Teachers’ Situation-Specific Skills With a Particular Focus on Classroom Management

Evidence From a Systematic Review and Novice-Expert Studies

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List of Original Papers

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Zusammenfassung

Situations-spezifische Fertigkeiten sind ein wichtiger Teil von Lehrerexpertise und insbesondere im Bereich des Klassenmanagements bedeutsam. Vor dem Hintergrund der allgemeinen und klassenmanagement-spezifischen Kompetenz- und Expertiseforschung hat die vorliegende Dissertation bisherige Befunde systematisch synthetisiert und weiterhin untersucht, wie sich Novizen- und Expertenlehrpersonen in ihren Fertigkeiten hinsichtlich des Klassenmanagements unterscheiden. Studie 1 fasste den Forschungsstand in einem systematischen Review von 60 empirischen Studien zusammen und arbeitete dabei Erkenntnisse zu Fertigkeiten und ihrer Förderung sowie zum konzeptuellen Rahmen der Studien heraus. Für Studie 2 und Studie 3 wurden die Fertigkeiten von 20 Noviz*innen und 20 Expert*innen mit Hilfe von Videoausschnitten untersucht, die für das Klassenmanagement relevante Ereignisse zeigen. Studie 2 erforschte mit Hilfe von Eye-Tracking-Methoden insbesondere die Fertigkeit der Wahrnehmung sowie unterrichtsformatspezifische Expertiseeffekte. Es fand sich bei Expert*innen ein Fokus auf Schüler*innen und ihr Lernen, während Noviz*innen vor allem beim Partnerarbeitsformat weniger ausgeprägte Fertigkeiten zeigten. Studie 3 untersuchte anhand von retrospektiven verbalen Analysen von Klassenmanagementereignissen Expertiseeffekte hinsichtlich des Wahrnehmens, Interpretierens und Entscheidens. Expertise war erneut durch einen Fokus auf Schüler*innen gekennzeichnet. Zudem boten Expert*innen mehr Handlungsmöglichkeiten an als Noviz*innen. Zusammenfassend lässt sich feststellen, dass Expert*innen vor allem hinsichtlich des Entscheidens überlegen sind. Weiterhin deuten die Ergebnisse darauf hin, dass offenere Unterrichtsformate für Noviz*innen besonders herausfordernd sind. Die Bedeutung der Ergebnisse wird hinsichtlich der allgemeinen Expertise- und Kompetenzforschung sowie der Klassenmanagementforschung diskutiert. Die Studien zeigen theoretische Inkohärenz hinsichtlich des Konstrukts situations-spezifischer Fertigkeiten auf, sowie eine zu starke Fokussierung bisheriger Forschung auf Störungsmanagement in Frontalunterrichtsszenen.

Abstract

Situation-specific skills are an important part of teacher expertise and are particularly relevant in the area of classroom management. Against the background of general and classroom management-specific teacher competence and expertise research, this dissertation systematically synthesized previous findings and also investigated how novice and expert teachers differ in their skills with regard to classroom management. Study 1 summarized the state of research in a systematic review of 60 empirical studies, thereby identifying insights into teachers' skills and their facilitation, as well as the conceptual frameworks of the studies. For Study 2 and Study 3, the skills of 20 novice and 20 expert teachers were examined using video clips that show events relevant to classroom management. Study 2 investigated format-specific expertise effects and, in particular, the skill of perception by using eye tracking methods. Experts were found to focus on students and their learning, while novices showed less pronounced skills, especially in the partner work format. Using teachers' retrospective verbal analyses of classroom management events, Study 3 examined expertise effects with respect to teachers' perception, interpretation and decision-making. Again, expertise was characterized by a focus on students. In addition, experts proposed more alternative courses of action than novices. In summary, it can be concluded that experts are superior to novices especially with regard to the skill of decision-making. Furthermore, the results indicate that more open formats of instruction are particularly challenging for novices. The relevance of the results is discussed with regard to general expertise and competence research as well as classroom management research. The studies point to theoretical ambiguities regarding the construct of situation-specific skills, as well as an overemphasis of previous research on behavioral management in whole-group instruction settings.

1 Introduction and Relevance

"Everyone in our society, including teachers, thinks they already know what an expert teacher is, without any serious consideration of the research."

(Stigler & Miller, 2018, p. 431)

The question of what makes a good teacher has been asked for a long time. Not only does society have very different answers to this important question, but so does research. Different paradigms in teacher education research took distinct perspectives and applied diverse research methods to investigate how learning and teaching can be improved and how novice teachers can be supported in developing expertise. Within the teacher traits paradigm of the 1950s and 1960s, the focus of research was on personality traits that have different educational impacts and that can be measured psychometrically (Bromme, 2001). However, since the traits in question were often very general or complex, it remained an open question how they actually affected teaching and learning. In line with the growing influence of behavioristic methodology, the following process-product paradigm was instead concerned with the empirical effects of specific skills[1] that were close to performance (i.e. process variables) on measures of student achievement (i.e. product variables) (Bromme, 2001; Seidel & Shavelson, 2007). As the effects of a single teacher skill also depend on many other factors and their interplay, the isolated consideration of individual skills became less prominent.

In the subsequent expertise approach, the focus of research was on the assembly of a teacher's competence that enables them to teach (Berliner, 2001, 2004; Bromme,

[1] A skill is defined as "an ability that allows a goal to be achieved within some domain with increasing likelihood as a result of practice" (Rosenbaum et al., 2001, p. 454). Skills are needed in specific situations with similar demands (Blömeke, Gustafsson, et al., 2015).

2001). Applying methods from expertise research in cognitive psychology, both qualitative and quantitative differences in novice and expert teachers' declarative and procedural knowledge[2] as well as their skills and judgement were analyzed (Bromme, 2001; Stigler & Miller, 2018). If the teacher expertise paradigm is adopted, teaching is thus to be considered as a specific domain of expertise. This domain differs from others typically investigated in expertise research, such as chess, sports or medicine (Gobet & Simon, 1996; Mann et al., 2007; Norman et al., 2018). In the domain of teaching, teachers face a multitude of interrelated challenges in the classroom, as teaching "is a complex system with many moving parts" (Stigler & Miller, 2018, p. 433). Numerous different events take place in the classroom – many of them even simultaneously and many need to be addressed straightaway (Doyle, 2006). This multidimensionality, simultaneity and immediacy of teaching is particularly challenging for beginning teachers (Sabers et al., 1991). Examining how novice and expert teachers differ in their knowledge, skills and judgement helps to answer not only the question of what makes a good teacher, but also how teacher education and professional development can support teachers' expertise development.

While the expertise paradigm has been particularly prominent in the U.S., the notion of competence has gained importance in Europe, and especially in Germany, over the last two decades: The bologna reform of 1999 (Murtonen et al., 2017) and the so-called PISA-Shock (Ertl, 2006) led to an increased competence-orientation in education and teacher education research in Germany. Research initially focused on teachers' dispositions as the foundation of their practice, such as their knowledge or their beliefs (e.g. COACTIV: Baumert & Kunter, 2013; TEDS-M: Blömeke et al., 2010). Increasingly, recent research has been also focusing on teachers' more situated skills as components of their competence (Stahnke et al., 2016). Teachers' *situation-specific skills* play a crucial role as they support transforming teachers' dispositions into practice in the

[2] Declarative knowledge or "knowing that…" includes factual and conceptual knowledge, while procedural knowledge or "knowing how" is more situated (Eysenck & Keane, 2007; Putnam & Borko, 2000).

classroom (Blömeke, Gustafsson, et al., 2015). In the context of teaching, this concerns the three skills of what teachers perceive in a classroom situation, how they interpret what they perceived and what alternative courses of action they develop based on their interpretations (Blömeke, Gustafsson, et al., 2015; Kaiser et al., 2017). These skills have been increasingly the focus of research in recent years – especially in the field of mathematics teacher education research. However, studies used very different theoretical and methodological approaches, some of which originated from very different research paradigms as, for example, the competence or expertise paradigm. In order to be able to support teachers in developing these important skills, a systematic summary of the state of research is needed that takes into account the different perspectives on teachers' situation-specific skills.

One aspect of teaching where these situated skills are particularly important is classroom management as it poses situated and spontaneous challenges to teachers that call for immediate action (Doyle, 2006). These challenges are reflected in the finding that classroom management is one of the most common concerns of pre-service and beginning teachers and is often associated with teacher stress (Chaplain, 2008; Kaufman & Moss, 2010; Schmidt et al., 2017). Classroom management is also very important for students and their learning: It is a central dimension of instructional quality and crucial for student achievement, motivation and emotions (Korpershoek et al., 2016; Kunter et al., 2013; Wang et al., 1993). The important role of classroom management was further emphasized by Berliner (2001), who argued that successful classroom management skills and routines must be learned first before other areas of teacher expertise can be developed. Considering the importance of classroom management, teachers' situation-specific skills with regard to classroom management are increasingly the focus in research, thereby adopting methods from both competence and expertise research as well as new technologies such as eye tracking (Biermann et al., 2020). However, studies have mainly focused on the management of student misbehavior or disengagement as only one dimension of classroom management in whole-group activities. Yet, insights into teachers' skills regarding instructional or affective-motivational management as well as other formats of instruction are needed.

The goals of this cumulative dissertation are twofold: On the one hand, the dissertation aims to contribute to research on teachers' situation-specific skills in general by systematically reviewing the state of mathematics education research (Study 1). This specific domain is chosen because it accounts for the majority of empirical published studies on teachers' skills and thus provides a solid basis for conclusions on the characteristics of teachers' situation-specific skills. On the other hand, the dissertation further aims to investigate situation-specific skills with regard to classroom management as a strongly situated aspect of teaching (Study 2 and Study 3). The empirical studies and analyses carried out here are based on a comprehensive understanding of classroom management beyond behavioral control (Study 2 and Study 3) and additionally consider the distinct demands of different instructional formats on teachers' classroom management skills (Study 2) as well as methodological challenges in eliciting teachers' situated skills (Study 2 and Study 3).

In the next section, theoretical approaches and conceptualizations of teachers' situation-specific skills are reviewed (Chapter 2.1 and Chapter 2.2). Then, methods for eliciting and analyzing teachers' situation-specific skills are discussed (Chapter 2.3). In the following section the relevance, definitions and dimensions of classroom management are addressed (Chapter 2.4) before the state of research on novice and expert teachers' situation-specific skills regarding classroom management is summarized (Chapter 2.5). Based on the theoretical framework and the state of research described, the goals and research questions of the dissertation are formulated (Chapter 3) and subsequently addressed in the three studies. In Study 1, empirical mathematics education research is systematically reviewed with respect to theoretical frameworks, methods and results of research on teachers' situation-specific skills (Chapter 4). Study 2 reports an empirical study of 20 novice and 20 expert teachers' noticing and visual processing of classroom management-related events in a whole-group instruction and a partner work format (Chapter 5). Study 3 investigates 19 novice and 20 expert teachers' situation-specific skills by comparing their verbal analyses of the classroom management-related events noticed in two video clips (Chapter 6)[3]. Next, the results are summarized and discussed with respect to classroom management and situation-specific skills in general. In addition, strengths and limitations of this dissertation are discussed and reflected (Chapter 7). Finally, conclusions and directions for further research are proposed (Chapter 8).

[3] Study 2 and Study 3 draw on the same sample of 20 novice and 20 expert teachers. For Study 3, data of one novice teacher had to be excluded from data analyses (cf. Chapter 6).

2 Conceptual Framework

2.1 Perspectives on Teachers' Situation-Specific Skills

In the last few decades of teacher education research, two main strands of research were interested in teachers' situated skills. On the one hand, teacher expertise research, which was more prominent in the U.S., was interested in novice and expert teachers' situated skills and accessed them close to teachers' practice. On the other hand, initiated by the bologna reform of 1999, the notion of competence was more widely accepted and applied in Europe. More situated skills were increasingly considered as important outcomes of education besides knowledge. In the German context, the PISA shock additionally contributed to a stronger output and competence orientation in student and teacher education (Ertl, 2006). In the following section, the two concepts of competence and expertise are addressed first. Afterwards the perspectives on teachers' situation-specific skills that are linked to both concepts are described. Finally, the model of competence as a continuum, which connects both perspectives, is discussed.

The concept of competence is by no means defined or used consistently. In organizational psychology research of the 1970s, a behavioristic approach was chosen and research focused on a person's performance in tasks that are crucial for their profession (Blömeke, Gustafsson, et al., 2015). In contrast, teacher competence research pursued a cognitivist approach for a long time. In this regard, competence was conceptualized as context-specific cognitive dispositions that can be learned (Koeppen et al., 2008). A definition that has often been referred to is given by Weinert (2001b):

> The theoretical construct of action competence comprehensively combines those intellectual abilities, content specific knowledge, cognitive skills, domain-specific strategies, routines and subroutines, motivational tendencies, volitional control systems, personal value orientations, and social behaviors into a complex system. (p. 51)

Although this definition is very comprehensive, empirical research initially focused on cognitive (and to a lesser extent affective-motivational) dispositions in particular, defining and distinguishing between different knowledge facets. Adapting Shulman's classification (1986), the content knowledge, pedagogical content knowledge, pedagogical knowledge of pre- and in-service teachers were investigated (e.g. COACTIV: Baumert & Kunter, 2006; or TEDS-M: Blömeke et al., 2010). More recent approaches to teacher competence increasingly addressed situation-specific skills by developing more situated standardized test-instruments that use written or video vignettes as item stems (e.g. Bruckmaier et al., 2016; Kaiser et al., 2017). This extension of the conceptualization of competence was motivated by the insight that effective teachers do not only need knowledge, but also more context-specific cognitive skills that are closer to practice (Blömeke, Gustafsson, et al., 2015). Thus, teacher competence research has, for a long time, taken a strongly cognitive perspective by focusing mainly on cognitive dispositions and only recently addressed situated skills.

A second research tradition that investigated teachers' situated skills is teacher expertise research, adopting research questions and methods from cognitive psychology. Expertise is defined as "highly skilled competent performance in one or more task domains" (Sternberg & Ben Zeev, p. 365). Adopting this general definition, novice and expert teachers' declarative and procedural knowledge, their schemata and scripts, their skills as well as their judgments or representations[4] were analyzed and compared in order to explain their superior performance (Bromme, 2001; Hogan et al., 2003; Stigler & Miller, 2018). Successful teachers were regarded as expert teachers and "there is no basis to believe there are differences in the sophistication of the cognitive

[4] Schemata are knowledge structures of information about the typical events or regularities in the world that are stored in long-term memory (McNamara, 1994). Scripts are one type of schemata that store knowledge about events and their consequences (Eysenck & Keane, 2007; Wolff et al., 2020). Judgement research is interested in a person's integration of different cues to infer what is actually happening (Eysenck & Keane, 2007). A representation is a mental construction of real objects, people or events (McNamara, 1994).

processes used by teachers and experts in other domains" (Berliner, 2001, p. 471). Expertise is considered to be built on knowledge and skills which are learnable and empirically accessible (Bromme, 2001). During the development from novice to expert through deliberate practice, the initially isolated and explicit knowledge base of novices is restructured and evolves towards more integrated and organized schemata or scripts (Boshuizen et al., 2020; Lachner et al., 2016; Wolff et al., 2020).

Teaching as a domain, however, is different from other domains: Teaching is a complex system that is not completely under control of the teacher, it is also culturally embedded and highly contextualized (Stigler & Miller, 2018). Furthermore, in contrast to other domains teachers spent most time in performance, as practicing is often not possible as it would be for an athlete or musician (Stigler & Miller, 2018). Expert-novice comparisons (Chi, 2006) showed important differences in teachers' general situated skills including their perception of classroom situations, their interpretation of events or their instructional decisions (Carter et al., 1988; Copeland et al., 1994; Sabers et al., 1991). However, these results are decades old and not necessarily valid today. Recently, teacher expertise research has again become more prominent with research focusing on teachers' noticing or professional vision (Jacobs et al., 2010; M. G. Sherin & van Es, 2009; van Es & Sherin, 2002). Moreover, new research methods have been applied: Eye tracking, for instance, helped to gain insights into novice and expert teachers' visual perception (Beach & McConnel, 2019). In comparison to teacher competence research, teacher expertise research has always taken a more situated perspective by focusing on novice and expert teachers' situated skills close to practice.

Both strands of research differ in their perspective on situation-specific skills and the methods applied: From the perspective of competence research (i.e. a more cognitive perspective) the dispositions of a teacher are the foundation of competent performance (Blömeke, Gustafsson, et al., 2015; Depaepe et al., 2013). In order to improve teaching, the knowledge and resources underlying teachers' practice should be investigated. However, these dispositions are not sufficient for effective teaching and fairly disconnected from practice. Thus teachers' more situated skills should additionally be analyzed as they support teachers in putting their dispositions into practice (Blömeke, Gustafsson, et al., 2015). Typically, research from the cognitive perspective aims at analyzing distinguishable facets and the structure of dispositions and skills with standardized instruments, thus yielding generalizable results that are, however, rather detached from the classroom and can lack ecological validity (Depaepe et al., 2013). From the perspective of expertise research (i.e. a more situated perspective) finding out more about characteristics of novice and expert teachers' enacted knowledge or skills is instrumental for improving teaching. Not only what teachers know or what skills they have is important, but also how these are organized and structured and which processes are involved when they are applied in the classroom (Boshuizen et al., 2020). Research often takes place in the classroom or close to the classroom and usually choses a more qualitative or process-focused methodological approach. Consequently, sample sizes are often small and thus results have a limited generalizability (Blömeke, Gustafsson, et al., 2015; Depaepe et al., 2013).

In more recent approaches to teacher competence, the cognitive and situated perspectives are united, combining advantages of both. In the competence model of Blömeke, Gustafsson and Shavelson (2015) "competence is viewed along a continuum from traits that underlie perception, interpretation, and decision-making skills, which in turn give rise to observed behavior in real world situations" (P. 3). Thus, competence is considered to be a multi-dimensional construct that encompasses teachers' cognitive and affective-motivational dispositions, their situation-specific skills and their performance. Teachers' situations-specific skills are assigned a key role as they are linking dispositions and observable performance (Blömeke, Gustafsson, et al., 2015).

2.2 Conceptualizations of Teachers' Situation-Specific Skills

Assuming the key role of situation-specific skills in connecting dispositions and performance, conceptualizations of such skills differ in their scope and focus. Within the competence as a continuum model, teachers' situation-specific skills include (P) *perception*, (I) *interpretation* and (D) *decision-making* (Blömeke, Gustafsson, et al., 2015). Thus, in the *PID model* teachers' skills are described as their perception of events in an instructional setting, their interpretation of these perceived events and finally, their decision-making as proposing a response to students or alternative courses of action (Blömeke, Gustafsson, et al., 2015; Kaiser et al., 2015). A similar concept is teachers' *professional noticing* which is concerned with teachers' "attending, interpreting and deciding how to respond at a given moment" (Jacobs et al., 2010, p. 173). However, in comparison to the PID model, this approach is mainly concerned with teachers' professional noticing of children's mathematical thinking. Originating from anthropology (Goodwin, 1994), the concept of *professional vision* is mainly concerned with the two skills of perception and interpretation. Thus, two sub-processes are assumed: First, noticing describes "how the teacher decides where to pay attention at a given moment" (M. G. Sherin & van Es, 2009, p. 22) and second, knowledge-based reasoning includes the "ways in which a teacher reasons about what is noticed based on his or her knowledge and understanding" (p. 22). Other studies have emphasized perception only and examined teachers' *noticing* or "what (preservice) teachers attend to (...) when they view a classroom" (Star & Strickland, 2008, p. 111). There are other related conceptualizations, which also deal with one or more situated skills, but which will not be further elaborated on in this dissertation (e.g. situation awareness: Endsley, 2018; usable knowledge: Kersting et al., 2012). The aforementioned conceptualizations of teachers' situation-specific skills thus address perception only, perception and interpretation or even all three skills. A further impediment to a coherent understanding of research on teachers' skills is the inconsistent use of the term noticing. In order to maintain clarity throughout this dissertation, the term noticing will be defined as teachers' attending to events in a classroom (Star & Strickland, 2008), therefore focusing on perception, while the term situation-specific skills will address all three skills assumed in the PID-model (Blömeke, Gustafsson, et al., 2015).

Research on all three situation-specific skills, particularly in mathematics education, became more prominent in recent years referring to the different conceptualizations described. Studies have been investigating both the *what* (i.e. the topic or actors of teachers' noticing) and the *how* of teachers skills (the stance, i.e. whether descriptions, interpretations or suggestions are made) (e.g. Jacobs et al., 2007; M. G. Sherin & van Es, 2009; van Es & Sherin, 2002). Given the heterogeneity of conceptualizations as well as a lack of conceptual clarity, it is difficult to conclude consistent findings from existing studies as for instance noticing in two studies with similar titles and abstracts might mean something very different. A systematic review of the state of research on teachers' situation-specific skills and their development that also takes into account which specific skills are actually investigated could advance the research field.

2.3 Methods for Eliciting and Analyzing Teachers' Situation-Specific Skills

Due to their situatedness, teachers' situation-specific skills can only be elicited with the help of specific situations or contexts. Such situations are, for instance, written vignettes or video clips of instruction. After eliciting teachers' skills with, for example, video clips as in this dissertation there are a number of methods to analyze teachers' skills. This section first discusses the opportunities and challenges of using video clips. Afterwards eye tracking and verbal reports are described as two methods of analyzing teachers' situation-specific skills that have both been applied in this dissertation.

2.3.1 Video Clips to Elicit Teachers' Situation-Specific Skills

Teachers' situation-specific skills are only accessible if a situation can be perceived, interpreted or decided on. Video clips are a promising approach in this context as they offer a look into the classroom with all its richness that would not be possible with, for example, written vignettes. In recent years, video has been increasingly used in research and teacher training (Gaudin & Chaliès, 2015; Kaiser et al., 2015; Seidel et al., 2011; Towers, 2004). Video clips, in particular, show "the complexity and subtlety of classroom teaching as it occurs in real time" (Towers, 2004). Especially un-staged video clips are authentic, situated and contextualized representations of real classroom situations. However, in contrast to actual teaching, viewing video clips does not put the pressure on teachers of having to react immediately (M. G. Sherin, 2004), thus giving the opportunity to rewatch or reflect specific events.

Taking a competence perspective on situation-specific skills, video vignettes or video clips were often used in standardized test instruments in order to capture usable knowledge or competence facets in a more situated and authentic way (e.g. Gold & Holodynski, 2017; Kersting et al., 2012; König, Blömeke, Klein, et al., 2014). Furthermore, they were also used in rather qualitative studies that, for instance, compare novice and expert teachers' verbal analyses of video clips, thus taking a more situated perspective (Copeland et al., 1994; Wolff et al., 2015). A substantial disadvantage of using video clips is closely related to its major advantage of authenticity: Strictly speaking, the generalizability of research results is limited to those complex scenes that teachers have seen (Jarodzka et al., 2020; Seidel et al., 2010). Thus, video clips should be carefully selected to include typical and authentic classroom situations and events. A number of studies have identified factors that influence teachers' analyses of video clips and consequently should be considered or discussed in future research designs. For example, teachers' professional vision was found to differ depending on the subject they taught and also the subject displayed in the video clips that they saw (Blomberg et al., 2011). Moreover, it appeared to impact teachers' professional vision whether they saw video clips of one's own or someone else's teaching (Seidel et al., 2011) or whether they were trained with video of their own teaching or of others' or a combination of both (Gold et al., 2020). The methodological decision of whether a video clip can be viewed only once or twice also influenced how teachers analyze a video clip (Kerrins & Cushing, 2000). Altogether, video clips can be instrumental in accessing teachers' situated skills in an ecologically valid way if they are carefully developed and selected. However, some limitations in terms of generalizability are hardly avoidable.

2.3.2 Analysis of Teachers' Eye Movements

In expertise research, eye tracking methods (i.e. recording and analyzing eye movements) have a long tradition and have been applied in various domains such as reading (Rayner, 2009), chess (Chase & Simon, 1973) and sports (Mann et al., 2007). Eye movements can be classified into two events: On the one hand, a *fixation* describes a period of time where the eye is motionless and looks at the same area of a stimulus (Holmqvist et al., 2011). One the other hand, the eye's fast motion from one fixation to the next is called a *saccade* (Holmqvist et al., 2011). Research that analyzes a person's fixations does generally assume that the position of a person's gaze is linked with their allocation of attention. This eye-mind assumption was first proposed by Just and

Carpenter (1976, 1980), who assumed that a person fixates on those areas that are being processed at a given moment and that the duration of a fixation is a direct indicator of the duration of the cognitive processing of the fixated area (the so-called strong eye-mind hypothesis). Due to contradicting results, this assumption was relativized and further factors weakening the relation of fixation and attention were identified, as for instance parafoveal perception (Anderson et al., 2004). Thus, when designing eye tracking experiments the eye-mind assumption should only be made after thorough deliberation, and (if possible) triangulation with verbal data or other data sources (Orquin & Holmqvist, 2017).

In a meta-analysis that summarized nearly 300 effect sizes reported in empirical studies from different domains, Gegenfurtner, Lehtinen and Säljö (2011) found expertise differences in the comprehension of visualizations. Compared to novices, experts made shorter fixations, more frequent fixations on task-relevant areas and less frequent fixations on task-redundant areas. However, expertise differences were moderated by task, type of representation and domain. Thus, the expertise effects found do not necessarily apply to teachers' perception in general or in terms of a specific area of teaching.

In recent years, eye tracking has been increasingly used in educational science research (Jarodzka et al., 2017), teacher expertise research (Beach & McConnel, 2019) and research on teachers' professional vision in the field of classroom management (Biermann et al., 2020). Measures of teachers' gaze have often been used as operationalizations of noticing as the allocation of visual attention is necessary to identify note-worthy events in a classroom scene (Biermann et al., 2020; Seidel et al., 2020). Research has either used mobile eye tracking methods, thus analyzing what teachers look at during teaching (Cortina et al., 2015; McIntyre et al., 2017, 2019; Stürmer et al., 2017), or video-based eye tracking methods, investigating what teachers' look at when they watch a classroom scene (Seidel et al., 2020; van den Bogert et al., 2014; Wolff et al., 2016). While mobile eye tracking has a higher ecological validity than video-based eye tracking, it also brings more difficulties regarding the generalization of results as every lesson is unique and many factors can influence perception (e.g. gender, subjects, age, teaching format) (Jarodzka et al., 2020). Using video clips can help to control some of these factors by ensuring that all participants at least see the same classroom scenes or events.

2.3.3 Analysis of Teachers' Verbalizations

A method frequently used in expertise research is the elicitation and analysis of experts�much and novices‛ verbalizations during problem-solving or other meaningful tasks and activities (Ericsson, 2018; van Someren et al., 1994). This method differs considerably from traditional interviews: The goal is to gain insights into the cognitive processes taking place while a person is using their skills in a task that is crucial for the respective domain (Chi, 1997; Ericsson, 2018). Furthermore, a person is not generally asked to talk about their skills, but instructed in a certain way to express thoughts as they occur during the application of skills in a specific situation (Ericsson, 2018). Novices' or experts' verbalizations can be collected *concurrently* (during the task) or *retrospectively*, i.e. after completion of the task (Ericsson, 2006a; Ericsson & Simon, 1980). Concurrent verbalization[5] is generally considered to be a more accurate and valid collection of thought processes than retrospective reports (Ericsson, 2018).

However, concurrently verbalizing thoughts is often not possible if tasks are complex and involve time pressure, as is the case with many tasks in the domain of teaching. Verbalizing what a person thinks could interfere with their cognitive processes actually taking place during the respective task (van Gog et al., 2005). In some cases, concurrent verbalizations during tasks can even distort data provided by eye tracking

[5] Terms that are used instead of concurrent verbalization include concurrent think-aloud or concurrent reports (van Gog et al., 2005).

(Prokop et al., 2020). Therefore, retrospective verbalizations[6] are often used after the completion of such complex tasks. One way to support the validity of these retrospective reports is to stimulate verbalizations with cues for the cognitive processes that actually took place during the task (Guan et al., 2006; van Gog et al., 2005). Specifically, video-cued or eye movement-cued retrospective verbalization have been found to be more informative in situations where concurrent or un-cued retrospective verbalization has drawbacks (Hyrskykari et al., 2008; Prokop et al., 2020; van Gog et al., 2005). Combining analyses of teachers' gaze data while watching video clips and their cued retrospective verbalization data can further ensure validity in terms of triangulation (Beach & McConnel, 2019). First steps in this direction have been made in the field of classroom management by combining eye movement data with lexical analyses (Wolff et al., 2016) or content analyses of novice and expert teachers' verbalizations regarding video clips (Wyss et al., 2020).

[6] Terms that are used instead of retrospective verbalization include (stimulated) retrospective reporting, retrospective recall or retrospective think-aloud (van Gog et al., 2005).

2.4 Relevance, Definitions and Dimensions of Classroom Management

"Nearly everything a teacher does, aside from communicating the content of the academic curriculum, is part of classroom management."

(Schwab & Elias, 2015, pp. 94–95)

2.4.1 Relevance and Definitions of Classroom Management

Classroom management is highly relevant for students, teachers and administrators. Yet, there is little systematic research about teachers' situated skills in this important area (Evertson & Weinstein, 2006). However, efficient classroom management is unanimously considered to be a fundamental dimension of instructional quality (Charalambous & Praetorius, 2018; Kunter et al., 2013) but also a major concern and source of stress, particularly for pre-service and beginning teachers (Chaplain, 2008; Kaufman & Moss, 2010; Schmidt et al., 2017). Therefore, it is not surprising that indicators of classroom management are covered in most teacher evaluations rubrics (Gilmour et al., 2018) as well as in teacher education programs all over the world (Wubbels, 2011). One reason for this prominence of classroom management is its impact on student achievement, motivation and emotion (Korpershoek et al., 2016; Seidel & Shavelson, 2007; Wang et al., 1993).

Research of classroom management draws on many different disciplines and perspectives. Thus, it is not surprising that definitions are often broad and "use phrases that elucidate the aims that classroom management pursues rather than its techniques" (Wubbels, 2011, p. 114). For Brophy (1986), for instance, classroom management is defined as "the ability to establish, maintain, and (when necessary) restore the classroom as an effective environment for teaching and learning" (p. 182). Similarly, Doyle (1986) defines classroom management as "how order is established and maintained in classroom environments" (p. 99). These aims of establishing and maintaining order are grounded in distinct features of a classroom (Doyle, 1986, 2006): In the classroom many different events take place, many different actors are present that have similarly different goals (multidimensionality). Many things happen at the same time (simultaneity) and at a high pace, thus teachers need to react quickly (immediacy). Furthermore, teachers' actions are often witnessed by many students (publicness) and the turn of events is frequently hardly predictable (unpredictability). However, classes have built up norms and routines through earlier experience (history). These characteristics of multidimensionality, simultaneity, immediacy, publicness, unpredictability and history of classrooms makes classroom management such a challenge for teachers (Doyle, 2006).

A very comprehensive definition often referred to is given by Evertson and Weinstein (2006) who describe classroom management as "the actions teachers take to create an environment that supports and facilitates both academic and social-emotional learning (…). It not only seeks to establish and sustain an orderly environment so students can engage in meaningful academic learning, it also aims to enhance students' social and moral growth" (p. 4). Such a comprehensive definition of classroom management is also applied in this dissertation.

2.4.2 Classroom Management Strategies

In order for teachers to have a positive influence on student outcomes, they need a broad repertoire of *classroom management strategies*, which they should use adaptively (Kounin, 1970; Simonsen et al., 2008) in order to "support and facilitate effective teaching and learning" (Korpershoek et al., 2016, p. 2). What strategies are actually adaptive in a situation depends on various aspects. For example, different instructional formats place different demands on teachers' classroom management (Doyle, 2006; Emmer & Stough, 2001). While whole-group instruction requires the teacher to monitor student learning and behavior as well as the flow of the lesson, in group work formats, contrastingly, they need to monitor multiple student groups' progress and be available for individual questions (Doyle, 2006).

Classroom management strategies are usually distinguished into *preventive and reactive strategies*[7] (Bear, 2015; Clunies-Ross et al., 2008; Piwowar et al., 2013). Reactive classroom management strategies refer to teachers‘ reactions following student disruption, misbehavior or disengagement such as verbal warnings, referring to rules or even detention (Clunies-Ross et al., 2008; Glock & Kleen, 2019). In contrast, preventive strategies aim at the prevention of such student behavior and the support of student learning including rules and routines, monitoring student engagement and learning, student motivation or establishing positive student-teacher relationships (Bear, 2015). However, pre-service teachers seem to struggle with the adaptive use of these classroom management strategies: They do use more harsh reactive strategies as interventions to minor student misbehavior (Glock & Kleen, 2019), particularly in comparison to in-service teachers (Woodcock & Reupert, 2013). Even though pre-service teachers consider both types of strategies to be similarly effective they more often fall back on reactive strategies as they feel more confident in applying them (Reupert & Woodcock, 2010). This preoccupation with reactive strategies is also reflected in pre-service teachers framing of classroom management as being mainly about maintaining discipline and behavioral control (Kaufman & Moss, 2010). The focus on the reactive management of student behavior is unfavorable in two ways: It is associated with more teacher stress and also less student time-on-task (Clunies-Ross et al., 2008).

To become an efficient classroom manager, beginning teachers need to acquire both knowledge about classroom management and classroom management strategies

[7] Some researchers further differentiate between preventive and proactive strategies, the former relating to the anticipation and prevention of misbehavior and the latter to rituals and rules as well as transparency of consequences of misbehavior (Spoden & Fricke, 2018). In this dissertation, the term preventive strategy includes both proactive and preventive strategies.

as well as skills. While their declarative and procedural general pedagogical knowledge is a significant predictor of students' rating of effective classroom management and other indicators of instructional quality (König & Pflanzl, 2016), their situated classroom management skills are even more predictive than their knowledge (König & Kramer, 2016). These skills, however, seem to be developed only after teacher education during induction, while knowledge about classroom management is already acquired at university (König & Kramer, 2016). Consequently, different approaches to foster both knowledge and skills at university during teacher education have been developed and evaluated (Dicke et al., 2015; Gold et al., 2013, 2020; Kramer et al., 2017; Piwowar et al., 2013; Weber et al., 2018). It is encouraging that many of these approaches have been successful at fostering teachers' knowledge and skills regarding classroom management and classroom management strategies. However, without further research about what exactly constitutes expert classroom managers' skills, we know little about what features of these interventions exactly lead to expertise or competence development and what processes are crucial in this development.

2.4.3 Dimensions of Classroom Management

Even though research on classroom management is so diverse, a number of different dimensions of classroom management can be distinguished based on research findings and conceptualizations of classroom management. *Behavioral management* is the dimension that is most strongly associated with and dominating researchers' understanding of classroom management (Bullough & Richardson, 2015). Behavioral management is concerned with preventing or dealing with student misbehavior or disengagement (Kounin, 1970; Martin & Sass, 2010). It includes, for example, monitoring students or establishing rules and routines (for more details on monitoring and establishing rules and routines cf. Gold & Holodynski, 2015 and Kounin, 1970). Expanding the behavioral focus, *instructional management* refers to teachers' techniques and methodologies of instruction used to reach their content-related goals including seatwork, structure and clarity or instructional formats used (Froyen & Iverson, 1999; Martin et al., 2016; Martin & Sass, 2010). An important aspect of instructional management is also to establish smooth transitions between activities (for more details on managing momentum cf. Gold & Holodynski, 2015 and Kounin, 1970).

Another area of classroom management, which will be referred to in this dissertation as the *affective-motivational* dimension of classroom management, is concerned with "all teacher actions and associated cognitions and attitudes involved in creating the social emotional aspect of the learning environment" (Wubbels et al., 2015, p. 363). This includes, for example, the appreciation and motivation of students as well as building positive teacher-student relationships (Froyen & Iverson, 1999; Martin et al., 2016; Piwowar et al., 2013; Schwab & Elias, 2015). A few conceptualizations of classroom management differentiate systematically between these dimensions (e.g. Froyen & Iverson, 1999; Martin et al., 1998; Piwowar et al., 2013). In their conceptualization of classroom management, Piwowar, Thiel and Ophardt (2013) distinguish between the management of student behavior (including the areas rules, dealing with disruptions and monitoring), the management of instruction (procedures; group mobilization, time management, clarity of program of action) and the management of teacher-student relationships (working alliance and conflicts among students). A final dimension of classroom management that is often not addressed in conceptualizations of classroom management is teachers' *self-management* comprising their self-regulation, self-control and particularly their self-presentation (their attitude, presence, gesture or facial expression) (Fenwick, 1998; Martin et al., 2016; Sutton et al., 2009).

In light of this state of research, this dissertation is framed by a comprehensive conceptualization of classroom management that identifies the following dimensions of classroom management: *Reactive* and *preventive behavioral management* (Bear, 2015; Doyle, 2006; Kounin, 1970), *instructional management* (Froyen & Iverson, 1999; Martin et al., 2016), *affective-motivational management* (Froyen & Iverson, 1999; Schwab & Elias, 2015; Wubbels et al., 2015), and *teachers' self-presentation* (Martin et al., 2016).

2.5 State of Research on Teachers' Situation-Specific Skills with regard to Classroom Management

The two perspectives on teachers' situation-specific skills as outlined in Chapter 2.1 can also be found with regard to classroom management. On the one hand, standardized test-instruments have been developed based on a cognitive or a competence perspective. On the other hand, taking a more situated perspective, teachers' perception, interpretation and decision-making with respect to classroom management have been investigated close to practice by choosing a more qualitative or process-focused methodological approach while comparing novice and expert teachers.

Using written vignettes that were low in complexity, Gold and Holodynski (2015) developed a situational judgement test for strategic knowledge of classroom management in elementary school and later on a video-based test instrument measuring teachers' professional vision of classroom management (Gold & Holodynski, 2017). Both instruments distinguish three facets of classroom management (monitoring, managing momentum and establishing rules and routines) and are sensitive to differences in expertise, thus experts scored better on both measures than novices (Gold & Holodynski, 2015, 2017). Furthermore, these skills can be fostered in teacher education with adequate opportunities to learn (Gold et al., 2017, 2020). Also using video vignettes of classroom situations, König and Lee (2015) developed an instrument for so-called classroom management expertise. Thereby three cognitive demands are measured: Accuracy of perception, holistic perception and justification of action. Similarly to Gold and colleagues' instruments, classroom management expertise was more pronounced among expert teachers than among novice teachers (König & Kramer, 2016). Additionally, classroom management expertise was a stronger predictor of students' ratings of aspects of instructional quality than teachers' general pedagogical knowledge (König & Kramer, 2016).

These instruments certainly offer advantages in terms of objectivity, reliability, economy and generalizability of results, but they may fail to capture important aspects of teachers' situation-specific skills, namely their situatedness and spontaneity. Teaching is characterized by multidimensionality, simultaneity, and immediacy and thus poses spontaneous challenges for teachers' that call for immediate reactions (Doyle, 2006; Sabers et al., 1991). Thus, using a test instrument that addresses these challenges only to some extent by choosing pre-defined response option and focused questions might mask important differences between novice and expert teachers. Therefore, this dissertation will particularly draw on research taking a more situated approach with less standardized instruments.

Studies building on teacher expertise research have chosen a more situated approach: Novice and expert teachers' (visual) perception, their interpretation and their decision-making during instruction or in reaction to video of instruction have been examined in a more process-focused and qualitative way. In terms of teachers' visual perception, experts showed more and shorter fixations on relevant areas indicating faster encoding than novices (Biermann et al., 2020). Novice teachers also paid less attention to students or areas where student activity can be observed than experts (McIntyre et al., 2017, 2019; McIntyre & Foulsham, 2018; Wolff et al., 2016). Additionally, experts tended to distribute their attention more evenly between students or student groups than novices (Cortina et al., 2015; van den Bogert et al., 2014). It should be noted, however, that not all studies found differences in novice and expert teachers' visual perception regarding classroom management (Yamamoto & Imai-Matsumura, 2013).

Surprisingly, there is not much research yet on teachers' perception in the sense of noticing specific classroom management events. Generally, experts focused more on student learning and less on student discipline than novices in sequences where both novices and experts noticed classroom management events (Wolff et al., 2015, 2017). Focusing on only one particular student discipline event, Yamamoto and Imai-

Matsumura (2013) found no expertise effects for teachers' noticing of this event[8]. Yet, findings about which events experts and novices actually notice could inform teacher education.

Focusing on teachers' verbalization about classroom management in video clips, differences in novices' and experts' perception, interpretation and decision-making have been revealed. Experts made more interpretations and suggestions than novices who in turn stated more perceptive comments (Wolff et al., 2015, 2017). In addition, novices referred more to order and discipline than experts do, while experts talked about student learning, teacher-student interactions and the impact of teaching (Wolff et al., 2015, 2017). In a recent theoretical model on teachers' classroom management scripts, Wolff and colleagues (2020) proposed that novices' perception is characterized by bottom-up processing or being image-driven while experts' perception is characterized by top-down processing or being knowledge-driven. Experts monitor a classroom scene automatically based on their knowledge and scripts, while novices have to consciously guide their attention to students and their activity, thus often missing note-worthy events. Experts' knowledge and scripts also support them in building useful classroom event representations that help to understand what is going on and what actions are required (Wolff et al., 2020). Thus, teachers' classroom management scripts impact their perception, interpretation and decision-making.

The studies referred to previously are on the one hand very diverse: They differ considerably in the cultural context, the experimental procedures, the methods of data analyses and the video clips used. It remains unclear if differences in research results are linked to this diversity or to genuine expertise effects. On the other hand, the studies discussed are very similar in one point: They mainly focus on behavioral classroom management in whole-group instruction formats. This is, of course, one important aspect of classroom management. Yet, it is an open question if similar results as

[8] This misbehavior referred to two students not closing the book after being instructed to do so. This student behavior is probably not considered misbehavior in other cultural contexts (cf. Ding et al., 2008; Glock, 2016).

reported above can be found for other crucial dimensions of classroom management and other formats of instruction, too.

In summary, there is evidence for expertise differences concerning the *what* and the *how* of teachers' situation-specific skills regarding classroom management. Expertise seems to be linked to a stronger focus on students and their learning both in terms of visual attention and verbalizations about noticed events (the what of teachers' situation-specific skills: Cortina et al., 2015; McIntyre et al., 2017, 2019; McIntyre & Foulsham, 2018; van den Bogert et al., 2014; Wolff et al., 2015, 2016, 2017, 2020). Furthermore, experts make more interpretive comments and more suggestions for improvements than novices, whose verbalizations are more perceptive (the how of teachers' situation-specific skills: Wolff et al., 2015, 2017, 2020).

Whether these expertise effects can be found for other formats than whole-group instruction and for dimensions of classroom management beyond behavioral management remains an open question. Furthermore, it is unclear which and how many events are actually noticed by both expertise groups and how the situations-specific skills displayed in teachers' verbalizations (the how) and their focus of analysis (the what) are linked.

3 Goals and Research Questions of the Dissertation

Based on a comprehensive understanding of teachers' situation-specific skills, thus including perception, interpretation and decision-making and an equally broad conceptualization of classroom management, the guiding research question of this dissertation is

HOW DO NOVICE AND EXPERT TEACHERS DIFFER REGARDING THE *WHAT* AND *HOW* OF THEIR SITUATION-SPECIFIC SKILLS?

Against this question, two goals are pursued: The first goal relates to the state of research on situations-specific skills of mathematics teachers, the second goal to teachers' skills with regard to classroom management as a crucial aspect of teaching.

The first goal of this dissertation is to systematically review and synthesize research on teachers' situation-specific skills in the domain of mathematics education, which offers a majority of empirical studies on teacher' skills. In recent years, the importance of situated skills has been more widely recognized (cf. Blömeke, Gustafsson, et al., 2015; Depaepe et al., 2013), as reflected in the number of empirical studies addressing such skills both from a competence as well as an expertise perspective. However, heterogeneous conceptualizations (Blömeke, Gustafsson, et al., 2015; Jacobs et al., 2010; Star & Strickland, 2008; van Es & Sherin, 2006) as well as a lack of conceptual clarity make studies difficult to compare and hinder the deduction of coherent and consistent findings. Addressing this desideratum, four research questions are raised:

Research Question 1a: Which situation-specific skills are being investigated in empirical research on mathematics teachers' skills?

Research Question 1b: Which theoretical frameworks are being referred to in empirical research on mathematics teachers' skills?

Research Question 1c: Which designs and methods are used in empirical research on mathematics teachers' skills?

Research Question 1d: What are the main results of empirical research on mathematics?

Study 1 (Chapter 4) addresses these research questions with a systematic review (Petticrew, 2015; Petticrew & Roberts, 2008) of empirical mathematics education research on teachers' perception, interpretation and decision-making. After identifying relevant studies, their theoretical frameworks, methods and results are systematically analyzed and summarized. Thereby, inconsistencies and ambiguities of conceptualizations are exposed and studies are compared with regard to the skills that they actually investigate (i.e. perception, interpretation and / or decision-making).

The second goal of the dissertation is to generate insights into teachers' situation-specific skills with respect to classroom management as an area of teaching where such skills are particularly important. Previous research on novice and expert teachers' skills emphasized behavioral management in whole-group instructions formats (e.g. Wolff et al., 2015, 2017). Such a narrow focus neglects essential areas of classroom management as novice teachers must also learn to deal with the challenges of instructional or social-emotional aspects of classroom management as well as more open formats of instruction (Bear, 2015; Doyle, 2006; Schwab & Elias, 2015). However, little is known about teachers' skills regarding these other dimensions of classroom management or other formats. Of the studies that have been conducted to date, either teachers' visual processing (e.g. van den Bogert et al., 2014; Wolff et al., 2016) or their verbal analyses of specific events were investigated (e.g. Wolff et al., 2015). What is unclear, though, is which classroom management events are actually noticed by novices and experts. Furthermore, even though initial insights into the what and the how of teachers' skills have been developed, it is not clear how the what and the how are interrelated. Against this background, seven research questions address these research gaps:

Research Question 2a: How do novice and expert teachers differ in their identification of note-worthy classroom management events in whole-group instruction versus partner work?

Research Question 2b: How do novice and expert teachers differ in their gaze directed at student groups and the teacher in whole-group instruction versus partner work?

Research Question 2c: How do novice and expert teachers differ in their gaze directed at specific classroom management events in whole-group instruction versus partner work?

Research Question 2d: How do novice and expert teachers differ in the skills displayed when analyzing classroom management events (perception, interpretation and decision-making)?

Research Question 2e: How do novice and expert teachers differ in their focus of analysis when analyzing classroom management events (students, teacher or context)?

Research Question 2f: How are skills displayed and focus of analysis related within the two groups of novice and expert teachers?

Research Question 2g: How do novice and expert teachers differ in their reports regarding different dimensions of classroom management?

To answer these research questions the narrow focus of prior research on behavioral management and whole-group instruction is extended by applying a comprehensive understanding of classroom management. In Study 2 (Chapter 5), novice and expert teachers' gaze at student groups and the teacher in a classroom scene and their noticing of classroom events are investigated. Thereby, research question 2a, 2b and 2c are addressed and whole-group and partner work activities are compared as two formats of instruction. Combining both eye tracking and verbal data on teachers' identification of note-worthy events, the skill of perception is investigated in particular.

Study 3 (Chapter 6) focuses on teachers' perception, interpretation and decision-making reflected in their verbal analyses of noticed classroom management events in both formats of instruction. Novice and expert teachers are compared with regard to the what, the how, the relation of both as well as the dimension of classroom management addressed in their verbalizations. For both studies, video clips have been selected through several steps that show multiple dimensions of classroom management.

4 Study 1 – Teachers' Perception, Interpretation, and Decision-Making: A Systematic Review of Empirical Mathematics Education Research

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Abstract: Research in mathematics education has investigated teachers' professional knowledge in depth, comprising two different approaches: a cognitive and a situated perspective. Linking these two perspectives leads to addressing situation-specific skills such as perception, interpretation and decision-making, indicative of revealing a teacher's knowledge while in the act of teaching. The aim of this study is to systematically review empirical research on mathematics teachers' situation-specific skills. From the databases ERIC, PsycINFO and MathEduc a total of 60 articles were included in the review, based on specific criteria. The studies were categorized with respect to the theoretical frameworks used, designs and methods applied as well as the main findings of each study. Teachers' noticing or teachers' professional vision, and teachers' (situated) professional knowledge were found to be the most frequent frameworks. Designs ranged from comprehensive case studies with a variety of methods to confirmatory studies testing a large sample with standardized instruments. The main findings suggest: (1) Teachers' expertise and experience positively influences noticing and teachers' noticing can be successfully fostered by (video-based) professional development programs. (2) Pre-service teachers struggle with perceiving and interpreting students' work. Thereby, their mathematical knowledge plays an important role. (3) Teachers' in-the-moment decision-making is influenced by their knowledge, beliefs and goals. (4) Teachers' knowledge and belief facets predict their situation specific-skills, which in turn correlate with aspects close to instructional practice. (5) Teachers have difficulties interpreting tasks and identifying their educational potential. Methods and implication of this systematic review are thoroughly discussed.

Keywords: Teacher Professional Knowledge | Teacher Cognition | Situation-Specific Skills | Perception | Interpretation | Decision-Making

4.1 Introduction

Teachers' subject-specific professional knowledge is a strong predictor of students' achievement (Hattie, 2009; Helmke, 2009; Kunter et al., 2013; Sowder, 2007). In the last decade, many studies investigated teachers' professional knowledge, affective-motivational beliefs, instructional practice, and in-the-moment performances in the classroom (Baumert et al., 2010; Blömeke et al., 2011; Kunter et al., 2013; Schoenfeld, 1998). Based on Shulman (1986), different frameworks of mathematics teachers' professional knowledge emerged contributing analytically distinguishable knowledge facets (Ball, 2000; Ball & Bass, 2000; Baumert & Kunter, 2006; Kaiser et al., 2014). These approaches have pursued a cognitive perspective and emphasized the significance of teachers' profound subject-specific knowledge base for the quality of instruction. Other research contributions in mathematics education have rather drawn on a situated perspective on teachers' professional knowledge. These studies adapt frameworks and methods from expertise research (Berliner, 1992; Borko et al., 1992; Carter et al., 1988). Comparing novice and expert teachers' perception and interpretations of teaching situations is characteristic of such research. In contrast to purely cognitive approaches, these studies use proximal measures of teachers' abilities such as classroom videos, video vignettes or exemplary student work (e.g. Jacobs et al., 2010; Kersting, 2008; van Es & Sherin, 2002).

Linking these two perspectives on teachers' professional knowledge can contribute to a more comprehensive understanding (Depaepe et al., 2013; Kaiser et al., 2014; Santagata & Yeh, 2016). In this regard, Blömeke et al. (2015) stated that "processes such as the perception and interpretation of a specific job situation together with decision-making may mediate between disposition and performance" (p. 7). The aim of this article is to present a systematic review of mathematics teachers' situation-specific skills: Perception, interpretation, and decision-making. This review reports the different conceptualizations and methodological approaches used in mathematics education empirical research and lists the main findings. The guiding questions are: To what theoretical frameworks does empirical research on mathematics teachers' situation-specific skills refer? What designs and methods are used to access perception, interpretation and decision-making of prospective and practicing mathematics teachers? What results do the studies on situation-specific skills offer, and can these findings contribute to a comprehensive understanding of the link between teachers' dispositions and their performances?

4.2 Teachers' Situation-Specific Skills in Mathematics Education Research

In the last 30 years, many efforts have been made to explore the connection between mathematics teachers' professional knowledge and their instructional practices, with respect to their students' achievement. Rowland and Ruthven (2011) raised the question "whether mathematical knowledge in teaching is located 'in the head' of the individual teacher, or is somehow a social asset, meaningful only in the context of its application" (p. 3). Current discussions in the field label these two perspectives on mathematics teachers' professional knowledge as cognitive and situated (Depaepe et al., 2013). The aim of this section is first to outline essential contributions to both perspectives. Second, the role of situation-specific skills as mediating what teachers know and how they act is explored.

4.2.1 Perspectives on Mathematics Teachers' Professional Knowledge

Large-scale assessments like *cognitive activation in the classroom: the orchestration of learning opportunities for the enhancement of insightful learning in mathematics* (COACTIV; Bruckmaier et al., 2016; Kunter et al., 2013), the *teacher education and development study* in mathematics (Blömeke et al., 2010) and the follow-up study TEDS-FU (Hoth et al., 2016; Kaiser et al., 2014) have contributed substantially to conceptualizing and measuring mathematics teachers' professional knowledge. Based on Shulman's (1986) seminal work, these studies analytically distinguished mathematics teachers' knowledge and belief facets and explored diverse relations. The COACTIV study revealed positive effects of mathematics teachers' pedagogical content knowledge (PCK), enthusiasm for teaching, and self-regulatory skills on their instructional quality and students' outcomes (Kunter et al., 2013). Based on the notion of competence (Weinert, 2001a), the TEDS-M study investigated the professional knowledge as well as affective-motivational characteristics of (prospective) mathematics teachers. Summarizing the international state-of-the-art, Blömeke and

Delaney (2014) emphasized that in advance of TEDS-M there has been limited systematic research on teachers' professional knowledge.

Other research traditions have placed emphasis on revealing conditions of effective teaching practice close to real classroom situations. While also considering teaching as a "knowledge-intensive domain with different knowledge and affective-motivational resources" (Kaiser et al., 2015, p. 370), these research approaches focus on aspects of teachers' professional knowledge in use. Schoenfeld (1998) has contributed a theory of teaching-in-context and modeled teaching as a function of a teacher's knowledge, goals, and beliefs. Later, he extended his approach to a theory of goal-oriented decision-making and replaced the concepts of knowledge and beliefs by resources and orientations. Particularly, he pointed out that "the notion orientation / resource / goal clusters is a lens through which teacher activity can be examined — and studies of coherence and change along these dimensions could be very interesting and useful" (Schoenfeld, 2010, p. 194). In their "provisional framework for proficiency in teaching mathematics", Schoenfeld and Kilpatrick (2008) highlighted mathematics as a knowledge-intensive domain. For effective teaching, they considered as equally important knowledge about students' learning, managing adequate learning environments as well as substantially supporting classroom discourses. Ball et al. (2008) also demanded a practice-based theory of mathematical knowledge for teaching "to unearth the ways in which mathematics is involved in contending with the regular day-to-day, moment-to-moment demands of teaching" (p. 395).

Another line of research, drawing on expertise research (Berliner, 2001), elaborates on mathematics teachers' professional vision to describe and analyze their teaching practice (Jacobs et al., 2007, 2010; M. G. Sherin & van Es, 2005; van Es & Sherin, 2008). Although the definitions and conceptualizations used partly differ, teachers' abilities to analyze teaching are in the focus. As presented above, mathematics teachers' professional knowledge has been investigated differently. In their systematic review on pedagogical content knowledge, Depaepe et al. (2013) provided evidence for distinguishing a cognitive and a situated perspective:

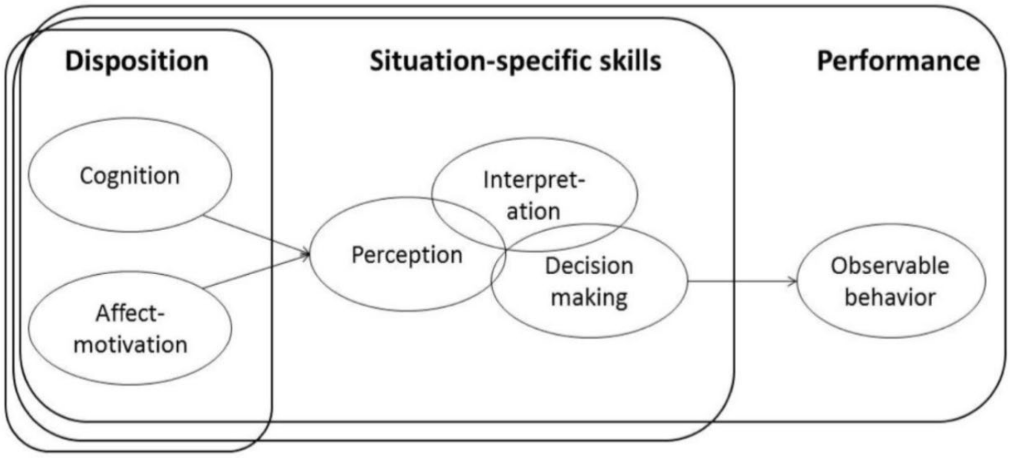
> Adherents of a cognitive perspective, in which PCK is conceived as a category of teacher's knowledge base, typically define – in line with Shulman – a limited number of components to be part of PCK and distinguish PCK from other categories of teachers' knowledge base, such as content knowledge and general pedagogical knowledge. By contrast, proponents of a situated perspective on PCK as knowing-to-act within a particular classroom context, typically acknowledge that the act of teaching is multi-dimensional in nature and that teachers' choices simultaneously reflect mathematical and pedagogical deliberations. (p. 22).

Based on their findings, Depaepe et al. (2013) demand a more integrated view on conceptualizing and assessing teachers' professional knowledge. Rowland and Ruthven (2011) already criticized that many research studies treat "mathematical knowledge for teaching as residing solely in the classroom teacher" (p. 2). Thus, the next section elaborates on the processes that link mathematics teachers' knowing and acting.

4.2.2 Relevance of Situation-Specific Skills

Depaepe et al. (2013) revealed several shortcomings for the two perspectives discussed above: Within the cognitive perspective, research on teachers' professional knowledge is disconnected from real classroom situations. Neither the socio-historical context nor the way different accounts of teacher knowledge interact were considered. Within the situated perspective, the sample sizes are often small and the findings have only limited validity. Also, teachers' choices during teaching and their justifications are not accessible by classroom observations only. Blömeke et al. (2015) emphasized the connection between teachers' cognition and affective-motivational beliefs (dispositions) and their teaching behavior (performance). For integrating a cognitive and a situated perspective, Blömeke et al. (2015) suggested considering competence as a continuum (cf. Figure 1).

Figure 1. *Competence modeled as a continuum (Blömeke, Gustafsson, et al., 2015, p. 5)*



The framework considers competence as a multidimensional construct, and resolves the dichotomy of disposition versus performance as follows: "[…] our notion of competence includes 'criterion behavior' as well as the knowledge, cognitive skills and affective-motivational dispositions that underlie that behavior" (Blömeke, Gustafsson, et al., 2015, p. 3). Following this understanding, a key role is assigned to situation-specific skills. That is, perception, interpretation and decision-making are linking teachers' professional knowledge to observable behavior.

So far, only a few studies have combined the two perspectives on teachers' professional knowledge. One prominent example is TEDS-FU. The study enriches the rather cognitive alignment of TEDS-M by assessing teachers' performances proximal to their classroom behavior (Kaiser et al., 2014). In TEDS-FU "professional experience, deliberate practice and the ability of perceiving essential details in class are included as well as aspects of performance like dealing with heterogeneity in a flexible manner" (Kaiser et al., 2015, p. 373). Drawing on the framework proposed by Blömeke et al. (2015a), Kaiser et al. (2015) elaborated on situation-specific skills relevant for teaching mathematics in their so-called PID-model: (P) Perceiving particular events in an instructional setting, (I) interpreting the perceived activities in the classroom and (D) decision-making, either as anticipating a response to students' activities or as proposing alternative instructional strategies (p. 374). The PID-model can be applied to reveal specific aspects as, for instance, teachers' diagnostic competence (Hoth et al., 2016).

Lindmeier et al. (2013) also integrated a cognitive and a situated perspective on teachers' professional knowledge. Their aim was "to capture facets of teacher cognition that go "beyond" knowledge in the sense that the scales depend on professional knowledge but mirror further abilities to use knowledge in typical teaching tasks" (p. 439). Particularly, teachers' abilities to address students' cognition, to cope with student's individual strategies and misconceptions, and to handle representations and explanations during instruction were analyzed. Although Lindmeier et al. (2013) did not refer explicitly to situation-specific skills, the aforementioned facets imply such aspects.

A situated perspective on teachers' knowledge emphasizes teachers' professional experiences, deliberate practice and ability to perceive and to attend to essential classroom situations (Putnam & Borko, 2000). Focusing on teachers' situation-specific skills draws attention to seminal research on teacher expertise (Berliner, 1992; Chi, 2011; Yeping Li & Kaiser, 2011). Research on situated skills such as perception accuracy (Carter et al., 1988) reveals how expert and novice teachers differ fundamentally in what and how they perceive classroom incidents. The concept of noticing addresses diverse facets of teacher expertise relevant for acting in the classroom (König, Blömeke, Paine, et al., 2014; van Es & Sherin, 2006). Teacher noticing builds on the notion of professional vision defined by Goodwin (1994) as "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (p. 606). Sherin et al. (2011b) have "focused on noticing as professional vision in which teachers selectively attend to events that take place and then draw on their existing knowledge to interpret these noticed events" (p. 80). The components of "attending to particular events in an instructional setting" and "making sense of an event in an instructional setting” are commonly shared among researchers interested in noticing (M. G. Sherin, Jacobs, et al., 2011). However, Sherin et al. (2011) emphasized that research purposes vary as studies address either the diversity of what teachers notice or teachers’ subject-specific expertise in depth. Making sense includes teachers’ interpretations of classroom events such as classroom discussions or students’ work. However, Sherin et al. (2011) emphasized that “it is not helpful to think of teacher noticing as simply another category of teacher knowledge. […] The word noticing names a process rather than a static category of knowledge” (p. 5). In their framework, van Es and Sherin (2002) define the concept of 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 the framework of van Es and Sherin (2002) is often referred to, interpretation and application of the construct vary substantially. First, although many researchers conceptualize noticing as attending to and making sense of particular events in the classrooms, there is no consensus on what making sense means. Second, there is a debate on the scope of the notion. For instance, Star and Strickland (2008) considered as teachers’ noticing “what catches their attention and what they miss […] when they view a classroom lesson” (p. 111). Jacobs et al. (2010) took a broader view on professional noticing as not only including teachers’ attention to and interpretation of classroom situations, but also teachers’ intended responding. Thus, the use of the concept of teachers’ noticing ranges from including perception solely, connecting perception with interpretation to also comprising decision-making.

4.2.3 Purpose of This Study

Teachers’ situation-specific skills are processes linking their professional knowledge and performance. Systematically reviewing research on mathematics teachers' situation- specific skills is the aim of the study. Thereby, the following research questions are pursued:

Research Question 1: What situation-specific skills are investigated in empirical research in mathematics education?

Research Question 2: To what theoretical frameworks does empirical research on mathematics teachers' situation-specific skills refer?

Research Question 3: What designs and methods are used to assess perception, interpretation and decision-making of mathematics teachers?

Research Question 4: What results do the studies on situation-specific skills offer?

4.3 Method

A systematic review (Petticrew & Roberts, 2008) of the research literature was conducted using the three databases ERIC, PsycINFO and MathEduc. Since searching for the comprehensive but rather specific term “situation-specific skills” (typeset between quotation marks to ensure that the entire term is included in the searching process) had not led to any significant results, the term was decomposed into corresponding concepts. Thus, the processes perception, interpretation and decision-making were addressed by searching[9] for “perception*”, “attending”, “interpret*”, “decision*”, “notic*, “professional vision”, “situated”, and “video-based”. In addition, overarching concepts were included by referring to the search strings “competenc*”, “knowledge”, “skill*”, “education”, and “cognition”. Since the systematic review is focused on (prospective) teachers in the domain of mathematics, the mandatory search terms “math*” and “teach*” were additionally considered. In addition, one term concerning processes and one term concerning concepts was obligatory.[10] The search was carried out across the titles, keywords, and abstracts included in the databases. The search was restricted to peer-reviewed journal articles (written in English) published between January 1st, 1995 and January 31st, 2016. Applying these initial search criteria ensures a broad spectrum of high quality international research.

In total, the search algorithm yielded 1418 results (1001 in ERIC, 437 in PsycINFO, 549 in MathEduc; among them 569 duplicates retrieved from two or all three databases). The contributions in this special issue – if matching the criteria – were also

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[9] By using truncation characters at the end of terms (*) it is specified that the search algorithm of ERIC, PsycINFO, and MathEduc includes all possible word endings, particularly plural forms or gerund (e.g. teacher, teachers or teaching)

[10] Combination of search fields in detail (for ERIC): TI, AB, IF (teach* AND (competenc* OR knowledge OR skill* OR education OR cognition) AND (perception* OR attending OR interpret* OR decision* OR noticing OR notice OR "professional vision" OR situated OR “video-based“) AND math*).

included. The articles matching the search terms were then checked for six exclusion criteria (EC):

(EC1) The article reports empirical data. Editorials, (narrative) literature reviews, discussion papers, theoretical articles or commentaries were excluded as they do not provide information on their database (in sum 304 articles).

(EC2) The focus of the study is on teacher variables. Thus, articles focusing on student achievement, student motivation or emotion, students' gender or ethnicity, parents' involvement, parents' views, or parents' socio-economic status were excluded (in sum 293 articles).

(EC3) The article's context is teaching mathematics in pre- to secondary school or in tertiary education. Thus, studies focusing on other subjects (e.g. science, engineering, arts or social studies), on special education or mathematic education for other professions (e.g. medicine) were excluded (in sum 173 articles).

(EC4) The article investigates teachers' cognition or practice embedded in mathematics. Therefore, articles on curriculum (reform), on policy as well as articles evaluating software, specific materials or specific lesson designs were excluded (in sum 332 articles).

(EC5) The study investigates aspects of teachers' cognition or practice that are specific for teaching mathematics. Hence, studies dealing with general pedagogical topics such as classroom management or technical skills (even if conducted in mathematics lessons) were excluded (in sum 60 articles).

(EC6) The article is concerned with investigating situation-specific skills. Thus, articles using perception in the sense of an attitude or opinion, contributions that dealt with decisions on a higher level (e.g. curriculum decisions) as well as studies assessing teachers' knowledge from a cognitive perspective only were excluded (in sum 205 articles).

Applying these criteria resulted in a final database of 60 research articles. Nine of these studies are published in this special issue. Each study was read and analyzed by two authors of this systematic review. The articles were reviewed and summarized with respect to the theoretical frameworks, research questions; sample sizes and characteristics of the participants; research designs and methods, and main results. With respect to investigating situation-specific skills and their relation to disposition and performance, a coding scheme was applied that distinguished between research on perception, interpretation and / or decision-making (a dichotomous coding for each aspect was applied with 0 = not investigated; 1 = investigated) and focus of research on skills per se, in relation to dispositions and / or performance (a dichotomous coding for each aspect was applied with 0 = not investigated; 1 = investigated). The percentages of agreement ranged between 75 % for decision-making and 86 % for interpretation with an agreement of 78 % for perception. For focus of research the coding showed substantial agreement: 78 % for situation-specific skills, 85 % for disposition and 82 % for performance. Disagreements were thoroughly discussed among the three authors until consensus was reached.

4.4 Results

In this section, the research questions of this systematic review are answered successively. First, situation-specific skills investigated in the studies are summarized (Sect. 4.4.1). Then, the theoretical frameworks referred to are analyzed (Sect. 4.4.2). Subsequently, the designs and methods used to assess perception, interpretation and decision-making are reported (Sect. 4.4.3). Finally, the main focus lies on analyzing the results the studies on situation-specific skills report (Sect. 4.4.4).

4.4.1 What Situation-Specific Skills are Investigated in Empirical Research in Mathematics Education?

Most of the studies investigated interpretation (78.3 %), the majority of studies perception (63.3 %) and about half of the articles researched decision-making (53.3 %). Research on teachers'[11] perception or interpretation varied from identifying the potential of mathematical tasks (Klymchuk & Thomas, 2011) and elaborating on student errors (e.g. Pankow et al., 2016) to recognizing instructional features in a classroom video (e.g. Star & Strickland, 2008). Decision-making was primarily accessed by asking teachers to respond to a classroom situation (e.g. Jacobs & Empson, 2016) or by analyzing teachers' planning and enactment of instructional decisions (e.g. Escudero & Sánchez, 2007). Studies often examined teachers' perception and interpretation (19 of 60 studies) or all three situation-specific skills (15 of 60 studies). Table 1 gives an overview of the teachers' situation-specific skills investigated and the material used.

[11] The term teachers is used for pre- and in-service teachers in this section, if not further specified.

Table 1. *Investigated aspects of teachers' situation-specific skills*

Author(s)	P[a]	I	D	Material used to assess teachers' situation-specific skills
Alsawaie and Alghazo (2010)	X	X		Video clips of mathematics lessons
Amador and Weiland (2015)	X	X		Student thinking in a mathematics lesson
Blömeke et al. (2015)	X	X	X	Video material of classroom situations Responding to classroom situations
Bruckmaier et al. (2016)			X	Responding to classroom situations on video
Colestock and Sherin (2009)	X	X		Video clips of teacher and students discussing mathematical ideas
Cooper (2009)	X	X	X	Errors and misconceptions in children's work Instructional strategies
Derry et al. (2007)		X		Students' solutions of multiple representations in algebraic tasks
Dreher und Kuntze (2015)		X		Written vignettes on multiple representations in of classroom situations
Dunekacke et al. (2015)	X		X	Video clips of mathematics-related situations Planning actions to foster mathematical learning
Dunekacke et al. (2016)	X		X	Video clips of mathematics-related situations Planning actions to foster mathematical learning
Dyer and Sherin (2016)		X	X	Teaching a mathematics lesson
Escudero and Sánchez (2007)			X	Planning lessons and instructional adaptions in the classroom
Fernández et al. (2013)	X	X		Students' problem solving in written answers
Gal (2011)	X	X	X	Students' difficulties during instruction Coping with difficulties during instruction
Galant (2013)		X	X	Mathematical content of multiplication tasks Sequencing of tasks for teaching
Hines and McMahon (2005)		X		Students' proportional reasoning strategies in written answers
Ho and Tan (2013)		X		Classroom practices
Hoth et al. (2016)	X	X	X	Video clips of classroom situations and written student solutions Responding to classroom situations and students
Houssart (2000)	X	X		Mathematical tasks (partly) on pattern
Huang and Li (2012)	X	X		Video material of two mathematics lessons (prize-winning vs. traditional)
Ingram (2014)	X	X		Video material of teaching sequences with mathematical/pedagogical focus and four reactions to each sequence
Jacobs and Empson (2016)			X	Teaching mathematics lessons
Jacobs et al. (2010)	X	X	X	Student thinking in video and written work Problem to be posed next
Jakobsen et al. (2014)		X		Students' work on a task
Kersting (2008)	X	X	X	Video clips of classroom episodes of teacher helping behavior/ student mistakes Alternative teaching strategies
Kersting et al. (2016)	X	X	X	Video clips of classroom episodes of teacher helping behavior/ student mistakes Alternative teaching strategies
Klymchuk and Thomas (2011)	X			Mathematical tasks
Knievel et al. (2015)	X	X	X	Video material of classroom situations and written student solutions Responding to classroom situation or student solution
Lande and Mesa (2016)			X	Animations of community college classroom situations
Lee and Kim (2005)	X	X		Mathematical problems
Magiera et al. (2013)	X	X		Algebraic tasks and students thinking in written solutions
Nickerson and Masarik (2010)		X	X	Tasks and student responses Pedagogical moves
Norton et al. (2011)		X		Student thinking in video
Osmanoglu et al. (2015)	X	X		Quality of instruction, activities and student thinking in lesson video
Pankow et al. (2016)	X	X		Student error(s) in written solutions
Paterson et al. (2011)			X	Teaching a mathematics lecture
Roth McDuffie et al. (2014)	X	X		Students' mathematical knowledge bases shown in a lesson video

Author(s)	P[a]	I	D	Material used to assess teachers' situation-specific skills
Sánchez-Matamoros et al. (2015)		X		Students' understanding revealed by written solutions
Santagata (2009)	X	X	X	Student thinking and understanding in lesson video Alternative teaching strategies
Santagata and Yeh (2016)	X	X	X	Video material of classroom episodes Responding to classroom episodes
Santagata et al. (2007)	X	X	X	Video clips of mathematics lessons Responding to classroom episodes
Schack et al. (2013)	X	X	X	Children's mathematical thinking in a video clip Problem to be posed next
Sherin and van Es (2005)	X	X		Video material of mathematics lessons
Sherin and van Es (2009)	X	X		Video material of mathematics lessons
Sherin et al. (2008)	X	X	X	Video material of mathematics lessons Selection of noteworthy clips
Sleep (2012)	X	X	X	Teacher's own lesson on video Planning and teaching of a mathematics lesson
Son (2013)		X	X	Students' error(s) in written teaching situations Responding to student errors
Son and Kim (2015)			X	Mathematical tasks from textbook and their enactment in teaching
Son and Sinclair (2010)		X	X	Students' error(s) in written teaching situations (I) Responding to student errors (D)
Star and Strickland (2008)	X			Instructional features of a classroom video (P)
Stockero (2008)	X	X		Video clips of students solving tasks (P; I)
Stockero and Van Zoest (2013)			X	Pivotal teaching moments (D)
Thomas and Yoon (2014)			X	Teaching a mathematics lesson (D)
van Es and Sherin (2002)	X	X		Video material of mathematics lessons (P; I)
van Es and Sherin (2006)	X	X		Video material of mathematics lessons (P; I)
van Es and Sherin (2008)	X	X		Video material of mathematics lessons (P; I)
Wager (2014)	X	X	X	Children's participation in lesson on video (P; I) Responding to children's participation (D)
Weiland et al. (2014)	X	X		Students' thinking in formative assessment interviews (P; I)
Zahner et al. (2012)		X	X	Students' conceptual understanding and error(s) in a lesson (I) Responding to student contributions and error(s) in a lesson (D)
Zimmerman (2015)			X	Teaching a mathematics lesson (D)

[a] P = Perception; I = Interpretation; D = Decision-making.

4.4.2 To What Theoretical Frameworks Does Empirical Research on Mathematics Teachers' Situation-Specific Skills Refer?

The studies referred to a variety of concepts or constructs in their theoretical frameworks. Teachers' noticing or teachers' professional vision, and teachers' (situated) professional knowledge were the most frequent frameworks. About half of the studies (31 studies) were related to teachers' professional knowledge, and used a relevant framework. Several studies focused on PCK with respect to a specific mathematical theme such as fractions or proportional reasoning (e.g. Houssart, 2000; Jakobsen et al., 2014; Son, 2013; Son & Sinclair, 2010). Other studies investigated multiple facets of teachers' professional knowledge, including teachers' situation-specific skills

(Blömeke, Hoth, et al., 2015; Bruckmaier et al., 2016; Dunekacke et al., 2015, 2016; Knievel et al., 2015).

Numerous studies (26 studies) referred to teachers' noticing or professional vision in their framework. Drawing on the noticing framework by van Es and Sherin (2002), most of these studies included perception and interpretation. Other studies considered noticing as merely being perception (Star & Strickland, 2008) or as additionally including decision-making (Jacobs et al., 2010; Schack et al., 2013). Three studies took a theme-specific perspective and investigated teachers' noticing of multiple representations (Dreher & Kuntze, 2015), mathematics problem solving (Fernández et al., 2013) or the derivative (Sánchez-Matamoros et al., 2015). Further concepts or constructs referred to were lesson analysis (Amador & Weiland, 2015; Santagata, 2009; Santagata et al., 2007) and teachers' resources, goals and orientations (Paterson et al., 2011; Thomas & Yoon, 2014; Zimmerman, 2015).

4.4.3 What Designs and Methods are Used to Assess Perception, Interpretation and Decision-Making of Mathematics Teachers?

This section reports on the samples included as well as the research designs and methods used to access teachers' situation-specific skills. Additionally, they were coded for assessing teachers' dispositions or performances in relation to situation-specific skills.

4.4.3.1 Sample Size and Characteristics of the Participating Teachers

Table 2 reports sample sizes (i.e. the number of participants included in the data analysis), characteristics of the participants (pre-service teachers, in-service teachers and teacher trainers/lecturers) as well as school level (defined by the grades that the participating teachers taught or for which they were certified). The studies analyzed very different sample sizes with N = 1 being the minimum (case studies) and N = 676 being the maximum (Kersting et al., 2016). The mean sample size is 56.35 participants (*SD* = 106.50) and the median is 19.50 participants. About half of the studies focused on pre- or in-service teachers' situation-specific skills (28 and 26 studies). Only five studies included pre- and in-service teachers. Of these five studies two analyzed differences between pre- and in-service teachers' situation-specific skills (Dreher & Kuntze, 2015; Jacobs et al., 2010). One study concentrated on the development of primary teachers and thus reported data ranging from the last year of teacher education to 4 years of teaching experience (Blömeke, Hoth, et al., 2015). With regard to school level, about half the studies assessed elementary, middle or secondary school teachers, respectively. Only a few studies investigated pre-school teachers (Dunekacke et al., 2015, 2016) or higher education teachers or lecturers' situation-specific skills (Paterson et al., 2011; Thomas & Yoon, 2014).

Table 2. *Sample and school level of participants*

	N[a]	Pre-service teachers	In-service teachers	Teacher trainer/ educator	School level (certification)				
					Pre school	Elementary[b]	Middle[c]	Secondary[d]	Higher education
Alsawaie and Alghazo (2010)	26 (13)	X					X	X	
Amador and Weiland (2015)	32	X	X	X		X			
Blömeke et al. (2015)[e]	231	X	X			X			
Bruckmaier et al. (2016)	284		X				X	X	
Colestock and Sherin (2009)	15		X				X	X	
Cooper (2009)	86	X				X	X		
Derry et al. (2007)	20/10		X				X		
Dreher and Kuntze (2015)	144	X	X				X	X	
Dunekacke et al. (2015)	354[f]	X			X				
Dunekacke et al. (2016)	354[f]	X			X				
Dyer and Sherin (2016)	2		X					X	
Escudero and Sánchez (2007)	2		X					X	
Fernández et al. (2013)	36	X				X			
Gal (2011)	1	X					X		
Galant (2013)	46		X			X			
Hines and McMahon (2005)	11	X					X	X	
Ho and Tan (2013)	2		X	X		X			
Hoth et al. (2016)	133		X			X			
Houssart (2000)	26		X			X			
Huang and Li (2012)	20		X					X	
Ingram (2014)	19	X				X	X	X	
Jacobs and Empson (2016)	1		X			X	X		
Jacobs et al. (2010)	131	X	X			X			
Jakobsen et al. (2014)	49	X				X			
Kersting (2008)	62	X	X			X	X	X	
Kersting et al. (2016)	676		X			X	X		
Klymchuk and Thomas (2011)	203		X					X	X
Knievel et al. (2015)	85		X			X			
Lande and Mesa (2016)	20		X						X
Lee and Kim (2005)	22	X				X			
Magiera et al. (2013)	18	X				X	X		
Nickerson and Masarik (2010)	4		X				X		
Norton et al. (2011)	42 (19)	X				X			
Osmanoglu et al. (2015)	15	X				X			
Pankow et al. (2016)	137		X				X		
Paterson et al. (2011)	8		X						X
Roth McDuffie et al. (2014)	73	X				X	X		
Sánchez-Matamoros et al. (2015)	8	X						X	
Santagata (2009)	33		X				X		
Santagata and Yeh (2016)	3	X				X			
Santagata et al. (2007)	35/30	X					X	X	
Schack et al. (2013)	94	X				X			
Sherin and van Es (2005)	4/12[g] (6)	X	X				X	X	
Sherin and van Es (2009)	4/7[g]		X			X	X		
Sherin et al. (2008)	1		X					X	
Sleep (2012)	17	X				X			
Son (2013)	57	X				X	X	X	
Son and Kim (2015)	3		X			X	X		
Son and Sinclair (2010)	54	X				X			
Star and Strickland (2008)	28	X					X	X	

	N[a]	Pre-service teachers	In-service teachers	Teacher trainer/ educator	School level (certification)				
					Pre school	Element-ary[b]	Middle[c]	Second-ary[d]	Higher education
Stockero (2008)	21	X					X	X	
Stockero and Van Zoest (2013)	6		X				X	X	
Thomas and Yoon (2014)	1		X					X	
van Es and Sherin (2002)	12[g]	X					X	X	
van Es and Sherin (2006)	7[g]/6		X			X			
van Es and Sherin (2008)	11 (4)		X			X			
Wager (2014)	13		X			X			
Weiland et al. (2014)	2	X				X			
Zahner et al. (2012)	3		X				X		
Zimmerman (2015)	6	X					X	X	

[a] *N* refers to the number of participants analyzed. When more than one study is reported the samples are marked by a /; When participants were partly assigned to a control group the number is given in ( ).

[b] Studies involving teachers from grade 1 to grade 4 were categorized as 'elementary school'.

[c] Studies involving teachers from grade 5 to grade 8 were categorized as 'middle school'.

[d] Studies involving teachers from grade 9 to grade 13 were categorized as 'secondary school'.

[e] Blömeke et al. (2015) report longitudinal data of primary school teachers from their last year of teacher education to 3 years in the profession.

[f] Studies report on the same sample, but conducted different analysis.

[g] Studies report on the same sub-sample.

4.4.3.2 Research Design and Methods

The studies differ with respect to their research design and the methods used to investigate situation-specific skills. Studies that included only one or a few teachers and reported results case-wise were categorized as case studies. Studies investigating the effects of some form of intervention (e.g. a professional development course) were categorized as intervention studies. Studies conducted to confirm hypotheses or presumptions were categorized as confirmatory studies. The research methods used to assess situation-specific skill were tests[12], questionnaires[13], interviews, lesson observations, other observations (e.g. observation of discussions), and the analysis of documents (reflection papers, lesson plans or homework assignments). Table 3 gives an overview of the research designs and methods.

[12] Instruments were categorized as tests, when they were (partly) derived from already validated instruments or provided information on reliability and validity of the instrument applied. Furthermore, assessments composed of mathematical tasks teachers had to solve were categorized as tests.

[13] Video-based assessments with open-end format as well as interviews that were conducted in written format were categorized as questionnaires.

Table 3. *Research designs and methods used*

	Research design	Research methods: Test	Questionnaire	Interview	Lesson observation	Other observation	Analysis of documents	D/P
Alsawaie and Alghazo (2010)	I						X	
Amador and Weiland (2015)	I					X		
Blömeke et al. (2015)	CO	K; B; X						D
Bruckmaier et al. (2016)	CO	K; B; X						D; P
Colestock and Sherin (2009)	CO			X				
Cooper (2009)	CO						X	
Derry et al. (2007)	I	K				X	X	D
Dreher and Kuntze (2015)	CO	K	X					D
Dunekacke et al. (2015)	CO	K; X						D
Dunekacke et al. (2016)	CO	K; B; X						D
Dyer and Sherin (2016)	CA			X	X			P
Escudero and Sánchez (2007)	CA			X	X			D
Fernández et al. (2013)	CO		X					
Gal (2011)	CA		B	X	X		X	P
Galant (2013)	CO			X				D
Hines and McMahon (2005)	CO			X			X	
Ho and Tan (2013)	CA				X			
Hoth et al. (2016)	CO		X [a]					D
Houssart (2000)	CO			X				
Huang and Li (2012)	CO		X					
Ingram (2014)	CO					X		
Jacobs and Empson (2016)	CA				X	X		P
Jacobs et al. (2010)	CO		X					D
Jakobsen et al. (2014)	CO		X					D
Kersting (2008)	CO	X						D
Kersting et al. (2016)	CO	X						D
Klymchuk and Thomas (2011)	CO		X					
Knievel et al. (2015)	CO	K; X						D
Lande and Mesa (2016)	CO					X		
Lee and Kim (2005)	I		X	X			X	
Magiera et al. (2013)	CO	K		X		X	X	D
Nickerson and Masarik (2010)	I			X				
Norton et al. (2011)	I	X						D
Osmanoglu et al. (2015)	I			X			X	
Pankow et al. (2016)	CO	X						
Paterson et al. (2011)	CA			X	X		X	
Roth McDuffie et al. (2014)	I					X	X	
Sánchez-Matamoros et al. (2015)	I		X					
Santagata (2009)	I	K	X				X	D
Santagata and Yeh (2016)	CA	X		X	X			P
Santagata et al. (2007)	I		X				X	
Schack et al. (2013)	I		X					
Sherin and van Es (2005)	I					X	X	
Sherin and van Es (2009)	I			X	X	X		P
Sherin et al. (2008)	CA			X	X			
Sleep (2012)	CO			X	X			
Son (2013)	CO	K	X					D
Son and Kim (2015)	CA		X	X	X			D; P
Son and Sinclair (2010)	CO	K	X					D
Star and Strickland (2008)	I		X					
Stockero (2008)	I					X	X	
Stockero and Van Zoest (2013)	CO				X			P
Thomas and Yoon (2014)	CA			X	X		X	P
van Es and Sherin (2002)	I						X	
van Es and Sherin (2006)	I			X				
van Es and Sherin (2008)	I			X		X		
Wager (2014)	I						X	D
Weiland et al. (2014)	CA					X		P
Zahner et al. (2012)	CO				X			P
Zimmerman (2015)	CO			X	X			

Note. CO confirmatory study, CA case study, I intervention study, D disposition, P performance, K method to capture knowledge from a cognitive perspective, thus not situated, B method to capture beliefs.

[a] Hoth et al. (2016) used items of TEDS-FU, but conducted a qualitative analysis of open-ended answers.

4.4.3.3 What is the Specific Situation?

The studies drew on rather different situations ranging from interpreting mathematical tasks (e.g. Galant, 2013) to deciding upon teaching moves during instruction (Jacobs & Empson, 2016). Studies investigating teachers' situated PCK primarily used written documents of students' work (e.g. Hines & McMahon, 2005; Son, 2013). Some studies applied videos of students solving tasks (e.g. Knievel et al., 2015; Stockero, 2008) or participating in an assessment interview (Weiland et al., 2014).

Studies analyzing teachers' noticing mostly used video of classroom situations (e.g. Colestock & Sherin, 2009; R. Huang & Li, 2012; M. G. Sherin & van Es, 2009; Star & Strickland, 2008; van Es & Sherin, 2008). Exceptions were those studies that investigated theme-specific noticing by written documents of students' work (Dreher & Kuntze, 2015; Fernández et al., 2013; Sánchez-Matamoros et al., 2015). A few studies used a combination of both written documents of students' work and video of classroom situations (Hoth et al., 2016; Jacobs et al., 2010; Knievel et al., 2015). Some studies took different approaches such as animations (Lande & Mesa, 2016) or lessons to be observed live or taught (e.g. Amador & Weiland, 2015; Jacobs & Empson, 2016; Santagata & Yeh, 2016). Table 1 reports the situations used to investigate teachers' situation-specific skills.

4.4.3.4 Are Teachers' Situation-Specific Skills Investigated in Relation to Their Dispositions or Teaching Performance?

A study that included cognitive or affective-motivational aspects (e.g. content knowledge or beliefs) in the data analysis was considered to investigate dispositions. For coding the studies as including performance data, a rather strict criterion was applied. Only if data of actual teaching and instruction practice had been reported, the study was coded accordingly. About one-third of the studies analyzed teachers' dispositions (i.e., their knowledge or beliefs). Twelve studies were concerned with teachers' performance. Of these studies two reported data on teachers' dispositions and their teaching practice (Bruckmaier et al., 2016; Son & Kim, 2015). Table 3 indicates whether studies included aspects of dispositions or performance in their data analysis.

4.4.4 *What Results do Studies on Situation-Specific Skills Offer?*

The studies report on a variety of results due to the different aspects of situation-specific skills investigated. Thus, in order to maintain clarity and comprehensibility, the results of the studies are summarized with respect to similar constructs or concepts and aims. The findings are presented along the following research lines: (1) teachers' skill to notice classroom situations, (2) teachers' skill to perceive, interpret and respond to students' mathematical thinking, (3) teachers' situation-specific skills embedded in practice, (4) teachers' situation-specific skills in relation to their knowledge (or other dispositions) and (5) and teachers' skill to perceive and interpret mathematical tasks and their educational potential. Studies reporting different aspects of situation-specific skills were allocated to several foci. The emphasis is on studies reporting quantitative results: Effect sizes are presented if reported in the studies or, if possible, were calculated based on the data reported[14]. Case studies or qualitative data are briefly summarized as well.

4.4.4.1 Teachers' Skill to Notice Classroom Situations

A large part of the studies included in this systematic review address mathematics teachers' noticing or teachers' professional vision. Some of these studies investigated teachers' noticing with a focus on students' mathematical thinking, whereas other studies took a broader perspective on noticing. The findings indicate what and

[14] Effect sizes (Cohens' *d* or *r*) are reported, if given in the studies or if they could be calculated from presented data. When structural equation models were used in the studies, standardized coefficients (βs) are reported. When latent class analysis was conducted, odds are reported. Information about significance is provided, when presented in the studies.

how teachers notice and how teachers' noticing can be improved (Table 4). Studies allocated to this research line took a rather situated approach. Several studies revealed that what teachers notice in a classroom as well as how teachers notice classroom events is related to their expertise and teaching experience. Experienced or expert teachers tended to show higher levels of noticing or noticed more events (Dreher & Kuntze, 2015; Fernández et al., 2013; R. Huang & Li, 2012; Jacobs et al., 2010). Ho and Tan (2013) found a researcher's and a teacher's professional vision of the same lessons to differ. Studies considering decision-making as a component of pre-service teachers' noticing showed this skill to be the least developed (Jacobs et al., 2010; Schack et al., 2013). Ingram (2014) described how teachers notice differently when discussing teaching videos on mathematical or pedagogical situations, whereas Colestock and Sherin (2009) provided evidence that different teachers used rather similar sense-making strategies when viewing video of classroom situations.

Many studies reported on successful interventions to foster teachers' noticing: A majority of these studies provided evidence for improving pre-service and in-service teachers' noticing skills with video-based training tools (Alsawaie & Alghazo, 2010; Osmanoglu et al., 2015; Roth McDuffie et al., 2014; Schack et al., 2013; M. G. Sherin & van Es, 2005, 2009; Star & Strickland, 2008; van Es & Sherin, 2002, 2006, 2008; Wager, 2014). Other contributions provided evidence for different formats of professional development (Amador & Weiland, 2015; Sánchez-Matamoros et al., 2015).

Table 4. *Results of the studies examining teachers' skill to notice classroom situations*

References	Design (N)[a]	Focus	Findings
What and how do teachers notice?			
Huang and Li (2012)	CO (20)	Noticing of mathematics classroom events	Expert teachers paid more attention (than novice teachers) to Developing mathematical thinking and ability (r = 0.73***) Developing knowledge coherently (r = 0.55**) Teachers' enthusiasm and passion (r = 0.51**) Developing higher-order thinking (r = 0.41*) Students' participation (r = 0.37*) Novice teachers paid more attention (than expert teachers) to teachers' effective guidance (r = −0.37*)
Jacobs et al. (2010)	CO (131)	Professional noticing of children's mathematical thinking	Four groups (with growing level of expertise) with significant monotonic trend in Attending to children's strategies (d = 0.58 − d = 0.66) Interpreting children's understanding (d = 0.49 − d = 1.06) Deciding how to respond on the basis of children's understanding (d = 0.88 − d = 0.99)
Dreher and Kuntze (2015)	CO (144)	Theme-specific noticing (theme: multiple representations)	ISTs and PSTs showed low frequency of theme-specific noticing ISTs showed still higher theme-specific noticing than PSTs (d = 0.72**) *Dispositions* and theme-specific noticing The view that changing between representations is necessary for understanding showed a positive relation to theme-specific noticing for ISTs (r = 0.32**) Specific CK and theme-specific noticing showed a positive relation for PSTs (r = 0.25*)
Fernández et al. (2013)	CO (36)	Noticing of students' mathematical thinking	Level of PSTs' noticing of students' mathematical thinking (proportional and un-proportional reasoning) Most teachers were on level 1: No discrimination of proportional and additive problems (25 of 39 PSTs or 64 %) Only few PSTs were on higher levels (level 2, 3 and 4)
Colestock and Sherin (2009)	CO (15)	Sense-making strategies/noticing	Substantial overlap in what different ISTs notice Substantial overlap in strategies used to make sense of classroom instruction
Ho and Tan (2013)	CA (2)	Professional vision	The researcher developed the following categories to capture professional vision: heuristics-instruction, teaching of concepts and skills, going over assigned work, allocating class time for student activities The teacher did not characterize his teaching the way the researcher did
Ingram (2014)	CO (19)	Professional vision	When events in the video shifted to mathematics, PSTs focus changed from themselves as teachers to the learners (conversely for video on classroom management issues) After PSTs watched video of possible reactions to a classroom situation, comments became more evaluative and interpretative
Fostering teachers' noticing by using video			
Roth McDuffie et al. (2014)	I (73)	Noticing of students' multiple mathematical knowledge bases	Video-case activity improved PSTs depth of noticing and moved their foci from attending primarily to teacher moves to becoming aware of significant interactions
Osmanoglu et al. (2015)	I (15)	Noticing of teacher actions	PSTs' noticing of teacher actions that reflect specific domains of teacher knowledge (CK, PCK, GPK) increased over time (by online discussions and video case-based activities)

References	Design (N)[a]	Focus	Findings
Schack et al. (2013)	I (94)	Noticing of children's early numeracy	Five-session-module with video-excerpts of diagnostic interviews improved PSTs noticing significantly from pre- to post-assessment: Attending: $d = 0.79^{***}$ Interpreting: $d = 0.82^{***}$ Deciding: $d = 1.29^{***}$
Sherin and van Es (2005)	I (4/12 (6))	Noticing	Study 1: Video club participation shifted ISTs attention from pedagogy to students mathematical thinking Study 2[b]: PSTs working with VAST (video analysis support tool) developed more interpreting stance and showed more evidence-based comments
Sherin and van Es (2009)	I (4/7)	Professional vision	Participation in one of the two video clubs (Nile and Mapleton) influenced ISTs noticing as exhibited in video club meetings, interviews and during instructional practice
Star and Strickland(2008)	I (28)	Noticing	PSTs participating in a methods course using video (among other activities) showed Significant general improvement of noticing ability Significant improvement in four of five categories of noticing: classroom environment; tasks; mathematical content; communication
van Es and Sherin (2006)	I (7/6)	Noticing	Results for Mapleton club cf. Sherin and van Es (2009) Wells Park club: ISTs started with a narrow range of noticing and developed a range of perspectives for discussing the video segments.
van Es and Sherin (2008)	I (11 (4))	Noticing	There were three paths identified along which ISTs learned to notice (all reaching a narrow vision): Direct, cyclical and incremental
Alsawaie and Alghazo (2010)	I (26 (13))	Analyzing mathematics teaching	PSTs participating in course (including case-methods and video analysis) learned Paying attention to student learning Interpreting classroom events (not merely describing or evaluating) Making connections between classroom events and the NTCM vision of teaching and learning
Wager (2014)	I (13)	Noticing children's participation	Two groups of ISTs identified based on the number of comments: Frequent noticers (FN) and emergent noticers (EN): Groups showed significant differences in the components of noticing (attending, interpreting, responding)
Fostering teachers' noticing by other interventions			
Amador and Weiland (2015)	I (32)	Professional noticing	PSTs' development while participating in the lesson study Initially, PSTs focused on student thinking in 33 % of their comments Focus on student thinking dropped to 18.8 % in the fifth lesson Concerning the last lesson, about 33 % of the comments again addressed student thinking
Sánchez-Matamoros et al. (2015)	I (8)	Noticing of students understanding of the derivative concept	PSTs' levels of noticing of students' understanding increased after participating in the teaching module on students' understanding of the derivative concept

Note. CO confirmatory study, I intervention study, CA case study, PST pre-service teacher, IST in-service teacher.

* $p < .05$; ** $p < .01$; *** $p < .001$.

[a] N refers to the number of participants analyzed. When more than one study is reported the samples are marked by a/; When participants were partly assigned to a control group the number is given in ().

[b] The same results are reported in van Es and Sherin (2002) and will not be presented repeatedly.

4.4.4.2 Teachers’ Skill to Perceive, Interpret and Respond to Students’ Thinking

Twelve studies examined mathematics teachers’ perception and interpretation of students’ thinking or products of students’ thinking and their responding to students’ work. The results give insight into teachers’ ability to identify errors and to interpret students’ solutions. They also provide information on how to improve teachers’ ability to analyze students thinking. Table 5 provides an overview of the results.

There was evidence in the included studies that pre-service teachers had difficulties in perceiving and interpreting students’ errors and solutions. This applied especially for common misconceptions or student errors (Hines & McMahon, 2005; Jakobsen et al., 2014; Pankow et al., 2016; Son, 2013; Son & Sinclair, 2010). Some studies indicated that teachers’ skills to perceive and interpret students’ solutions and mathematical thinking were related to their professional knowledge. Teachers’ own difficulties with mathematics tasks influenced their perception and interpretation (Hoth et al., 2016; Jakobsen et al., 2014; Magiera et al., 2013). Teachers’ proposed instructional strategies for dealing with students’ misconceptions or errors seemed to rather focus on reteaching (Cooper, 2009) or showing students’ how to do it correctly (Son, 2013). Other studies reported on promising formats to improve teachers’ situation-specific skills with regard to student thinking, among them video-based approaches or contrasting case activities (Derry et al., 2007; Nickerson & Masarik, 2010; Norton et al., 2011; Stockero, 2008; Weiland et al., 2014).

Table 5. *Results of the studies examining teachers' skill to perceive, interpret and respond to students' thinking*

References	Design (*N*)[a]	Focus	Findings
Teachers' perception, interpretation and responding to student thinking			
Hines and McMahon (2005)	CO (11)	Proportional reasoning strategies	PSTs considered students' solutions as developmentally advanced, if equations were used or a routine problem solving procedure was consistently applied
Magiera et al. (2013)	CO (18)	Solutions of algebraic tasks	PSTs' own algebraic thinking was related to their ability to recognize students' overall ability during one-to-one interviews, but were not related to their ability to analyze students' overall ability based on written solutions
Jakobsen et al. (2014)	CO (49)	Elementary students' work on fraction task	PSTs had difficulties in solving fraction tasks PSTs revealed difficulties in making sense of solutions different from their own solution
Son and Sinclair (2010)	CO (54)	Elementary students' errors in geometric tasks	30 of 54 PSTs (56 %) identified students' errors to be based on conceptual aspects of reflection rather than on procedural aspects About the same number or PSTs coped with these errors by invoking procedural knowledge (22 of 54 PSTs or 41 %) or conceptual knowledge (25 of 54 PSTs or 46 %), respectively
Son (2013)	CO (57)	Errors (ratio and proportion in similar rectangles)	Over half of PSTs identified students' errors as being linked to procedural aspects of similarity, although the errors were linked to conceptual aspects of similarity These PSTs proposed interventions focused on procedure-based instruction Pedagogical strategies were majorly showing or telling how. Using the student's error was proposed by less than half of the PSTs
Cooper (2009)	CO (86)	Computation al errors	All PSTs could identify the error pattern 67 of 86 of PSTs (80 %) proposed a reasonable rationale 54 of 86 of PSTs (67 %) proposed some form of "reteach" as an instructional strategy (e.g. focusing on procedures or simplifying the problem)
Pankow et al. (2016)[b]	CO (137)	Student's error	Non-complex tasks ISTs that correctly and ISTs that falsely identified the error, showed a short anticipation time. Complex tasks ISTs that correctly identified the error showed a longer anticipation time (i.e. are slower in identification) Significant differences in anticipation time between correct and false answers for the three most complex tasks: $d = -0.7^{***}$; $d = -0.4^{*}$; $d = -0.8^{*}$
Hoth et al. (2016)[b]	CO (133)	Diagnostic competence	ISTs coped with diagnostic tasks during teaching differently Different perspectives in perceiving and solving diagnostic situations could be reconstructed: a content-related mathematical perspective and a student-related, more pedagogical perspective *Dispositions*: ISTs taking a content-related perspective tended to have higher mathematics content knowledge and general pedagogical knowledge
How can teachers' perception, interpretation and responding to student thinking be improved?			
Derry et al. (2007)	I (20/10)	Algebraic thinking	Contrasting case activities improves ISTs' analysis of student work in terms of Sophistication of description of representation/solution ($d = 0.87^{*}/d = 1.5^{**}$) Inferences about students' ability and understanding ($d = 0.95^{**}/d = 1.39^{**}$) Pedagogically useful inferences about students' mathematical trajectory ($d = 1.17^{**}/d = 1.41^{**}$). No improvement of teachers' metacognitive reflections
Nickerson and Masarik (2010)	I (4)	Middle-school students' work	The professional development program improved PSTs' interpretive power. PSTs showed shifts in their ability to anticipate students' responses
Norton et al. (2011)	I (42 (19))	Video of students' solving tasks	PSTs participating in iterative model building" course (IMB) vs. control group Video-based prediction assessment rubric for CK, model (of

References	Design (N)[a]	Focus	Findings
			students' thinking), prediction (accuracy and detail) and use of model Components of assessment rubric (apart from CK) correlated with participation in IMB course Components interactions were stronger after participation in IMB course
Stockero (2008)	I (21)	Linear functions	PSTs participated in video-based curriculum for "Learning and Teaching Linear Functions" (LTLF) PTSs started to analyze teaching in terms of how it affects students' thinking, to consider multiple interpretations of student thinking and to develop a more tentative stance of inquiry PSTs' reflective stance improved during the video curriculum and transferred to their course field experience
Weiland et al. (2014)	CA (2)	Formative assessment	PSTs developed their questioning practice within the context of a face-to-face interaction with students PSTs showed two areas of questioning practice needing improvement: asking leading questions and missing opportunities to probe students' thinking

Note. CO confirmatory study, I intervention study, CA case study, PST pre-service teacher, IST in-service teacher.

[*] $p < .05$; [**] $p < .01$; [***] $p < .001$.

[a] N refers to the number of participants analyzed. When more than one study is reported the samples are marked by a/; When participants were partly assigned to a control group the number is given in ().

[b] The study is to be published in this special issue.

4.4.4.3 Teachers' Situation-Specific Skills Embedded in Practice

Most of the studies reporting on teachers' in-the-moment decision-making were case studies or reported mainly qualitative data. The same applies to those studies that investigated teachers' situation-specific skills close to practice. Three studies in this review explored the effects of lesson study on teachers' situation-specific skills. An overview on the studies that explored teachers' situation-specific skills embedded in practice is provided in Table 6.

Table 6. *Results of the studies examining situation-specific skills embedded in practice*

References	Design (*N*)[a]	Focus	Findings
Teachers' situation-specific skills embedded in practice (and their development)			
Gal (2011)	CA (1)	Development after course	One IST expanded and deepened her understanding of students' ways of thinking She increased her awareness of her students' processes of thinking to identify their difficulties She enhanced her ability to retrieve and utilize knowledge while making instructional decisions
Santagata and Yeh (2016)[b]	CA (3)	Development of beginning teachers' competence	While at each moment in time teachers' own understanding of mathematical ideas and their beliefs about children's mathematics learning informed their sense making, interviews also highlighted how teachers sometimes made decisions based on particular instructional approaches recommended by their colleagues or required by their school leadership
Escudero and Sánchez (2007)	CA (2)	Knowledge integration in decisions	ISTs had similar backgrounds and experiences but showed differences in the domains of knowledge they integrated into their planning decisions as well as their decisions during instruction
Paterson et al. (2011)	CA (8)	Lecturer decisions	Schoenfeld's framework of resources, goals and orientations tended to be useful for explaining lecturers' decisions
Thomas and Yoon (2014)	CA (1)	Lesson on graphical antiderivatives	Presents details of one teacher's resources, orientations, and goals and how this was related to resolutions of the conflict between his competing goals and the decisions he made.
Zahner et al. (2012)	CO (3)	Lesson on interpreting graphs of motion	The more successful ISTs allowed time for students to use the curriculum and software and discuss it with peers. They used formal mathematical discourse along with less formal language, and they responded to student errors using higher-level moves
Lande and Mesa (2016)[b]	CO (20)	Lesson on trigonometry	Both groups of faculty members (full-time and part-time) justified their decisions in similar ways; the way in which they talked differed Part-time faculty members' language was more tentative, which hints at their tenuous status in their institutions
Sleep (2012)	CO (17)	Steering instruction towards the mathematical point	Steering instruction towards the mathematical point involves several tasks, e.g. Attending to and managing multiple purposes Developing and maintaining a mathematical storyline Keeping focus on meaning
Stockero and Van Zoest (2013)	CO (6)	Pivotal teaching moments (PTMs)	Study developed a preliminary framework for helping teachers to learn to identify and respond to PTMs that occur during instruction Results highlight the importance of preparing teachers to understand the mathematical terrain their students are traversing, to notice high-leverage student mathematical thinking and to act productively on that thinking
Zimmerman (2015)	CO (6)	Practical intentions	Different practical intentions often occurred simultaneously Four prominent intentions: the desire to maintain lesson momentum; the desire to cover content; the desire to support student needs; and the desire to foster independent student thinking
Sherin et al. (2008)	CA (1)	Professional vision in action	Study investigated a new technology to study professional vision in action (small head-camera) that allowed the teacher to capture clips of events he considered as noteworthy The collected clips varied from whole class discussions, small group work, and student presentations to teacher talk Reasons for selecting these clips were student thinking, discourse, teacher moves, teacher strategies and student engagement

References	Design (*N*)[a]	Focus	Findings
Dyer and Sherin (2016)[b]	CA (2)	Responsive teaching	Three types of instructional reasoning about interpretations of student thinking used by the ISTs: making connections between multiple specific moments of student thinking, considering the relation between the mathematics of student thinking and the structure of a mathematical task, and developing tests of student thinking
Jacobs and Empson (2016)[b]	CA (1)	Teaching moves	The study developed a framework with four major categories of teaching moves Ensuring the child is making sense of the story problem, exploring details of the child's existing strategy, encouraging the child to consider other strategies, connecting the child's thinking to symbolic notation
Fostering teachers' situation-specific skills with lesson study			
Amador and Weiland (2015)	I (32)	Lesson study	PSTs participating in the lesson study showed higher level of noticing than classroom teachers or university facilitators
Santagata (2009)	I (33)	Lesson study	ISTs encountered difficulties with questions on the basic understanding of target mathematics topics, knowledge of their students understanding, and the analysis of students' work and reasoning beyond classification into right and wrong answers
Santagata et al. (2007)	I (35/30)	Lesson study	PSTs' ability to analyze lessons improved significantly on all five criteria: elaboration, mathematics content, student learning, critical approach, and alternative strategies

Note. CO confirmatory study, I intervention study, CA case study, PST pre-service teacher, IST in-service teacher.

[a] N refers to the number of participants analyzed. When more than one study is reported the samples are marked by a/; When participants were partly assigned to a control group the number is given in ().

[b] The study is to be published in this special issue.

4.4.4.4 Teachers' Situation-Specific Skills in Relation to Their Knowledge (or Other Dispositions)

Some studies assessed teachers' perception, interpretation and decision-making with validated, standardized tests and in relation to dispositions. Most studies revealed evidence for the impact of CK, PCK or beliefs on teachers' situation-specific skills. Table 7 gives an overview of these findings.

Table 7. *Results of studies examining teachers' situation-specific skills in relation to dispositions*

References	Design (*N*)[a]	Findings
Dunekacke et al. (2015)	CO (354)	*Dispositions*: Pre-school PSTs' mathematical content knowledge (MCK) Was direct predictor of PSTs' perceptions of pre-school situations (β = 0.55*) Was an indirect predictor of PSTs' planning of actions and mediated by the perception of the situation (β = 0.43*) PSTs' perception of a situation was a predictor of their planning of actions (β = 0.95*)

References	Design (N)[a]	Findings
Dunekacke et al. (2016)[b]	CO (354)	*Dispositions* Pre-school PSTs' MCK could predict their mathematical pedagogical content knowledge (MPCK) (β = 0.45*) MPCK and an application orientation (epistemological belief) could predict perception (β = 0.60* and β = 0.29*) MPCK was an indirect predictor of PSTs' planning of actions and was mediated by the perception of the situation (β = 0.51*) PSTs perception of a situation was a predictor of their planning of actions (β = 0.94*)
Blömeke et al. (2015)	CO (231)	*Dispositions* Development of beginning primary teachers' knowledge/beliefs: significant increase of general pedagogical knowledge (GPK) and dynamic belief After 3 years of profession three profiles identifiable (unfavorable; regular and optimal profile) based on knowledge and beliefs Climate of trust in school reduced odds of having an unfavorable versus a regular profile (0.34*) and the odds of having an unfavorable versus a favorable profile (0.20**) Perception, interpretation and decision-making skills in mathematics teaching and in classroom management were significantly higher in the optimal profile than in the unfavorable profile
Bruckmaier et al. (2016)[b]	CO (284)	*Dispositions of ISTs* Situated reaction-competency (SCR) correlated with CK (r = 0.28**), PCK (r = 0.33**) and beliefs (constructivist belief: r = 0.26** and transmissive belief: r = −0.32**) SCR differed with school type (academic track > other school types: d = 0.51 and d = 1.34) *Performance* Subject-specific sub-competency showed significant relation with aspect of instructional quality (cognitive activation: β = 0.22)
Kersting (2008)	CO (62)	Development of classroom video analysis survey (CVA) to measure knowledge of teaching mathematics in concrete teaching situations Indications for reliability and validity of CVA Four rubrics: mathematics in the clip; student thinking; suggestions of improvement; overall interpretation depth and coherence Moderate correlation of CVA-Score with mathematical knowledge for teaching (paper-pen-test; r = 0.53**)
Kersting et al. (2016)[b]	CO (676)	Results of a different approach to the CVA instrument were reported. They are consistent with the view that usable teacher knowledge requires individual knowledge components as well as an overarching ability to access and apply those components that are most relevant in a teaching situation
Knievel et al. (2015)	CO (85)	Development of an instrument to measure teachers' subject-specific competences in and for teaching mathematics with threefold structure: basic knowledge (BK), action-related competence (AC) and reflective competence (RC) Indications for the reliability and validity of the instrument Moderate difference for RC and BK between elementary ISTs without and with certification for teaching mathematics (d = 0.63*** and d = 0.77***)
Norton et al. (2011)	I (42 (19))	Development of a video-based prediction assessment instrument as a measure of PSTs' ability to model students' mathematical thinking Indications for reliability and validity of instrument Prediction assessment rubric for CK, model (of students' thinking), prediction (accuracy and detail) and use of model Components of assessment rubric correlated with participation in "iterative model building" (IMB) course Components interactions are stronger (and all significant) after participation in IMB course

Note. CO confirmatory study, I intervention study, CA case study, PST pre-service teacher, IST in-service teacher.

* $p < .05$; ** $p < .01$; *** $p < .001$.

[a] N refers to the number of participants analyzed. When more than one study is reported the samples are marked by a/; When participants were partly assigned to a control group the number is given in ().

[b] This study is to be published in this special issue.

The studies allocated to this research line took a rather cognitive approach but included situated measures of teachers' situation-specific skills. The six studies provided evidence for linking teachers' dispositions and situations-specific skills. Dunekacke et al. (2016) showed that MCK and MPCK are predictors of pre-school teachers' perception of classroom situations and (mediated by perception) of their planning of actions. Similarly, Bruckmeier et al. (2016) reported correlations between situated reaction-competency and CK, PCK and beliefs. In addition, this study reported a significant relationship between a sub-facet of situated reaction-competency and aspects of teachers' instructional quality (Bruckmaier et al., 2016). Blömeke et al. (2015) provided evidence for the impact of knowledge, beliefs and a school climate of trust on beginning mathematics teachers' perception, interpretation and decision-making skills. Two studies revealed a strong interrelation of teachers' knowledge facets and situation-specific skills (Kersting et al., 2016; Norton et al., 2011). Kersting (2008) and Knievel et al. (2015) reported evidence on the reliability and validity of their developed instruments and found teachers' knowledge related to their situation-specific skills.

4.4.4.5 Teachers' Skill to Perceive and Interpret Mathematical Tasks and Their Educational Potential

Some studies focused on the material used during instruction. Studies on mathematical tasks found teachers' perceptions, interpretations and decision-making to differ partly from curriculum guidelines or research recommendations. Table 8 gives an overview of the results.

Three studies indicated that pre-service as well as in-service teachers struggled with differentiating routine from non-routine mathematics task and choosing adequate formats for fostering their students' learning (Galant, 2013; Klymchuk & Thomas, 2011; Lee & Kim, 2005). In addition, teachers' interpretation of task-related features (Houssart, 2000; Magiera et al., 2013) and their decision-making corresponded with their professional knowledge and beliefs about student thinking (Son and Kim 2015).

Table 8. *Results of studies examining teachers' skills to perceive and interpret mathematical tasks and their educational potential*

References	Design (*N*)[a]	Tasks	Findings
Magiera et al. (2013)	CO (18)	Algebraic tasks	PSTs recognized some features of tasks (to engage students in algebraic thinking) more often than other features Predicting pattern > chunking information (d = −1.38) Predicting pattern > different representation (d = −1.64)
Klymchuk and Thomas (2011)	CO (203)	Calculus tasks (advanced)	Most secondary ISTs and nearly all lecturers did not identify non-routine problems and found them suitable for year 13 students
Houssart (2000)	CO (26)	Tasks (partly) on pattern	The word "pattern" was used frequently Some ISTs had a more sophisticated view on pattern than others
Galant (2013)	CO (46)	Multiplication tasks	Eight of 46 ISTs (17 %) chose the "advanced" tasks as the first to be done
Son and Kim (2015)	CA (3)	Tasks in textbooks	Analysis revealed four particular aspects that are related to teachers' decisions on selecting and enacting textbook problems Match between beliefs and goals and these of the textbooks, views on the textbooks, interpretation of state curriculum framework and assessment, and knowledge or orientation toward student thinking
Lee and Kim (2005)	I (22)	Good problems	Majority of PSTs rated routine problems as good After input/discussion most PSTs would have changed ratings, but expected difficulties in utilizing non-routine problems

Note. CO confirmatory study, I intervention study, CA case study, PST pre-service teacher, IST in-service teacher.

[a] N refers to the number of participants analyzed. When more than one study is reported the samples are marked by a/; When participants were partly assigned to a control group the number is given in ().

4.5 Conclusion and Discussion

This systematic review reported on 60 empirical research studies on teachers' situation-specific skills. These studies, published in English-speaking peer-reviewed journals, were selected based on a systematic search in the databases ERIC, PsycINFO and MathEduc as well as in this Special Issue. The systematic review was guided by the following research questions: *What situation-specific skills are investigated in empirical research in mathematics education? To what theoretical frameworks does empirical research on mathematics teachers' situation-specific skills refer? What designs and methods are used to assess perception, interpretation and decision-making of mathematics teachers? What results do the studies on situation-specific skills offer?*

Regarding the first research question, most studies investigated interpretation (47 studies), followed by perception (38 studies) and decision-making (32 studies). One-third of the studies explored perception and interpretation. One quarter of the studies analyzed all three situation-specific skills. With concern to the second research question, the studies referred to two main theoretical frameworks that are teachers' noticing and teachers' (situated) professional knowledge. Only a few studies combined both frameworks. Articles included in this review were case studies, intervention studies or confirmatory studies. These studies used a variety of methods to investigate pre-service and in-service teachers' situation-specific skills, ranging from standardized tests to observing teachers during instruction. Only a few studies combined diverse methods or compared pre- and in-service teachers' situation-specific skills.

The last research question addressed the results obtained by the studies. The results revealed evidence for the significance of expertise or experience on teachers' noticing. Pre-service teachers tend to have difficulties in perceiving or interpreting students' work. These skills seemed to be influenced by their level of mathematical knowledge. A noteworthy finding is that video-based professional development programs can foster teachers' noticing successfully.

Decision-making appeared to be most challenging for pre-service teachers. Teachers' showed deficits in terms of proposing instructional strategies to foster students' understanding that go beyond "showing how to do it right". Case studies revealed the complexity of teachers' in-the-moment decision-making. Based on these studies, factors hypothesized to influence teachers' decisions were ranging from teachers' knowledge, beliefs to goals. These hypotheses were confirmed in studies assessing the relations between teachers' knowledge, beliefs and situation-specific skills by using standardized tests and large samples. The studies provided evidence for MCK, MPCK and beliefs being predictors of situation-specific skills, which in turn correlate with aspect of instructional quality.

Based on selection and restriction criteria, this review systematically searched for and included empirical studies. Due to the specific selection and restriction criteria applied, this review might be biased. First, the limitation to English-speaking empirical journal articles may have caused a possible bias. Excluding all non-English articles could have resulted in overlooking substantial research published in other languages. Second, the search terms (individually or combined) as well as the inclusion or exclusion criteria might have impacted the sensitivity and specificity of the search. Due to the diverse terms and concepts used in mathematics education research, the search strategy–especially combining the different terms–might have led to a specific subset of studies. On the one hand, studies that analyze situation- specific skills, but use terms other than the chosen search terms, could have been missed. On the other hand, the criteria for including papers into the systematic review were rather lenient. That is, articles were included that investigated situation-specific skills but did not explicitly refer to perception, interpretation, and decision-making.

This article is published in the ZDM - Mathematics Education Special Issue on "Perception, interpretation and decision-making: Understanding the missing link between competence and performance". The studies of this special issue report on important and diverse topics. In case they met the review criteria, the articles were included in the review. Several studies taking a rather cognitive approach (i.e. measuring teachers' professional knowledge) and a strongly situated approach (i.e. observing teachers' practice) were considered. The three commentary papers in this issue by Mason, Schoenfeld and Scheiner (2016) discuss the contributions of the special issue thoroughly and emphasize a huge variance on the two levels of theoretical considerations and methodological choices. This systematic review has a broader frame, as the last 20 years of empirical research in mathematics education were analyzed. Some striking observations were made in terms of conceptual clarity: across the studies different terms were used for the same aspect as well as the same terms were used for different aspects. The same lack of clarity can be observed in the theoretical frameworks used. For instance, the definitions of noticing and what situation-specific skills constitute noticing vary strongly. As Jacobs et al. (2010) stated, "researchers define noticing in a multitude of ways, but the connecting thread is making sense of how individuals process complex situations" (p. 171).

The different terminologies and conceptualizations of situation-specific skills also impact on how perception, interpretation and decision-making are studied empirically. In their systematic review on PCK, Depaepe et al. (2013) pointed out that measurements can be distinguished along the cognitive and situated perspective, that is:

> Advocates of a cognitive perspective on PCK believe it can be measured independently from the classroom context in which it is used, most often through a test. […] Adherents of a situated perspective on PCK, on the contrary, typically assume that investigating PCK only makes sense within the context in which it is enacted. (p. 22).

In this systematic review, the distinction between a cognitive and a situated perspective on teachers' professional knowledge is even more challenging when it comes to methodological approaches. There is a growing body of research developed from a cognitive perspective that reflects upon situation-specific skills as *knowledge-*

based skills which are applied in contexts approximating classroom situations (Blömeke, Gustafsson, et al., 2015; Kaiser et al., 2014). These approaches developed standardized video-based instruments displaying classroom situations closer to practice but not embedded in practice. Other studies investigated teachers' behavior near or in the classroom and considered teacher knowledge as integral part of teaching. Studies that investigate the long-term development of teachers' situation-specific skills *and* include both perspectives are scarce: So far only Blömeke, Hoth, et al. (2015) have conducted a longitudinal study.

This review shows that a considerable body of research contributions dealing with perception, interpretation and decision-making from either a cognitive or a situated perspective already exists. Comprehensive and integrative approaches that connect teachers' situations-specific skills to teachers' competence in terms of professional knowledge and performance are scarce yet. Research would highly benefit from combining both a cognitive and a situated perspective not only theoretically but methodologically as well. In this respect, Kersting (2016) aptly emphasizes:

> Understanding what mathematics teachers need to know, and what it takes to be able to apply that knowledge in the classroom, is critical for helping teachers improve their practice and their students' learning. For years, imprecise and inconsistent use of terminology, a lack of well-developed theories, and a paucity of measures hampered progress toward this goal (p. 1).

The initial aim of this systematic review was to explore teachers' situation-specific skills, i.e., perception, interpretation and decision-making. These skills display the missing link between mathematics teachers' dispositions (professional knowledge, affective motivational features) and their performance (observable behavior) (Blömeke, Gustafsson, et al., 2015). Approaching teachers' situation-specific skills from a rather cognitive or situated perspective led to substantial research findings. These two approaches could be brought closer by acknowledging the respective advantages and findings. Existing frameworks and methods might be used to develop integrative research designs that allow for dealing more effectively with the complexity of teaching.

In this systematic review, research on situation-specific skills in mathematics education research was analyzed. Following Petticrew's (2015) reflections, systematically reviewing research contributions concerning teachers' situation-specific skills does not provide a comprehensive overview on "what works", but rather describes "what happens" in this field. Having mapped this landscape, researchers can now proceed to direct research in this area onto solid ground where reliable findings can advance teaching practice.

5 Study 2 – Novice and Expert Teachers’ Noticing of Classroom Management Events in Whole-Group and Partner Work Activities: Evidence from Teachers’ Gaze and Identification of Events

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Highlights:

- Eye-tracking was used to examine how teachers perceive classroom situations
- Novice and expert teachers' noticing of classroom management was compared.
- Expertise was characterized by a focus on students.
- Noticing of experts and novices varied by instructional format.
- The partner work format was more challenging for novice teachers.

Abstract: This eye-tracking study investigates how novice and expert teachers' noticing of classroom management events differs in two formats of instruction. 20 novices and 20 experts participated in the study, watching short video clips of whole-group and partner work teaching situations. Their retrospective verbal reports were analyzed for events identified as note-worthy along with their allocation of visual attention as indicators of their noticing. Experts noticed more classroom management events in the partner work format than novices. Furthermore, their noticing was characterized by a focus on student-related events. Similarly, their gaze prioritized students more than novices', particularly in the partner work format. In contrast, novice teachers' attention was more drawn to the teacher in both formats of instruction. The results show that expertise in teachers' noticing of classroom management is characterized by a focus on students with the partner work format being more challenging for novice teachers.

Keywords: Teacher Expertise | Classroom Management | Professional Noticing | Visual Expertise | Eye Tracking

5.1 Introduction

Teaching is a domain that is characterized by multidimensionality, simultaneity and immediacy, thus teachers must respond quickly to various demands in the classroom (Doyle, 2006; Sabers et al., 1991). In order to react adaptively in a teaching situation, they do not only need relevant knowledge but also situated skills to be able to transform their knowledge into practice (Blömeke, Gustafsson, et al., 2015). One important situated skill is teacher noticing, which is their knowledge-based ability to selectively attend to and to notice relevant events in a classroom situation (Star & Strickland, 2008; van Es & Sherin, 2002). Many studies about teachers' content-related noticing revealed insights into teachers' skills, in particular, remarkable differences between novice and expert teachers noticing (Stahnke et al., 2016).

Yet, concerning classroom management (CM) as an important generic aspect of teaching, recent research on teachers' noticing is less comprehensive. Being able to notice critical events during instruction is particularly relevant with regard to CM, because it poses situated and spontaneous challenges to teachers that call for immediate action (Doyle, 1986, 2006). Initial results indicate a key role of such skills, as they seem to predict teachers' CM performance better than their pedagogical knowledge about CM (König & Kramer, 2016).

To identify characteristics of expertise, novice-expert comparisons are an established research approach in several domains (Chi, 2006), often also investigating participants' allocation of visual attention to relevant areas (Gegenfurtner et al., 2011).

Although such comparisons have the potential to provide new insights into the characteristics of teachers' skills and their development, this approach has only recently been applied to teachers' noticing of CM. Analyzing teachers' visual attention to and verbal analysis of classroom video clips, these recent studies yielded partly contradictory results (van den Bogert et al., 2014; Wolff et al., 2016; Yamamoto & Imai-Matsumura, 2013).

Prior research focused particularly on behavioral management (i.e. preventing and dealing with student misbehavior) in sequences of whole-group instruction. While this is a core aspect of teachers' CM practice, for other dimensions of CM - e. g. instructional management or teacher-student relationships - as well as other formats of instruction with distinct demands on teachers' CM (Doyle, 2006) further research is needed.

Against this background, the objective of our study is to investigate novice and expert teachers' noticing of CM events in video clips displaying two different instructional formats (whole-group instruction and partner work) and including CM events that go beyond behavioral CM. Thereby, we want to provide insights into format-specific expertise differences in teachers' noticing, thus expanding the current state of research focusing on behavioral management and whole-group formats with regard to teachers' noticing of diverse CM events in different formats of instruction.

5.2 Theory

5.2.1 Novice and Expert Teachers' Noticing of Classroom Events

One way to learn more about the nature and development of skills are expert-novice comparisons (Chi, 2006). Early studies on general characteristics of teacher expertise showed that expert teachers can deal better with the simultaneity, multidimensionality and immediacy that characterizes a classroom than novice teachers (Sabers et al., 1991). They are able to monitor events, to integrate information fast and to interpret what happens in a classroom (Carter et al., 1988; Copeland et al., 1994; Sabers et al., 1991). Overall, Berliner (2001, 2004) events and having faster and more accurate recognition in their domain than novices. Recently, studies started to use eye-tracking methods in order to analyze novice and expert teacher general allocation of attention in the classroom (Beach & McConnel, 2019; Jarodzka et al., 2017). With regard to teachers' visual attention during teaching (as measured with eye tracking glasses), experts prioritized students with their gaze (McIntyre et al., 2019; McIntyre & Foulsham, 2018) and distributed their attention more evenly between individual students than novice teachers (Cortina et al., 2015). To what extent these results also apply to CM events, in particular to different formats of instruction, is not clear yet.

The superior performance of experts is not only be based on teachers' knowledge, but also on their situations-specific skills (Blömeke, Gustafsson, et al., 2015; Lachner et al., 2016). During the development from novice to expert, the initially isolated and explicit knowledge base of novices is restructured and evolves towards more integrated and organized scripts (Boshuizen et al., 2020; Lachner et al., 2016; Wolff et al., 2020). Teachers' noticing, reasoning and acting skills help to apply these scripts to situations that are not pre-structured (Lachner et al., 2016). Thus more generally speaking, the three skills of perception, interpretation and decision-making play an important role when teachers' knowledge needs to be put into performance in a specific classroom situation (Blömeke, Gustafsson, et al., 2015). The skills are nevertheless knowledge-based as teachers' knowledge and scripts guide their noticing or interpretation of important events as well as their decisions on how to act (Lachner et al., 2016).

The present study particularly focusses on teachers' *noticing* as the first of these three skills which is defined as attending to and identifying what is important in a classroom situation (Star & Strickland, 2008; van Es & Sherin, 2002). One important aspect of teachers' noticing is their visual attention to relevant areas of a classroom scene, as this allocation of attention is necessary in order to be able to identify important aspects of a scene. Thus, analyzing teachers' gaze as an operationalization of teachers' noticing in addition to their identification of note-worthy events is a promising approach (Seidel et al., 2020).

5.2.2 Classroom Management

CM is an important indicator of instructional quality (Charalambous & Praetorius, 2018) and has positive effects on students' academic, social and emotional learning (Korpershoek et al., 2016). It has also an impact on the well-being of teachers, as CM is one of the most common concerns of pre-service (Kaufman & Moss, 2010) as well as beginning teachers (Chaplain, 2008).

Since Kounin's early studies (1970) it has been evident that a good classroom manager not only reacts appropriately to student misbehavior or disengagement but also prevents such behavior from occurring or spreading (Bear, 2015; Brophy, 1986; Doyle, 2006; Kounin, 1970). Expanding this focus on *student discipline* with *student learning*, Martin and Sass (2010) proposed two dimensions of CM: Behavioral management includes teachers' reaction to student misbehavior and efforts to prevent it; instructional management focusses on teachers' instructional aims and methodologies. Furthermore, recent research proposed that more attention should be given to affective-motivational learning (e. g. motivation of students or teacher-student relationships) (Bear, 2015; Schwab & Elias, 2015; Wubbels et al., 2015). Thus, in this study we apply such a comprehensive understanding of CM as the "actions teachers take to create an environment that supports and facilitates both academic and social-emotional learning" (Evertson & Weinstein, 2006, p. 4).

Teachers' CM behavior is often classified as either *reactive* (following misbehavior or disengagement) or *preventive* (preventing misbehavior and supporting student learning with e. g. routines, monitoring, or building of student-teacher relationships) (Clunies-Ross et al., 2008; Piwowar et al., 2013). Both types of strategies are essential for managing a classroom (Korpershoek et al., 2016; Simonsen et al., 2008). Yet, novices seem to be mostly concerned about student discipline and behavior control (Kaufman & Moss, 2010) and report to use reactive strategies more frequently than preventive strategies (Reupert & Woodcock, 2010). However, reactive CM is correlated with higher teacher stress as well as a decrease in students' on-task behavior (Clunies-Ross et al., 2008).

Being able to apply a broad repertoire of CM strategies adaptively is particularly important because different formats of instruction pose different challenges (Doyle, 2006). In whole-group instruction, the teacher needs to monitor the flow of the lesson as well as student learning and student behavior on the group level. In contrast, during periods of partner work or small group work the teacher has to observe many individual students or student groups, determine their learning progress and be available for individual student questions (Doyle, 2006). Thus, these formats can place high demands on teachers' noticing.

5.2.3 Teachers' Noticing of Classroom Management

Managing a classroom poses unpredictable and spontaneous challenges to teachers that call for immediate action (Doyle, 1986, 2006). Therefore, noticing relevant CM events is a particularly important skill in this context. Addressing this area of research with standardized test instruments, studies revealed that teachers' situated skills were significantly positively related to teachers' level of expertise (Gold & Holodynski, 2015; König & Kramer, 2016). Furthermore, teachers' CM skills predicted their CM performance better than their pedagogical knowledge (König & Kramer, 2016). However, standardized test instruments lack the immediate and spontaneous character that makes noticing with regard to CM challenging for teachers (Doyle, 1986). Studies analyzing teachers' spontaneous noticing of CM events without directed questions along with their gaze address this challenge in an ecologically more valid way.

Concerning teachers' spontaneous noticing of events, expert teachers generally focus more on student learning while novice teachers talk more about student discipline (Wolff et al., 2015, 2017). However, the video clips used in these studies focused on behavioral CM and did not investigate how many and which specific events were noticed. On the contrary, analyses were limited to teachers' comments about those events that were frequently noticed by both novice and expert teachers (Wolff et al., 2015, 2017). Focusing on one event only, Yamamoto and Imai-Matsumura (2013) found no differences between novices' and experts' noticing of student misbehavior (two students not closing their textbook after being instructed to do so) in a video clip of whole-group instruction where the teacher was not visible.

Regarding teachers' gaze as one aspect of noticing, studies differed considerably in their methodology, yet also mainly focused on behavioral problems. In the study by Yamamoto & Imai-Matsumura (2013), no expertise effect was found for teachers' gaze. In contrast, choosing video clips "representative of typical classroom behavior" that "require(s) teacher intervention" (p. 210), van den Bogert and colleagues (2014) found that expert teachers tended to distribute their visual attention more evenly across student groups in those segments of video clips where many CM-related events were frequently noticed by both groups. However, only few differences between both groups were found for segments where no events were happening or only experts noticed CM events. Wolff et al. (2016) compared novice and expert teachers' visual processing of CM in whole-group instruction without the teacher being visible. Experts attended more to areas showing students and classroom activity than novices. Wolff et al. (2020) concluded in a recent theoretical model on teachers' CM scripts that novice teachers' classroom perception is more image-driven (i.e. bottom-up processing) while experts' is more knowledge-driven (i.e. top-down processing), thus allowing them to direct their attention to informative areas. While novices consciously monitor classroom activity and engagement focusing on student behavior, experts monitor classroom activity automatically in terms of engagement and student learning based on their CM knowledge and scripts (Wolff et al., 2020). If such differences can also be observed beyond behavioral CM and in different formats of instruction has not been investigated yet.

Regarding the format of instruction, a recent study on teachers' diagnostic skills found more expertise effects in teachers' visual attention to different student profiles for a seatwork sequence in comparison to a whole-group sequence (Seidel et al., 2020). The authors argued that bottom-up drivers of visual attention are more salient in a whole-group setting where teacher-student interactions take place and students raise their hands. In seatwork scenes, such salient drivers are absent, thus allowing expert teachers' knowledge and scripts to guide their perception top-down (Seidel et al., 2020).

5.3 Research Questions

The current study aims to expand the state of research on teachers' noticing of CM, which has so far focused on whole-group instruction and behavioral management. More specifically, this study investigates how novice and expert teachers' noticing of CM events differs regarding whole-group instruction and partner work in teaching situations that display events beyond behavioral management. Three aspects of teachers' noticing are of particular interest: their *identification* of note-worthy CM events, their *visual attention to student groups or the teacher* as well as their *visual attention to specific CM events*. Thus, the three research questions (RQ) are:

RQ 1: Do novice and expert teachers differ in their identification of note-worthy CM events in whole-group instruction vs. partner work?

Based on prior research, we assume experts, firstly, to generally notice more CM events than novices, particularly in the partner work scene as it is more demanding with respect to teachers' monitoring (Doyle, 2006) and allows top-down processing (Seidel et al., 2020). Secondly, novices are expected to notice more events relating to reactive CM and student discipline, while experts notice more events focusing on preventive CM and student learning (Kaufman & Moss, 2010; Wolff et al., 2020). Since partner work requires a broader range of CM strategies (Doyle, 2006; Reupert & Woodcock, 2010), we expect that these expertise differences show up more clearly in this format.

RQ 2: Do novice and expert teachers differ in their gaze directed at student groups and the teacher in whole-group instruction vs. partner work?

Against the background of prior research, expertise effects are expected to be generally weaker for the whole-class setting than partner work, as visual processing should be more bottom-up in the first setting for both groups (Seidel et al., 2020). Nevertheless, in both formats novice teachers can be expected to pay more attention to the teacher than experts, who in turn can be assumed to attend more to students (McIntyre et al., 2019; Wolff et al., 2020).

RQ 3: Do novice and expert teachers differ in their gaze directed at specific CM events in whole-group instruction vs. partner work?

Based on the few results available (Yamamoto & Imai-Matsumura, 2013), there are no differences expected between novices and expert teachers' gaze directed at specific CM events. As formulated in the second research question, expertise is expected to guide experts' attention to potentially relevant broader areas (i.e. student groups), yet not at the granular level of specific CM events.

5.4 Methods

5.4.1 Participants

40 German pre-service and in-service secondary school teachers voluntarily participated in this study. Although CM is considered to be generic, this study focused on mathematics and biology teachers to reduce the possible impact of teachers' familiarity with typical contents or formats of instruction. Participants were recruited via multiple channels (e. g. professional development networks or university courses). Novices were defined as pre-service teachers in their master studies who had no teaching experience beyond the short practice phases included in their teacher education program. Expertise was defined by professional membership and experience, thus following recommendations of teacher expertise research (Caspari-Sadeghi & König, 2018; Palmer et al., 2005): Experts were required to have at least five years of teaching experience after finishing their teacher education program. Furthermore, they had to be selected for additional responsibilities and tasks in their schools (e.g. head of the biology department) or in teacher education (e.g. supervision of preservice teachers) as indicators of an external evaluation of their outstanding quality.

Data collection took place where teachers could arrange their participation best (at the lab in the university, at schools or at teachers' homes). Expert teachers were on average 20 years older (M_{age}= 45.10, SD = 9.69; 15 female, 5 male) than novices (M_{age}= 26.70, SD= 3.79; 12 female, 8 male). Novices were on average in their final semester of master studies ($M_{semester}$= 3.35, SD = 0.90) for becoming secondary school teachers for biology (N = 10) or mathematics (N =10). Experts had on average 18 years of teaching experience ($M_{experience}$= 18.30; SD = 10.89) after their teacher education program for either biology (N = 9) or mathematics (N = 11).

5.4.2 Material

Participants watched four short video clips (between 1 and 2 min long) from authentic biology and mathematics lessons in lower secondary classes in Germany. These lessons were taught by beginning to intermediate teachers who were expected to show both successful as well as more critical CM actions, thus resulting in many different observable CM events in the video clips. Video clips were selected in four steps: (1) First, video clips with low audio or video quality were excluded. (2) Eight clips showing CM events that display multiple CM aspects were selected by the first author, e.g. teachers' management of misbehavior, transparency and clarity, routines, motivation of students, or teacher-student relationships (cf. Piwowar et al., 2013 for rating scheme used). (3) These clips were rated by five experts from research and practice with respect to the observability of different CM aspects as well as general authenticity and typicality. The raters' expertise was in video-based research, CM research and teacher education. High ratings in authenticity and typicality should ensure that video clips were selected that do not feel staged and show representative situations of teachers' jobs regarding CM (Blömeke, Gustafsson, et al., 2015). (4) (4) Finally, four segments were selected based on experts' agreement on the occurrence of events, authenticity and typicality as well as the final set displaying multiple aspects of CM.

For the purpose of this paper, data analysis will focus on those two video clips where more CM events are visually observable (as opposed to audible events). In both video clips, nearly all students of the class and the teacher are visible. One video clip shows a whole-group activity: The teacher guides the comparison of solutions for math fraction problems. Students are taking turns at presenting at the smartboard, while the rest of the class should listen but is rather loud. The second video clip shows a partner work activity: The teacher walks through the classroom while students are working on an assignment on osmosis. Some students are distracted and not working on the assignment. Subject knowledge is not necessary for understanding what is going on in both sequences.

5.4.3 Procedure

The full experiment took between 45 and 75 minutes. After participants signed consent and release forms, the Miles Test (Holmqvist et al., 2011; Miles, 1929) was used to determine each participant's ocular dominance. Participants had normal or corrected to normal vision. A test trial followed to familiarize participants with the eye-tracking equipment and the retrospective reporting method. The eye-tracker was calibrated to participants' eyes before each video clip (9-point calibration). The order of video clips was incompletely counterbalanced.

While viewing a video clip for the first time, participants' eye movements were recorded. Participants were instructed to push a button every time they noticed a CM event they considered to be relevant (cf. van den Bogert et al., 2014). During the first viewing, the video could not be paused because we were interested in teachers' spontaneous noticing of and visual attention to classroom events.

Immediately after the first viewing participants saw the video clip again enriched by a visualization of their own prior eye movements. The video was paused at each timestamp and participants were instructed to report what they had noticed at this specific moment in the video clip. We chose retrospective reports instead of concurrent verbalizations due to the complexity of the task. However, teachers' initial thoughts were cued with the help of time stamps and by displaying their own prior eye movements. When concurrent verbalizations are not suitable, such a procedure can help to elicit verbalizations (Hyrskykari et al., 2008; van Gog et al., 2005).

Video clips were presented on a 20-inch display (1650x1050 pixels) using Experiment Center 3.7 (SensoMotoric Instruments, 2016b). A SMI RED-m eye tracker recorded participants' eye movements with a temporal resolution of 120 Hz. Retrospective reports were recorded with a camera attached to the screen.

5.4.4 Measures

5.4.4.1 Classroom Management Events Noticed

Retrospective reports were transcribed verbatim and coded consecutively by the first author using MAXQDA (VERBI Software, 2017). Since participants often reported more than one event per time stamp, the number of events identified in their reports was analyzed. Coding started with a list of noticeable events based on the expert rating which was also used for selecting the video clips. New codes were added when events were noticed that had not been reported before. Once verbal reports of all participants were coded, all codes were checked for consistency and refined if necessary. Smaller interrelated events were integrated into one event if they represented the same episode while codes were differentiated if they represented distinct events in close temporal or spatial proximity. For the first video clip 26 noticeable events were identified, and 30 events for the second video clip.

Each event noticed was categorized as one of four event types based on prior research on CM and CM strategies: Events where the teacher is the actor were categorized as a reactive teacher event (TR events: the teacher is or should be reacting to student disengagement or misbehavior), or a preventive teacher event (TP events: the teacher is or should be preventing student disengagement or misbehavior or supporting learning). Each event noticed was categorized as one of four event types based on prior research on CM and CM strategies: Events where the teacher is the actor were categorized as a reactive teacher event (TR events: the teacher is or should be reacting to student disengagement or misbehavior), or a preventive teacher event (TP events: the teacher is or should be preventing student disengagement or misbehavior or supporting learning). Events where one or more students are the actor are either a student discipline event (SD events: i.e. students are misbehaving or disengaged) or a student learning event (SL events: i.e. students are learning or their learning is supported or hindered) (see Appendix A for codes).

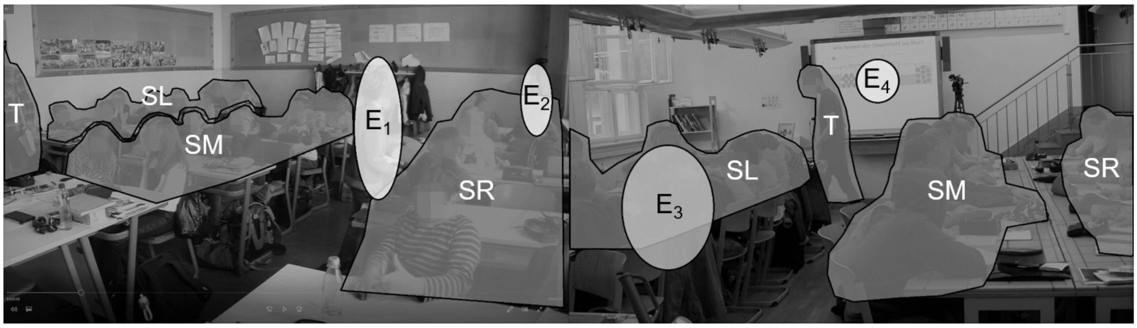
Two independent raters coded whether novices and experts did notice or did not notice these events for 10 % of all verbal reports. Interrater reliability was strong with κ_1= 0.81 (92.31%) for the first video clip and κ_2=0.87 (94.17%) for the second video clip (McHugh, 2012).

5.4.4.2 Teachers' Visual Attention to Student Groups and the Teacher

Participants' eye movement data were analyzed with BeGaze 3.7 (SensoMotoric Instruments, 2016a) with regard to their proportion of gaze and fixation count on predefined areas of the classroom. Fixations, where the eye remains relatively motionless (Holmqvist et al., 2011), were identified with a dispersion algorithm with a minimal duration of 80 ms and a maximum dispersion of 100 pixels.

To answer the second research question, proportions of gaze and fixation count were analyzed. For this purpose, areas of interest (AOIs) were defined for larger visually separated groups of students (three groups in each video on the right, in the middle and on the left side of the classroom) as well as the teacher (cf. Figure 2). The proportion of gaze represents a measure of participants' summarized dwell time (including fixations and quick scans) at an AOI relativized by the duration of the video clip. Areas with higher gaze proportions can be interpreted as more prioritized. Such measures have recently been used in teacher gaze studies (McIntyre et al., 2019). Similarly, we analyzed number of fixations on four AOIs as a second indicator of teachers' visual attention. A high number of fixations indicates that teachers' repeatedly allocated their attention to these areas (Holmqvist et al., 2011).

Figure 2. Areas of interest in the whole-group instruction (left) and the partner work format (right)



Note. SL = left student group, SM = middle student group, SR = right student group, T = teacher, E_1 = event 1 (student lingers and clowns around), E_2 = event 2 (student is raising hand and being ignored), E_3 = event 3 (two students fool around), E_4 = event 4 (timer on smartboard).

5.4.4.3 Teachers' Visual Attention to Classroom Management Events

With respect to the third research question, we focused on events that were clearly linked to specific visual areas of the classroom and noticed by at least five teachers, because these events were thus identified as relevant to CM by a considerable proportion of teachers. Again, AOIs were created manually: For the first video clip, we identified two events (cf. Figure 2): (a) a student lingers and clowns around while going back to his seat after presenting his solution (E_1); (b) a student in the back is raising her hand and is being ignored (E_2). For the second video clip, two events were identified as well: (c) two students fool around behind the back of the teacher (E_3); (d) a timer at the smart board shows the time remaining for the assignment (E_4). Teachers' proportion of gaze and fixation count on these AOIs were compared for novices and experts.

5.4.4.4 Statistical Analysis

Data analysis was conducted with SPSS 25. As the video clips were not controlled for complexity posed by the instructional format, effects of the level of expertise on dependent measures are investigated separately for whole-class instruction and partner work. Separate *t*-tests for independent samples or non-parametric Mann-Whitney tests were carried out. Dependent variables were inspected for outliers. There were no extreme outliers (data more than three interquartile ranges above the 75% quartile or under the 25% quartile). Shapiro-Wilk tests were carried out for all dependent variables within groups to find out whether the data were normally distributed. If a variable was not normally distributed, non-parametric tests were applied to examine our research questions[15]. If the homogeneity of variances was not given, adjusted values are reported.

An *a priori* power analysis was conducted using G*Power (Faul et al., 2007) with $\alpha = .05$ and power $(1-\beta) = .80$. There are only few studies available concerning expertise differences regarding teachers' gaze to meaningful areas that could guide this analysis. A recent study on teachers' skills with a similar design reported moderate to large effect sizes for the number of fixations on different student groups (Seidel et al., 2020). However, it should be noted that no prior effect sizes are available for proportions of dwell times. Assuming similar effect sizes, the sufficient sample size for independent *t*-tests ($d = 0.80$) is $N = 42$. Our sample size of 40 teachers is slightly smaller yielding an acceptable post-hoc power of $(1-\beta) = .799$ for t-tests.

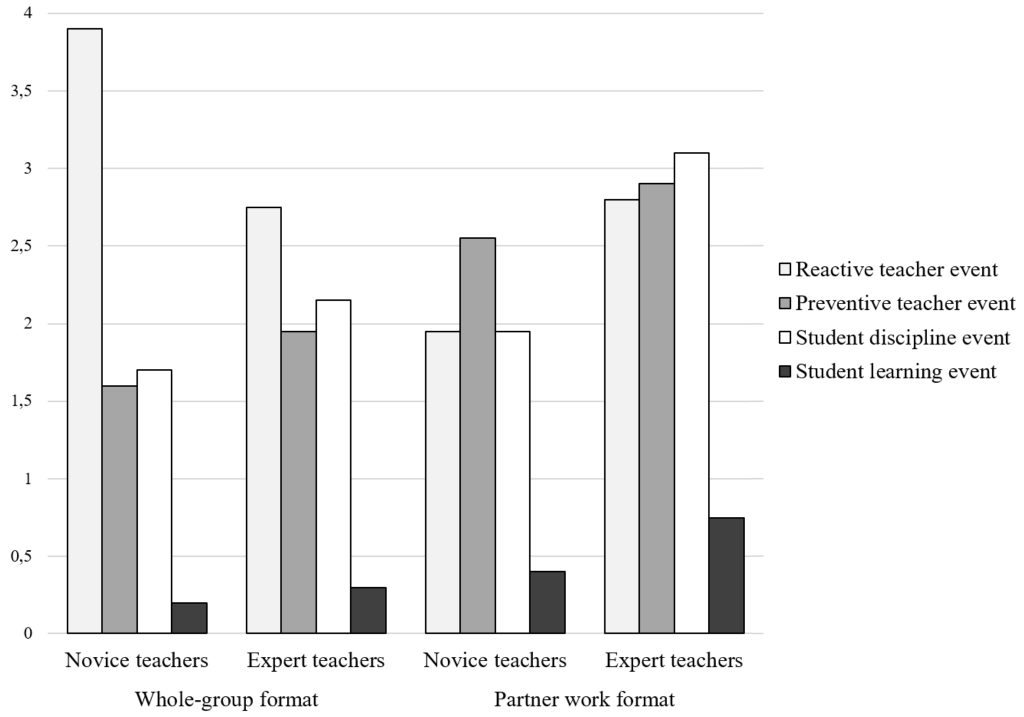
[15] Due to the relatively small sample size, non-parametric tests were also carried out for those dependent variables that fulfilled all preconditions for parametric testing to check the robustness of our results. The non-parametric tests revealed similar results. Thus, they are not reported additionally.

5.5 Results

5.5.1 Noticing of Classroom Management Events

To answer the first research question, the number and type of events noticed by novice and expert teachers was analyzed for both formats of instruction. Figure 3 shows the results for both groups of teachers (cf. Appendix A for details on specific events).

Figure 3. *Number of events noticed by novice and expert teachers in the whole-group and the partner work format by type of event*



Descriptive results and results of independent t-tests or Mann-Whitney-U tests are reported in Table 9 for the whole-group instruction format and in Table 10 for the partner-work format. For the whole-group format, there were neither significant differences between novices and experts for the overall number of events noticed nor for the types of CM events (cf. Table 9). Novices tended to notice more reactive teacher events than experts with a moderate effect size. Yet, the difference failed the level of significance ($t(38) = 1.91$, 95% CI [-0.07, 2.37], $p = .064$, $d = 0.60$).

Table 9. *Expertise differences in teachers' noticing of CM events in the whole-group instruction format*

	Novice teachers *(n =20)*		**Expert teachers *(n = 20)***				
	M (SD)	*Mdn*	*M (SD)*	*Mdn*	Inferential statistics	*p*	*d*
Number of events noticed	7.40 (3.33)	6.50	7.15 (3.08)	7.50	$t(38) = 0.25$, 95% CI [-1.80, 2.30]	.807	0.08
Teacher events noticed	5.50 (2.52)	5.50	4.70 (2.70)	5.00	$t(38) = 0.97$, 95% CI [-0.87, 2.47]	.339	0.31
Reactive	3.90 (1.74)	4.00	2.75 (2.05)	2.50	$t(38) = 1.91$, 95% CI [-0.07, 2.37]	.064	0.60
Preventive	1.60 [a] (1.39)	1.50	1.95 [a] (1.70)	1.00	$MR_{no} = 19.65$; $MR_{ex} = 21.53$, $U = 217.00$	.659	-0.15
Student events noticed	1.90 (1.30)	2.00	2.45 (1.23)	2.50	$t(38) = -1.38$, 95% CI [-1.36, 0.26]	.177	-0.44
Discipline	1.70 (1.17)	2.00	2.15 [a] (1.04)	2.00	$MR_{no} = 17.88$; $MR_{ex} = 23.12$, $U = 252.50$	.157	-0.46
Learning	0.20 [a] (0.41)	0.00	0.30 [a] (0.47)	0.00	$MR_{no} = 19.50$; $MR_{ex} = 21.50$, $U = 220.00$	.602	-0.17

Note. **a** = Group data deviates significantly from a normal distribution ($p < 0.05$, Shapiro-Wilk test). Thus, results of Mann-Whitney-U tests are reported instead of t-tests.

For the partner work format, expert teachers noticed significantly more relevant CM events overall than novices ($t(38) = -2.49$, 95% CI [-4.89, -0.51], $p = .017$, $d = -0.79$). Further analysis of the type of events showed that experts identify significantly more events focusing on students as note-worthy with regard to CM than novices ($t(38) = -2.97$, 95% CI [-2.52, -0.48], $p = .005$, $d = -0.94$), especially events focusing on student discipline (Mean rank = MR; $MR_{no} = 15.65$; $MR_{ex} = 25.35$, $U = 297.00$, $p = .008$, $d = -0.91$). Experts also tentatively noticed more reventive teacher events than novices ($MR_{no} = 16.98$; $MR_{ex} = 24.02$, $U = 270.50$, $p = .056$, $d = -0.63$).

The hypotheses regarding our first research question were only partly supported by our data. As assumed, expertise effects were more prominent in the partner work format than in the whole-group format. However, against our assumptions a stronger focus of novices on student discipline, of experts on noticing student learning events as well as on preventive teacher events could not be confirmed. Furthermore, novices only tentatively noticed more reactive events in the whole-group format, while in the partner work format such events were more often noticed by experts.

Table 10. *Expertise differences in teachers' noticing of CM events in the partner work format*

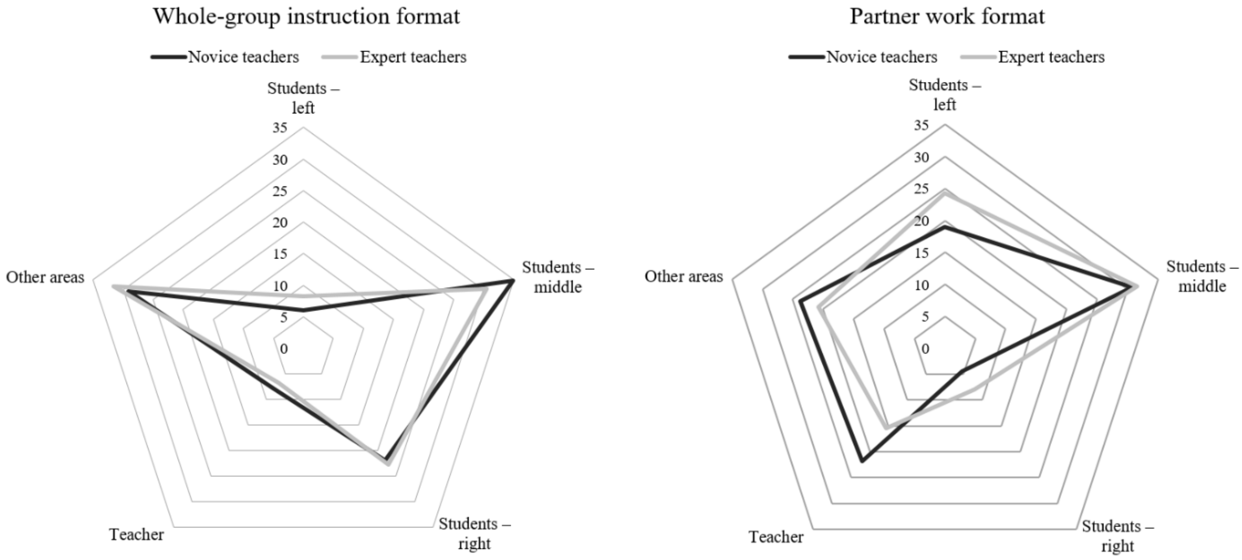
	Novice teachers ***(n =20)***		**Expert teachers** ***(n = 20)***				
	M (SD)	*Mdn*	*M (SD)*	*Mdn*	Inferential statistics	*p*	*d*
Number of events notice	6.85 (3.70)	7.00	9.55 (3.12)	9.50	t (38) = -2.49, 95% CI [-4.89, -0.51]	**.017**	-0.79
Teacher events noticed	4.50 (2.63)	5.00	5.70 (2.08)	6.00	t (38) = -1.60, 95% CI [-2.72, 0.32]	.117	-0.51
Reactive	1.95 (1.43)	2.00	2.80 [a] (1.24)	2.50	MR_{no} = 16.98; MR_{ex} = 24.02, U =270.50	.056	-0.63
Preventive	2.55 (2.04)	2.50	2.90 (1.71)	3.00	t (38) = -0.59, 95% CI [-1.56, 0.86]	.560	-0.19
Student events noticed	2.35 (1.60)	2.00	3.85 (1.60)	4.00	t (38) =-2.97, 95% CI [-2.52, -0.48]	**.005**	-0.94
Discipline	1.95 (1.40)	2.00	3.10 [a] (1.30)	3.00	MR_{no} = 15.65; MR_{ex} = 25.35, U =297.00	**.008**	-0.91
Learning	0.40 [a] (0.50)	0.00	0.75 [a] (0.77)	1.00	MR_{no} = 18.10; MR_{ex} = 22.90, U =248.00	.201	-0.42

Note. **[a]** = Group data deviates significantly from a normal distribution ($p < 0.05$, Shapiro-Wilk test). Thus, results of Mann-Whitney-U tests are reported instead of t-tests.

5.5.2 Teachers' Visual Attention to Student Groups and the Teacher

To answer our second research question, novice and expert teachers' proportion of gaze and the number of their fixations to three student groups or the teacher were compered for both formats of instruction. Descriptive results and inferential statistics are reported in Table 11 and Table 12. Figure 4 shows the distribution of novices' and experts' gaze.

Figure 4. *Average proportion of gaze spent in the areas of interest by novice and expert teachers in the whole-group instruction and partner work format*



In the whole-group format, both groups' proportions of gaze and number of fixations were highest for the middle and the right student group. Most gaze measure did not differ between novices and experts with the exception of the proportion of gaze to the left student group and the fixation count on the teacher. Experts' proportion of gaze to the left student group was significantly higher than novices' ($t(38) = -2.13$, 95% CI [-0.04, -0.0001], $p = .040$, $d = -0.67$). As hypothesized, novices allocated significantly more fixations to the teacher in the whole-group format than expert teachers ($t(38) = 2.23$, 95% CI [0.48, 11.32], $p = .034$, $d = 0.71$).

Table 11. *Expertise differences in teachers' proportion of dwell time and fixation count on student groups and the teacher in the whole-group instruction format*

		Novice teachers (*n* =20)		Expert teachers (*n* = 20)				
		M (SD)	*Mdn*	*M (SD)*	*Mdn*	Inferential statistics	p	d
Left student group	Prop. of gaze	0.06 (0.03)	0.05	0.08 (0.04)	0.08	t (38) = -2.13, 95% CI [-0.04, -0.001]	**.040**	-0.67
	No. of fixations	15.25[a] (9.22)	14.00	17.75 (7.15)	15.50	MR_{no} = 18.12; MR_{ex} = 22.88, U =247.50	.201	-0.42
Middle student group	Prop. of gaze	0.35[a] (0.09)	0.33	0.31 (0.08)	0.32	MR_{no} = 22.45; MR_{ex} = 18.55, U =161.00	.301	0.34
	No. of fixations	79.20 (19.99)	76.00	67.50 (21.54)	66.00	t (38) = 1.78, 95% CI [-1.60, 25.00]	.083	0.56
Right student group	Prop. of gaze	0.22 (0.09)	0.23	0.23 (0.10)	0.23	t (38) = -0.28, 95% CI [-0.07, 0.05]	.778	-0.09
	No. of fixations	50.95 (19.73)	52.50	48.60 (19.33)	46.00	t (38) = 0.38, 95% CI [-10.16, 14.86]	.706	0.12
Teacher	Prop. of gaze	0.08 (0.04)	0.08	0.07 [a] (0.07)	0.05	MR_{no} = 22.75; MR_{ex} = 18.25, U =155.00	.231	0.39
	No. of fixations	17.75 (8.12)	19.00	11.85 (8.81)	10.00	t (38) = 2.23, 95% CI [0.48, 11.32]	**.034**	0.71

Note. **[a]** = Group data deviates significantly from a normal distribution (p < 0.05, Shapiro-Wilk test). Thus, results of Mann-Whitney-U tests are reported instead of t-tests.

In the partner work format, significant expertise effects were found for the left and the right student group as well as the teacher which is in line with our assumption. Expert teachers' showed a significantly higher proportion of gaze than novices to the left (t(38) = -2.08, 95% CI [-0.104, -0.001], p = .044, d = -0.66) and the right student group (MR_{no} = 15.65; MR_{ex} = 25.35, U =297.00, p = .008, d = -0.91). Similarly, the number of fixations on the right student group was significantly higher for expert than for novice teachers (MR_{no} = 15.65; MR_{ex} = 25.35, U =297.00, p = .008, d = -0.91). In contrast and as hypothesized, novices allocated a significantly higher proportion of gaze towards (MR_{no} = 24.55; MR_{ex} = 16.45, U = 119.00, p = .028, d = 0.74) and fixated more often on the teacher than experts (MR_{no} = 24.80; MR_{ex} = 16.20, U = 114.00, p = .020, d = 0.79).

Table 12. *Expertise differences in teachers' proportion of dwell time and fixation count on student groups and the teacher in the partner work instruction format*

		Novice teachers (*n* =20)		**Expert teachers (*n* = 20)**				
		M (SD)	*Mdn*	*M (SD)*	*Mdn*	Inferential statistics	p	d
Left student group	Prop. of gaze	0.19 (0.07)	0.18	0.24 (0.09)	0.26	t (38) = -2.08, 95% CI [-0.10, -0.001]	**.044**	-0.66
	No. of fixations	33.80[a] (12.22)	30.00	40.45 (13.00)	43.50	MR_{no} = 17.40; MR_{ex} = 23.60, U =262.00	.096	-0.55
Middle student group	Prop. of gaze	0.31[a] (0.07)	0.31	0.32 (0.05)	0.32	t (38) = -0.38, 95% CI [-0.05, 0.03]	.703	-0.12
	No. of fixations	47.85 (15.27)	45.50	48.60 (7.96)	49.00	t (38) = -0.20, 95% CI [-8.55, 7.05]	.847	-0.06
Right student group	Prop. of gaze	0.05[a] (0.03)	0.04	0.08 (0.04)	0.07	MR_{no} = 15.65; MR_{ex} = 25.35, U =297.00	**.008**	-0.91
	No. of fixations	8.45[a] (6.25)	7.00	14.35 (7.74)	14.00	MR_{no} = 15.65; MR_{ex} = 25.35, U =297.00	**.008**	-0.91
Teacher	Prop. of gaze	0.22 (0.09)	0.22	0.16[a] (0.11)	0.12	MR_{no} = 24.55; MR_{ex} = 16.45, U =119.00	**.028**	0.74
	No. of fixations	37.75 (12.90)	40.50	28.50[a] (19.16)	19.50	MR_{no} = 24.80; MR_{ex} = 16.20, U =114.00	**.020**	0.79

Note. **[a]** = Group data deviates significantly from a normal distribution (p < 0.05, Shapiro-Wilk test). Thus, results of Mann-Whitney-U tests are reported instead of t-tests.

Our hypotheses for the second research question were generally supported by the data as more expertise differences were found in the partner work format and experts allocated more attention to student groups (in particular on the left and right side of the classroom) while novices paid more attention to the teacher in both formats of instruction.

5.5.3 Teachers' Visual Attention to Classroom Management Events

Generally, teachers noticed a variety of events in both video clips (see Appendix A for details on all events noticed). Some events were based on visual, others on audible perception. To examine the third research question, we focused on events grounded in visual perception. There were no significant differences between novice and expert teachers' visual attention to the four corresponding AOIs in terms of proportions of gaze or number of fixations (cf. Table 13). Thus, our hypothesis was confirmed.

Table 13. Expertise differences in teachers' proportion of dwell time and fixation count on student groups and the teacher in the partner work instruction format

		Novice teachers *(n =20)*		**Expert teachers *(n = 20)***				
		M (SD)	*Mdn*	*M (SD)*	*Mdn*	Inferential statistics	*p*	*d*
Student lingers and clowns around	Prop. of gaze	0.04 (0.01)	0.04	0.04 (0.02)	0.05	*t* (38) = -1.25, 95% CI [-0.005, 0.003]	.220	-0.40
	No. of fixations	8.60 (3.12)	8.00	9.45 (3.30)	9.50	*t* (38) = -0.84, 95% CI [-2.91, 1.21]	.408	-0.27
Student is raising her hand and being ignored	Prop. of gaze	0.07[a] (0.05)	0.07	0.06[a] (0.05)	0.06	MR_{no} = 22.70; MR_{ex} = 18.93, *U* =168.50	.398	0.27
	No. of fixations	17.60 (9.17)	18.00	13.30 (7.77)	13.50	*t* (38) = 1.60, 95% CI [-1.14, 9.74]	.118	0.50
Two students fool around and fight each other	Prop. of gaze	0.13 (0.06)	0.14	0.16[a] (0.06)	0.18	MR_{no} = 16.95; MR_{ex} = 24.05, *U* =271.00	.056	-0.64
	No. of fixations	21.50[a] (11.36)	20.50	26.10 (9.61)	29.50	MR_{no} = 17.18; MR_{ex} = 23.82, *U* =266.50	.072	-0.59
Timer on the smartboard as orientation for students	Prop. of gaze	0.03[a] (0.03)	0.02	0.02[a] (0.03)	0.02	MR_{no} = 21.88; MR_{ex} = 19.22, *U* =172.50	.461	0.24
	No. of fixations	4.20[a] (3.59)	4.50	3.50[a] (3.12)	3.00	MR_{no} = 22.15; MR_{ex} = 18.85, *U* =167.00	.383	0.29

Note. **a** = Group data deviates significantly from a normal distribution (*p* < 0.05, Shapiro-Wilk test). Thus, results of Mann-Whitney-U tests are reported instead of t-tests.

5.6 Discussion, Limitations and Conclusions

5.6.1 Summary and Discussion

This study examined how novice and expert teachers' noticing of CM events differs with regard to whole-group instruction and partner work activities. In particular, teachers' identification of note-worthy events based on their verbal reports and their visual attention to broader areas and specific events in the classroom video were investigated. Furthermore, with the video clips selected for this study, the narrow focus of prior research on behavioral management was broadened. In summary, experts noticed more CM events in the partner work format than novices and were further characterized by a focus on student events. Analyses of teachers' gaze revealed a stronger focus of experts on student groups, again especially in the partner work format. Novices paid more attention to the teacher than experts in both video clips. Finally, we found no evidence for a relationship between expertise and teacher gaze to specific CM events.

Expanding prior research that focused on CM in whole-group settings, our study added an examination of partner work. That these two formats may be associated with different demands on teachers' CM was already suggested by Doyle (2006). In the present study, we found indeed that experts noticed significantly more CM events than novices in the partner work format. Thus, these results support the assumption that partner work may be more challenging for novice teachers in terms of noticing CM events. This result is also consistent with novices' tendency to regard CM as a primarily behavioral issue that calls for reactive CM (Kaufman & Moss, 2010; Reupert & Woodcock, 2010): The partner work format requires teachers to master a broader repertoire of strategies and novices might not have developed the CM scripts (Wolff et al., 2020) yet, thus might fail to notice CM events in this format.

So far it has been reported that novices tended to focus more on reactive CM as well as student discipline (Reupert & Woodcock, 2010; Wolff et al., 2015, 2017). In this study, we were not able to replicate this focus. Only for the whole-group format, novices tentatively noticed more reactive teacher events than experts. However, the opposite tentative result was found for the partner work scene with experts noticing more reactive teacher events and significantly more student discipline events. It is possible, that novices fail at noticing these events in the partner work format as they are not as salient as in the whole-group format. Novices might have at least developed some CM knowledge about behavioral problems in whole-group settings as this is the aspects of CM that is often stressed in training programs and also in teachers' worries (Bear, 2015). Thus, novices' lack of CM scripts that guide their noticing becomes particularly apparent in the partner work format.

Against our expectations, experts did not notice more preventive teacher events than novices. We can only speculate about the reason for this result which may be due to the fact that not only behavioral problems were displayed in the video clips, but also, for example, instructional management (e.g. seating arrangements, time management, and lesson flow). Maybe these CM events are less subtle thus easier to notice for novices. However, prior studies investigated teachers' verbal analysis of CM-related events which is not necessarily comparable to the number and type of events noticed. Thus, the reported focus of novices on discipline and experts on learning might also be found in this study when teachers' comments about single, specific events are analyzed more qualitatively (cf. Wolff et al., 2015, 2017).

For the second research question, teachers' proportion of gaze and number of fixations at student groups or the teacher supported our hypotheses. Overall, experts looked longer and more often at student groups on the left and right side of the classroom, thus prioritizing those areas were potentially important student learning or student discipline events took place. This result is consistent with findings on general visual teacher expertise showing that experts focus more on students than novices (Cortina et al., 2015; McIntyre et al., 2019; McIntyre & Foulsham, 2018; Wolff et al., 2016). Monitoring student learning is particularly demanding in partner work (Doyle, 2006). Thus, keeping an eye on students in partner work is crucial for effective CM.

Experts' prioritizing of students with their gaze might be the reason for their noticing of significantly more CM events, particularly of student discipline events that are less salient in the partner work than in the whole-group format. Novice teachers more bottom-up processing of classroom scenes (Wolff et al., 2020) was further confirmed in both formats as they allocate more attention to the teacher than experts: The teacher was salient by guiding the whole-group activity or interacting with student groups in the partner work activity.

Regarding the third research question, we further analyzed novice and expert teachers' gaze at specific CM events. Our result that the level of expertise did not make a difference in terms of visual attention to individual CM events, was previously also found with respect to one student event (Yamamoto & Imai-Matsumura, 2013). With the complexity of teaching in mind, these results may not be surprising. Both groups of teachers noticed many different events in both short classroom scenes. Noticing one among these CM events is probably a too specific and fine-grained measure. However, as shown in the second research question, expertise is characterized by an allocation of attention towards students, where such events can potentially take place.

5.6.2 Limitations

Limitations of the present study need to be discussed before we turn to conclusions. Due to the high demands of analyzing eye tracking and verbal data, the sample size is rather small, but comparable to other eye tracking studies. Also, power analysis showed that the sample size is sufficient to uncover similarly large effects as previously reported. However, it would be desirable to increase the sample size in future studies in order to uncover possible smaller effects.

Since teachers volunteered to participate, a self-selection bias is possible: Teachers that felt more confident could have been more willing to participate. However, this could apply to both novices and experts and thus balance each other. Our selection of experts was based on domain-specific experience (at least five years after qualification) and external evaluation (indicated by being selected for additional responsibilities and tasks in school or teacher education). However, we could not use student achievement or peer nomination as a further criterion of expertise (Caspari-Sadeghi & König, 2018; Palmer et al., 2005) because there is no longitudinal student testing in Germany that would allow to relate student achievement to a specific teacher. Since German teachers do not often observe their colleagues' lessons either (Richter & Pant, 2016), peer nominations might be uninformed.

Our study was conducted in Germany and here in an urban context. While the results might be similar in other Western nations, different results could be expected in other cultures or to some extent even in rural areas. Daily practices and concerns of CM (Bear et al., 2016) and teachers' gaze patterns can differ across cultures (McIntyre et al., 2019). We analyzed teacher's noticing in video segments of another teachers' instruction. Results could be different if teachers' observed their own instruction (Seidel et al., 2011). Additionally, the ecological validity of our results might have been higher if teachers' eye movements were recorded during teaching.

different formats of instruction allowed for a situated investigation of novice and expert teachers' noticing. This choice may include limited generalizability of results though. The representativeness of the selected video clips was ensured by an expert rating. However, while recording authentic teaching situations the complexity of the resulting video clips could only be controlled to some extent. Thus, it cannot be ruled out that idiosyncratic features of the video clips may affect the generalizability of our results, particularly regarding the eye-tracking data. Further research is needed that uses multiple sequences of one instructional format yielding more generalizable results.

5.6.3 Conclusions

The present study yielded new insights into teachers' noticing of CM events in two different formats of instruction thereby expanding the state-of-research beyond behavioral management in whole-group instruction. The format-specific effects found regarding teachers' identification of note-worthy CM events and teachers' gaze point to the relevance of instructional formats for generalizing research results. We cannot take it for granted that findings are valid across different formats of instruction.

Furthermore, our results indicate that novice teachers may have different developmental needs regarding different formats of instruction. Therefore, further research should investigate format-specific differences in novice and expert teachers noticing. Also, teacher education and professional development programs may want to pay attention to CM in these different formats. The results of this study suggest that partner work is particularly challenging for novice teachers. In order to support novice teachers' in developing knowledge in this regard, using video-based or case-based activities could be promising approaches in teacher education (Boshuizen et al., 2020; Gaudin & Chaliès, 2015), as they could allow deliberate practice. How such interventions can change teachers' gaze priorities or identification of events is of particular interest with respect to the development of noticing: Can it be accelerated so that becoming an expert does not necessarily take many years of teaching experience?

In the present study, video clips were selected that showed CM events beyond behavioral CM. We regard these clips therefore to be more representative for a comprehensive understanding of CM than the narrower focus on behavioral management. With this approach, we did obtain some results that differed from previous studies. Therefore, further research on teachers' noticing is needed that accounts for such an understanding by paying attention to instructional management or social, emotional and motivational aspects of CM as well (Bear, 2015).

6 Study 3 – Novice and Expert Teachers' Situation-Specific Skills Regarding Classroom Management: What do They Perceive, Interpret and Suggest?

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Highlights:

- Novice and expert teachers' analysis of classroom management is compared.
- Experts are more interpretive and make more suggestions than novices.
- Experts focus more on students and the context of the classroom scene than novices.
- Preventive behavioral management is more often addressed by experts than by novices.

Abstract: The study investigates 39 novice and expert teachers' perception, interpretation and decision-making skills with respect to classroom management events which they observed in two video clips. Their retrospective comments were analyzed with a multi-category coding scheme. Experts interpreted more and suggested more alternative courses of action than novices. They also focused more on student learning and the context of instruction. Concerning the relation of skills and focus, experts perceived and interpreted more than novices when talking about students while making more suggestions when addressing the teacher or the context. Experts spoke more often about preventive classroom management. Conclusions for developing expertise are drawn.

Keywords: Teacher Expertise | Classroom Management | Situation-Specific Skills | Expert-novice teachers | Verbal data analysis

6.1 Introduction

Recent research has increasingly investigated teachers' situation-specific skills (SSS) by confronting them with authentic classroom situations, either through written vignettes or videos of instruction (Kaiser et al., 2017; Stahnke et al., 2016). According to the PID paradigm, these knowledge-based skills can be distinguished into "perception" (P), "interpretation" (I) and "decision-making" (D) and are regarded as crucial for transforming teachers' knowledge into practice (Blömeke, Gustafsson, et al., 2015). Teachers' SSS have also been studied under the terms of "professional vision" (Gold & Holodynski, 2017; M. G. Sherin & van Es, 2009) or "professional noticing" (Jacobs et al., 2010).

With respect to classroom management (CM) as a crucial dimension of instructional quality (Charalambous & Praetorius, 2018), there is evidence that teachers' skills are more predictive for their management actions in the classroom than their knowledge, thus suggesting a mediating role between knowledge and performance (König & Kramer, 2016). Although teachers' SSS with respect to CM is a growing field of research, many questions remain open. As most studies investigated pre-service teachers' SSS, further research is needed on the differences between novice and expert teachers' skills. In this regard, insights from novice-expert studies could be instrumental for the design of teacher education and professional development.

Whereas expert-novice studies are a well-established approach in the domains of medicine (Norman et al., 2018) or sports (Mann et al., 2007) and also with respect to the overall development of teachers (Berliner, 2001), there are substantially fewer studies regarding novices' and experts' skills with respect to CM (e.g. Wolff et al., 2015). The few studies available have provided important insights (Wolff et al., 2016, 2017). However, so far this research has primarily emphasized *behavioral* CM, in particular focusing on teachers' *reactions* to problematic student behavior. In contrast, CM is considered to be multidimensional including *instructional* CM or *affective-motivational* CM but also behavioral CM focusing the *prevention* of problematic student behavior

(Froyen & Iverson, 1999; Martin et al., 2016; Piwowar et al., 2013). Therefore, it is important to learn more about teachers' CM skills, applying a multi-dimensional conceptualization that reflects the recent state of research. This study aims to close part of this research gap by comparing novice and expert teachers' analysis of video clips that display dimensions of CM including but also going beyond behavioral management. Furthermore, we account for the situatedness of teachers' skills, by utilizing visualizations of teachers' eye movements as cues for the elicitation of teachers' situated and spontaneous cognitions about complex classroom management events.

6.2 Conceptual Framework

6.2.1 Classroom Management and Classroom Management Strategies

Since Kounin's (1970) seminal videotape studies on discipline and group management, it has become evident that CM holds a key role in successful teaching and that a good classroom manager should have a diverse repertoire of CM strategies. There is substantial evidence that teachers' effective CM behavior is an essential dimension of instructional quality and thus crucial for students' learning, motivation and emotions (Korpershoek et al., 2016; Kunter et al., 2013; Wang et al., 1993). In particular, teachers should be able to fall back on a variety of strategies and use them adaptively (Simonsen et al., 2008). CM does also impact pre-service and in-service teachers' well-being in terms of stress, emotional exhaustion or burnout (Chang, 2009; Chaplain, 2008; Kaufman & Moss, 2010; McCarthy et al., 2015; Schmidt et al., 2017).

Despite the great relevance of CM, there is some ambiguity regarding its definition. The umbrella term CM covers a variety of theoretical approaches and a wide range of CM strategies. Evertson and Weinstein (2006) gave a comprehensive definition which has been often adopted by recent studies: CM includes

> the actions teachers take to create an environment that supports and facilitates both academic and social-emotional learning (…). It not only seeks to establish and sustain an orderly environment so students can engage in meaningful academic learning, it also aims to enhance students' social and moral growth. (p. 4)

Despite this broad definition, it is possible to distinguish analytically between different dimensions of CM, namely reactive and preventive behavioral management, instructional management, affective-motivational management, and teachers' self-presentation. Martin et al. (2016) distinguish between behavioral management and instructional management: The former refers to dealing with and preventing student misbehavior, the latter to plans, methods and techniques utilized to reach teachers' content-related goals. In the case of behavioral CM, strategies for dealing with inappropriate student behavior that has already occurred are important (reactive strategies), as are strategies for preventing future misbehavior (preventive strategies) (Bear, 2015; Brophy, 1986; Doyle, 2006; Kounin, 1970). Similarly, Froyen and Iverson (1999) differentiate between the management of conduct (reactive dealing with disciplinary problems) and the management of content (material, space, equipment, lessons). With the management of covenant (social dynamics and relationships), Froyen and Iverson (1999) name another dimension of CM that concerns teacher-student relationships. The importance of such relationships as well as students' social-emotional learning has been emphasized recently (Schwab & Elias, 2015; Wubbels et al., 2015). Other conceptualizations of CM are similarly comprehensive including behavioral, instructional and affective-motivational CM as well as a repertoire of corresponding CM strategies (e.g. Piwowar et al., 2013).

Recently, another dimension of CM has been recognized with teachers' self-management: It includes both self-presentation (body language, facial expressions and presence) and self-control, in particular of emotions (Martin et al., 2016). While preventive CM strategies often refer to behavioral CM, they can also aim at instructional CM or affective-motivational CM (Bear, 2015; Froyen & Iverson, 1999). However, although pre-service teachers consider both preventive and reactive CM strategies to be equally successful, they more often use reactive CM strategies as they feel more confident in them (Reupert & Woodcock, 2010; Woodcock & Reupert, 2013).

Against this state of research on conceptualizations of CM as well as empirical results about CM and CM strategies, a comprehensive conceptualization of CM will frame the present study that distinguishes between different dimensions of classroom management: *reactive* and *preventive behavioral management* (Bear, 2015; Doyle, 2006; Kounin, 1970), *instructional management* (Froyen & Iverson, 1999; Martin et al., 2016), *affective-motivational management* (Froyen & Iverson, 1999; Schwab & Elias, 2015; Wubbels et al., 2015), and *teachers' self-presentation* (Martin et al., 2016).

Despite calls for applying such a broad perspective on CM to empirical research, studies on CM tended to focus on teachers' maintaining of discipline and dealing with student misbehavior (Bear, 2015; Bullough & Richardson, 2015). The same limitation can be seen with respect to pre-service teachers' understanding of CM: They tend to focus on behavioral management (e.g., controlling student behavior and establishing rules) when asked how they define CM and what they would do to manage a classroom well (Kaufman & Moss, 2010).

6.2.2 Teachers' PID Skills

The state of research on teacher competence reveals that knowledge is not sufficient to implement teaching activities of high quality in a classroom. Teachers do also need situation-specific cognitive skills that support transforming teachers' dispositions (knowledge or beliefs) into practice in the classroom (Blömeke, Gustafsson, et al., 2015). For instance, and specifically with respect to classroom management, teachers need to perceive that a student is not paying attention, interpret why this is the case and decide on appropriate courses of action to respond to the students' behavior (based on their knowledge and beliefs).

Accordingly, the PID model (Blömeke, Gustafsson, et al., 2015) comprises three situated knowledge-based skills: (P) perception of particular events in a teaching situation, (I) interpretation of what is perceived in order to make sense of events, and (D) decision-making as anticipating responses to student learning and behavior or as proposing alternative courses of action (Blömeke, Gustafsson, et al., 2015; Kaiser et al., 2017; Stahnke et al., 2016). This comprehensive understanding provides the framework for this study that aims at comparing novice and expert teachers' skills.

Other conceptualizations vary in their scope: In part, only teachers' perception is considered (Star & Strickland, 2008). Under the terms "noticing" (e.g. Barnhart & van Es, 2015; Jacobs et al., 2010; Yang et al., 2019) or "professional vision" (e.g. Gold & Holodynski, 2017; M. G. Sherin & van Es, 2009; Steffensky et al., 2015), other approaches also look at interpretation (M. G. Sherin & van Es, 2009). Again other studies expand the concept of professional vision by including a priori decision-making (Jacobs et al., 2010; Kaiser et al., 2017).

6.2.3 Teacher Expertise

Novice-expert comparisons are used in expertise research in various domains to learn more about what constitutes expertise and how novices can develop such domain-specific expertise (Chi, 2006). Teaching as a domain is a complex and culturally embedded system and highly contextualized (Stigler & Miller, 2018). Thus, defining who is an expert teacher is challenging. In general, expert teachers are described as highly experienced and qualified teachers. However, what this means in terms of identifying expert teachers' has been interpreted differently (Berliner, 2004; Caspari-Sadeghi & König, 2018; Palmer et al., 2005). Palmer et al. (2005) suggest a two-gate procedure: First, to be considered an expert a teacher needs to have at least three to five years of experience and teaching knowledge as evidenced by a certification or degree. Second, he or she should be recognized as an exemplary teacher by relevant groups (e. g., teacher educators, principals or colleagues) and should have positive, documented impact on student achievement.

Studies on characteristics of novice and expert teachers that adapted methods from psychological expertise research have often touched on teachers' general perception, interpretation or their decision-making skills (Berliner, 2001, 2004; Chi, 2011; Tsui, 2009), without focusing on particular skills such as CM. In general, expert teachers showed a superior perception in form of fast and accurate recognition and monitoring of classroom events (Carter et al., 1988; Sabers et al., 1991). In comparison to novice teachers, experts' interpretations tended to be more elaborate and interconnected (Copeland et al., 1994; Needels, 1991). Experts seemed to have developed efficient event-based knowledge and elaborate schemata for making sense of what they perceive, and they formed more connected and holistic representations of their perceptions than novices (Bromme, 2001; Carter et al., 1988). They viewed student behavior in the context of teacher behavior, thinking about reasons and solutions (Sabers et al., 1991). Experts generally also made more suggestions for alternative courses of action than novice teachers (Carter et al., 1988; Copeland et al., 1994).

It should be noted, however, that the studies described have investigated novice and expert teachers' SSS with a broad perspective (e.g., commenting a videotaped lesson without giving a focus of analysis) and do not focus on CM. Therefore, it cannot necessarily be assumed that the same novice-expert differences would occur regarding CM. In addition, several of the studies are about thirty years old and have been carried out with (videos of) direct teacher-centered instruction (e.g. Carter et al., 1988; Copeland et al., 1994; Sabers et al., 1991). In contrast, teaching in the last decades has become more student-centered including formats like cooperative learning activities, flipped classrooms or student experiments, which pose new challenges for teachers as they require different CM strategies than direct teaching (Emmer & Stough, 2001).

With regard to the development of expertise, different approaches have been considered: The concept of deliberate practice, on the one hand, assumes that focused, well-structured and programmatic practice leads to expertise (Ericsson, 2006b; Ericsson & Lehmann, 1996). Chi (2011), on the other hand, sees a shift of perspective as essential in the development of expertise. This change of perspective is, for example, a shift from perceiving single entities to perceiving the system or seeing parts versus seeing the whole. Focusing on teachers' adaptive expertise (in contrast to their routine expertise), a similar shift of focus from themselves to the students as well as developing an understanding of the complexity of teaching are considered to be indicators of high expertise, too (Anthony et al., 2015). How these concepts apply to teacher expertise with respect to CM remains to be investigated.

6.2.4 Teachers' PID Skills With Respect to Classroom Management

Due to the situated nature of teachers' PID skills, they are only accessible through classroom situations presented to teachers which they then have to perceive, interpret and decide on. Studies that have chosen a quantitative approach to the investigation of teachers' SSS with regard to CM typically used standardized written or video-based vignettes and closed or structured item formats (e.g. Situational Judgment Test of Strategic Knowledge of Classroom Management in Gold & Holodynski, 2015; Video-based Test for Classroom Management Expertise König & Lee, 2015). These instruments either distinguished between areas of CM (monitoring, managing momentum, rules and routines in Gold & Holodynski, 2015) or cognitive demands (accuracy of perception, holistic perception, justification of action in König & Lee, 2015). Validation studies revealed that the skills of in-service teachers were generally better than those of pre-service teachers thus indicating the tests' sensitivity to expertise and expertise development (Gold & Holodynski, 2015; König & Kramer, 2016).

While these instruments offer advantages in terms of objectivity, reliability and economy, they may miss out on the spontaneous nature of these knowledge-based situated skills due to pre-defined response options or focused questions. Yet, CM in particular poses situated and spontaneous challenges to teachers that call for immediate action (Doyle, 2006). The spontaneous aspect of SSS is especially important against the background that CM and teaching in general are characterized by multidimensionality, simultaneity and immediacy (Doyle, 2006; Sabers et al., 1991). More situated novice-expert studies could therefore lead to further valuable insights with the potential to inform teacher education and professional development with respect to CM.

Focusing on teachers' *visual* processing of classroom situations or selective attention to CM *during instruction*, first studies revealed that expert teachers focused more on students (McIntyre et al., 2019; McIntyre & Foulsham, 2018; Wolff et al., 2016) and distributed their visual attention more evenly between students than novice teachers (Cortina et al., 2015; van den Bogert et al., 2014). Such studies are important as expertise effects were found to depend on the domain (Gegenfurtner et al., 2011) and thus, findings from other domains such as medicine do not necessarily translate to teaching in general or to CM in particular.

Novice and expert teachers' SSS beyond visual perception can be made accessible by eliciting teachers' verbalizations with the help of authentic video clips showing relevant CM events. However, eliciting teachers' skills through verbalizations can be challenging: While concurrent verbalizations are generally considered to be more accurate and valid than retrospective reports (Ericsson, 2018), verbalizing thoughts concurrently is too overwhelming when tasks are complex and involve time pressure, as it is the case with many tasks in the domain of teaching. Expressing one's own thoughts parallel to watching classroom situations could therefore interfere with teachers' cognitive processes that take place during the task at hand (van Gog et al., 2005). Therefore, retrospective verbalizations can be used when complex tasks are involved.

One way to support the validity of such retrospective reports is to stimulate verbalizations with cues for the cognitive processes that took place during the task (Guan et al., 2006; van Gog et al., 2005). Video-cued or eye movement-cued retrospective verbalization have been found to be more informative in situations where concurrent or un-cued retrospective verbalization have drawbacks (Hyrskykari et al., 2008; van Gog et al., 2005). In this study, we applied this state of research to our design: During watching a video clip, teachers marked relevant CM events by pushing a button while their eye movements were recorded (cf. van den Bogert et al., 2014). During watching each video clip a second time, teachers spoke about the marked events and saw their prior eye movements as cues for their previous cognitive processes. Teachers' verbal reports were thus linked to those specific events that they marked as relevant by using their own prior eye movements as cues. This procedure allows for a situated and spontaneous elicitation of teachers' skills (which is less possible in standardized tests) while not limiting teachers' cognitive capacity through concurrent verbalization (van Gog et al., 2005). Thus, this study aims to contribute to our knowledge of teachers' SSS regarding CM by adding to the few situated expert-novice comparisons that so far focused on behavioral CM (Wolff et al., 2015, 2017).

First studies have compared novice and expert teachers' perception, interpretation and decision-making regarding CM. When talking about classroom management events in video clips while watching them for the second time, expert teachers made more interpretive statements and more suggestions, but less comments about what they perceived than novices (Wolff et al., 2015, 2017).These in turn referred more to order and discipline than experts, who focused more on student learning, teacher-student-interactions and the impact of the teacher (Wolff et al., 2015, 2017). Thus, for the case of CM novice and expert teachers seem to differ with regard to the respective skills they showed (P, I or D) (the *how* of their SSS) as well as their focus of analysis (the *what* of their SSS).

Little is known about the relation of the *how* and the *what*: It is not yet clear whether experts are more interpretive than novices only with regard to student learning or also concerning the teacher in the classroom scene as well as the context of instruction. Furthermore, the aforementioned studies are rather limited to behavioral CM or problematic student behavior though. Behavioral CM is without doubt a key dimension of CM. However, this is true for instructional management, affective-motivational management and teachers' self-presentation as dimensions of CM, as well. The present study wants to contribute to the first insights on novice and expert teachers' SSS with regard to CM by applying such a comprehensive understanding of CM and further investigating the interrelation of the skills displayed in verbal analysis and the focus of teachers' analysis. Thereby, we use a situated method that helps teachers to express their spontaneous thoughts about CM events. In particular, their PID skills, their focus of analysis and their consideration of different CM dimensions are analyzed.

6.3 Research Questions

This study aims to investigate differences between novice and expert teachers' situation-specific skills regarding CM while considering multiple dimensions of CM and cuing their retrospective verbalization with their prior eye movements to increase the validity with respect to situatedness and spontaneity. Specifically, the skills and focus displayed by teachers in their analysis of classroom scenes and the dimensions of CM they refer to will be investigated more closely with the following research questions:

Research Question 1: How do novice and expert teachers differ in the PID skills displayed (perception, interpretation or decision-making)?

Research Question 2: How do novice and expert teachers differ in the focus of analysis (students, teacher or context)?

Research Question 3: How are PID skills and the focus of analysis related within the two groups of novice and expert teachers?

Research Question 4: How do novice and expert teachers differ in their reports regarding dimensions of CM (reactive and preventive behavioral management, instructional management, affective-motivational management or self-presentation)?

6.4 Methods

6.4.1 Participants

Forty German mathematics or biology teachers voluntarily took part in a larger project, where both teachers' eye movements and verbal analysis were recorded. For the purpose of this paper, we focus on analyzing teachers' verbal comments. Despite CM being considered generic, we focused on biology and mathematics teachers in order to reduce the possible impact of teachers' familiarity with typical contents or formats of instruction or classroom interior. Recruitment of participants was carried out via various channels (teacher education program courses or professional development networks).

In line with the results from expertise research (Caspari-Sadeghi & König, 2018; Palmer et al., 2005), expertise was defined by experience and professional membership: Firstly, expert teachers had to have a full teaching license for teaching biology or mathematics in secondary schools and at least five years of professional teaching experience. Secondly, they had to be assigned to distinct tasks at their school (e.g. head of department) or teacher training (e.g. supervision of young teachers) that can be regarded as indicators of expertise. Novice teachers in contrast were still undergoing biology or mathematics teacher training and had no teaching experience beyond short internships that are part of these programs. Novice teachers received 8€ for their participation.

Data collection took place where teachers could best arrange their participation (at the university laboratory, their schools or at home). After inspecting the data graphically and statistically, one extreme outlier was identified and excluded from further analysis (cf. Appendix B).[16] Thus, analyses are based on nineteen novice and twenty expert teachers. The novice teachers (M_{age} = 26.89, *SD* = 3.78; 12 female, 7 male) were on average about 20 years younger than the expert teachers (M_{age} = 45.10, *SD* = 9.69; 15 female, 5 male). On average, experts had 18 years of teaching experience ($M_{\text{experience}}$ = 18.30; *SD* = 10.89) after completing their teacher training, either in biology (N = 9) or mathematics (N = 11). Novices were in their master studies ($M_{semester}$ = 3.37, *SD* = 0.96) to become teachers of mathematics (N = 9) or biology (N = 10) in secondary schools.

6.4.2 Material and Procedure

The participants watched four short video clips from biology and mathematics lessons. These lessons were recorded at secondary schools in Germany. The lessons were taught by male beginning to intermediate teachers as we expected them to show both critical and successful CM actions, thus yielding many different observable CM events. In three steps, the four video clips were selected for the study: First, clips were excluded based on insufficient audio or video quality. Second, the first author selected eight video clips, each considered to show several dimensions of CM. Third, to ensure the authenticity and typicality of the video clips as well as the observability of various dimensions of CM, five experts from teacher education and research independently rated

[16] This participant's transcript was of extreme length with the number of idea units being more than 3 interquartile ranges above the 75% quartile (cf. Appendix B). The participant did rather evaluate the teachers' behavior in general than report on classroom management events he considered to be important in the video clips and why. Thus, we considered the data point to be erroneous as it seems to be based on other cognitive processes than intended and excluded it (Osborne & Overbay, 2004). Leaving it in the data set would have in addition considerably distorted data analysis as it is largely based on frequencies.

the eight clips according to these criteria. These experts were familiar with video-based research and classroom management.

Four clips were finally selected based on experts' agreement so that the selection of clips represented multiple dimensions of CM (reactive and preventive behavioral CM; instructional CM, affective-motivational CM, teacher's self-presentation). The video clips were between one and two minutes long. Even though not all aspects of CM can be displayed in such short video clips of instruction (e. g. phasing of a lesson or building relationships with students), many classroom events are observable also in short video sequences (Gold & Holodynski, 2017; Kaiser et al., 2015).

For the purpose of this paper, we selected the two video clips showing the largest variety of dimensions of CM, one in mathematics and one in biology to balance potential subject-matter relations (although CM is conceptualized in the literature and in this study as a generic construct). In video clip one, the students alternately present their solutions to fraction problems on the smartboard, while the rest of the class should listen, but is quite noisy. The teacher is leaning on the door frame and ignoring a student raising her hand. In the second video clip, the students are working on a group task on the subject of osmosis and are given instructions. A timer is displaying the remaining time for the assignment on the smartboard. The teacher walks through the rows and encourages students to focus on the task. Both clips are easily comprehensible without subject matter knowledge.

Teachers' verbal data and eye tracking data were collected. This paper focuses on teachers' verbal data. Participation in the experiment took about 45–75 min. At the beginning the participants were familiarized with the eye tracking and retrospective reporting method with the help of a test trial. Participants saw the video clips twice. The order of the video clips was incompletely counterbalanced. The procedure when watching one video clip was always the same: First, the eye tracker was calibrated to participants' eyes. The participants saw the video for the first time and were asked to press a button whenever they noticed a relevant classroom management event, thus, producing a timestamp for every event they considered relevant (cf. van den Bogert et al., 2014). Directly after the first viewing, the participants watched the video clip a second time, enriched by a representation of their own earlier eye movements. At each timestamp, the video clip was paused and the participants were instructed to retrospectively report and state why they made that timestamp and what they thought when they first saw the video. The video clip could not be paused at the first viewing, at the second viewing the teachers could tell as much about each timestamp as they wanted and add comments at the end of each video. Thus, the spontaneous nature of teachers' SSS was accounted for by collecting timestamps and eye movements during the first watching while teachers nevertheless were able to express complex and lengthy thoughts during the second watching. Teachers' verbalizations were linked to their initial thoughts by displaying their own prior eye-movements and pausing the video for comments whenever they marked a note-worthy event. Such a procedure can yield more informative verbalizations when concurrent verbalization is not suitable due to the complexity of the task (Hyrskykari et al., 2008; van Gog et al., 2005). A 20-inch display (1650 × 1050 pixels) presented the video clips. A camera attached to the screen recorded the stimulated retrospective reporting data.

6.4.3 Data Analysis

6.4.3.1 Units of Analysis and Coding

Teachers' retrospective reporting data were transcribed verbatim and further analyzed with the software MAXQDA 2018 (VERBI Software, 2017). A first version of the categories and codes for PID skills, focus of analysis and dimensions of CM was developed deductively based on models of teachers' PID skills (Blömeke, Gustafsson, et al., 2015; Jacobs et al., 2010; Kaiser et al., 2017) and already validated coding schemes from research on teachers' interpretation of CM (Wolff et al., 2015, 2017) and dimensions of CM (Piwowar et al., 2013). Following Mayring's (2015) deductive category assignment, code labels, code definitions and example codings were tested and revised through multiple rounds of (re-) coding transcripts of novice and expert teachers. In order to develop a coding scheme that best represented the data and could identify differences between experts and novices, codes that only occurred rarely were dropped, other codes were further differentiated or added.

The coding procedure comprised three steps: First, transcripts were segmented into idea units where each unit represented one clear thought. Second, each idea unit was coded with two codes: one code for the PID skill referred to and one code for the focus of analysis (students, teacher or context). In a third step, all idea units linked to one timestamp and the units made after the end of the video were considered as one utterance. Each utterance was coded according to the dimensions of CM addressed (none, one or multiple codes possible). Thus, the units of analysis for PID skills and focus were smaller (idea units representing one clear though) while those for dimension of CM were larger (whole utterances including all units linked to a timestamp). Two raters independently coded 10% of the material covering both novice and expert teacher groups equally. The interrater-reliability was moderate to strong with k = 0.77 for PID skills, k = 0.80 for focus of analysis and k = 0.76 for dimensions of CM (McHugh, 2012).

Regarding PID skills, the codes covered the three subcategories perception, interpretation and decision-making (cf. Table 20 in Appendix C). The subcategory perception included statements that merely described what a participant saw or heard in the video clip (description code) or statements about information that he or she was missing or wanted to know something about (missing information code). The subcategory interpretation was divided in six codes: Inference codes refer to statements about the cognitive, motivational and/or affective states of students or the teacher; prediction codes refer to statements about possible future teacher or student actions or effects of the lesson beyond the scope of the video clips; positive or negative evaluation codes refer to statements that evaluate the teacher, their actions or intentions either positively or negatively; orienting codes refer to statements in which the participant is orienting him- or herself in the classroom scene; and finally, contextualizing codes refer to statements in which the participant puts earlier statements into perspective with alternative explanations or comparisons. Decision-making codes included statements about contextualized suggestions or comments about how the specific situation can be improved as well as generalized suggestions or comments about how teaching can be improved in general.

Regarding teachers' focus of analysis, the codes covered the subcategories students, teacher and context (cf. Table 21 in Appendix C). Within the student subcategory five codes are included, addressing negative student behavior, positive or neutral student behavior, student learning, student motivation as well as student emotions and well-being. The teacher sub-category includes eight codes including statements that address the teacher's control of the lesson flow, his reaction to student misbehavior, his monitoring of students, his motivating of students, his appreciation of students, his attitude or presence, his other behaviors and finally his emotions. Three codes are included in the context sub-category for statements addressing the classroom and surroundings, school or class rules and the phase or mode of instruction.

Regarding the dimensions of CM (cf. Table 22 in Appendix C), the codes covered utterances that address reactive behavioral management (student misbehavior and reactively dealing with such behavior), preventive behavioral management (student misbehavior and preventing such behavior), instructional management (lesson planning and flow, structure, phasing and mode of instruction), affective-motivational management (appreciation and motivation of students, teacher-student relationship) and self-presentation (teacher attitude, presence or impression). A more detailed description of codes and examples is given in the coding scheme (Appendix C).

6.4.3.2 Statistical Analysis

SPSS version 25.0 (IBM Corp., 2017) was used for analysis of code frequencies (for sub-categories and individual codes). Since we were interested in the amount of comments of different types and not their ratio, frequencies rather than proportions were analyzed. Descriptive results are reported in Table 14, Table 15, Table 16 and Table 17. All dependent variables considered for inference statistics were tested for normal distribution within both groups. T-tests were applied comparing novice and expert teachers if the data followed a normal distribution. If the assumption of equal variances was violated the adjusted parameters are reported. Non-parametric Mann-Whitney-U-Tests were used to compare both groups if normal distribution was not given. Results of inference statistics are reported for all sub-categories and for cross-codings as well as individual codes if both groups differed significantly.

Assuming the same large effect sizes as reported in comparable recent studies (Wolff et al., 2015, 2017), a power analysis with g*power (Faul et al., 2007) and α = .05 yielded acceptable test power for t-tests (β = .79) and non-parametric Mann-Whitney-U-Tests (β = .77).[17]

[17] Even though multiple statistical tests were conducted, we decided against an alpha correction for two reasons: First, the tests conducted did not constitute one test family. Thus, family-wise correction is not advised (Tutzauer, 2003). Second, due to the qualitative and more explorative nature of this study, we considered the consequences of an alpha error to be less severe than the effects such a correction would have on test power. However, effect sizes should be considered in addition to significance.

6.5 Results

6.5.1 Research Question 1: Teachers' PID Skills

Overall, the retrospective reports of experts were significantly longer than the statements of novices thus consisting of more idea units ($t(37) = 2.73$, $p = .01$, $d = 0.88$). Descriptive results for the frequencies of PID skills displayed in teachers' statements are reported in Table 14. Concerning teachers' PID skills, the differences in the number of idea units between experts and novices can mainly be attributed to interpretive statements and suggestions for alternative decisions. Experts and novices did not differ significantly in the number of statements related to perception ($t(37) = 1.49$, $p = .15$, $d = 0.48$).

Expert teachers made significantly more interpretative comments than novice teachers with a medium effect size ($MR_{No} = 15.82$, $MR_{Ex} = 23.98$, $U = 269.50$, $z = 2.24$, $p = .024$, $d = 0.77$). This difference for interpretive codes is particularly noticeable for predictions of future teacher actions or student learning after the end of the video clip ($MR_{No} = 16.24$, $MR_{Ex} = 23.57$, $U = 261.50$, $z = 2.108$, $p = .044$, $d = 0.68$) and negative evaluations of the teacher's actions or intentions ($MR_{No} = 16.00$, $MR_{Ex} = 23.80$, $U = 266$, $z = 2.139$, $p = .033$, $d = 0.73$). Regarding the skill of decision-making, experts did not express more action-oriented thoughts than novice teachers ($MR_{No} = 16.32$, $MR_{Ex} = 23.50$, $U = 260.00$, $z = 1.98$, $p = .05$, $d = 0.66$). However, this result was on the borderline of significance with a medium effect size. Especially regarding contextualized suggestions, experts make significantly more statements than novices ($MR_{No} = 16.26$, $MR_{Ex} = 23.55$, $U = 261.00$, $z = 2.25$, $p = .047$, $d = 0.67$).

Table 14. Mean frequencies (standard deviation) of codes related to PID skills

	Teacher group		
	Novices (*n* = 19)	Experts (*n* = 20)	Total (*N* = 39)
Perception	19.95 (8.36)	24.85 (11.85)	22.46 (10.46)
Description	19.32 (8.27)	24.40 (11.84)	21.92 (10.45)
Missing information	0.63 (0.76)	0.45 (0.83)	0.54 (0.79)
Interpretation*	20.95 (13.78)	32.90 (21.04)	27.08 (18.65)
Inferences	2.68 (2.16)	3.10 (3.55)	2.90 (2.93)
Prediction*	0.79 (1.23)	1.85 (2.16)	1.33 (1.83)
Positive evaluation	3.42 (6.36)	2.80 (2.61)	3.10 (4.76)
Negative evaluation*	8.32 (7.80)	16.60 (15.23)	12.56 (12.74)
Orienting	3.42 (2.91)	5.15 (4.55)	4.31 (3.89)
Contextualizing	2.32 (2.08)	3.40 (2.91)	2.87 (2.57)
Decision-Making^{+}	4.26 (4.91)	9.95 (9.62)	7.18 (8.12)
Contextualized suggestion/comment*	3.95 (2.91)	8.20 (7.79)	6.13 (6.83)
Generalized suggestion/ comment	0.32 (0.58)	1.75 (2.83)	1.05 (2.16)
No code applicable	0.63 (0.68)	2.55 (2.70)	1.62 (2.20)
Total number of idea units	45.79 (21.94)	70.25 (32.74)	58.33 (30.29)

* $p < .05$; $^{+}$ $p = .05$

6.5.2 Research Question 2: Teachers' Focus of Analysis

Descriptive results for the frequencies of teachers' focus of analysis are reported in Table 15. Expert teachers commented significantly more frequently on students than novices, and this happened with a large effect size ($t(37) = 2.79$, $p = .009$, $d = 0.88$). Experts made in particular significantly more statements about student learning than novice teachers ($MR_{No} = 15.84$, $MR_{Ex} = 23.95$, $U = 269.00$, $z = 2.25$, $p = .026$, $d = 0.76$).

Overall, there was no difference between both groups of teachers concerning the number of statements related to the teacher ($MR_{No} = 16.50$, $MR_{Ex} = 23.32$, $U = 256.50$, $z = 1.87$, $p = .06$, $d = 0.63$). However, on the level of individual codes expert teachers made more statements about the teacher's monitoring of students than novices ($MR_{No} = 15.95$, $MR_{Ex} = 23.85$, $U = 267.00$, $z = 2.20$, $p = .03$, $d = 0.74$). Experts spoke in addition significantly more frequently about the context than novice teachers with a medium effect size ($t(37) = 2.26$, $p = .032$, $d = 0.712$). There were no significant differences between expert and novice teachers for the individual context codes.

Table 15. Mean frequencies (standard deviation) of codes related to focus of analysis

	Teacher group		
	Novices (*n* = 19)	Experts (*n* = 20)	Total (*N* = 39)
Students in focus*	13.05 (7.59)	23.25 (14.35)	18.28 (12.53)
Student behavior: negative	8.42 (5.55)	13.70 (9.76)	11.13 (8.33)
Student behavior: neutral or positive	1.84 (2.01)	2.45 (2.11)	2.15 (2.06)
Student learning*	1.89 (1.91)	5.50 (5.53)	3.74 (4.51)
Student motivation	0.42 (0.61)	0.90 (1.71)	0.67 (1.31)
Student emotions and well-being	0.47 (0.77)	0.70 (1.17)	0.59 (0.99)
Teacher in focus	26.63 (15.27)	35.65 (18.38)	31.26 (17.12)
Control of lesson flow	4.00 (4.40)	6.00 (9.18)	5.03 (7.24)
(Non)reaction to misbehavior	15.47 (8.28)	18.65 (8.41)	17.10 (8.39)
Monitoring students*	2.32 (3.42)	6.15 (6.98)	4.28 (5.80)
Motivating students	2.42 (2.84)	1.60 (2.11)	2.00 (2.49)
Appreciation of students	0.74 (1.59)	0.70 (1.46)	0.72 (1.50)
Attitude or presence	1.16 (1.68)	2.05 (2.14)	1.62 (1.96)
Other teacher behaviors	0.47 (0.91)	0.15 (0.37)	0.31 (0.69)
Teacher emotions	0.05 (0.23)	0.35 (0.75)	0.21 (0.57)
Context in focus*	4.79 (3.23)	8.40 (6.34)	6.64 (5.33)
Classroom (and surrounding)	0.95 (1.62)	2.50 (2.89)	1.74 (2.46)
School or class rules	0.53 (1.12)	1.45 (2.46)	1.00 (1.96)
Phase or mode of instruction	3.32 (2.65)	4.45 (4.08)	3.90 (3.46)
No code applicable	1.32 (1.16)	2.95 (2.37)	2.15 (2.03)
Total number of idea units	45.79 (21.94)	70.25 (32.74)	58.33 (30.29)

* $p < .05$.

6.5.3 Research Question 3: Interplay of Teachers' PID Skills and Focus of Analysis

Cross-codings for PID skills and focus of analysis displayed in novice and expert teachers' statements were compared on the level of sub-categories (Table 16). Significant differences were found for four of nine cross-codings. Concerning statements about students, experts made more perceptive comments ($t(37) = 2.41$, $p = .020$, $d = 0.77$) as well as interpretive comments than novices ($MR_{No} = 15.92$, $MR_{Ex} = 23.88$, $U = 267.50$, $z = 2.20$, $p = .028$, $d = 0.74$). With respect to idea units focusing on the teacher, experts suggested more alternative decisions than novices ($MR_{No} = 16.24$, $MR_{Ex} = 23.57$, $U = 261.50$, $z = 2.03$, $p = .044$, $d = 0.68$). Similarly, expert teachers suggested more alternative decisions concerning the context than novice teachers ($MR_{No} = 16.05$, $MR_{Ex} = 23.75$, $U = 265.00$, $z = 2.46$, $p = .035$, $d = 0.72$). For the remaining cross-codings there were no significant differences between expert and novice teachers.

Table 16. *Mean frequencies (standard deviation) of cross-codings of PID skills and focus of analysis*

	Teacher group		
	Novices (*n* = 19)	Experts (*n* = 20)	Total (*N* = 39)
Perception			
Perception x Students*	9.11 (5.98)	15.90 (10.83)	12.59 (9.35)
Perception x Teacher	10.05 (4.78)	8.05 (5.56)	9.03 (5.22)
Perception x Context	0.55 (0.77)	0.80 (1.01)	0.67 (0.90)
Interpretation			
Interpretation x Students*	3.05 (2.55)	6.20 (5.27)	4.67 (4.41)
Interpretation x Teacher	13.47 (10.95)	20.25 (14.95)	16.95 (13.43)
Interpretation x Context	3.95 (3.06)	5.70 (4.54)	4.85 (3.94)
Decision-Making			
Decision-Making x Students	0.89 (1.25)	1.15 (1.76)	1.03 (1.51)
Decision-Making x Teacher*	3.05 (3.94)	6.95 (5.77)	5.05 (5.28)
Decision-Making x Context*	0.34 (0.82)	1.85 (3.27)	1.10 (2.50)

* p < .05

6.5.4 Research Question 4: Dimensions of Classroom Management

Descriptive results for the frequencies of which dimensions of CM were addressed by the teachers are reported in Table 17. . The average number of CM dimensions coded per utterance did not differ between novice and expert teachers ($t(37) = 0.216$, $p = .83$, $d = 0.07$). Generally, experts made more utterances than novices ($MR_{No} = 15.87$, $MR_{Ex} = 23.93$, $U = 268.50$, $z = 2.23$, $p = .026$, $d = 0.76$). Experts made significantly more utterances addressing preventive behavioral management than novices with a large effect size ($MR_{No} = 14.79$, $MR_{Ex} = 24.95$, $U = 289.00$, $z = 2.83$, $p = .005$, $d = 1.00$). However, expert and novice teachers did not differ with respect to reactive behavioral CM ($MR_{No} = 16.63$, $MR_{Ex} = 23.20$, $U = 254.00$, $z = 1.82$, $p = .074$, $d = 0.60$) or instructional CM ($t(37) = 1.59$, $p = .123$, $d = 0.50$). There was also no difference between both groups for affective-motivational CM ($MR_{No} = 22.11$, $MR_{Ex} = 18.00$, $U = 150.00$, $z = -1.18$, $p = .270$, $d = 0.37$) or self-representation ($MR_{No} = 18.58$, $MR_{Ex} = 21.35$, $U = 217.00$, $z = 0.84$, $p = .460$, $d = 0.25$).

Table 17. Mean frequencies (standard deviation) of dimensions of CM

	Teacher group		
	Novices (*n* = 19)	Experts (*n* = 20)	Total (*N* = 39)
Reactive behavioral management	6.47 (2.34)	9.30 (5.06)	7.92 (4.18)
Preventive behavioral management*	1.26 (1.63)	3.00 (2.05)	2.15 (2.03)
Instructional management	1.53 (1.26)	2.60 (2.72)	2.08 (2.18)
Affective-motivational management	1.37 (1.30)	0.95 (1.23)	1.15 (1.27)
Self-presentation	0.58 (0.77)	0.90 (1.07)	0.74 (0.94)
Total number of utterances*	7.89 (2.35)	11.75 (5.46)	9.87 (4.62)
Number of CM dimensions per utterance	1.44 (0.28)	1.46 (0.30)	1.45 (0.28)

* $p < .05$

6.6 Discussion, Limitations and Conclusions

6.6.1 Summary and Discussion

The present study investigated novice and expert teachers' perception, interpretation and decision-making skills with respect to CM. Thereby, we investigated teachers' verbalizations in reaction to video clips showing multiple dimensions of CM (reactive and preventive behavioral CM, instructional CM, affective-motivation CM and the teacher's self-presentation) with a multi-category coding scheme. Accounting for the situatedness of teachers' skills, we used eye tracking data as cues for the elicitation of teachers' situated and spontaneous cognitions about complex CM events. In summary, differences between novice and expert teachers were found in two of the three knowledge-based situated skills. Experts were found to make more interpretive statements and suggested tentatively more alternative decisions than novices. Their analysis of CM focused more on students as well as on the context of teaching than novice teachers. Concerning the relation of PID skills and focus of analysis, experts made more perceptive and interpretive statement about students as well as suggestions for alternative decisions concerning the teacher and the context than novices. For the dimensions of CM, experts' analyses are characterized by a stronger focus on preventive behavioral management. In contrast to previous studies, we did not find a stronger attention of novice teachers to reactive behavioral management or student discipline compared to experts. In the following, we interpret these results along the four research questions in relation to the state of research, before we discuss limitations of our study as well as conclusions and further research needed.

Regarding the first research question *How do novice and expert teachers differ in the PID skills displayed (perception, interpretation or decision-making)?* the data revealed in line with the state of research that expert teachers showed more pronounced interpretation and decision-making skills when analyzing classroom scenes in general (Copeland et al., 1994; Sabers et al., 1991) or scenes of problematic behavioral CM events (Wolff et al., 2015, 2017). Our data revealed in addition that they showed the same skills with respect to other dimensions of CM considered crucial for students' academic and social-emotional learning.

These results may, on the one hand, be explained by differences in building representations. Experts form more interconnected and elaborate representations of what they perceive in a classroom than novices. This may result in more interpretative statements to provide meaning to what they noticed in the videos (Carter et al., 1988; Sabers et al., 1991; Wolff et al., 2017). On the other hand, due to their efficient event-based knowledge (Carter et al., 1988), experts can draw on a larger number of and more reasonable explanations of what they have perceived. Probably for the same reason, expert teachers tended to suggest more alternative courses of action than novices, because their event-based knowledge enables them to process the situation, predict further developments and propose solutions (Carter et al., 1988; Wolff et al., 2015).

Contrary to other studies (Sabers et al., 1991; Wolff et al., 2015, 2017), novice teachers were not found to talk significantly more about what they perceive than experts. This may have been due to our method of analysis and the fact that novices generally recognized less relevant incidents, as suggested by the lower number of utterances. However, there could be expertise effects for the skill of perception if only comments on those incidents were analyzed that both groups consider to be relevant.

With respect to the second research question, *How do novice and expert teachers differ in the focus of analysis (students, teacher or context)?* our data supported novices' focus on the teacher and expert teachers' shift of focus to students found in the literature with respect to behavioral CM (Wolff et al., 2015, 2017) or (adaptive) expertise development (Anthony et al., 2015; Chi, 2011). Our data revealed in addition, a broader focus of experts given that they also paid more attention to the context of CM events which can be considered as indicative of experts' more comprehensive understanding of CM and its complexity.

To answer the third research question *How are PID skills and focus of analysis linked for novice and expert teachers?* our cross-codings revealed distinct characteristics. Compared to novices, experts' perceptions and interpretations were more directed towards students, in other words towards those who CM has to adjust to, while their decision-making was more directed towards teachers and contexts, in other words towards those CM elements that are able to adjust or can be adjusted. Thus, this study indicates that expertise with respect to CM is reflected in teachers P, I and D skills, their focus of analysis as well as the interplay of both. The pattern of skills that has emerged as characteristic for expertise is supporting expert teachers' adaptive CM: In order to manage a classroom well teachers' need to perceive how students behave and learn, interpret what influences their behavior and learning in this specific situation and derive possible strategies to improve the situation with the aim of improving student learning (Simonsen et al., 2008).

With respect to the fourth research question *How do novice and expert teachers differ in the dimensions of CM referred to (reactive and preventive behavioral management, instructional management, affective-motivational management or self-presentation)?* expert and novice teachers mostly did not differ in the CM dimensions addressed. Our study does thus not confirm the focus of novices on reactive behavioral CM, as found in other studies (Reupert & Woodcock, 2010; Wolff et al., 2015, 2017). Actually, both groups talk most about reactive behavioral CM issues, but do also address multiple dimensions of CM. Thus, novice and expert teachers may share a comprehensive understanding of CM, that is not yet reflected in research about teachers CM skills which often focuses on behavioral problems. Experts' analysis does, however, more often address preventive behavioral management than novices', especially with respect to teachers' monitoring of classroom management. Experts seem to be more aware of the importance of preventing students' off-task behavior before it occurs. It should be noted that the analysis of this research question refers to entire utterances and did not only include most frequently noticed scenes (cf. Wolff et al., 2015). Thus, the different results could be grounded on methodological decisions.

6.6.2 Limitations

Before we turn to conclusions some limitations need to be pointed out. The first one is related to the selection of our sample. Due to the effort involved in the data collection and the qualitative data analysis, the sample size is rather small but comparable to similar studies (e.g. Wolff et al., 2015) and large enough to provide sufficient test power. Since teachers participated voluntarily, a self-selection bias cannot be entirely ruled out. We applied a criterion commonly used in Germany to make sure that we not only recruited experienced but indeed expert teachers, namely teachers' leader functions (Caspari-Sadeghi & König, 2018). These functions are often related to promotion in the career ladder and typically assigned after competitive application processes and in-depth evaluations by committees. Nevertheless, our definition is thus not fully in line with the recommendations made by Palmer et al. (2005). Since it is unusual for German teachers to observe teaching of their colleagues (Richter & Pant, 2016), peer nominations could not be used because a risk exists that they would be based on factors other than actual expertise. Also, in the German context it is not possible to attribute student achievement to a single teacher as there are no longitudinal assessments.

The situatedness of teachers' SSS makes it necessary to use relevant situations in the investigation. The resulting disadvantage may be limited generalizability of the results. In the case of this study, the results are valid for mathematics and biology teachers for lower secondary school in a metropolitan area in Germany viewing classroom scenes displaying teacher-centered direct teaching and more student-centered group work that was taught by other teachers. Whether the findings are transferable to other contexts, e.g. viewing video of their own instruction (Blomberg et al., 2011; Seidel et al., 2011) or of other subjects (Blomberg et al., 2011) remains an open question. Other teacher variables such as their cultural background or pedagogical knowledge were not addressed in this study, but should be considered in further research.

The quality of teachers’ statements was not in the focus of this study. The coding scheme applied aggregated teachers’ verbal data across different CM events. A more qualitative analysis of all novice and expert comments on one specific CM event could provide important insights into the quality and argumentative processes involved. As the focus of this study is on the quantity of different types of comments, frequencies are analyzed rather than proportions. However, further research should also analyze proportions of statements as both groups could show similar patterns for PID skills or focus of analysis but different frequencies. This paper does neither investigate which visual attention processes precede the noticing of CM events or which specific events are noticed and whether novice and experts agree on these events. Future studies could bring important insights in these regards.

The procedure of this study involved teachers’ re-watching the video clips enriched by their own prior eye movements and verbally commenting what they found relevant about a specific event. In line with the state of research, such a procedure is expected to encourage teachers to report the situated and spontaneous thoughts they had while first watching the video clip. However, a limitation could be that teachers’ attempt to be consistent with their prior behavior could affect their comments.

6.6.3 Conclusions

The present study contributed to the state of research regarding CM expertise in three ways. First, it extended and updated research on characteristics of expertise with regard to CM skills while using a procedure that supports teachers in expressing their spontaneous thoughts about CM events. The fact that teachers’ situated skills are important aspects of expertise is widely acknowledged (Stahnke et al., 2016). Perception, interpretation and decision-making skills help teachers to quickly put their knowledge and beliefs into practice in a specific classroom situation and in relation to specific events. Therefore, these skills should be assessed in a similar spontaneous and event-related manner. The procedure used in this study meets this requirement. To learn more about the potential impact of different procedures on uncovered differences between novice and expert teachers' SSS, further research should systematically compare for instance the procedure proposed in this study and standardized instruments.

Second, the present study extended our understanding of what teachers consider important in terms of multiple dimensions of CM. Expert and novices are aware of all dimensions of CM. However, novices address to a lesser extent the crucial aspect of preventive behavioral CM which may imply that teacher education and professional development programs should address preventive CM strategies more. Further research on expertise effects in terms of quality of teachers' analysis of one specific CM event or in terms of which different events are considered to be relevant with respect to a specific dimension of CM (e.g. affective-motivational management) is needed in order to complete our understanding of CM expertise.

Third, this study yielded insights into the relation of novice and expert teachers PID skills (the *how* of teachers' SSS) and their focus of analysis (the *what* of teachers' SSS) for different dimensions of CM. Successful CM requires the adaptive application of a repertoire of different CM strategies (Simonsen et al., 2008). To decide which strategy is adaptive in a specific context or situation, teachers need SSS in addition to declarative and procedural pedagogical knowledge. Based on the expertise effects found in this study, we conclude that fostering teachers' interpretation and decision-making skills as well as their skills to consider the role of the students, the teacher as well as the context of instruction for CM can help them to develop expertise. The PID paradigm (Blömeke, Gustafsson, et al., 2015) regards the skills of perceiving, interpreting and decision-making as instrumental for putting knowledge into practice. It remains unclear, if these skills are sequentially used in practice or need to be developed sequentially. For domains other than CM, similar characteristics of expertise have been found with respect to the *how* of teachers' SSS. Against this background, some features of teachers' SSS could be more generic (the *how*) while other aspects might be more content-specific (the *what*). Further research of expert and novice teachers' skills in this regard is needed and can informing teacher education.

As demonstrated for the domain of mathematics education (Stahnke et al., 2016), SSS skills can be developed with more practical learning opportunities which are often rare in teacher education programs (Greenberg et al., 2014). Thus, integrating situated learning opportunities in teacher education and professional development programs can be beneficial for preservice teachers' development of SSS in general and with respect to CM. Further research is needed on the necessary elements of such opportunities in order to enable deliberate practice, that is characterized by conscious concentration on the skill and informative feedback on the performance (Ericsson, 2006b). Video analysis, expert feedback and guided reflections are promising approaches in this regard (Piwowar et al., 2013; Weber et al., 2018).

7 General Discussion

7.1 Summary of Results

In the following section, the results of the three studies (Chapter 4, Chapter 5 and Chapter 6) are briefly summarized with regard to the research questions posed in Chapter 3. The first study (Stahnke et al., 2016) addressed research questions 1a, 1b, 1c and 1d. In a systematic review, 60 empirical studies that were published in English, peer-reviewed journals were first selected from 1418 publications based on specific criteria. The selected studies were systematically analyzed and summarized. The studies revealed that perception and interpretation or all three skills were often analyzed together. The situations or contexts included identifying the potential of mathematical tasks or analyzing written student solutions or videotaped classroom situation (*research question 1a)*. About half of the studies referred to (situated) professional knowledge or dispositions in their theoretical framework while nearly all other studies focused on teachers' noticing or professional vision (*research question 1b).* The reviewed studies ranged from case studies to larger samples of pre-service and in-service teachers as well as teacher educators. The studies used a multitude of methods, often utilizing interviews, document analysis as well as additional tests of knowledge or lesson observations. Furthermore, teachers' situation-specific skills were investigated together with and linked to dispositions or performance *(research question 1c)*. The reviewed studies yielded four main results: (1) Teachers' dispositions (content knowledge, pedagogical content knowledge or beliefs) and their situation-specific skills are linked. (2) Pre-service teachers have difficulties to perceive and interpret student solutions and errors. (3) Decision-making is the skill most challenging for pre-service teachers. (4) Teaching expertise or experience is related to what teachers notice and how they notice classroom events. (5) Teachers' noticing skills or professional vision can be fostered with situated (e.g. video-based) tools *(research question 1d)*.

The second study (Stahnke & Blömeke, 2021a) addressed research question 2a, 2b and 2c. In the study, 20 novice and 20 expert teachers' gaze at student groups and the teacher along with their verbal identification of events noticed were compared for a whole-group instruction and a partner work format. Only in the partner work format were expert teachers found to notice more classroom management events and specifically more student related events than novice teachers *(research question 2a).* Similarly, expert teachers prioritized students with their gaze while novices allocated more attention to the teacher in both formats (r*esearch question 2b).* However, on the level of specific classroom management events, no expertise effects regarding teachers' visual attention to these events were found *(research question 2c).*

The third study (Stahnke & Blömeke, 2021b) addressed research questions 2d, 2e, 2f and 2g by investigating 19 novice and 20 expert teachers' perception, interpretation and decision-making skills regarding classroom management events. Teachers' retrospective comments about events they noticed were analyzed with a multi-category coding scheme. Expert teachers made more interpretive comments and suggested more alternative courses of action than novice teachers *(research question 2d).* Expertise was further characterized by focusing more on students and the context of a classroom management event than on the teacher in the video clip (r*esearch question 2e)*. Concerning the relation of the skills displayed (the *how*) and the focus of analysis (the *what*), experts made more perceptive and interpretive comments about the students as well as more suggestions of alternative courses of action directed at the teacher and the context than novices *(research question 2f).* In terms of classroom management dimensions addressed, experts refer more often to preventive behavioral management than novice teachers (r*esearch question 2g*).

After this brief summary, the results regarding classroom management are discussed first before discussing all findings with respect to teachers' situation-specific skills in general.

7.2 Discussion – Teachers' Situation-Specific Skills With Regard to Classroom Management

The following section discusses the results of Study 2 and Study 3 with regard to the second goal of this dissertation, which was to generate insights into the *what* (i.e. the topic or actors of teachers' analyses) and the *how* of teachers' situation-specific skills (i.e. whether descriptions, interpretations or suggestions are made) with respect to classroom management.

Concerning the *what* of teachers' situation-specific skills, expertise was characterized by allocating visual attention to students (instead of the teacher), by noticing many student-related events and by particularly addressing students and their learning as well as the context when commenting on classroom management events.

Starting with teachers' visual perception, experts paid more attention to student groups than novices, who, in turn, prioritized the teacher with their gaze in both scenes. Thereby, experts prioritized those areas where note-worthy student learning or student discipline events will probably take place. Similar results have been reported for teachers' general visual expertise or behavioral management in whole-group instruction (Cortina et al., 2015; McIntyre et al., 2019; McIntyre & Foulsham, 2018; Seidel et al., 2020; Wolff et al., 2016) and were now extended to other dimensions of classroom management as well as the partner work format. Expert teachers paying more attention to students as the aim of efficient classroom management thus confirmed experts' top-down processing (Wolff et al., 2016, 2020): Their knowledge and skills guide their attention towards areas that might show relevant classroom management events. Similarly, novices' higher visual attention to the teacher in the scenes supports the assumption that their processing can be characterized as more bottom-up (Wolff et al., 2016, 2020): They look more often at salient areas, as, for example, the teacher guiding the whole-group activity or the teacher interacting with student groups in the partner work activity. How novice teachers' gaze can be redirected towards areas that are more relevant is an open question for further research.

Because teachers can only notice what they see (or hear), it is crucial that they monitor students and their engagement. Thus, it is not surprising that experts also noticed more classroom management events and particularly student events and student discipline events than novices as they had allocated more visual attention to students. However, this expertise effect was only found for the partner work format. Monitoring student engagement can be very demanding in a more open format as many events take place simultaneously (Doyle, 2006). Accordingly, keeping an eye on students is especially important in such formats. As novices have probably not yet developed the necessary knowledge or scripts to guide their attention and consequently their noticing, the partner work format is particularly challenging for them because note-worthy events can be less salient within the many interactions of student groups. A second possible explanation of novice teachers' noticing fewer student events is that they might look at an important event but not notice it as potentially note-worthy for classroom management. As novice teachers tend to view classroom management as a primarily behavioral issue calling for reactive strategies (Glock & Kleen, 2019; Kaufman & Moss, 2010; Reupert & Woodcock, 2010) and behavioral problems in whole-group settings are often stressed in training programs (Bear, 2015), they might not have developed the necessary skills regarding other dimensions of classroom management in more open formats of instruction. More process-related research is needed to further elaborate how noticing takes place and what role teachers' allocation of (visual) attention plays.

When teachers reported why they considered an event note-worthy with respect to classroom management, expertise was again linked with a particular focus on this event's relevance for students and their behavior and learning. This focus is useful and goal-oriented, as enabling and supporting student learning is exactly what efficient classroom management intends to do (Brophy, 1986; Evertson & Weinstein, 2006). Experts also talked more about the teachers' behavior in one respect: Their monitoring of students. Moreover, there was a stronger concern for the context of teaching among experts in comparison to novice teachers. A similar shift of attention from focusing on the teacher to focusing on the students and the context has previously been reported for adaptive teacher expertise (Anthony et al., 2015) and for behavioral management (Wolff et al., 2015, 2017, 2020). Experts' additional consideration of the context might be grounded in their knowledge about, experience with or scripts for different situations and contexts, thus enabling them to analyze why an event developed or how changing the context could have prevented it or could improve the current situation. A perspective shift might be a necessary step towards this expertise development as already proposed by Chi (2011): Novices still focus on only parts or individual entities while experts see the whole or the system including how an event evolved and what could improve the situation. How such a shift of perspective can be accelerated in teacher education or professional development is an important question for future studies.

Taking a broader perspective and looking at the dimensions of classroom management attended to, expertise effects only existed for the dimension of preventive behavioral management. In their retrospective reports on note-worthy events, expert teachers addressed this dimension more often than novices. This difference is not unexpected, since novices were found to rely less on preventive strategies (Reupert & Woodcock, 2010; Woodcock & Reupert, 2013). Overall, both groups comment most about reactive behavioral management, but generally consider multiple dimensions of classroom management. Hence, both groups might share a comprehensive understanding of classroom management including, for instance, behavioral, instructional and affective-motivational management. Unfortunately, this broad understanding is not yet adopted in research about teachers' classroom management skills, which often focuses on behavioral problems (Bear, 2015).

While the results reported above have generally confirmed or extended previous research findings, some results concerning the *what* of teachers' skills are contradicting recent studies. Prior research has repeatedly reported on novice teachers' focus on reactive behavioral strategies and student order and discipline (Reupert & Woodcock, 2010; Wolff et al., 2015, 2017). They have previously also been found to use more reactive strategies than experts (Glock & Kleen, 2019; Woodcock & Reupert, 2013). However, in the present study, novices did not refer to reactive behavioral management more often than experts. The reason for these unexpected findings could lie in the understanding of classroom management that has been applied in prior studies: Studies were mostly concerned with behavioral problems and reactive or preventive classroom management strategies. In Study 2 and Study 3, however, video clips were used that show many events displaying different dimensions of classroom management. Furthermore, teachers' spontaneous noticing and reports were analyzed, instead of only investigating if they would rather use reactive or preventive strategies. Novice teachers' concentration on reactive management may thus only exist when video clips of behavioral problems in whole-group instruction scenes are used.

With regard to the *how* of teachers' skills, the results are in line with the state of research of experts showing pronounced interpretation and decision-making skills when analyzing classroom scenes in general (Copeland et al., 1994; Sabers et al., 1991) or scenes of problematic behavioral classroom management events (Wolff et al., 2015, 2017, 2020). The data revealed that experts made more interpretive comments (especially predictions and negative evaluations) as well as more contextualized suggestions than novices. Thus, previous results could be confirmed for other dimensions of classroom management and regarding two formats of instruction. Experts' prior knowledge and scripts probably help them to build more elaborated and interconnected representations of the events they noticed, thereby making sense of and interpreting what they perceived (Carter et al., 1988; Sabers et al., 1991; Wolff et al., 2017, 2020). Having already developed more event-based knowledge and classroom management scripts, they can also draw on possible explanations, probable further development of events as well as adaptive strategies or courses of action for the events they noticed (Carter et al., 1988; Wolff et al., 2015, 2020). Again, these findings point to a shift of perspective towards considering the whole system when making sense of a classroom management event (Chi, 2011).

Linking the *what* and *how* with regard to teachers' verbal analyses reveals a specific pattern among experts: They especially expressed more perceptive and interpretive thoughts focusing on students and the meaning of the particular events for student learning than novices. Thus, experts directed their perceptions and interpretations more towards those to whom classroom management should adapt. They also make more suggestions addressing the teacher's behavior and promising adaptions of the context of teaching than novices. Accordingly, experts focus their decision-making skills on those elements of the system that can adapt to students and their learning. These specific characteristics have been described as essential for adaptive classroom management: A good manager needs to perceive how students behave and learn, interpret what influences students' behavior and learning at this moment and develop adaptive strategies to improve student learning quickly (Brophy, 1986; Simonsen et al., 2008).

Overall, the results of both Study 2 and Study 3 highlight that expertise effects in teachers' skills are not uniform for all dimensions of classroom management and formats of instruction. Particularly, the partner work format seems to be challenging for novice teachers. Furthermore, novice teachers are not preoccupied with reactive behavioral management when rich video clips are used that show multiple dimensions of classroom management. Further research is needed that investigates which characteristics of expertise are more generic, and what might be specific for different dimensions of classroom management or formats of instruction.

7.3 Discussion – Teachers' Situation-Specific Skills in General

This section discusses the results of Study 1 (and, to a lesser extent, also Study 2 and Study 3) with respect to the first goal of this dissertation, which was to systematically synthesize research on teachers' situation-specific skills. A systematic review (Petticrew & Roberts, 2008) of 60 empirical studies on mathematics teachers' situation-specific skills was conducted with a particular focus on theoretical frameworks, methods and results of the studies.

Analyzing the theoretical frameworks of the studies revealed a concerning lack of clarity in terms and definitions, particularly in studies taking a situated perspective. On the one hand, similar conceptualizations used different terms, thus impeding readers to link these studies even though they investigate very similar skills. On the other hand, the same terms were used for different conceptualizations and operationalizations. These inconsistencies could lead to future studies referring to prior research that supposedly yields results or insights about the same constructs, yet actually investigating different skills. Future research would benefit from conceptual clarification and shared definitions. It should be clear what to expect in a study investigating teachers' noticing or professional vision. At least abstracts should clearly indicate whether perception, interpretation or decision-making were analyzed in order to enable researchers and practitioners to understand what is actually happening in this field of research.

The methods used in the studies are as diverse as the conceptualizations and terms used: Cognitive perspective studies often used standardized tests that were still rather removed from practice, while studies from the situated perspective mostly conducted interviews, observations or document analysis, often relying on small samples or even case studies. The studies generally either took a cognitive perspective by heavily relying on large samples and low-inference data or a situated perspective and looked at small samples and more qualitative and high-inference data. Combining both perspectives and both low and high-inference data could yield more reliable and ecological valid insights into teachers' situation-specific skills.

Concerning the results of the 60 studies included in the systematic review, the competence as a continuum model was supported in multiple ways. First, expert teachers' situation-specific skills were more pronounced than novice teachers' in the studies reviewed as well as in Study 2 and Study 3 of this dissertation. Therefore situation-specific skills are one aspect of expertise or competence that beginning teachers still need to develop. Second, the studies indicated a relationship between teachers' mathematical content knowledge or pedagogical content knowledge and teachers' perception, interpretation and decision-making. Hence, teachers' situation-specific skills are knowledge-based as particularly substantiated by studies taking a cognitive perspective and testing teachers' dispositions. Third, many situated perspective studies tested interventions that aim at fostering teachers' noticing and found video-based or other situated learning opportunities to be effective. Thus, situation-specific skills are learnable as substantiated by many intervention studies. These interventions aim at the *what* and/or the *how* of teachers' skills with regard to a specific area of teaching as, for instance, children's early numeracy (Roth McDuffie et al., 2014). Forth, the studies reviewed (as well as Study 2 and Study 3) in this dissertation indicate that the three skills of perception, interpretation and decision-making can be differentiated and are dissimilarly challenging for pre-service teachers. Overall, decision-making appears to be the most demanding of the three situation-specific skills. Finally, a few studies indicate that teachers' skills are linked to their practice or instructional quality. Therefore, there is reason to propose that teachers' situation-specific skills are predictive of performance, as has also been shown for classroom management (König & Kramer, 2016).

Against the background of all three studies, some features of the *what* and *how* of teachers' situation-specific skills seem to be more generic. Suggesting further courses of action and interpreting and making sense of what is perceived is particularly challenging for novice teachers. Expertise is further characterized by paying attention to and adapting to students and their learning. What is needed to support student learning differs of course from different perspectives (e.g. a classroom management or a learning algebra perspective). In order to design promising learning opportunities for teacher education or professional development, insights into the *what* and *how* of teachers' skills in the respective area of teaching are needed.

7.4 Strengths and Limitations of the Dissertation

This section will discuss strengths and weaknesses of this dissertation. Thereby, theoretical and methodological aspects are reflected in particular. A first major strength of this dissertation is the *integration of multiple perspectives on and constructs of situations-specific skills*. Paradigms and findings from (teacher) competence research, (teacher) expertise research, classroom management research and cognitive psychology were integrated in a meaningful and beneficial way. In particular, the consideration of both competence and expertise research, i.e. a cognitive and a situated perspective, should be mentioned. So far, studies usually referred to only one approach, which makes it difficult to relate results to each other. The dissertation has made an important contribution to reduce this ambiguity and to combine the advantages of both paradigms.

The new insights in this dissertation were generated through a systematic review and synthesis of prior research (Study 1) as well as through novice-expert-comparisons regarding classroom management-related skills (Study 2 and Study 3). In both cases, *innovative methodological approaches* in the respective research fields have been applied. One the one hand, systematic reviews or meta-analyses are not yet as common in educational research as they are in psychology or medicine. Study 1 of this dissertation conducted a systematic review to synthesize and systemize research in the increasingly prominent but often inconsistent area of situation-specific skills. In the process, 1418 titles and abstracts were screened and based on systematic exclusion criteria, 60 peer-reviewed empirical studies were selected, reviewed and further summarized in the first comprehensive and systematic review in the field of mathematic teachers' situation-specific skills. Study 1 thereby provided an overview of what happens in this field (for details on systematic reviews cf. Petticrew, 2015). On the other hand, novice-expert comparisons that adapted methods from cognitive psychology and expertise research in other domains yielded crucial insights into the *what* and *how* of teachers' situation-specific skills with respect to classroom management. The methods for eliciting and analyzing teachers‵ situation-specific skills with regard to classroom management were fairly elaborate and time-consuming and included video-taping twelve hours of instruction and selecting classroom management-related video clips through multiple steps including an expert rating, recording eye tracking and retrospective report data from 62 pre- and in-service teachers[18], manually creating dynamic areas of interest, developing a reliable multi-category coding scheme and coding extensive retrospective reports with regard to the events noticed and the skills displayed. Furthermore, in the analysis of teachers’ situation-specific skills with respect to classroom management, low-inference eye movement data were combined with high-inference verbal data allowing data *triangulation,* which is especially recommended in the case of visual expertise research (Holmqvist et al., 2011; Jarodzka et al., 2017). Moreover, the multiple data sources allowed the investigation of all three skills of perception, interpretation and decision-making in a differentiated way and the procedure used supported the situatedness and the immediacy of teachers’ skills.

Another strength of this dissertation lies in the *comprehensive understanding of classroom management* that has been applied and the comparison of two different *instructional formats*. Insights into the *what* and *how* of teachers’ skills beyond behavioral management in whole-group instruction were generated that point out the importance of broadening the research focus. What constitutes expertise regarding group work or other open formats as well as other dimensions of classroom management remains an open question. This dissertation can be the starting point of further research in this regard.

Finally, in contrast to previous studies, a focus was placed on the *STEM* subjects of biology and mathematics. Although classroom management is considered to be generic, it is nevertheless plausible that classroom management as well as typical

[18] Some participants had to be excluded from data analysis because of low eye-tracking data quality. This was due to droopy eyelids, varifocals or lighting conditions which are common reasons for low data quality (Holmqvist et al., 2011).

instructional formats in, for instance, sports, music or art education might look different or require different skills than in *STEM* education. These differences are probably not due to characteristics of the subjects themselves or the content itself, but rather to the typicality or frequency of instructional formats, to student behavior that is usually expected or to the way that learning is supposed to take place. Such effects of the subject were controlled by focusing on the two subjects mathematics and biology.

Despite the strengths of this dissertation, some limitations in terms of *generalizability* need to be acknowledged. First, the results of the systematic review are specific for mathematics education, while the results for Study 2 and Study 3 are specific for biology and mathematics education in lower secondary classes in urban areas in Germany. Thus, generalizability is limited to these contexts and, strictly speaking, to the video clips used. Further research is needed to investigate if the results can be replicated in other subjects (Blomberg et al., 2011; Steffensky et al., 2015), different experimental designs (Kerrins & Cushing, 2000; Seidel et al., 2011) or in non-Western cultures (Bear et al., 2016; McIntyre et al., 2017, 2019; McIntyre & Foulsham, 2018) as well as rural areas (Martin & Yin, 1999; Petticrew & Roberts, 2008).

The sampling in Study 2 and Study 3 reveals some weaknesses that need to be addressed as well. The selection criteria applied for expert teachers did not fully align with recommendations often referred to by Palmer and colleagues (2005), who propose a two-gate identification procedure. While the first gate of screening (years of experience and certification) was met, the second gate of performance indicators (e.g. through peer-review and student achievement data) was not fully applied, since German teachers generally do not observe each other's teaching (Richter & Pant, 2016) and longitudinal student achievement data is not available. Instead, external evaluation indicators of exceptional expertise were required for teachers to be considered an expert, as, for instance, additional responsibilities and tasks in schools or teacher education. However, it cannot be assumed with certainty that all teachers were indeed exceptional experts. Furthermore, the analyses in Study 2 and Study 3 did not use any normative standards in terms of what teachers should notice or should perceive, interpret or decide to be considered a good classroom manager as such guidelines do not exist yet. However, this dissertation can help to develop such standards based on characteristics of experts' skills.

The opportunity sampling in Study 2 and Study 3 is another limitation in terms of generalizability of the results. Moreover, a self-selection bias is possible that could lead to a sample of, for example, more open minded or extraverted participants than would be representative for the sample of novice or expert teachers. In addition, using a rather small sample due to the very high effort of recording and analyzing eye tracking and verbal data limits generalizability. However, as reported in Study 2 and Study 3 test power was high enough to reveal expertise differences similar to the effect sizes reported in prior studies.

The innovative character of the *methods* applied has also disadvantages. Especially when analyzing eye movements, it should be noted that the eye-mind-assumption is not always valid. Research on visual expertise in different domains reveals that expertise effects are highly context specific as well (Jarodzka et al., 2017; Orquin & Holmqvist, 2017). Although triangulation with verbal data assured validity to some extent, further research is needed to develop quality criteria for eye tracking research in such a complex domain as teaching. Also, asking participants to retrospectively report what they found noteworthy could generally have been less valid than letting them report concurrently. However, observing teaching is more demanding and complex than, for instance, playing chess and simultaneously thinking aloud, thus concurrent reports could interfere with cognition. Moreover, retrospective reports were stimulated with teachers' prior eye movement, supporting the validity of the verbal data obtained (Hyrskykari et al., 2008; van Gog et al., 2005).

8 Conclusions and Further Research

In this final chapter, conclusions are drawn and directions of further research are proposed against the background of the results of this dissertation and the guiding question:

HOW DO NOVICE AND EXPERT TEACHERS DIFFER REGARDING THE *WHAT* AND *HOW* OF THEIR SITUATION-SPECIFIC SKILLS?

Situation-specific skills regarding classroom management

Building on the results of Study 2 and Study 3, conclusions can be drawn regarding expertise effects as well as the conceptualizations and methods for future research and teacher education. Novice-expert differences with medium to large effect sizes indicate that expertise is characterized by a (visual and verbal) focus on students, by more pronounced interpretation and decision-making skills and a stronger emphasis on preventive classroom management (Stahnke & Blömeke, 2021a). The format-specific expertise effects in Study 2 strongly suggest that the varying challenges of different formats of instruction need to be addressed in further research. A too narrow focus on whole-group instruction could impede the uncovering of format-specific demands on teachers' classroom management skills. Also, with respect to the conceptualization of classroom management, the need for a broader focus became apparent in Study 2 and Study 3: When video clips are used that show many different dimensions of classroom management, expertise effects are found that contradict previous research focusing on behavioral management. However, sharing a broad understanding of classroom management is not sufficient, it is also necessary to explore specific challenges of different dimensions of classroom management, for example, by using video clips of similar events in different formats of instruction. Other context variables such as culture, urban or rural areas or the teaching subject have also not yet been considered. Further studies could provide evidence for the generalizability of expertise effects in this regard.

The procedure and methods used to elicit teachers' skills in Study 2 and Study 3 were developed based on findings from expertise research (Guan et al., 2006; Hyrskykari et al., 2008; Prokop et al., 2020; van Gog et al., 2005) and preserved the spontaneous character of teachers' skills that is particularly important regarding classroom management. On the one hand, this procedure was more situated than standardized instruments (Gold & Holodynski, 2015; König & Lee, 2015). Yet on the other hand, it was less situated than studies using mobile eye tracking methods during instruction instead of video-based designs (Cortina et al., 2015; McIntyre et al., 2019). A systematic comparison or even triangulation of more and less standardized methods for eliciting or measuring skills is needed as well as comparing their predictive validity for teachers' classroom management behavior. Such research could tell if, for instance, eye tracking studies are worth the additional effort.

The findings of this dissertation also imply that multiple dimensions of classroom management as well as formats of instruction that are frequently used in today's schools need to be included in teacher education curricula and professional development. However, to date, teacher education often focused on behavioral problems in whole-group instruction (Wubbels, 2011). Moreover, the focus of novices should be redirected towards students and their learning as the goal of efficient classroom management, rather than framing classroom management as a matter of discipline and order. Overall, there is evidence that the development of a perspective towards considering the whole system of learning and instruction instead of only isolated aspects or parts, is instrumental in becoming a good classroom manager. To learn how this shift can be supported would greatly help teacher education.

Situation-specific skills in general

Considering the results of all three studies, it can be concluded that some characteristics of experts' situation-specific skills are more generic (especially regarding the *how* of teachers' skills) while other aspects are more content- or context-specific (particularly in terms of the *what* of teachers' skills). For instance, characteristics of expert teachers' classroom management-related skills differ by instructional format, however being more interpretive and making more suggestion are features of expertise across content areas (Stahnke et al., 2016; Stahnke & Blömeke, 2021b; Wolff et al., 2017). Which characteristics are indeed generic and which are content-specific is an important question for further research and teacher education.

With regard to the goal to systematically review and synthesize research, Study 1 (Stahnke et al., 2016) has confirmed key assumptions of the competence as a continuum model (Blömeke, Gustafsson, et al., 2015): The skills are learnable, they are indicators of expertise and they are linked with both dispositions and performance. More recent research further elaborated on the relation of teachers' competence in terms of dispositions and skills and instructional quality as well as students' achievement indicating that both dispositions and skills are needed to predict instructional quality and student achievement (König et al., 2021). A major constraint that became apparent through the systematic review, though, is the lack of conceptual clarity. While the term *noticing* is especially still used inconsistently for either focusing on perception or on all three skills, there have been other theoretical developments since Study 1 was conducted and published. Whereas the model of Blömeke and colleagues (2015) focused on classroom interactions, other researchers have proposed that noticing includes contexts such as curriculum planning or lesson reflection as well (Amador et al., 2017; Choy et al., 2017). Recently, van Es and Sherin (2021) contended the continuum model (Blömeke, Gustafsson, et al., 2015) in an expansion of their conceptualization. They argued that noticing is not a passive skill but involves actively interacting with the environment and thus, they proposed *shaping* as a third dimension of noticing that "involves constructing interactions and contexts to gain access to additional information" (van Es & Sherin, 2021, p. 3). In the same way, focusing on the reacting teacher might neglect the collaborative nature of teaching where the teacher and the students interact constantly (Nückles, 2020). In this regard, expanding the analyses of teachers' skills from being investigated at one point in time in one specific situation towards more process-based time-series or teacher-student interaction analyses are promising directions for further research (Kersting et al., 2021; Mainhard et al., 2012; Panis et al., 2020; Pennings et al., 2014). For instance, a recent study conducted time-series analyses on teachers' gaze data, which was synchronized with student behavior and found novice teachers' attention to be most attracted by salient and active learning behavior (Goldberg et al., 2021). However, as eye tracking, time series or interaction analyses produce extensive process-data, the potential benefits of new data analysis methods such as data mining or machine learning should be explored (Goldberg et al., 2019; Shin & Shim, 2020).

The three situation-specific skills assumed in the continuum model were investigated together in many studies (Stahnke et al., 2016; Stahnke & Blömeke, 2021b). While there is general consensus among these studies that three skills can be differentiated, an open question is whether perception, interpretation and decision-making represent three sequential steps or phases or if they are applied cyclically (Scheiner, 2016). It is also unclear whether teachers' skills are, apart from their importance during teaching, also necessary skills to enable teachers' reflections and deliberate practice, which is instrumental in the development of expertise (Ericsson, 2006b). More qualitative analysis of teachers' verbalization along with their visual attention could help to learn more about the relation of the three skills and how they are each applied.

Similarly, with respect to the definition of particular skills, more specificity regarding the involved cognitive processes is needed. The skill of perception can be conceptualized in many different ways, starting with teachers' visual perception as in the visual search or scene perception paradigm from cognitive psychology (Biermann et al., 2020; Kaakinen, 2020; Rayner, 2009), or as noticing certain events that are assumed to be relevant, or also as what teachers talk about (thus, attend to) in their comments (B. Sherin & Star, 2011). These various conceptualizations of perception actually address very different cognitive processes, that each represent separate strands of (expertise) research. Such processes might involve visual and auditory perception, selective attention, scene perception, visual search, mental models, schemata and scripts or memory (Ericsson et al., 2006). Similarly, decision-making as it is operationalized in different studies, addresses aspects of judgement, reasoning or decision-making (Eysenck & Keane, 2007). Further research should reflect this lack of clarity in definitions (and operationalizations) and aim for a more comprehensive and detailed model of teachers' skill that integrate or clearly exclude the cognitive processes mentioned above. Such a model would allow future research to rely on more specific findings and methods from expertise research.

Building on the question of how situation-specific skills are conceptualized is the question of operationalization. Study 1 showed that a situated perspective grounded in expertise research was mostly linked to more situated and qualitative measures, while a cognitive perspective shared by competence research preferred more standardized instruments. Depending on the conceptualization of teachers' skills, the notion of such standardized assessment might not be fully compatible with the situated nature of these skills (Chan et al., 2020). However, further research is needed in order to determine if more standardized instruments actually miss any crucial aspects of teachers' skills or are an economic and valid way to investigate larger samples of teachers. A major disadvantage of more situated instruments are limitations in terms of generalizability. Video clips used might differ considerably in complexity or other aspects that could impact the results of research (Jarodzka et al., 2020). Studies that systematically analyze the influence of complexity or other context variables are needed. Such studies should clearly state what characteristics video clips are supposed to have and why video clips have been selected in order to fulfill these particular features.

This dissertation has shown that with respect to the *how* of teachers' skills across different contents and contexts, it is especially decision-making that challenges novice teachers and should be supported (Stahnke et al., 2016; Stahnke & Blömeke, 2021b). With regard to the support of the *what* of teachers' skills, content-specific insights are necessary for identifying novices' strengths and weaknesses (Stahnke et al., 2016; Stahnke & Blömeke, 2021a). While fostering a focus on students' learning seems to be generally advantageous, more research is needed in order to investigate what exactly means relevant and thus note-worthy in a classroom management scene or a student solution. Investigating experts' agreement on note-worthy events or note-worthy features of student solutions and their meaning is a promising direction for further research in this context.

As Study 1 showed, teachers' skills can be fostered with situated learning opportunities including video-based interventions or lesson analysis (Stahnke et al., 2016). Current studies further investigated the influence of specific characteristics of interventions (Amador et al., 2021), for instance, if functional or dysfunctional scenarios are used (Thiel et al., 2020) or if an observer or protagonist perspective is taken when analyzing videos (Gold et al., 2020). This research field is still very heterogeneous and many questions regarding the design of interventions remain open. It would be very valuable if empirically supported design principles were developed on how to translate results about this *what* and *how* into the design of content-specific teacher education or professional development programs. Incorporating innovative technologies as, for instance, in the use of eye movement models (Jarodzka et al., 2013), simulations (Y. Huang et al., 2021) or gaze-augmented video-replays of teaching (Cortina et al., 2018) are further promising approaches. Such techniques can, on the one hand, preserve the situatedness of teachers' skills (e.g. gaze-augmented video replays). On the other hand, simulations or eye-movements models can reduce the complexity of situations and help novices to focus their attention on the relevant aspects of a scene (Jarodzka et al., 2017).

Integrating such new technologies and methods can not only be useful in terms of the situated nature of skills. Methods such as simulations or data mining also enable research to pay more attention to processes instead of outcomes, while not being constrained to very small samples. The increasing focus on competence, in particular in Germany as motivated by the PISA shock and the bologna reform, was accompanied by a strong cognitivist understanding of competencies. Consequently, a behaviorist epistemology including a focus on learning outcomes regained popularity, which has recently been criticized (Murtonen et al., 2017). Regarding teachers' situation-specific skills, more process-based research, as conducted in this dissertation, would substantially complement outcome-focused research methods and findings of the last two decades and help to answer the larger question of what makes a good teacher.

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Appendix A – Events Noticed

Table 18. *Events noticed in video clip 1 – Whole-group instruction format*

Event	**Novice teachers**	**Expert teachers**	**All teachers**	**Type of event**
Individual events in temporal order				
Students take turns at presenting their solution at the smart board				
Teacher alternates between boys and girls	N = 5	N = 0	N = 5	TP
Student lingers and clowns around after his presentation *	N = 4	N = 10	N = 14	SD
Transition between students is not structured well	N = 2	N = 2	N = 4	TP
Teacher urges students to be quit for the first time				
Teacher calls students' names and urges them to be quiet	N = 16	N = 11	N = 27	TR
Teacher asks students to pull through because the break is close	N = 13	N = 11	N = 24	TR
Teacher is unmotivated and on edge	N = 4	N = 1	N = 5	TR
Anna presents her solution on the smartboard				
Teacher wants Anna to explain her solution	N = 6	N = 3	N = 9	TP
Students don't listen to Anna (uncomfortable for Anna)	N = 6	N = 8	N = 14	SD
Teacher presses Anna: "But you must be able to explain your solution!"	N = 3	N = 3	N = 6	TP
Teacher doesn't discipline the students during Anna's presentation	N = 5	N = 4	N = 9	TR
Teacher urges students to be quiet again				
Teacher asks students to be quiet.	N = 13	N = 9	N = 22	TR
Teacher asks students to pull through because the break is close	N = 16	N = 10	N = 26	TR
Teacher asks students louder and more urgently to be quiet.	N = 9	N = 6	N = 15	TR
Teacher seems desperate.	N = 2	N = 3	N = 5	TR
Class is getting calmer.	N = 3	N = 3	N = 3	SD
Students not receptive anymore. Time for a break?	N = 1	N = 1	N = 2	SL
Lasting or repeated events				
Teacher doesn't keep an eye on students	N = 2	N = 3	N = 5	TP
Source of noise in the background	N = 1	N = 3	N = 4	TP
Whole class is unruly and loud	N = 15	N = 12	N = 27	SD
Student is raising her hand and being ignored*	N = 6	N = 9	N = 15	TP
Teacher's position in the room	N = 5	N = 6	N = 11	TP
Teacher's posture and presence	N = 1	N = 5	N = 6	TP
Missing structure and task	N = 0	N = 4	N = 4	TP
Wasted time, low time-on-task	N = 1	N = 1	N = 2	TP
Individual students are engaged and attentive	N = 3	N = 5	N = 8	SL
Individual students are disengaged and misbehaving	N = 6	N = 10	N = 16	SD
	N =148	N = 143	N = 291	

Note. TP = preventive teacher event, TR = reactive teacher event; SD = student discipline event; SL = student learning event; * = visible, frequently noticed event.

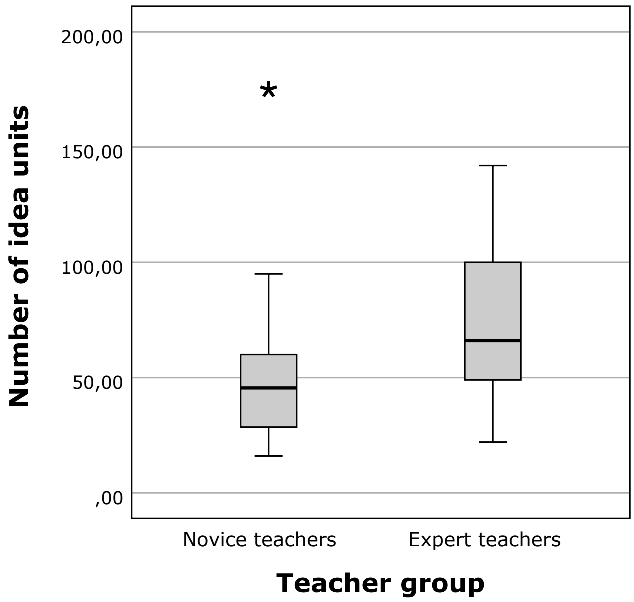
Table 19. *Events noticed in video clip 2 – Partner work format*

Event	Novice teachers	Expert teachers	All teachers	Type of event
Individual events in temporal order				
Whole class is loud at the beginning				
Students are loud and not paying attention	N = 3	N = 3	N = 6	SD
Teacher does not react to noisy class	N = 1	N = 3	N = 4	TR
Two students are fighting each other behind the teachers' back				
Two students fool around and fight each other*	N = 6	N = 12	N = 18	SD
Teacher does not notice the students fighting	N = 0	N = 3	N = 3	TR
Teacher does not react to students fighting each other	N = 2	N = 5	N = 7	TR
The boy with the hoody				
Student is hooded – against rules	N = 2	N = 7	N = 9	SD
Teachers does not react to hooded student (yet)	N = 1	N = 5	N = 6	TR
Student seems to be unmotivated and sad	N = 5	N = 7	N = 12	SL
Teachers talks briefly to hooded student	N = 5	N = 3	N = 8	TR
Teachers is hunched over and talks to hooded student (again)	N = 9	N = 8	N= 17	TR
Teacher goes through rows and monitors students	N = 7	N = 9	N = 16	TP
The boy with the hat				
Student puts on a hat – against rules	N = 10	N = 16	N = 26	SD
Teachers does not react to student with hat (yet)	N = 6	N = 13	N = 19	TR
Teacher pulls students' hat	N = 15	N = 16	N = 31	TR
Student takes off hat	N = 5	N = 6	N = 11	SD
Teacher talks to student in the left front corner	N = 1	N = 2	N = 3	TP
Lasting or repeated events				
Teacher doesn't keep an eye on students	N = 1	N = 3	N = 4	TP
Good student-teacher-relationship	N = 1	N = 3	N = 4	TP
Whole class is unruly and loud	N = 7	N = 14	N = 21	SD
Group work or partner work (phase and mode of instruction)	N = 13	N = 11	N = 24	TP
Teacher's position in the room	N = 1	N = 2	N = 3	TP
Teacher's posture and presence	N = 9	N = 6	N = 15	TP
Missing structure and task	N = 3	N = 3	N = 6	TP
Furnishing and architecture of the room	N = 2	N = 1	N = 3	TP
Seating arrangements	N = 4	N = 7	N = 11	TP
Right group and students in the front are attentive	N = 2	N = 4	N = 6	SL
Timer on smartboard as orientation for students*	N = 4	N = 4	N = 8	TP
Rule of no jackets or headdress in science rooms	N = 4	N = 8	N = 12	TP
Individual students are engaged and attentive	N = 1	N = 4	N = 5	SL
Individual students are disengaged and misbehaving	N = 6	N = 4	N = 10	SD
	N = 137	N = 191	N =328	

Note. TP = preventive teacher event, TR = reactive teacher event; SD = student discipline event; SL = student learning event; * = visible, frequently noticed event.

Appendix B – Boxplot of Novice and Expert Teachers' Number of Idea Units

Figure 5. *Boxplot of novice and expert teachers' number of idea units*



Appendix C – Coding Scheme

Table 20. *Perception, interpretation and decision-making skills codes*

Code	Definition	Example
Perception		
Description[1]	Statements that describe what can be seen or heard in the video.	"He's repeating that now, that he wants quiet, please."
Missing information[1]	Statement that point out that something cannot be seen or heard, such as people or activities not captured by the camera	"The teacher is also again, I think, in front at the teacher's desk or I do not know where... You can't see it."
Interpretation		
Inference[1]	Assumptions about cognitive, motivational and/or affective states of students or teacher	"Yeah, and he had – he kind of wanted to get some order back."
Prediction[1]	Assumptions about actions the teacher or the students will perform soon, about student learning or possible effects of the lesson (goes beyond the scope of the video clips)	"Well, I think he is inviting them to act up someday."
Positive evaluation	Statements that positively evaluate the teacher, his actions or intentions	"So here he gives thanks again, some praise and appreciation, which I thought was good."
Negative evaluation	Statements that negatively evaluate the teacher, his actions or intentions	"He (the student) has said something and it is not appreciated, neither positively nor negatively. He is completely ignored. That was – I didn't like it."
Orienting	Statements about the participant orientating himself or herself in the classroom scene	"Could also be that somehow (...) that they're just experimenting in groups."
Contextualizing	Statements that put one's own statements into perspective with alternative interpretations or by comparing them with other situations	"But I didn't think it was dramatic. That's just how teaching is."
Decision-Making		
Contextualized suggestion/comment[1]	Statements on how to improve the specific situation	"I'd have found it more appropriate to react differently."
Generalized suggestion/ comment[1]	Statements on how to improve teaching in general	"I always try to give the lesson some structure, first."
No code applicable	Statement cannot be assigned to any other code	"I can't think of anything else."

[1] Categories are adapted based on (Wolff et al., 2015, 2017).

Table 21. *Focus of analysis codes*

Code	Definition	Example
Students in focus		
Student behavior: negative[1]	Statements about negative student behavior (misbehavior and disengagement)	"No one is listening to the teacher!"
Student behavior: neutral or positive	Statements about neutral or positive student behavior (absence of misbehavior or active engagement)	"Now, everyone's paying attention too."
Student learning[1]	Statements about student learning and its outcomes	"Well, this is no learning atmosphere - so in THIS classroom, very few students will learn anything!"
Student motivation	Statements about student motivation	"Actually, the students seem quite motivated."
Students emotions and well-being	Statements about student emotions and student well-being	"it's not always about saying something right, because especially when with very quiet children they are afraid what they're saying might be wrong."
Teacher in focus		
Control of lesson flow[2]	Statements about teacher's control of lesson flow, the clarity of goals and lesson smoothness	"I think he's very transparent about what he does, what he expects from the students and what will follow."
(Non)reaction to misbehavior[2]	Statements about teacher's (non)reaction to student misbehavior or inappropriate behavior	"He said 'The others are quiet, please' or something like that."
Monitoring students[2]	Statements about the teacher keeping an eye on the students, noticing what is going on or failing to do so	"He walks through the rows and looks what they (students) are doing."
Motivating students[2]	Statements about the teacher activating or motivating the students	"He says-. He motivates them again, he motivates-. Tries to motivate them to be quiet for another five minutes and then /umm/ they're finished."
Appreciation of students	Statement about teacher's appreciation and esteem for students	"I noticed, that the teacher thanked her for presenting her solution."
Attitude or presence	Statements about teacher's attitude, presence, body language or mimic	"And then the teacher came into the picture and I had the feeling: Is that a teacher or is that a student? Because /umm/ I don't like his presence."
Other teacher behaviors	Statements about other teacher behaviors	"He talks to the girl."
Teacher emotions	Statement about teacher's emotions and feelings	"In this situation he seems insecure – and /umm/ desperate."
Context in focus		
Classroom (and surrounding)	Statements about the classroom and the school environment	"So, there's background noises like children screaming or something, so I don't know if it's a schoolyard or if there's something going on in the hallway."
School or class rules[2]	Statements about rules (for the class or the school)	"There doesn't seem to be a rule that you have to put your hand up when you want to say something."
Phase or mode of instruction	Statements about the phase of the lesson or mode of instruction	"It's not quite clear whether they're supposed to work together on the problem or not."
No code applicable	Statements cannot be assigned to any other code	"I don' know. Where was I?"

[1] Categories are adapted based on (Wolff et al., 2015, 2017).

[2] Categories are adapted based on (Piwowar et al., 2013).

Table 22. Dimensions of classroom management codes

Code	Definition	Example
Reactive behavioral management	Utterance addresses reactive dealing with student misbehavior or disengagement (can include actual teacher behavior or suggestions)	"He said 'The others are quiet, please' or something like that. He was a little louder because they still have not gotten quiet, and they are getting louder and louder, the students. It was just his intention that the students could work quietly."
Preventive behavioral management	Utterance addresses actions in order to prevent student misbehavior or disengagement (can include rules or monitoring; can include actual teacher behavior or suggestions)	"I noticed the position of the teacher. And he doesn't have the students in view, /umm/ with where he faces and were his back is."
Instructional management	Utterance addresses planning of lesson, control of lesson flow, phasing, methods and techniques (can include actual teacher behavior or suggestions)	"There on the Smartboard is a clock, which I would assume, indicates how much time they (the students) still have for their group work. (…) The students can orientate themselves on how much time they have left and consider for themselves how concentrated and hard they have to work in the remaining time."
Affective-motivational management	Utterance addresses student-teacher-relationship, appreciation or motivating of students (can include actual teacher behavior or suggestions)	"I noticed that the student volunteered to go to the blackboard. And (...) it's no big point of criticism now, but I think that the teacher /umm/ is making a bit of a reproach that she can't explain it properly – even though the attempt was actually made to /umm/ participate actively in the classroom."
Self-Presentation	Utterance addresses teacher attitude, impression, facial expression or gesture (can include actual teacher behavior or suggestions)	"If he actually wants everyone's attention (…) I would say he is standing there quite relaxed at the side. Of course, this (...) doesn't signal this, this /umm/, this "Look here and pay attention!"

Selbstständigkeitserklärung zur Dissertation

Statement of authorship

Ich erkläre ausdrücklich, dass es sich bei der von mir eingereichten Arbeit mit dem Titel

Teachers' Situation-Specific Skills with a Particular Focus on Classroom Management:

Evidence from a Systematic Review and Novice-Expert Studies

um eine von mir selbstständig und ohne fremde Hilfe verfasste Arbeit handelt.
I expressly declare that the work I have submitted was written independently and without external help.

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Berlin, den 01.02.2021

Rebekka Stahnke