.

Most of the articles were framed as cognitive-psychological (74%). In addition, 24% were framed as socio-cultural, 20% were framed as expertise-related, 14% had a discipline-specific framework, and less than 5% adopted other frames. In only three papers no clear reference for the theoretical grounding could be identified (Brunvand & Fishman, 2006; Johnson, Wendell, & Watkins, 2017; Llinares & Valls, 2010).

Many papers (60%) referred to only one perspective, while a small group of nine papers (5%) included three perspectives. Eight adopted a frame that combined the socio-cultural, expertise-related, and cognitive-psychological perspectives (Gold & Holodyski, 2017; Meschede, Fiebranz, Möller, & Steffensky, 2017; Reuker, 2017a, 2017b; Roose, Goossens, Vanderlinde, Vantiegheem, & Van Avermaet, 2018; Schafer & Seidel, 2015; Seidel & Stürmer, 2014; Stahnke et al., 2016; Steffensky, Gold, Holdynski, & Möller, 2015). The paper by Amador and Weiland (2015) is the only one that combines the discipline-specific, expertise-related, and cognitive-psychological perspectives.

In the group of 59 papers (about one-third of our database) with two perspectives, we identified the following combinations (see Table B2 in Appendix B): socio-cultural and expertise-related (nine studies), socio-cultural and cognitive-psychological (19 studies), discipline-specific and cognitive-psychological (13 studies), and expertise-related and cognitive-psychological (16 studies). One paper (Sydnor, 2016) referred to socio-cultural and other theoretical perspectives (mainly reflective practice), and another paper (van Es, Tunney, Goldsmith, & Seago, 2014) referred to the cognitive-psychological perspective and other theoretical approaches (e.g., the situative perspective on learning). Overall, only about 5% of the papers did not refer to cognitive-psychological perspectives.

Of the 182 papers selected, 135 referred predominantly to the cognitive-psychological perspective of teacher noticing (74%), 35 (20%) referred predominantly to the socio-cultural perspective of teacher noticing, and only 12 (approximately 6%) referred to both

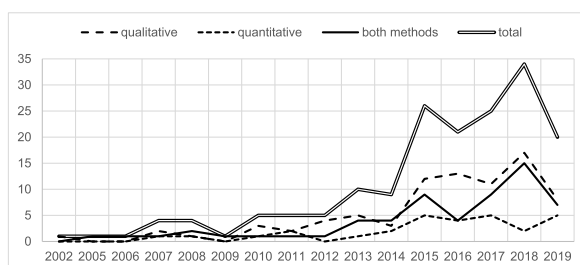


Fig. 2. Publication year of empirical studies ($n = 172$) published until June 2019.

perspectives. Papers that referred to both perspectives include the reviews by Kaiser and König (2019) and Stahnke et al. (2016) (see Table B.3 in Appendix B).

Of the papers with an empirical approach, the vast majority of qualitative studies (87%) referred to the cognitive-psychological perspective of teacher noticing. Half of the quantitative studies (52%, 15 papers) referred to the socio-cultural perspective of teacher noticing, and the other half (45%, 13 studies) referred predominantly to the cognitive-psychological perspective of teacher noticing. Studies that used both qualitative and quantitative methods referred to both perspectives more frequently, but overall they were rare (6 studies, see Amador & Carter, 2018; Lee, 2016; Reuker, 2017a, 2017b; Rieche, Leuders, & Renkl, 2019; Simpson, Vondrová, & Žalská, 2018; van Es & Sherin, 2008). The majority of empirical studies using both methods (70%, 43 papers) predominantly referred to only the cognitive-psychological perspective of teacher noticing.

In summary, the cognitive-psychological perspective of teacher noticing is clearly the most frequently used theoretical perspective in the studies included in this literature review, while the socio-cultural perspective of teacher noticing is applied much less frequently. Only very few publications (e.g., reviews) referred to both theoretical perspectives. About half of all quantitative studies referred to the socio-cultural perspective of teacher noticing, who originally applied it in the context of physics education (Stürmer et al., 2013, 2015, 2016, 2017; Blomberg, Stürmer, & Seidel, 2011; Seidel et al., 2011; Seidel & Stürmer, 2014; Stürmer & Seidel, 2015); it was later transferred to the context of elementary education by Holodynski and colleagues (Gold & Holodynski, 2017; Meschede et al., 2017; Steffensky et al., 2015; Todorova, Sunder, Steffensky, & Möller, 2017; Weber, Gold, Prilop, & Kleinknecht, 2018); and some other work used it in more general contexts (Kaendler, Wiedmann, Leuders, Rummel, & Spada, 2016; Wiedmann, Kaendler, Leuders, Spada, & Rummel, 2019). However, the socio-cultural significance of Goodwin's (1994) approach is rarely addressed in these approaches. In contrast facets of instructional quality (i.e., goal clarity, teacher support, and learning climate), and reasoning describing activities, which are closely related to the facets of noticing (i.e., description, explanation, prediction of classroom situations) are put in the foreground (Seidel & Stürmer, 2014).

There are eight qualitative studies that focus exclusively on the socio-cultural perspective of teacher noticing (see Table B.4 in the Appendix). Five of these papers refer to subjects other than mathematics, namely geography (Sezen-Barrie, 2018) or science (Criswell, Rushton, McDonald, & Gul, 2018; McDonald, 2016a, 2016b; McDonald et al., 2019; McDonald & Kelly, 2007). One paper addresses the political dimension of the approach proposed by Goodwin (Lefstein & Snell, 2011).

4.2.2. Definition of noticing: holistic vs. analytic approach

To determine how noticing is defined and what facets of the construct or sub-processes have been distinguished in previous papers, the articles included in this literature review were coded using a rubric that includes the following categories (see Appendix A): noticing as a holistic facet, cognitive processes of attending/perceiving, interpreting/reasoning, responding/decision-making, and making connections. Since the discursive practices by Goodwin (1994) were barely picked up in any of the papers, we did not include them in our coding.

Of the 182 contributions, one theoretical paper (Scheiner, 2016) could not be coded because it was based on a survey and reflection on current discourse. Therefore, the valid data used to create Fig. 3 were drawn from 181 papers, and each study was assigned to only one approach. The first type of studies conceptualized noticing as a holistic facet (25%). Noticing is viewed as a whole process with no further distinction between facets or processes. Another type of study, accounting for 75% of all papers, considers the differentiation of cognitive processes. All of these studies address attending or perceiving, either using this terminology (61%) or another terminology (14%). The second facet is interpreting or reasoning (68%), followed by the less frequently used facet of responding or decision-making (37%). Other cognitive processes, such as making connections (6%) or other processes (1%), are rarely mentioned.

The first type of studies focused exclusively on teacher noticing as a holistic facet. This includes three non-empirical papers (Cowie et al., 2018; Mason, 2015; Mason & Davis, 2013), 32 qualitatively oriented papers, three quantitatively oriented papers, and seven papers using both qualitative and quantitative methods. Overall, 39% of all qualitatively oriented papers (32 of 82), 10% of all quantitatively oriented papers (3 of 29), and 13% of all qualitative-quantitative papers (7 of 54) took noticing as a holistic concept. Overall, the holistic approach is clearly represented in the qualitative studies.

As Fig. 4 shows, there was a substantial increase in studies differentiating between facets of noticing from 2013. This clearly shows the influence of review papers, including the influential introductory chapter by Sherin, Jacobs, and Philipp (2011a) in the book they edited (794 citations on Google Scholar, as of March 2022) and the paper by Jacobs et al. (2010) proposing three clearly delineated facets of noticing (1,449 citations on Google Scholar, as of March 2022).

4.2.3. Domain-specific focus of teacher noticing and relation to facets of teacher competence

We coded the papers for their focus of teacher noticing (the three review papers (Kaiser & König, 2019; Scheiner, 2016; Stahnke et al., 2016) were coded as missing). For example, whereas teacher noticing investigated by Jacobs et al. (2018) appeared to focus on student thinking and subject-based artifact, teacher noticing in the study by van Es and Sherin (2002) had a focus on student thinking and instructional practices (see Table A.5 in the Appendix). Of the 179 papers, student thinking (59%) and instructional practices (56%) were the main focus of the studies, and subject-based artifacts were addressed less frequently (33%). Equity/diversity was addressed in very few studies (9%).

In a similar way, we also coded for the content of noticing (again, see Table A.5 in the Appendix). Most studies referred to mathematics education (63%), some to science education (26%), and a minority to language education (6%). Other subjects were rarely addressed (2%). General pedagogical topics were covered in many studies (57%), and the predominant topic was classroom management (17%). In summary, the most frequently studied areas were mathematics (63%) and general pedagogy (57%).

A small group of 27 papers (15%) related their noticing construct(s) to measurement constructs of teacher knowledge. These

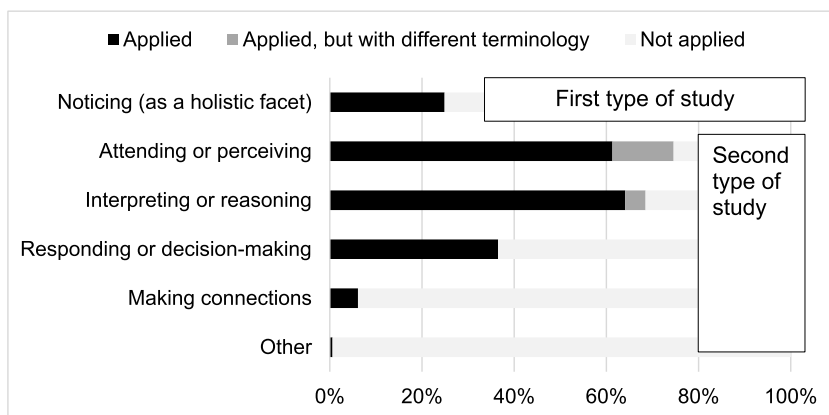


Fig. 3. Facets of noticing used in the study.

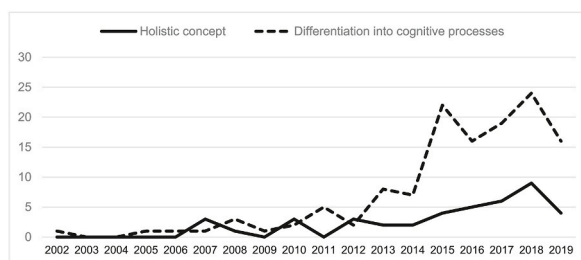


Fig. 4. Holistic vs. analytic study types by publication year.

include five non-empirical papers (Kaiser & König, 2019; Mason & Davis, 2013; Scholten et al., 2018; Stahnke et al., 2016; Thomas et al., 2017). Of the remaining 22 empirical studies, 19 focus on pedagogical content knowledge, 16 (additionally) on content knowledge, ten (additionally) on beliefs, and nine (additionally) on general pedagogical knowledge.

4.3. Research designs (research question 2)

4.3.1. Reported study designs

We classified the 172 empirical papers according to the basic principles of their design, following the classification by Campbell and Stanley (1963). We analyzed whether they were cross-sectional designs in which participants provided data on noticing once, pre-post designs in which data on noticing were measured before and after a treatment (including designs with waiting control groups), or longitudinal designs in which participants provided data on noticing three or more times. We clearly distinguished between studies with one period of data collection (cross-sectional) and those with two or more periods of data collection (repeated measures). However, there were two papers where such a distinction could not be easily made: Simpson et al. (2018), who conducted two studies, one non-experimental and cross-sectional and another with a true experimental design and pre-post design, and Seidel and Stürmer (2014), who reported three different studies, two cross-sectional and one pre-post. These papers were counted twice. Overall, 75 papers (43.6%) reported a cross-sectional design, 36 papers (20.9%) reported a pre-post design, and 63 (36.6%) reported a longitudinal design.

The majority of studies (73.8%, 127 papers) were neither 'non-experimental' nor 'true experimental'. Thirty-five (20.4%) were explicitly identified as 'non-experimental' meaning that they applied non-experimental designs (including pre-experimental and quasi-experimental designs), such as a natural' grouping of teachers or clusters (e.g., seminars). Only 10 papers (5.8%) adopted a 'true experimental' design (Campbell & Stanley, 1963, p. 8), in which two or more groups were compared in terms of collecting data based on randomized grouping (Alsawaie & Alghazo, 2010; Brunvand & Fishman, 2006; Chieu, Herbst, & Weiss, 2011; Fisher, Thomas, Jong, Schack, & Dueber, 2019; Prediger & Zindel, 2017; Scherrer & Stein, 2013; Seidel et al., 2011; Sherin & van Es, 2005; Simpson et al., 2018; Walkoe, Sherin, & Elby, 2019).²

² Three of the true experimental papers reported additional studies that were classified as "non-experimental" (Chieu et al., 2011; Seidel et al., 2011; Simpson et al., 2018).

4.3.2. Reported data collection methods

As a first step, we investigated the role of video material as a stimulus for data collection; the use of videos in video clubs has been very important since the beginning of the discussion on noticing (van Es & Sherin, 2002). Studies differed considerably on this issue; 48 papers (27.9%) used no video material at all. In 33 papers (19.2%), the performance of the (pre-service) teachers who participated in the study was videotaped, and this material ('one's own video') was used for noticing. The majority of papers (41.3%, 71 papers) used video material of another teacher's instruction ('others' video'). A small group of 19 papers (11.0%) used both options ('one's own video' and 'others' video'). In one paper (Castro, Pino-Fan, & Velásquez-Echavarría, 2018), it was unclear what type of video material was employed for data collection.

Different methods of data collection were reported in the papers. We coded written reports, interviews, standardized tests, questionnaires, video recordings (including audio), and observations. As shown in Table 1, written reports, video recordings (mostly of video clubs), and interview data were commonly used (in more than 30% of papers) to capture study participants' noticing. Standardized tests were used in fewer studies (about 20% of papers); very rarely (<5%) were observational methods or questionnaires used.

Studies with a purely quantitative approach generally used standardized tests. Studies with a purely qualitative approach mainly used written reports, video recordings, or interviews. In studies with both qualitative and quantitative methods, the full range of methods was used. This result shows the clear relationship between the data collection method and the underlying research paradigm, which is not an unexpected finding.

4.3.3. Reported samples

Since studies differed in terms of sample design, we distinguished between studies that used samples of pre-service teachers, in-service teachers, and other participants (see Table 2). Most studies used only one sample (the first three types in Table 2), and about 10% proceeded with a more complex design and included two or three samples. About half of the studies (51.2%) focused exclusively on pre-service teachers, about a third focused on in-service teachers (31.4%), and few included both groups (7%, 12 papers) or an additional group (2.9%, 5 papers). This means that studies with the potential to analyze differences in noticing between expert and novice teachers are rare, highlighting the limitations of existing research.

Sample sizes varied widely. Because five of the 172 studies did not report their sample size (Anthony, Hunter, & Hunter, 2015; Averill, Anderson, & Drake, 2015; Hand, 2012; Osmanoglu, 2016; Siry & Martin, 2014), they had to be excluded from the descriptive statistics that follow. For papers that contained multiple samples, a sum score was calculated. Due to large variations, both the arithmetic mean and the median are reported.

As shown in Table 3, the 167 studies included an average of 58 cases with a total of 9,686 cases. Thus, the data in the empirical noticing studies came from fewer than 10,000 participants. The 78 qualitative studies included an average of 17 participants, resulting in a total data set of 1,326 cases. Quantitative studies had a data set of 5,046 cases. Qualitative–quantitative studies had a data set of 3,360 cases. Half of the qualitative studies included eight or fewer cases (median = 8), and half of the qualitative–quantitative studies included 29 or fewer cases (median = 29). Half of all teacher noticing studies had a data set of 21 or fewer cases (median = 21). These differences can be explained by considering that qualitatively oriented studies tend to involve finer-grained and more extensive analyses. However, the limited data set of all studies on noticing calls into question the informational value or explanatory power of this body of research.

4.4. Findings about learning to notice (research question 3)

4.4.1. Reported impact of interventions

In our database, 71 articles were identified as intervention studies that focused on developing teacher noticing, either in the context of initial teacher education or teacher professional development programs. This means that a program or intervention was specifically designed as a learning opportunity for (pre-service) teachers learning to noticing. Consequently, we excluded those articles that examined noticing skills without an intervention framing the empirical study, or a teacher preparation course that did not focus on improving noticing skills. In Santagata et al. (2021), a detailed analysis of a subset of 35 studies of video-based interventions in mathematics is presented.

Intervention studies on teacher noticing used different study designs: 18 studies were cross-sectional (25.4%), 23 studies used a pre-post design (32.4%), and 30 studies applied a longitudinal design (42.3%). Due to heterogeneous study designs and data collection approaches, but also because very few studies reported statistical effects, we had to rely on what the authors themselves reported and

Table 1
Distribution of data collection methods in study designs.

| | Qualitative | Quantitative | Both methods | Papers (% of 172) |
|-----------------|-------------|--------------|--------------|-------------------|
| Written report | 41 | 5 | 29 | 75 (43.6%) |
| Video recording | 45 | 2 | 19 | 66 (38.4%) |
| Interview | 30 | 2 | 22 | 54 (31.4%) |
| Test | 0 | 25 | 12 | 37 (21.5%) |
| Observation | 3 | 0 | 2 | 5 (2.9%) |
| Questionnaire | 2 | 0 | 0 | 2 (1.2%) |

Table 2
Distribution of target groups in samples.

| Pre-service teachers | In-service teachers | Other | Papers (% of 172) |
|----------------------|---------------------|-------|-------------------|
| x | | | 88 (51.2%) |
| | x | | 54 (31.4%) |
| | | x | 4 (2.3%) |
| x | x | | 12 (7.0%) |
| x | | x | 4 (2.3%) |
| | x | x | 4 (2.3%) |
| x | x | x | 5 (2.9%) |

Table 3
Descriptive findings on sample size.

| | <i>n</i> | Median | Mean | <i>SD</i> | Min | Max | <i>n</i> x Mean |
|--------------|----------|--------|------|-----------|-----|-----|-----------------|
| Qualitative | 78 | 8 | 17 | 23 | 1 | 126 | 1,326 |
| Quantitative | 29 | 129 | 174 | 155 | 7 | 726 | 5,046 |
| Both methods | 60 | 29 | 56 | 70 | 1 | 321 | 3,360 |
| Total | 167 | 21 | 58 | 96 | 1 | 726 | 9,686 |

interpreted about the improvement in noticing skills. Therefore, codes were assigned if authors reported one or more of the following six categories (see Table A.4):

- Impact on attending is demonstrated (separate from reasoning)
- Impact on reasoning is demonstrated
- Impact on responding is demonstrated
- Impact on ability to propose alternative teaching strategies/suggestions for improvement is demonstrated
- Impact on instruction/classroom practice is demonstrated
- Impact on teacher self reflection is demonstrated

As can be seen in Fig. 5, on average 75% of the studies described that (pre-service) teachers improved their attending skills as a result of the intervention, and on average about 50% of the studies reported an improvement in reasoning skills. All other impacts were reported much less frequently. Impacts on responding have been reported in only 25% of the studies, whereas impacts on proposing alternatives were rarely reported (less than 10% of studies). These results are consistent with our analysis on the facets covered in empirical studies (see Fig. 3): it is clear that few authors can interpret their results in terms of an impact of their intervention when studies of noticing rarely collect data on a facet such as ‘responding or decision-making’. Similarly, demonstration of instruction or classroom practice and teacher self-reflection have rarely been reported.

As shown in Fig. 5, there are some differences between the study designs. However, only the mean differences in the reasoning dimension are significant ($F(2,67) = 3.572, p < .05, \eta^2 = .096$). There is a pairwise significant mean difference between cross-sectional studies and studies with pre-post designs.

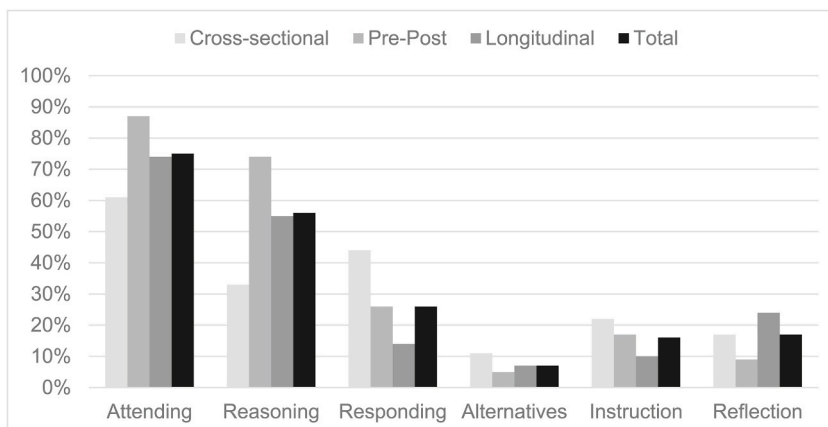


Fig. 5. Improvement of noticing skills as reported and interpreted in the studies.

4.4.2. Expert-novice differences in teacher noticing

As shown in Table 2 in Section 4.3.3, only 17 studies included both pre-service and in-service teachers, so that a relationship between noticing skills and different teaching experience or expertise background could be established. These studies differed in terms of how explicitly they focused on comparisons between experts and novices. While some studies had a clear comparative focus and related their research questions directly to the comparison between experts and novices or explicitly asked how teaching experience affects the noticing abilities of different groups of teachers (e.g., Jacobs et al., 2010; Wolff, Jarodzka, van den Bogert, & Boshuizen, 2016), other studies provided similar analyses but did not primarily aim to compare groups with different expertise or experience (e.g., Gold & Holodinsky, 2017; Meschede et al., 2017; Star & Strickland, 2008). While this second group was still valuable for our analysis, there was a third type of studies that did not provide specific results on differences between experts and novices or teachers with different levels of experience, although their samples included pre-service and in-service teachers (e.g., Amador & Carter, 2018; Sezen-Barrie, 2018; van Es & Sherin, 2002). Therefore, this third type of studies was excluded from the following analyses, and we consider only a final sample of 11 studies (see Table B.6).

Eight studies (i.e., all studies except Chieu et al., 2011; McDonald, 2016a, 2016b; Steffensky et al., 2015) provided quantitative analyses indicating mean differences between groups of novice and expert teachers. However, the constructs are different—in fact, each individual study uses a different construct—and the definitions of ‘novice’ and especially ‘experts’ vary. A common denominator is that novices are teachers who are in initial teacher education, and experts are in-service teachers and have at least a certain degree of teaching experience (see Table B.6). Although there is evidence that experience does not equate to expertise (Caspari-Sadeghi & König, 2018), we use the term expert-novice comparison for ease of reading and to relate the following findings to the expertise-related perspective of noticing proposed as part of our theoretical framework for this literature review.

In general, all eight studies reviewed here provided empirical evidence that ‘experts’ perform better than ‘novices’ (see Table B.6). This concerns the following main constructs covered in each study: noticing within classroom management (Gold & Holodinsky, 2017), attending to children’s strategies, interpreting children’s understandings, and deciding how to respond on the basis of children’s understandings in mathematics teaching (Jacobs et al., 2010), noticing of instructional support in elementary science (Meschede et al., 2017), observation of classroom environment, classroom management, tasks, mathematical content, and communication (Star & Strickland, 2008), fixation dispersion through eye-tracking (Wolff et al., 2016), theme-specific noticing related to multiple representations in mathematics classroom (Dreher & Kuntze, 2015a, 2015b), and noticing of student activities in physical education related to management, methodology, and didactics (Reuker, 2017a, 2017b), and corresponding knowledge-based reasoning (Reuker, 2017a, 2017b).

When effect sizes of mean differences are reported, they vary but are practically relevant (e.g., small to medium effect: Gold & Holodinsky, 2017; Meschede et al., 2017; large effects: Reuker, 2017a, 2017b, b). Other studies report only mean differences in scores but not effect sizes, or they report only differences in frequencies of correct solutions to categories constructed from content analysis (e.g., Star & Strickland, 2008).

Overall, the results of the expert-novice comparison confirm the findings of previous studies, namely the still low number of such comparisons in empirical research and the confirmation of the results of the expertise approach despite the use of more advanced technologies in a few studies. The differences between novices and experts seem to be quite stable across different subjects and research designs.

5. Discussion

This study provided a systematic review of the literature on teacher noticing, focusing on how researchers have conceptualized this theoretical construct, what research designs they have used, and what the studies tell us about learning to notice. We used a database of 182 journal articles, including 172 empirical studies and ten theoretical or review articles, published between 2002 and 2019.

5.1. Conceptualizations and theoretical perspectives

Following the development of the first conceptualizations, notably by van Es and Sherin (2002), there has been a surge in empirical research over the past decade, accompanied by reviews of limited scope (e.g., Stahnke et al., 2016). The proliferation of research on teacher noticing, shown in Fig. 2, indicates that this systematic literature review is timely.

Among the different theoretical perspectives that can be traced back to the 1980s (e.g., Berliner, 1988) and 1990s (Goodwin, 1994), the cognitive-psychological perspective clearly dominates research on teacher noticing, although it is enriched by combining it with other perspectives. The majority of papers refer to the cognitive-psychological perspective on teacher noticing and embed it in the international research discourse (which, however, is particularly fostered by researchers from the U.S. and Europe). The socio-cultural perspective associated with the notion of professional vision is far less frequent as a stand-alone approach and is associated with a considerable number of recent quantitative studies. Overall, the socio-cultural dimension of professional vision in Goodwin’s original approach has not been taken up in many studies, despite the increasing importance of equity in recent papers, which refer to more recent theoretical frameworks (van Es et al., 2022).

Noticing has been studied as a holistic concept in numerous qualitative studies, especially in the beginning, but since 2013 this situation has begun to change. Progress has been made in differentiating the concept into facets, such as attending/perceiving, interpreting/reasoning, and decision-making, in line with recent methodological innovations. In a recent paper, van Es and Sherin (2021) further developed their original framework by adding a third facet called shaping, which is defined as creating interactions and providing access to additional information to better attend and interpret noteworthy interactions.

In particular, researchers have increasingly employed quantitative methods instead of qualitative methods, or they have combined quantitative and qualitative methods. For example, quantitative studies influenced by recent competence models that emphasize the situation-specific teacher skills of perceiving, interpreting, and decision-making have developed novel sets of measures that operationalize different facets of noticing (Blömeke et al., 2015; Kaiser et al., 2015; Krauss et al., 2020).

From this overview, one could conclude that the two key aspects proposed by van Es and Sherin (2002, p. 573), ‘identifying’ noteworthy events and ‘making connections’ to broader principles, have been covered. However, only a small group of the empirical studies from our database (about 10%) actually analyze the link between noticing and facets of teacher knowledge, such as pedagogical content knowledge (for details, see Table B.5 in Appendix B). As pointed out, for example, by Schoenfeld (2011), the connection between noticing and knowledge should be accounted for in research. Scientific progress on the third key aspect of noticing suggested by van Es and Sherin (2002, p. 573), ‘using what one knows’ therefore seems to be still limited, leaving room for future research.

5.2. Research design

In the past, empirical research on teacher noticing has been dominated by qualitative studies, although quantitative studies—and, in particular, studies using both qualitative and quantitative methods—have come to the fore in the last decade (see Fig. 2). This recent development seems necessary and should be reinforced in the future to enable reliable, evidence-based conclusions about governance issues related to teacher education and professional development. For example, when making decisions for reforming teacher education, educational policy needs to know whether certain levels of teacher noticing are reached by pre-service teachers during initial teacher education or by in-service teachers during a professional development course (Kaiser & König, 2019). The fact that most studies have been classified as non-experimental may be due to the difficulty of implementing experimental designs in higher education, as university students typically make their own decisions about their courses and are difficult to assign to controlled groups. In addition, few studies use rigorous measures to capture noticing and its facets. Finally, small sample sizes, especially in qualitative studies, seem typical of empirical research on noticing. As a consequence, the generalizability of the findings is limited.

Approaches to empirically capturing teacher noticing are varied. Video material of teaching (one’s own, others’, or both) is clearly preferred by researchers as a means of stimulating noticing among pre-service or in-service teachers, which confirms the review of video viewing by Gaudin and Chaliès (2015). However, 28% of all empirical studies did not use video, suggesting that noticing goes beyond the use of video as a stimulus or data collection method. Various types of written reports, video recordings (e.g., group discussions, collective noticing in video clubs), interviews, and, less frequently, standardized tests have been used to collect data. Despite advances in current teacher competence research (Kaiser & König, 2019), the potential to systematically link noticing to standardized tests has not been exploited by empirical educational research. This is likely a major reason why hardly any empirical study in the present review reported predictive validity of noticing for instructional quality and student learning progress. An exception is the more recent study by Blömeke, Jentsch, Ross, Kaiser, and König (2022), which used multi-level modeling with 3,496 students from 154 classrooms to provide evidence that teacher noticing (operationalized by teachers’ skills of perception, interpretation, and decision-making) and measures of their observed instructional quality serve as mediators for the relation between teacher knowledge and students’ learning progress.

5.3. Learning to notice

There is broad consensus that teacher noticing is part of what makes the teaching profession distinctive and that pre-service teachers may be able to learn to notice. As our analysis of 71 intervention studies shows, the authors of these studies predominantly drew conclusions about the learning success of participants in the specific interventions or teacher preparation courses that focused on improving noticing. Despite this general finding, it seems problematic that research designs and outcome measures vary widely, so we could only code what the authors of each study discussed and interpreted. Our analysis is therefore limited in terms of reliability. The interventions developed and applied in these 71 studies also varied widely, making it difficult to draw more detailed conclusions about learning to notice across the studies. Results focusing on a subset of 35 video-based intervention studies in mathematics, can be found in Santagata et al. (2021), in which the intervention methods and their impact has been analyzed in more detail.

Nevertheless, the main focus of intervention studies seems to be on outcomes such as attending and reasoning as these are two specific facets of noticing (Fig. 5). The question arises whether it is more difficult to successfully educate (pre-service) teachers in facets like ‘responding’, ‘decision-making’, or ‘self-reflection’ because of limited amount of teaching experience. Considering that there is a very small number of studies in which authors reported successful demonstration of instruction as a result of a noticing intervention, it raises the question of how noticing as a teacher variable is actually related to measures of teaching practice. It seems that future interventions on noticing could place a greater focus on the higher level noticing facets and how improved noticing skills impact innovations in teaching practice. Another deficit of these studies is that hardly any factors influencing the change or growth of teacher noticing through interventions was analyzed. A consequence, little is known about specific characteristics of effective interventions on teacher noticing. Whereas the role of teacher educators (also denoted as facilitator or moderator) is supposed to be highly relevant in such interventions, there is hardly any empirical evidence on the significance of their personal variables and competence to educate pre-service or in-service teachers in such interventions.

As we outlined in our theoretical framework, expertise research serves, to varying degrees, as a central reference point for conceptualizing noticing perspectives and can therefore be considered a “precursor” to research on teacher noticing (Lachner et al., 2016, p. 198). Therefore, those studies in our database that analyzed differences in noticing among pre-service and in-service teachers—denoted as expert-novice comparisons for ease of reading—were of particular interest. Surprisingly, only about 6% of all

studies provided substantial results on this issue. All of these studies used different constructs and were not homogeneous in defining their target groups; in particular, they used different definitions regarding in-service teachers as ‘experts’. However, all of the studies demonstrated that, regardless of which construct was used, in-service teachers, i.e., the group with significantly more teaching experience, performed better than novice teachers who were still in the pre-service phase during their initial teacher education. This is an important conclusion we can draw from this particular type of empirical noticing research, as it confirms the basic assumptions of the theoretical framework, suggesting that noticing in different domains and cognitive facets seems to be part of the professional development from novice to expert. However, the very small number of studies using the expert-novice comparison principle suggests that expertise research on teacher noticing should be increased in the future.

5.4. Shortcomings of research on teacher noticing

Despite the growing number of studies that seek to differentiate facets of teacher noticing, our understanding of the cognitive processes underlying noticing is still limited, both theoretically and empirically. Recent research linking noticing to novel approaches to modeling and measuring teacher competencies appears promising, so innovative approaches can be expected in the near future.

Overall, we claim that a broadening of the discussion to include subjects other than mathematics is necessary. In addition, a shift away from non-subject-based studies to subject-based studies is needed to increase the specificity of noticing at the level of student learning within a school subject. This would also contribute to a more comprehensive understanding of noticing that intertwines subject-based aspects with pedagogical aspects. In addition, cultural aspects also need to be considered, as very few studies have done so to date. A few studies comparing East Asian and Western mathematics teachers emphasize the high influence of cultural norms on teacher noticing (Dreher, Lindmeier, Feltes, Wang, & Hsieh, 2021); other studies emphasize cultural differences in the foci of noticing, with Chinese teachers performing higher in noticing from a mathematics pedagogical perspective and German teachers displaying better achievements in noticing from a general pedagogical perspective (Yang, Kaiser, König, & Blömeke, 2019).

Greater engagement with the understanding and conceptualization of noticing seems necessary to extend research to other parts of the world. In East Asia, for example, research in disciplinary, subject-based categories may be of particular importance, as suggested by the theoretical approach proposed by Mason (2002), which is reflected in some studies involving East Asia (Yang et al., 2020). In addition, political aspects may be of particular importance in South America. Consideration of these aspects could evolve the original approach proposed by Goodwin (1994) to include political, racial, or ethnical aspects (Lefstein & Snell, 2011; Louie, 2018; McDonald, 2016a, 2016b; van Es et al., 2022). Overall, more differentiated approaches may be needed for the conceptualization and measurement of noticing in order to cater for these different needs.

If noticing is described with reference to the expertise paradigm and the approach proposed by Berliner (1988), more studies need to move beyond focusing solely on pre-service teachers who represent only the novice stage. To examine higher levels of expertise in noticing, more research should focus on in-service teachers, who should be selected based on criteria beyond practical experience (Caspari-Sadeghi & König, 2018; Stigler & Miller, 2018). Studies that have the potential to analyze differences between expert and novice teachers’ noticing are rare, highlighting the limitations of existing research. Furthermore, the rather limited database of studies on noticing calls into question the informative value or explanatory power of this body of research. Lastly, the research designs used rarely allowed for the determination of effect sizes, so important implications for teacher education and teacher professional development could not be reliably determined.

6. Limitations

This literature review provided an overview of important developments in research on teacher noticing over nearly two decades. Because advances in the field have been rapid, we anticipate new research perspectives in the near future. For example, new technological tools such as eye tracking could be used (Smith, 2012; Wolff et al., 2016). Our literature review does not include research on teacher situation-specific cognition, skills or expertise in which the term ‘noticing’ or ‘professional vision’ was not explicitly used (e.g., Blömeke et al., 2022; Kersting et al., 2016). Consideration of such studies is beyond the scope of an automated selection process and represents one of the known limitations of such an approach (i.e., the so-called ‘jingle-jangle fallacy’; Gonzalez, MacKinnon, & Muniz, 2021). Future research, however, could analyze the reasons why those authors decided to approach similar phenomena or different constructs. In this review, only journal papers written in English and those included in major databases were considered. This means that theoretical considerations often developed in book chapters may be underrepresented. Because the language of the articles included in this literature review is English, studies from South America, Africa, or Asia may not be adequately represented, although they may exist. In addition, there may be smaller studies that do not meet the quality standards of high-ranking journals. These limitations need to be overcome in further studies.

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Credit authors statement

König - Conceptualization, Formal analysis, Investigation, Visualization, Writing - original draft.
Santagata - Conceptualization, Formal analysis, Validation, Writing - review and editing.

Scheiner - Data curation, Methodology, Writing - review and editing.

Adleff - Formal analysis, Validation.

Yang - Validation.

Kaiser - Conceptualization, Supervision, Resources, Project administration, Writing - review and editing.

Declaration of competing interest

None.

Appendix A. Supplementary data

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