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Training & prompting pre-service teachers' noticing in a standardized classroom simulation – a mobile eye-tracking study

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Numerous events happening in classrooms require a teacher to select important and filter out irrelevant information. This crucial and challenging skill is referred to as noticing. For noticing classroom management events pre-service teachers have a smaller knowledge base and little teaching experience compared to expert teachers. Supporting pre-service teachers in developing their classroom management knowledge and noticing skill is, thus, of great importance for teacher education. Previous research finds positive effects of interventions on teachers' noticing during video observation. To our knowledge, no studies depict noticing during teaching. We examined $N = 46$ pre-service teachers' noticing with regard to classroom management during classroom teaching in a quasi-experimental between-subjects design. Pre-service teachers' took part in a standardized classroom simulation after a classroom management training, with one group receiving prompting regarding evidence-based classroom management strategies before and during the classroom simulation and one group receiving only training. We also included a control group without classroom management training. To assess differences in pre-service teachers' noticing, the classroom simulation elicited comparable conditions, including standardized classroom management events and student behavior. Mobile eye-tracking as well as retrospective video observations were used to explore teachers' event-related and global noticing. Event-related noticing was assessed via count and accuracy of noticed classroom management events. Global noticing included objective parameters of teachers eye movements (visit/fixation counts and duration) onto the students in the standardized classroom simulation. The results show that training and prompting significantly affected pre-service teachers' event-related noticing, with both experimental groups making fewer target and time errors compared to the control group. No significant differences were found with regard to global noticing. This includes fixation and visit count and duration on students. Correlational analysis showed a positive association between higher noticing accuracy and share of fixations on students. This study expands upon previous empirical research using mobile eye-tracking to obtain objective measures of teachers' noticing. It sheds light on the relevance of knowledge for teachers' noticing during teaching. It also takes a first step toward understanding how pre-service teachers' noticing during classroom teaching can be promoted through fostering knowledge about classroom management through a training.

KEYWORDS

noticing, classroom management, mobile eye-tracking, preservice teachers, instructional support, simulation-based learning

1. Introduction

With reference to the concept of professional vision and noticing (Goodwin, 1994; Seidel and Stürmer, 2014; van Es and Sherin, 2021), teachers are able to selectively attend to classroom events relevant for students' learning and interpret them based on their professional experience and knowledge. Teacher noticing is primarily based on visual perception (Wolff et al., 2021). Thus, current studies use (mobile) eye-tracking to explore teachers' eye movements and thereby aim to obtain objective measures of teachers selective attention. They explore teachers' noticing during the act of their own teaching (in-action: e.g. Cortina et al., 2015) and on-action contexts, which refer to teachers observing their own or others' classroom interactions after the act of teaching (e.g., video analysis: Sherin and Han, 2004). However, most in-action studies using (mobile) eye-tracking apply exploratory expert-novice comparisons. As they mainly use experience (years of teaching) or formal qualifications as a marker for expertise (e.g., Cortina et al., 2015; van Driel et al., 2021), they allow for only broad conclusions about whether and how it is possible to promote teacher noticing. With regard to classroom management, which has been shown to be a key determinant of student achievement (Seidel and Shavelson, 2007; Hattie, 2009), the identification of relevant events appears to be particularly important. We set out to investigate how the acquisition and activation of classroom management knowledge through an intervention (classroom management training and prompting) might affect pre-service teachers' (PSTs') noticing during a standardized classroom simulation. With this we aim to explore the relevance of classroom management knowledge for teachers' noticing during teaching. Hereby, we focus not solely on measuring PSTs' noticing as assessed by aggregated measures of eye movements to students in the classroom (global noticing). We also explore the number and accuracy of identified classroom events (event-related noticing) in a standardized classroom simulation by coding simulation recordings and retrospective think aloud commentaries of PSTs' simulation.

In this way, we contribute to discussions about the relevance of using different measures to assess teachers' noticing. In addition, we underline the importance of examining cognitive processing when assessing visual attention in-action. Implications for teacher education are discussed.

2. Theoretical background

2.1. Theoretical considerations about teachers' noticing with regard to classroom management

A teachers' skill of attending to significant and ignoring irrelevant events has been widely discussed under the holistic concept of professional vision (Goodwin, 1994; Sherin, 2001; van Es and Sherin, 2021). It is differentiated into different subfacets (König et al., 2022), depicting how teachers attend to events or situations and how they interpret those based on specific knowledge structures (cognitive scripts) and distinctive professional experiences (see Wolff et al., 2021). Seidel and Stürmer (2014) specifically describe the facets, noticing (selective attention) and knowledge-based reasoning, as two interrelated processes. Defined as how teachers selectively attend to or "see," noticing here posits teachers' visual perception as a precondition for subsequent interpretations of classroom events (Wolff et al., 2021). In this study, we particularly focus on the noticing process and refer to the term noticing synonymous with selective attention. We further focus on teachers' noticing with regard to classroom management events (Gold and Holodynski, 2017; van Driel et al., 2021), as this seems particularly useful for teacher education. Classroom management is a key determinant of student achievement (Seidel and Shavelson, 2007; Hattie, 2009) and described as a central knowledge component of teachers' professional competence (Baumert and Kunter, 2013; Blömeke et al., 2015). Specific knowledge about efficient classroom management might entail behavioral aspects of teachers' monitoring, including teachers withitness. In accordance to Gold and Holodynski (2017) and Kounin (1970), monitoring encompasses preventive strategies (non-verbal and verbal). These strategies depict communicating awareness to every individual student while maintaining a group focus on the class (e.g., pausing and calling on pupils, who do not participate) and keeping an eye on any events in the class in order to efficiently intervene and prevent disruptions (e.g., signaling with their gaze that one is aware of students engaging in disruptive behavior & walking around the whole classroom). In this line, Kounin (1970) also refers to the technical terms of time error (i.e., teacher notices and reacts to the disruption too late) and target error (i.e., teacher notices and addresses the wrong pupil). The behavioral strategies of monitoring show a proximity to the construct of noticing. In that focusing their gaze, wandering around the classroom and maintaining group focus (Kounin, 1970) seem important strategies for being able to direct attention to significant events happening in the classroom. Wolff et al. (2021), describe withitness as integrated situational awareness that forms the basis for teacher noticing. Thus, we conclude that specific knowledge structures about monitoring influence how preservice teachers selectively attend to classroom management events.

2.2. Assessment of teacher noticing using (mobile) eye-tracking (videos)

Seidel et al. (2020) argue that teachers' gaze assessed by (mobile) eye tracking provides a suitable operationalization for the noticing process to add on previous models of teacher cognition and professional vision (see Seidel and Stürmer, 2014; Lachner et al., 2016). Eye movements are guided by both top-down (e.g., knowledge) and bottom-up (e.g., saliency) processes (Schütz et al., 2011). As quantifiable measures of perceptual activity they indicate what objects, persons or events are currently being consciously processed, suggesting (selective) attention (see eye-mind hypothesis, Just and Carpenter, 1980).

To operationalize the process of noticing, previous works not only assess teachers' gaze but also the identification of events through for example think aloud procedures (Stahnke and Blömeke, 2021). In this paper, we adopt these different approaches by differentiating and investigating both global- and event-related noticing (see Grub et al., 2022b: global and event-related gaze behavior).

Previously, both in- and on-action studies explore teachers' global noticing by investigating eye movement measures (e.g., fixation/visit count and fixation/visit duration, see Grub et al., 2020), onto different objects, areas or persons (e.g., students, materials, task-relevant areas) in a classroom (video) (e.g., on-action: Yamamoto and Imai-Matsumura, 2013; van den Bogert et al., 2014; Kosel et al., 2021; in-action: Smidekova et al., 2020; Huang et al., 2021a; Chaudhuri et al., 2022). Global noticing measures are characterized by the fact that they represent aggregated eye movements over a certain time sequence, i.e., video length or lesson time. Sometimes they are also converted into ratios as the gaze relational index (Gegenfurtner et al., 2020) or the Gini coefficient (Cortina et al., 2015). Studies exploring these eye movement measures are mostly based on the eye-mind hypothesis (Just and Carpenter, 1980). This assumption posits that recorded eye movements indicate what area or contents are currently being consciously processed, suggesting a connection between attention and fixation measures. However, these studies exhibit limitations as they neglect the role of covert attention/peripheral vision, shown in different real-world tasks (e.g., Malik et al., 2022; Vater et al., 2022). Hence, by exploring global noticing, it is usually hardly possible to draw conclusions about the succession of individual cognitive processes and, thus, the application of knowledge.

Many on-action studies investigate event-related noticing, which refers to the identification of classroom events in ones' own or others classroom video (e.g., Wolff et al., 2016; Stahnke and Blömeke, 2021; Wyss et al., 2021; Grub et al., 2022a,b). A classroom event is defined in terms of content, for example effective instructional quality characteristics. With regard to classroom management this might refer to classroom disruptions, e.g., a student throwing a paper airplane during class time. Measures of event-related noticing can include eye movements (e.g., time to first fixation) related to these specific events in a classroom (video). In addition, indicators such as the number and type of noticed classroom management events as indicated by the participant (e.g., Stahnke and Blömeke, 2021; van Driel et al., 2021; Grub et al., 2022a). Based on the latter measures, collected through (retrospective) think-aloud protocols/stimulated recall interviews (Minarikova et al., 2021; Stahnke and Blömeke, 2021; Wyss et al., 2021; Grub et al., 2022a), we are able to more validly draw conclusions about attention.

To our knowledge, in-action studies rarely explore event-related noticing. The few examples include studies by van Driel et al. (2023) and Minarikova et al. (2021). There are several reasons why this is the case.

First and foremost, it is exceedingly difficult to ensure comparability between classrooms and classroom management events. Huang et al. (2021a) and Cortina et al. (2015) studied paired teachers teaching the same classrooms. Goldberg et al. (2021) and Stürmer et al. (2017) looked at standardized teaching simulations. To control specific bottom-up influences on teacher noticing and draw well-founded conclusions about the relevance of knowledge as a driver of attention during teaching, one challenge remains, namely establishing standardized conditions in a classroom context. Other factors that influence attention also speak in favour of standardization. Alongside knowledge and experience, studies ascertain classroom characteristics, seating order, students' gender (Smidekova et al., 2020), cultural factors (McIntyre and Foulsham, 2018; McIntyre et al., 2019) and student behavior (Goldberg et al., 2021; Kosel et al., 2023) to influence teachers' selective attention during classroom teaching. The affordances of the activity setting (student-directed partner work vs. teacher-directed whole-group activities) might also be relevant for teachers' noticing both during teaching (Cortina et al., 2015; Chaudhuri et al., 2022) and while observing teaching (Seidel et al., 2020; Stahnke and Blömeke, 2021).

In a similar vein, validly assessing event-related noticing requires (retrospective) think-aloud protocols/stimulated recall interviews. For in-action settings, such methods seem more difficult. Huang et al., (2021a, p. 3) describe the reasons for this as twofold. On the one hand, it does not seem possible to ask teachers to report on classroom events during instruction. On the other hand, remembering and verbalizing noticed classroom events might fail due to the relevant information not being consciously available. Recent studies, however, explore possibilities for assessing event-related noticing in-action through retrospective think-aloud protocols (Cortina et al., 2018; Minarikova et al., 2021; van Driel et al., 2022) and hand-signaling during instruction (van Driel et al., 2021).

In conclusion, using standardized classroom contexts and think-aloud approaches seems an inevitable step for in-action research in order to explore event-related noticing and the relevance of knowledge that guides the identification of classroom management events.

2.3. Knowledge and teaching experience as prerequisites for teachers' noticing

It is theoretically assumed that teachers' noticing is influenced by knowledge, stored as scripts in mind (Lachner et al., 2016; Wolff et al., 2021). Due to their lack of professional experiences in a classroom context, novices knowledge structures are limited compared to experts, who posses elaborate knowledge about classroom events as they were previously exposed to numerous classroom situations (Wolff et al., 2021, p.138). Comparisons of experts' and novices' eye movements are a common approach to support this assumption and understand teachers' noticing. Some eye-tracking research looking into global noticing indicates that novice teachers compared to experienced teachers differ greatly in how they use their gaze (e.g., Cortina et al., 2015), while others find few or distinctive differences within individual teachers (e.g., Smidekova et al., 2020; van Driel et al., 2021, 2023; Chaudhuri et al., 2022). Nevertheless, two central differences can be identified. Teachers with more experience tend to use their gaze more efficiently, similarly as in other fields of expertise, with shorter fixation durations and a higher number of fixations on task-related areas. This indicates improved information processing (Gegenfurtner et al., 2011). In addition, more experienced teachers show a selective focus of attention onto individual students and distribute their attention more evenly across (more) students (van den Bogert et al., 2014; Cortina et al., 2015; Dessus et al., 2016; Stürmer et al., 2017; Huang et al., 2021a,b; Kosel et al., 2023). Some previous studies using the Gini coefficient (GC), a statistical measure of unequal distribution (Cortina et al., 2015; Dessus et al., 2016), support this assumption. The Gini coefficient of novice teachers, in mean between 0.32 and 0.34, (Cortina et al., 2015; Dessus et al., 2016) indicates more difficulties in distributing attention equally. Some studies also focus event-related noticing. During the video observation of partner work compared to whole group scenes, Stahnke and Blömeke (2021) found expertise differences with regard to the frequency of noticed events. In contrast, van Driel et al. (2021) find teachers with different expertise levels noticing almost the same number of salient CM situations during teaching.

Based on these empirically found differences, expertise research reflects that top-down drivers (e.g., knowledge and experience) play a greater role for expert teachers compared to novices than bottom-up attention (e.g., directed by salient features in the classroom). With regard to teaching, this might mean that the selective attention by experienced teachers is more intentional (Haataja et al., 2019, p. 1). This is argued with respect to research on teachers' noticing during the act of teaching (i.e., in-action: e.g. Haataja et al., 2020; Goldberg et al., 2021; Huang et al., 2021a) and studies exploring it while observing own or others' classroom videos (i.e., on-action: e.g. Seidel et al., 2020; Stahnke and Blömeke, 2021; Grub et al., 2022b). Both contexts share the relevance of knowledge as a top-down driver of teachers noticing.

2.4. Promoting teachers' noticing using training and prompts

Based on expertise research, Wolff et al. (2021) describe a link between expert and novice teachers' different levels of classroom management knowledge and their visual processing of classroom management. They, thus, describe the importance of considering the role of classroom management scripts (Wolff et al., 2021), when designing training activities. The eye-tracking study by Grub et al. (2022a) supports this notion, as prospective teachers with higher knowledge more accurately noticed classroom management events. They detected more events related to classroom management and identified those faster (Grub et al., 2022a). In order for novice teachers to improve their noticing of classroom management events it, thus, seems useful to consider how to promote and activate knowledge about classroom management.

However, findings about general differences between expert and novice teachers' noticing can only be used to infer teacher education to a limited extent on how novices might develop expert-like approaches. The previous findings do not provide concrete information about how to promote novice teachers to activate and apply existing knowledge during noticing. Because knowledge is often indirectly assessed via teaching experience (years of teaching) (e.g., Cortina et al., 2015; van Driel et al., 2021) and expert teachers show more elaborate scripts, organized around professional experiences (Lachner et al., 2016), it is also more difficult to draw conclusions about direct effects of knowledge onto teachers' noticing. Expanding upon previous expert-novice noticing research, investigating concrete possibilities to promote and activate knowledge as a top-down driver of PSTs' noticing, hence, seems an interesting next step.

For this purpose, video-based research, relying on verbal reports and vignette tests, already reveals positive effects of interventions (e.g., trainings, instructional support) for supporting PSTs' noticing (Santagata et al., 2021; König et al., 2022). Trainings with regard to classroom management knowledge and video observation over several seminar sessions improved pre-service teachers noticing skills (Gold et al., 2020; Weber et al., 2020). Also shorter trainings (around 60–90 min) have shown positive effects on teacher noticing, in that pre-service teachers attend to more relevant events during video observation (e.g., Martin et al., 2022; Schreiter et al., 2022). For example Schreiter et al. (2022) included preceding knowledge training to examine the identification of difficulty-generating elements in a mathematic task. The experimental group with knowledge training identified more relevant task features and evaluated them correctly at a higher rate than the control group, suggesting a positive influence of specific knowledge components.

For scaffolding the application of previous knowledge and developing complex skills, also prompts have been shown to be effective tools (e.g., Hilbert et al., 2008; van der Meij and de Jong, 2011; Chernikova et al., 2019). In general, they help learners process information and support learning (e.g., Ifenthaler, 2012; Wong et al., 2021). They range from general instructions or questions to very precise and specific ones (Bannert, 2009, p. 139). Specifically with regard to perceptual processes, instructional cues (visual or verbal) during an activity, might direct attention to relevant areas (see de Koning et al., 2009). In this line, eye-tracking research, in general, shows that tasks or cognitions associated with previously acquired knowledge scripts and experiences, influence attention, altering eye movement measures (see Henderson et al., 2007; DeAngelus and Pelz, 2009; Glaholt et al., 2010; Gilbert and Li, 2013; Brams et al., 2019; Papesh et al., 2021). Facilitating medical students progression of eye movements and interpretations to be more "expert like" has successfully been done through training and cueing attention with experts eye movements or verbal guidance (e.g., training: Jarodzka et al., 2012; Kok et al., 2016, cueing during task completion: Chetwood et al., 2012, Leff et al., 2015).

Although teacher noticing research often uses prompts for guiding video analysis (e.g., van Es and Sherin, 2002), effects of different types of prompts on teachers noticing have seldom been studied in this domain (Martin et al., 2022). First eye-tracking studies with regard to teaching now tackle the question of how to promote expert-like noticing while observing classroom teaching by using prompts. A recent study by Grub et al. (2022b) implemented prompts in the form of a short general vs. specific instruction and showed that a specific task instruction seems to influence fixation and visit count (global noticing) among both novice and experienced teachers under specific circumstances (small effect). Additionally, Schreiter et al. (2022) investigated teachers' event-related global noticing of difficulty-generating elements in a mathematic task. More efficient visual processing with regard to task-relevant areas of interest were observed in the form of higher fixation counts, transitions and average fixation durations in the prompted group (Schreiter et al., 2022). The prompted group identified more relevant task features, suggesting a positive influence of prompting (Schreiter et al., 2022).

Summing up, all the studies explore how knowledge acquisition and activation directly affects teachers' noticing only during video observation. Thus, expanding upon previous on-action noticing research and investigating if it is possible to promote knowledge, as a top-down driver of PSTs' noticing in-action seems a promising next step.

3. Aim & research questions

The current study aims to better understand teachers' noticing and close the research gap as follows:

- First, mobile eye-tracking is rarely used to explore teachers' eye movements during teaching, but instead focuses on classroom video observation (on-action).
- Secondly, even when eye movements are assessed during teaching, research focuses on expert and novice comparisons and the

exploration of global noticing without considering teachers' accompanying cognitions. The studies seldom explore event-related noticing due to the lack of standardization and experimental control.
- Thirdly, in terms of significance for teacher education, hypothesis-driven designs that investigate how (prospective) teachers might learn or be triggered to successfully apply their classroom management knowledge in order to improve their noticing are scarce. Few center on teachers' noticing during classroom video observation.

We address these desiderata and apply a quasi-experimental design to explore how a classroom management training and additional prompting affects PSTs' noticing during a standardized classroom simulation. Specifically, on the one hand, we investigate to what extent PSTs are able to apply and activate evidence-based knowledge about classroom management strategies and with that practice more or less efficient noticing of classroom management events. We thus aim to provide new insights into possibilities to promote noticing during teaching in teacher education. On the other hand, we explore the potential association between two different operationalization of teachers' noticing previously reported as indicators of expertise, and explored both in in- and on-action contexts.

We expect certain eye movement patterns across our experimental groups, differing with regard to knowledge activation. We hypothesize that the experimental groups with more knowledge about classroom management use their gaze more intentional (i.e., more top-down selective attention). Hence, they show more efficient global and event-related noticing during teaching. We address the following research questions and hypotheses:

> Research question (RQ):
>
> RQ 1.1: (How) does a training and prompting affect PSTs' noticing as assessed by their global noticing of students?
>
> Hypothesis 1.1a: Trained and prompted PSTs have a higher percentage of visits/fixations and shorter mean fixation durations/visit durations on students in the classroom. The group of prompted and additionally trained PSTs shows the highest percentage of visits/fixations and shortest mean fixation durations/visit durations on students in the classroom.
>
> Hypothesis 1.1b: Trained and prompted PSTs distribute their attention more evenly across the seven simulated learners in the classroom and thus have a lower Gini coefficient (GC) with regard to visit count and duration. The group of prompted and additionally trained PSTs shows lowest Gini values.
>
> RQ 1.2: (How) does a training and prompting affect PSTs' noticing as assessed by their event-related noticing of classroom management events?
>
> Hypothesis 1.2: Trained and prompted PSTs exhibit a higher count and accuracy in noticing classroom management events compared to the control group. The group of prompted and additionally trained PSTs shows the highest noticing accuracy and event count.
>
> RQ 2: To what extent is event-related noticing associated with global noticing of students?
>
> Hypothesis 2: We expect both measures to be affected by more knowledge as a top-down driver. According previous hypotheses, we tentatively assume fixations and visit count to correlate positively with noticing accuracy and count of noticed events. Fixation and visit duration and Gini values we expect to correlate negatively with noticing accuracy and noticed events.

Our findings on the effects of a classroom management training and prompting teachers' noticing during teaching can provide information about whether (and how) it is possible to promote teachers' noticing. By adopting the differentiation (Grub et al., 2022b) between global and event-related noticing, we seek to bridge the gap between previous in- and on-action research. As we assess event-related noticing in an in-action setting, we are able to compare previous results of on-action research and investigate associations with previous eye movement measures used in real classrooms. The results, can advance our understanding of event-related noticing in in-action settings and further inform theory of teacher noticing.

4. Materials and methods

4.1. Design & participants

N = 52 PSTs (75% female) voluntarily took part in our eye-tracking study and participated in a standardized classroom simulation. All were enrolled in a teacher education program at Leibniz University Hannover, Germany. 34.6% of the PSTs studied secondary education and 65.4% aspired to teach special education. All study participants were completing master's degrees, with total semester counts (including bachelor's degrees) of $M_{semester} = 7.1$ ($SD_{semester} = 1.8$). The mean age was 24.9 years, with a standard deviation of 3.5 years. We pre-defined exclusion criteria for eye-tracking recordings as a gaze sample percentage of 80% or higher. We excluded six PSTs due to less gaze sample percentage. For the remaining data, we had a mean gaze sample percentage of 94% (SD = 3.84%); hence, one or both eyes were detected during 94% of the recording duration on average.

The study applied a quasi-experimental design displayed in Figure 1. It included one control group (CG) and two experimental groups: EG-T (experimental group with training) and EG-TP (experimental group with training and prompting). Both experimental groups received a training; one (EG-TP) additionally received prompting regarding evidence-based monitoring strategies. PSTs enrolled in three seminars were randomly divided into the two EGs. A fourth seminar formed the CG. PSTs in the CG took part in the simulation before learning about classroom management.

4.2. Standardized classroom simulation (TeachEye-ClasS)

The simulation "TeachEyeClasS" was embedded in four university courses on planning teaching practice and classroom management. In contrast to the real classrooms explored in previous studies, our standardized classroom simulation elicited comparable conditions for studying teacher noticing. It is a complexity-reduced and authentic approximation-to-practice (Grossman et al., 2009) developed for training and assessment purposes (Telgmann & Müller, in

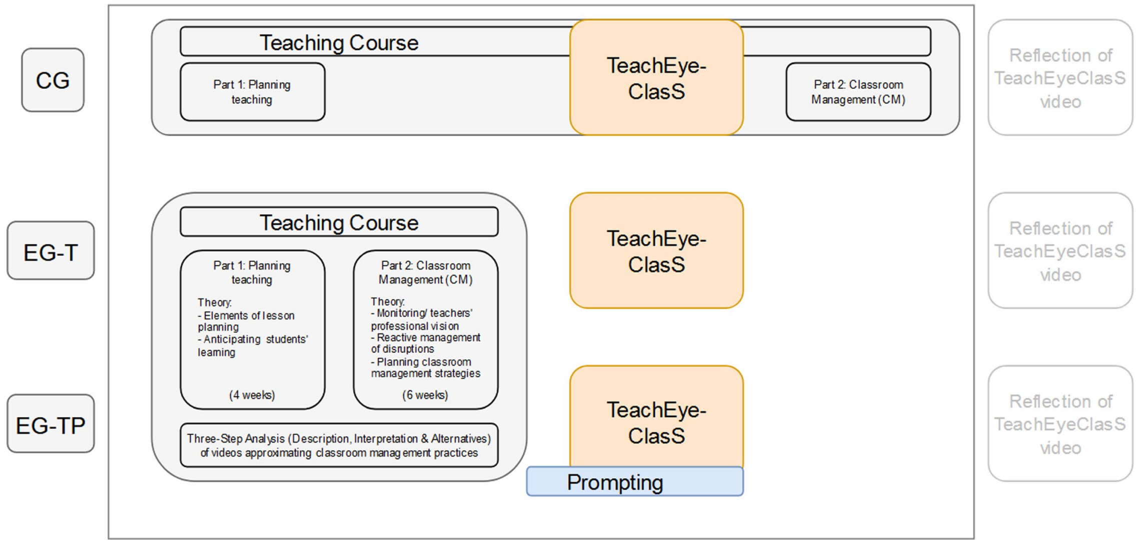

FIGURE 1
Study design. EG-T = Experimental group with training; EG-TP = Experimental group with training and prompting; CG = Control group.

preparation). PSTs' instruction during the 20-min simulation was based on a predefined lesson plan about a general topic in a 10th grade classroom. The lesson topic focused on the overarching theme of sustainability, specifically the introduction of two product labels, as a strategy for sustainable purchasing. This lesson was situated in the context of planning a sustainable class trip. As many previous studies focus on teacher-centered settings, we included both a teacher-led activity (~10 min) and a student-led activity (~10 min) within the lesson plan. We tried to establish a similar level of bottom-up attention for all PSTs by standardizing the occurrence of bottom-up drivers (e.g., student behavior and classroom management events). The simulation comprised the same set of seven pupils, played by trained student actors. The classroom seating order was standardized. Fourteen relevant classroom management events in the form of slight (e.g., looking out the window) and salient disruptions (e.g., talking loudly) were predefined (see Figure 2; slight events are shown in a grey box, salient in a blue circle). For each disruptions we pre-defined a certain time frame (e.g., minute 1–2) where it occurred, it was bound to the order of disruptions and foremost the didactic actions of the teacher (e.g., a disruption occurred, when the teacher introduced the first task). Additionally, we assigned the similar count and level of disruptions to both the teacher-led and student-led activity. The standardization also included the reactions of all other pupils to the relevant events. Thus, all PSTs faced the same challenging classroom management events, which require selective attention and not (over-) focusing on some students.

4.3. Experimental variation: training & prompting

Presuming that classroom management knowledge helps teachers identify and interpret visual information faster and more accurately (Wolff et al., 2021), we used a teaching course at university to prepare PSTs' to notice classroom management events and focus on students. The teaching course included 13 weekly meetings that were taught by the same two lecturers. They were phased into two course blocks, one on planning effective teaching and a second one focusing on classroom management (see Figure 2). Course content was divided between lecturers. Part 1 included repeating content about elements of lesson planning and how to anticipate students learning at the planning stage (e.g., setting appropriate learning goals). In this first part of the course all three groups applied their knowledge by planning a lesson with the similar learning goal and the same learning group of TeachEyeClasS. Part 2 focused on promoting specific classroom management knowledge for around 10.5 h and comprised video analysis homework in which students applied classroom management knowledge in an on-action setting (observing others' classroom management). Specific knowledge parts entailed classroom management strategies depicting rules and routines (Evertson and Emmer, 2012) and reactive management of disruptions (Ophardt and Thiel, 2013). Also how these strategies affect student behavior and learning. A focus was set to preventive strategies of teachers' monitoring (non-verbal and verbal) (Kounin, 1970; Gold and Holodynski, 2017) and how PSTs can use and plan these strategies for teaching. In the following, we refer to this intervention as training.

Accordingly, we presumed that PSTs in both experimental groups have specific knowledge about classroom management, but might not use it during the classroom simulation. Activating classroom management scripts might then help to elicit/evoke more knowledge-based (i.e., top-down) attention. To activate the respective cognitive scripts, we included specific cognitive prompts. In the domain of writing research and the use of learning strategies, cognitive prompts encouraging reflection on certain aspects of a topic have shown to be particularly effective learning aids (e.g., Glogger et al., 2009).

While preparing for the simulation in advance, we asked PSTs in EG-TP to remember and note down effective monitoring strategies within the standardized lesson plan. In addition, two events were added to the lesson plan and the PSTs were asked to plan effective monitoring strategies during these specific events (see Figure 3). To

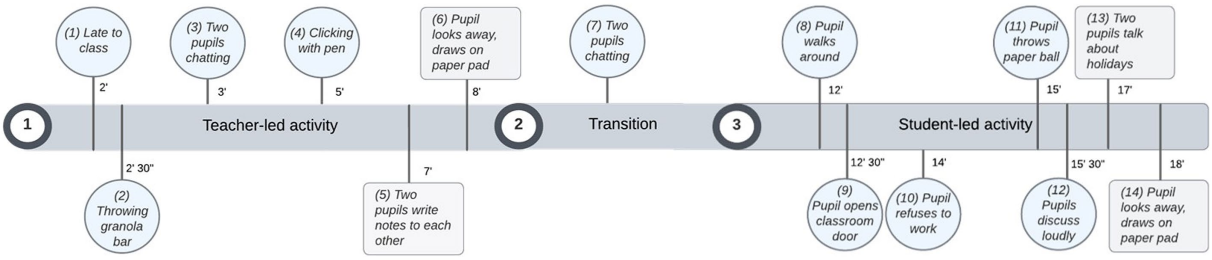

FIGURE 2
Description of classroom management events – disruptions within the simulation and approximate timing of occurrence. Slight events are shown in a grey box. Salient events are shown in a blue circle.

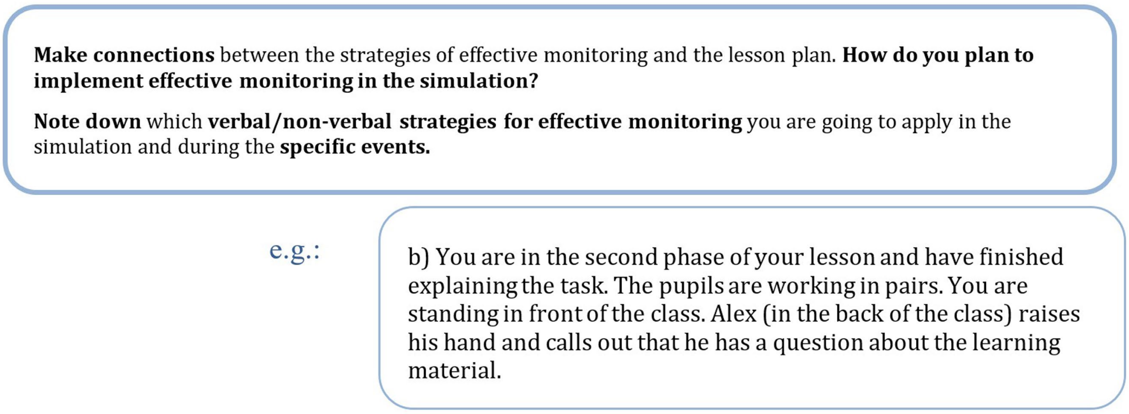

FIGURE 3
Cognitive prompt to activate classroom management scripts before the simulation.

activate classroom management scripts right before and during the simulation, an additional prompt card, shown in Figure 4 and displaying effective monitoring strategies, was given. The PSTs were instructed to implement the strategies and to put the prompt card on the teacher's desk during the simulation.

4.4. Study procedure

After the classroom management course (control group, respectively, after part 1 of the course) we were interested in assessing PSTs' cross-subject, general pedagogical knowledge (GPK) including their classroom management (CM) knowledge. For this, we used the short version of the Pedagogical Instructional Knowledge (PUW) test by König and Blömeke (2009, 2010), which was developed as part of the TEDS-M project. The test measures declarative and procedural knowledge across five dimensions: structuring lessons, motivation, dealing with heterogeneity, classroom management and assessing performance (König and Blömeke, 2009). The short version of the tests consists of 18 test items with either a closed or open response format. Specifically with regard to the dimension of classroom management, the test entailed four items (one open, three closed format) with regard to classroom management (e.g., planning aspects of concrete teacher behavior), effective use of teaching time (e.g., use of rules and routines) (König and Blömeke, 2009).

Further we used a questionnaire to assess self-efficacy (Schwarzer and Schmitz, 2002), socio-demographic data, semester count, experience in school contexts (i.e., internships, working as a substitute teacher) and extracurricular experiences with pedagogical references (e.g., club work).

The standardized lesson plan was given to the PSTs ten days before the simulation to allow them to get acquainted with it. We also provided pictures of the classroom and instructional materials placed in the room in advance. Other information included a detailed description of the group of learners (seven students). To ensure equal prior knowledge of the learning group and the topic to be taught, we proceeded as follows in selecting and implementing the topic of sustainability prior to the simulation. The selection of the topic in the context of sustainability was preceded by an investigation of the German curricula. We identified this topic as interdisciplinary and relevant in several subjects. To further ensure that the students enter the simulation with the same content-related prerequisites, all three groups received information material on the topic and learning goal. Furthermore, before taking part in the simulation we already presented this topic to the PSTs. In part one of the course on planning effective teaching, all three groups (including control) planned a lesson with the similar learning goal and the same learning group of TeachEyeClasS. This was also done to reduce cognitive load during the simulation, as our PSTs had limited practical experiences.

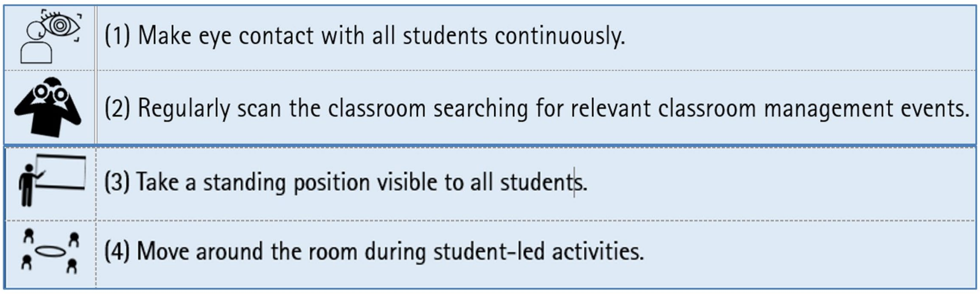

FIGURE 4
Specific prompt to activate classroom management scripts during the simulation.

Instructions were given to participants before the simulation while the equipment was being set up. To familiarize themselves with the equipment, the PSTs walked to the simulation room with the mobile eye-tracking glasses on. The PSTs also got the chance to see the classroom and locate instructional materials. After this, a one-point automatic calibration followed by a 3-point validation in the classroom was implemented to ensure data quality. The 3-point validation included three points within the classroom at three different distances. If calibration was not valid, the research assistant recalibrated until a satisfactory level was achieved. After successful calibration, the PSTs were asked to leave the room again. Following an acoustic signal (imitating a school bell), the simulation started and the PSTs entered the room. A research assistant filmed the simulation, ended it after approximately 20 min and escorted PSTs back to the preparation room to fill out a post-questionnaire about the simulation authenticity and cognitive load. The PSTs were also asked to hand in their commented lesson plan or notes used during TechEyeClasS. We collected these to retrace the use of prompts (see Figure 3) for the EG-TP.

Around ten days after the simulation (similar to Cortina et al., 2018), the PSTs in EG-T and EG-TP were asked to recall the simulation and retrospectively comment on their gaze video online. For the control group, this time frame was around three weeks longer. The PSTs observed their teacher gaze video via an online learning platform. They were able to stop their simulation video at relevant time stamps and interactively comment on it. The task given was the following: "Comment on your own mobile eye-tracking (MET) video using the interactive comment box next to the video as if you were thinking aloud. Recall the simulation again and indicate relevant events with regard to classroom management during the simulation. When did you notice a pupil who had problems following the lesson due to difficulties with content or motivation? And (possible) disturbances?"

Hence, all PSTs indicated where they noticed classroom management-related events (see Figure 5). After submitting their commentary, they were further asked to conduct a systematic video observation. Here, the PSTs conducted a three-step analysis describing, giving reasons for and generating alternative courses of action for all noticed classroom management events during the simulation. All PSTs were familiar with this form of analysis, as they had analyzed others' videos during the course.

4.5. Apparatus

Eye movements during the classroom simulation were recorded using Tobii Glasses Pro 3 at a sampling frequency of 50 Hz. Its technique includes corneal reflection and dark pupil tracking (4 sensors, 2 per eye) with scene camera resolution of 1920 × 1,080 pixels at 25 frames per second. The field of view of the scene camera was 95° horizontal, 106° diagonal and 63° vertical. The frame dimensions were 153 × 168 × 51 mm. The glasses include a reported accuracy by the manufacturer of 0.6°. The software used for recording was Glasses 3 (1.9.4). We standardized the eye-tracking conditions for all participants (same room, darkened windows, same ceiling light). In doing so, we reduced changes in illuminance over the course of the measurement and across participants. We used corrective lenses if participants had visual impairment and no contact lenses. The recording environment was a typical seminar room, set up to look like a school classroom.

In addition to the eye-tracking, we used two other cameras to record the scene and provide additional classroom footage for later coding: one in the back of the class, following the teacher (teacher camera: TC) and another stationary camera positioned in the front of the class (wide angle, student perspective, SC). The mobile eye tracker (Tobi Glasses Pro 3, 50 Hz) recorded the teachers' field of vision, resulting in a teacher gaze video.

4.6. Measures of PSTs' global and event-related noticing

In a first step, to answer RQ 1.1, we explore aggregated measures of eye movements as markers for teacher noticing during teaching. In doing so, we deliberately refer to global noticing (RQ 1.1) to stress the fact that this measure allows us to objectively capture PSTs' visual focus onto different objects in the classroom. As aggregated measures of eye movements are always a result of preceding cognitive processes (i.e., fixation count on one area of interest over the entire period of the simulation), we conclude that they in some way reflect teachers' noticing. In a second step, to assess teachers' event-related noticing (RQ 1.2) in a similar way as previous on-action research and account for covert attention/peripheral vision, we explore trained observers' coding of PSTs' gaze videos and retrospective video commentary and

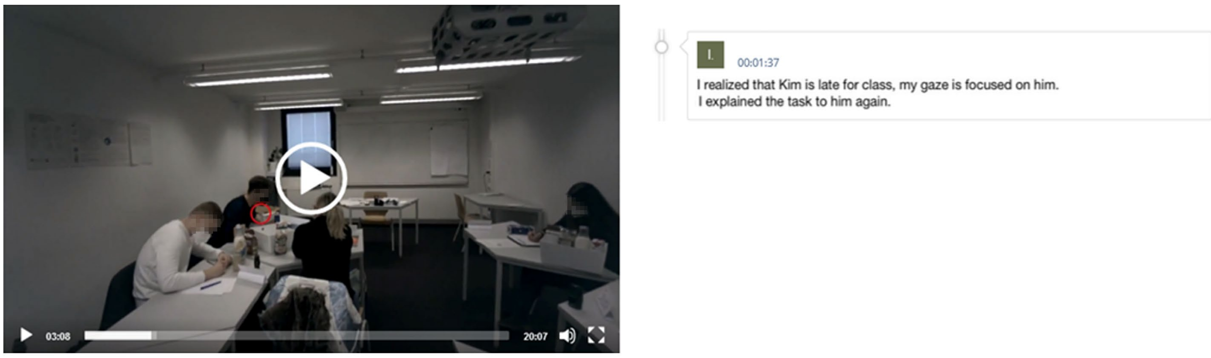

FIGURE 5
Example of PSTs' retrospective commentary on their own gaze video.

observation. Measures and procedures for coding and analysis are described below.

4.6.1. Assessment of global noticing (RQ 1.1)

4.6.1.1. Coding of eye-tracking data

Prior to the eye-tracking analyses, we defined areas of interest (AOIs). A wide-angle image of the standardized classroom simulation was first used to pre-define relevant semantic AOIs. Similarly to previous research (e.g., Stürmer et al., 2017; Huang et al., 2021a; Chaudhuri et al., 2022), we deductively developed AOIs: seven individual students; teacher & student material, lesson plan, prompt card as task-relevant objects and task-irrelevant objects: student & teacher desk, other objects and missing data. In order to observe differences in PSTs global noticing, we explore eye movement measures previously shown in expert-novice comparisons (RQ 1.1). Thus, in this study we only consider individual student AOIs and aggregated those to form the variable $AOI_{student}$. Figure 6 shows the relevant section of the screenshot used for data analysis in this study.

Instructions for coding the eye movement data included manually mapping all data onto the classroom image using the IVT-Attention Filter (velocity threshold parameter set to 100 degrees/s) in Tobii Pro Lab (Version 1.181.37603). In the few unclear cases (i.e., blurry frame, gaze outside the field of view of the scene camera), the coder was instructed to code the category "missing data." Gaze mapping was conducted, starting when the PST entered the simulation room and ending when simulation was interrupted after approximately 20 min.

One person coded all eye-tracking data in randomized order, while a second coder additionally coded 20% of the eye-tracking data (N = 10 videos). The first coder held a bachelor's degree and the second coder a master's degree in teacher education (first author). Both had experience collecting eye-tracking recordings in classroom settings. The coders received training on manual mapping in a half-hour training session with video material from a pilot study depicting a similar recording environment, classroom setting and AOIs. For the semantic AOI coding scheme we found good inter-coder agreement. It ranged from 88 to 94% with an average of 91%.

4.6.1.2. Eye movement measures

As previous expertise research indicates two central expert-novice differences, with experts showing more selective attentional focus on students and more even distribution of attention across (more) students, we explore the following eye movement measures. The ratio measure of the Gini coefficient (GC) (Cortina et al., 2015), mean fixation duration in milliseconds (ms), and percentage of fixation count on the aggregate $AOI_{student}$. For in-action studies some authors choose measures less sensitive to the eye movement event detector like visits and average dwell time (Smidekova et al., 2020, p. 6). Hence, we also report on visit duration in milliseconds (ms), and percentage of visit count on $AOI_{student}$. The GC is based on the fixation/visit count and duration for each individual student AOI during the whole video recording. A lower value indicates a more even distribution of attention (0 = perfectly equal distribution, 1 = one student gets all the attention). The reported results include a corrected Gini coefficient. In addition to fixation measures, we also examine the less sensitive measures of visit count and average dwell time/visit duration, similarly to Smidekova et al. (2020).

4.6.2. Assessment of event-related noticing (RQ 1.2)

4.6.2.1. Coding of video and retrospective commentary

To analyse the PSTs' event-related noticing, we collected the video from the student and teacher cameras, gaze video (recording of the mobile eye tracker) and PSTs' retrospective commentaries and systematic observations of their gaze video done online after participating in the simulation. To expand upon previous findings, we assess event-related noticing both in terms of the count of noticed events and qualitatively score PSTs' noticing accuracy. For this, trained observers assessed PSTs' event-related noticing based on their (gaze) videos and their retrospective commentary and observations. This procedure combines two advantages. Coding teachers' mobile eye-tracking video with gaze overlay (i.e., fixations displayed in the video) provides objective feedback about PSTs' noticing without manually coding PSTs' eye movements. In addition, consulting the PSTs' retrospective commentary and video observation allowed the observers to retrace accompanying cognitions. With coding based on all three video perspectives (teacher gaze, teacher and student cameras), we were able to ensure that the beginnings of all classroom management events (even if they were not in the teacher's field of view) appeared on the video recordings and could be used to assess noticing accuracy. We based our decision to include all video

FIGURE 6
Defined areas of Interests for individual students.

perspectives on a pilot study. There, effects of different video perspectives on the assessment of classroom management were found (Telgmann et al., in preparation). The second coding process for assessment of event-related noticing encompassed a three-step process shown in Table 1. The first author of this paper coded all video data in a randomized order. A research assistant again double coded 20% of the video data. Video coding was carried out using the software interact (Mangold International, 2020). To confirm reliability, we calculated the inter-correlation coefficient (*ICC*). The ICC was calculated in accordance with Wirtz and Caspar (2002), with an absolute agreement (ICC_{unjust}), 2-way mixed-effects model using IBM SPSS Statistics (Version 28.0.0.0 (190)). For the subsequent paired comparisons, we used the first coder's scoring, which is why we report single measures. The ICC shows an $ICC_{unjust} = 0.868$, which is considered good (Wirtz, 2004).

4.6.2.2. Measures of event-related noticing

The noticing accuracy score (sum of points after completion of the coding process, see Table 1) was used to assess teachers' event-related noticing. Each event had a maximum score of 3 points. These were summed over all fourteen classroom management events. The maximum score achievable was therefore 42 points. We further differentiated between noticing accuracy scores for slight (four events, maximum score: 12 points) and salient disruptions (ten events, maximum score: 30 points), as we expected the slight disruptions to require more efficient monitoring behavior. They might require more top-down processing as they do not catch PSTs' attention as easily. Previous studies did not include this distinction; hence, we compared the two measures in an exploratory fashion. To facilitate comparability with existing studies, we also report the overall number of noticed events (see Stahnke and Blömeke, 2021; van Driel et al., 2021; Schreiter et al., 2022) as an indicator of teachers' noticing. In this vein, we also report the number of time and target errors as negative indicators of noticing accuracy. The highest possible counts for events, target and time errors were each 14.

4.7. Preliminary data analysis

Using G*Power (Faul et al., 2007) we conducted an *a priori* power analysis (α error probability = 0.05 and power (1 − β error probability) = 0.95. Previous research in on-action contexts exploring the effects of training to scaffold pre-service teachers professional vision obtained large effect sizes for eye-tracking parameters (Schreiter et al., 2022). According to this, we assumed an effect size of $f = 0.40$ for the analysis of variances (ANOVA) with three groups. The calculated effect size was $N = 102$. We did, however, not recruit this "preferred" sample size due to high requirements of trained staff, time and materials of our quasi-experimental mobile eye tracking study and implications by the COVID-19 pandemic.

We calculated Kruskal-Wallis tests with the between-subjects factor "prompting" (prompt vs. no prompt vs. control group). We conducted non-parametric testing due to the small sample size in each group, as in previous eye-tracking studies (see Stahnke and Blömeke, 2021; Schreiter et al., 2022) and because the normal distribution assumption (Shapiro–Wilk test) was not met for all variables and groups. In a follow up-analysis, we calculated pair-wise comparisons via Dunn-Bonferroni *post hoc* tests. This was done to examine group differences in a more differentiated way. For RQ 2, we conducted a correlational analysis reporting Pearson correlation coefficients. N = 46 participants were included in the analyses. All measures were analysed using IBM SPSS Statistics (Version 28.0.0.0 (190)). We based all analyses on two-sided tests with an alpha level of 0.05 and report adjusted *p*-values.

In order to ensure comparability between groups, we did preliminary analyses and identified group differences with regard to semester of studies, experience in school and extracurricular contexts, self-efficacy, general pedagogical and classroom management knowledge. Preliminary analyses showed that the groups did not differ significantly with regard to their general pedagogical knowledge, $H(2) = 4.552$, $p = 0.103$. Nor did tasks capturing PSTs' classroom management knowledge show any differences, $H(2) = 1.805$, $p = 0.406$. We, thus, reanalyzed the classroom management item with an open response format dealing with planning aspects of concrete teacher behavior (König and Blömeke, 2009). Focusing only on the criterion of classroom management strategies for teaching we further looked at how often PSTs answered classroom management and specifically monitoring strategies. We found that both experimental groups name more classroom management strategies than control group participants, $H(2) = 8.714$, $p = 0.013$. *Post hoc* testing showed significant differences between CG and EG-T ($p = 0.015$) CG and EG-TP

TABLE 1 Coding scheme for event-related noticing.

Coding	Description	Example
Step (1) Identifying all fourteen events by looking at the relevant times of interest (standardized classroom management events).		
Event 1–14	The duration of the event is coded via the beginning and end of the event. This includes the teacher's reaction (if present).	e.g. Event 9 (minute 10–12): *As soon as Alex speaks up and asks a question about the assignment that has just been explained, Kim stands up. He walks through the entire classroom to the classroom door. He opens the door and closes it again shortly afterwards. He goes back to his seat. As soon as Kim opens the door and closes it, all other pupils look at Kim and interrupt their work.*
Step (2) Coding noticing accuracy in PSTs' (gaze) videos & validate decision with PSTs' retrospective commentary and/or systematic video observation by scoring each classroom management event.		
2 = event is noticed without time error	That the event was noticed presumes that the students and objects involved in the event are fixated on and a reaction to the event is evident and/or a reference to the event is found in the retrospective commentary. A reaction includes the option of fixating on and then ignoring the event at first. It might also be the case that the event is not fixated on, but noticed through peripheral vision or auditory cues. Thus, the final decision is made based on PSTs' retrospective commentary and observations. In addition, the teacher does not commit a timing error, i.e., the teacher reacts to the disruption early and no other pupil(s) gets(s) involved.	*As Kim gets up and walks to the door, the teacher notices the behavior. This happens before other pupils interrupt their work.*
1 = event is noticed with time error	Pupils and objects involved in the event are fixated on and a reaction to the event is evident and/or a reference to the event is found in the retrospective commentary. A reaction includes the option of fixating on and then ignoring the event at first. It might also be the case that the event is not fixated on, but noticed through peripheral vision or auditory cues. Thus, the final decision is made based on PSTs' retrospective commentary and observations. However, the teacher commits a timing error, i.e., the teacher reacts to the disruption too late and other pupil(s) gets(s) involved.	The definition of a timing error for each event was defined in advance, as the events and pupils' reactions to the pre-defined events were standardized. An example: *Only after the other pupils have become aware of Kim's behavior does the teacher identify the behavior.*
0 = event is not noticed	Pupils and objects involved in the event are not fixated on or no reaction to the event is evident and no reference to the event is found in the retrospective commentary. It is also possible that the event is fixated on but not cognitively processed. Thus, the final decision is made based on PSTs' retrospective commentary and observations.	*The teacher is engrossed in conversation with Alex and stands with her/his back to the class. The teacher does not identify the event, in that Kim standing up, opening and closing the door remains unattended. However, other pupils notice Kim's behavior and interrupt their work.*
Step (3) Coding whether noticing included a target error or not, i.e., identification of the wrong pupil(s) participating in the classroom management event.		
0 = target error 1 = no target error	Teachers might commit an object/ target error (Kounin, 1970) by fixating on and/or addressing the wrong pupil during the simulation or in their retrospective commentary and/or observation. If target error is observed, 1 is coded.	The definition of an object error for each event was defined in advance, as some events explicitly provoked target errors. e.g. Event 8: *As soon as the teacher writes the guiding question on the board, Robin starts a conversation with Kim. The teacher turns around, fixates only on Kim and admonishes him to please be quiet.*

($p = 0.049$). Only participants of the EG-T (36,9%) and the EG-TP (31,6%) specifically report monitoring strategies.

Self-efficacy, $H(2) = 0.388$, $p = 0.824$, and practical experiences in school $H(2) = 0.638$, $p = 0.727$, and outside of school $H(2) = 0.967$, $p = 0.617$, were not significant. The groups differed significantly with regard to their semester of studies, $H(2) = 11.324$, $p = 0.003$. Dunn-Bonferroni *post hoc* tests with adjusted p-values showed that there were no significant differences between EG-T and CG ($p = 0.598$), or

EG-T and EG-TP ($p = 0.084$). However, CG and EG ($p = 0.003$) differed significantly in that PSTs in EG-TP had been enrolled for an average of 6.00 semesters ($IQR = 1$) and in CG 7.00 semesters ($IQR = 2$).

For EG-TP, we also looked at visual intake of the prompt during and the usage of prompts before the simulation. For the former, we expected this to be an indicator of how often PSTs refocused on the task during the simulation. Preliminary analysis of the $AOI_{promptcard}$ showed differences with regard to visit count on the prompt card. One PST visited the prompt card 18 times, two ten times and another eight an average of three times during the simulation. However, the other four PSTs visited the prompt card zero times during the simulation. To investigate the usage of prompts before the simulation we explored the lesson plans handed in by the PSTs. Around two thirds (77,8%) of the EG-TP participants interacted with the cognitive prompts, in that we see notes with regard to the tasks (see Figure 4) in the lesson plan. Most of the EG-TP participants summarized effective monitoring strategies and planned strategies for one or both of the exemplary events (36,8%). 21,1% of PSTs summarized effective monitoring strategies but did not plan strategies for one or both of the exemplary events and 21,1% planned but did not summarize the strategies. The last group of PSTs (21,1%) showed no written notes of planning or summarizing monitoring strategies.

Although, the EG-T was not instructed to do so, we find that 30,0% of PSTs of EG-T noted down classroom management strategies in their lesson plan. Thus, they applied their classroom management knowledge and thought about how to use it during the simulation. This is not observed for any participant in the control group. It additionally supports the claim that both experimental groups gained knowledge about classroom management during the training.

5. Results

5.1. Global noticing (RQ 1.1)

The results in Table 2 refer to PSTs' global noticing. Out of the total number of fixations during the simulation, $AOI_{students}$ accounts for an average of around a third. Descriptive results show that fixation and visit count for the control group are lower compared to the training group and prompted group (see Table 2). However, the Kruskal-Wallis test revealed no significant differences between the three groups for either fixation or visit count (see Table 2). Nor did we find significant differences between groups for average visit and fixation duration.

As global measures, $GC_{fixationcount}$ (≥ 0.11; ≤ 0.31) and $GC_{visitcount}$ (≥ 0.07; ≤ 0.27) show that all PSTs seem to distribute their attention relatively evenly (zero expresses that all students receive the same amount of gaze). The GC tended to be lower for visit/fixation count than visit/fixation duration, which suggests that PSTs distribute how many times they look at students more equally than how long they look at each student. There were no statistically significant differences between groups in any GC measures (see Table 2).

5.2. Event-related noticing (RQ 1.2)

Table 3 shows results for all relevant measures concerning PSTs' event-related noticing. In general, none of the PSTs reached the maximum noticing accuracy score of 42 points. The medians for all three groups range around a bit more than two thirds of the achievable total score. They all show a high number of noticed events; however, high numbers of target and time errors resulted in lower noticing

TABLE 2 Results of the Kruskal-Wallis test with regard to PSTs' global noticing.

Variable	CG[a]		EG-T[b]		EG-TP[c]		Values of significance		
	Mdn	*(IQR)*	*Mdn*	*(IQR)*	*Mdn*	*(IQR)*	*H* (*df* = 2)	d	*p*
$AOI_{student}$									
Fixation count (%)	31.22	(12.01)	36.07	(9.01)	34.17	(10.28)	3.199	0.34	0.202
Visit count (%)	34.70	(5.58)	36.24	(3.98)	35.51	(1.95)	1.783	0.14	0.410
Average fixation duration (sec)	0.41	(0.14)	0.38	(0.18)	0.40	(0.18)	0.797	0.34	0.671
Average visit duration (sec)	0.89	(0.30)	0.87	(0.35)	0.88	(0.40)	0.207	0.42	0.902
Gini-coefficient (GC) $AOI_{student}$									
$GC_{fixation\ count}$	0.19	(0.08)	0.22	(0.09)	0.21	(0.05)	1.195	0.28	0.550
$GC_{visit\ count}$	0.17	(0.04)	0.16	(0.09)	0.18	(0.05)	2.807	0.28	0.246
$GC_{fixation\ duration}$	0.23	(0.06)	0.25	(0.11)	0.25	(0.06)	0.580	0.37	0.748
$GC_{visit\ duration}$	0.24	(0.07)	0.26	(0.11)	0.25	(0.09)	0.489	0.38	0.783

[a]Control group: $n = 12$.
[b]Experimental group with training: $n = 19$.
[c]Experimental group with training and prompting: $n = 15$.

accuracy scores. It is noticeable that lower noticing accuracy scores and higher numbers of time and target errors were especially common among control group participants and for slight classroom events. The trained and prompted group (EG-TP) exhibited the highest median score, the control group (CG) the lowest.

Inferential Kruskal-Wallis tests show that PSTs' total noticing accuracy scores did not differ significantly between groups. Though, we find significant differences with regard to noticing accuracy scores for all slight classroom management events. *Post hoc* tests revealed that there were significant differences between EG-T and EG-TP ($z = -3.114$, $p = 0.006$, $r = 0.46$). For the salient events, no significant differences were found (for box plots see Supplementary material). This is in line with the number of noticed classroom management events, where Kruskal-Wallis tests showed no significant differences.

We also looked at the number of target errors made by the PSTs. Here, we find a significant large effect. *Post hoc* testing revealed no significant differences between EG-TP and EG-T, but both experimental groups significantly differed from control group; EG-T and CG ($z = 3.132$, $p = 0.005$, $r = 0.57$); EG-TP and CG ($z = 3.743$, $p = 0.001$, $r = 0.72$). Similar differences were found for the number of time errors. Dunn-Bonferroni *post hoc* tests show that there were again no significant differences between EG-TP and EG-T, but between EG-T and CG ($z = 3.719$, $p = 0.001$, $r = 0.68$) and between EG-TP and CG ($z = 3.503$, $p = 0.001$, $r = 0.67$) (for box plots see Supplementary material). All significant differences have mid to strong effect sizes (Cohen, 1988), from $d = 0.83$ to $d = 1.41$ and $r = 0.46$ to $r = 72$.

5.3. Association of object- and event-related noticing measures (RQ 2)

Correlational analysis of the global and event-related measures revealed that the total noticing accuracy score and noticing accuracy score for salient events positively correlate with the percentage of fixation and visit count on $AOI_{student}$ (see Table 4). In addition, the noticing accuracy score for salient events had medium correlations with the Gini coefficients (GC) of fixation count (see Table 4). No further significant associations between the number of noticed classroom management events, target or time errors and global noticing measures were found.

6. Discussion

The aim of the present study was to empirically test whether training and prompting can promote PSTs' noticing during teaching. For this purpose, PSTs' knowledge and knowledge activation were varied experimentally over one control and two experimental groups. A standardized classroom simulation was used to control for the students, objects and events occurring in the classroom. Using eye movement measures, retrospective commentaries by PSTs and coding by trained observers, indicators of event- and global noticing were collected and compared between the three conditions.

Summing up the results with regard to RQ 1.1., training and prompting did not affect PSTs' global noticing of students. The results are not consistent with hypothesis 1.1a, in that neither intervention led to a higher percentage of visits/fixations and shorter mean fixation/visit duration on students in the classroom. Inferential statistics indicated no significant differences between the three groups in fixation/visit count or fixation/ visit duration on $AOI_{students}$. Additionally, hypothesis 1.1b was not confirmed. Trained and prompted PST did not have lower Gini coefficient values compared to the control group. No statistically significant differences between groups were found on any Gini coefficient value. The calculated Gini coefficients for mean fixation and visit count suggest that PSTs' distributed their gaze fairly evenly across the seven students in the standardized classroom simulation. Our Gini values for fixation and visit count are a bit lower than in previous studies (Cortina et al., 2015; Dessus et al., 2016; Smidekova et al., 2020) depicting novice teachers' attentional distribution. As it has been shown that classroom complexity (Huang et al., 2021b) can affect teachers' noticing, we might conclude that the lack of significant group differences on these measures was due to the limited number of students in the classroom rather than the PSTs' use of knowledge/noticing. Our standardized setting of a reduced-complexity classroom with only seven students may have elicited similar eye movements across all students.

For RQ 1.2, we conclude that training and prompting did affect PSTs' event-related noticing of classroom management events. Our results partly confirm hypothesis 1.2. Descriptive statistics show that PSTs with both training and prompting achieved higher noticing accuracy scores on the classroom management events compared to the control group. For the total score, no significant effects are observed for the experimental groups compared to the control group. Though, we find significant differences between PSTs receiving both training and prompting and those who received training only with regard to noticing accuracy of slight events. Differences in noticing accuracy scores for salient events were not found. Additionally, the number of noticed classroom management events did not differ significantly. Hence, prompting and training affected noticing accuracy of slight events but not the number of noticed classroom management events. We assume that more top-down attention improved noticing qualitatively rather than quantitatively. This is also supported by the following results. Both experimental groups made significantly fewer time and target errors compared to the control group. Training and prompting seems to have helped PSTs notice classroom management-related events more accurately, in that they selectively attended to the events at an earlier point in time and less often identified the wrong pupil. We see strong effect sizes here. Nevertheless, if we interpret these effects, we need to discuss and contextualize the specific group differences. At first glance, the differences between the experimental groups and the control group in terms of target errors do not seem to be very large, with 1 error versus 0 errors. For the count of time errors, the median is two less for the experimental groups (see Table 3). How meaningful these differences are for practice can be argued in different ways. Viewed over an entire lesson, an object or timing error may have little effect on the teacher in the short term. But if they accumulate over several lessons and we consider motivational outcomes of the students we might argue that these are of great relevance. This becomes even more important when we consider that our simulation is a complexity-reduced setting with only 20 min lesson time and seven students. It is noticeable, if more pupils become involved or if a student is wrongly reprimanded in the case of an object error, learning time is lost.

TABLE 3 Results of the Kruskal-Wallis test with regard to PSTs' event-related noticing.

Variable	CG[a]		EG-T[b]		EG-TP[c]		Values of significance			Results of post-hoc analysis		
	Mdn	*(IQR)*	*Mdn*	*(IQR)*	*Mdn*	*(IQR)*	*H* (*df* = 2)	*d*	*p*	CG vs. EG-T	CG vs. EG-TP	EG-T vs. EG-TP
Noticing accuracy score												
Total (Max. 42)	32.00	(6.00)	32.00	(7.00)	34.00	(4.50)	2.956	0.30	0.228	ns	ns	ns
Salient events (Max. 30)	25.00	(6.00)	27.00	(5.00)	26.00	(2.75)	3.261	0.34	0.196	ns	ns	ns
Slight events (Max. 12)	6.00	(4.00)	5.00	(3.00)	7.00	(1.75)	9.706	0.92	0.008**	ns	ns	-**
Number of												
Classroom management events (Max. 14)	12.00	(2.00)	11.00	(2.00)	12.00	(1.75)	2.109	0.10	0.348	ns	ns	ns
Time errors (Max. 14)	5.00	(1.00)	3.00	(1.00)	3.00	(1.75)	16.231	1.41	<0.001***	-***	-***	ns
Target errors (Max. 14)	1.00	(0.00)	0.00	(1.00)	0.00	(0.00)	15.136	1.33	<0.001***	-***	-***	ns

*$p < 0.05$, **$p < 0.01$,***$p < 0.001$, ns, not significant.
[a]Control group: $n = 11$.
[b]Experimental group with training: $n = 19$.
[c]Experimental group with training and prompting: $n = 17$.

TABLE 4 Results of correlational analysis between event-related and global noticing measures.[a]

Variable	$GC_{students}$				Fixation measures $AOI_{students}$		Visit measures $AOI_{students}$	
	Fixation count	Fixation duration	Visit count	Visit duration	Count	Average duration	Count	Average duration
Noticing accuracy score								
Total	0.212	0.109	0.149	0.139	0.323*	0.013	0.373*	0.084
Slight events	−0.079	−0.107	−0.085	−0.102	−0.114	−0.106	0.043	−0.162
Salient events	0.328*	0.220	0.254	0.254	0.504**	0.098	0.496**	0.231
Number of								
Classroom management events	0.221	0.116	0.156	0.139	0.196	0.021	0.265	0.054
Target errors	0.120	0.187	0.141	0.148	−0.170	0.181	−0.116	0.119
Time errors	−0.121	−0.227	−0.102	−0.240	−0.178	−0.072	−0.108	−0.086

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a]Pearson correlation coefficient.

From our results it is more difficult to confirm hypothesis 1.2 with regard to the differences between the two experimental groups. Whether only prompting affects PSTs remains unclear. Some of our results indicate that specifically the prompted group differed compared to the control group. We can cautiously conclude that prompting might have additionally helped to activate knowledge and might have contributed to more effective (or at least not less effective) event-related noticing especially for slight events. However, due to the different numbers of visits to the $AOI_{promptcard}$ during the simulation, we should be cautious with such conclusions. Additionally, our study had a more demanding, complex setting compared to studies exploring instructional effects during video observation (Schreiter et al., 2022; Grub et al., 2022b). During TeachEyeClass, PSTs are not able to concentrate solely on the task of observing classroom events and students, but must simultaneously teach and react to students' behavior. Accordingly, the influence of minimal instructions (in our case the cognitive prompt before the simulation) is an interesting question for future research. A future study might include one experimental group receiving only prompting, similar to Schreiter et al. (2022). In addition, we can investigate certain time spans in the simulation. The effect of cognitive prompting might fade over time. Further investigation might also include the different visual intake of the $AOI_{promptcard}$ as a possible influencing factor. This might be useful to explain the missing differences between the two experimental groups.

Finally, in RQ 2, we asked whether event-related noticing is associated with global noticing measures. Evaluating hypothesis 2, only one expected positive correlation between the fixation and visit count and noticing accuracy was found. PSTs with higher total noticing scores also had a higher percentage of fixations and visits on $AOI_{student}$. Exploratory comparisons also showed this for salient events. In addition, PSTs with higher accuracy scores for salient events also exhibited higher Gini values for fixation count. Thus, they distributed their attention less equally across students. This result seems especially important, when looking into the contextual nature of noticing, i.e., differences in noticing between events with varying levels of saliency. Although we cannot tell about a causal relationship here, our results indicate that noticing salient events is associated with global measures of attention. This might be due to the fact that salient events (students engaging in disruptive behavior) might catch teachers attention more and/or lead teachers to use their gaze to intervene or follow students behavior. We thus see increased percentage of fixation count, if teachers notice salient events more accurately. Further significant association with regard to the slight events were not found. Thus, we did not find support for the assumed associations between event-related and global noticing measures in the expected directions. In connection with theoretical considerations, it would be fruitful to discuss to what extent global noticing is part of the construct of teacher noticing. If we draw back on the different operationalizations of teachers noticing introduced in chapter 2.2, global noticing measures often show aggregated eye movements over an entire instructional period. It disregards specific students' behavior and may perhaps be less informative than event-related noticing measures. The influence of knowledge and possibly also experience onto global noticing during teaching, may be particularly dependant on individual classrooms and contexts (e.g., student behavior).

Based on the discussion of our results, we generally conclude that the selection of suitable eye movement measures is of central importance. This can be stated based on our study's results, but is also underlined by the heterogeneous findings in the field of teachers' noticing assessed by eye movements. In our quasi-experimental study, we find no significant effects with regard to measures of global noticing. In contrast to previous on-action studies using prompting and training (Schreiter et al., 2022), we do not find more efficient visual information processing with regard to the task-relevant area of students in the form of higher fixation/visit counts and average fixation/visit durations in the two experimental groups.

Positive effects of the classroom management training on event-related noticing were found. PSTs did not identify more relevant classroom managements events, but achieved a higher noticing accuracy. This is in line with previous in-action studies in which a similar number of noticed classroom management events were found between different expertise groups and partially in line with Grub et al.s' (2022a) on-action study. The latter showed that higher knowledge leads to classroom disruptions being identified more often and more quickly. As the experimental groups had a significantly lower count of time errors, we demonstrate an earlier event detection in both experimental groups in our study (who can be expected to have more knowledge compared to the control group). As Stahnke and Blömeke (2021) only found expertise differences with regard to the number of noticed events during video observation of partner work scenes, analysing event-related noticing measures separately for student-led vs. teacher-led activities during the simulation might be a promising next step.

The relevance of eye movement parameter selection is being emphasized by Smidekova et al. (2020) for expert-novice comparisons. Our results support this notion. They raise the question of whether the mere consideration of eye movement measures on objects in the classroom is less useful in intervention studies with inexperienced teachers (with very similar levels of teaching experience). The global eye movement measures used in this study might not be good indicators to exclusively examine when exploring instructional effects of PSTs' training and learning in teacher education. It would hence be fruitful to for future data analysis to include other eye movement measures, i.e., scanpaths (Kosel et al., 2021; Huang et al., 2021a) and event-related areas of interest (Stahnke and Blömeke, 2021; Grub et al., 2022b). It would also be interesting to bring more experienced teachers into the TeachEye-ClasS environment to test for expertise differences in global noticing like those found in previous studies in real classrooms (Cortina et al., 2015; Huang et al., 2021a). We might assume that classroom management scripts established through repeated exposure to events and teaching experiences (Wolff et al., 2021) particularly affect perception and thus global noticing. Accordingly, higher fixation counts and shorter fixation durations on students might be seen only among experts.

There also seems to be little indication that the Gini coefficient should be used as a marker of effective noticing. We could not substantiate the expected directional correlations and in contrast to event-related noticing, training and prompting did not significantly affect the attention distribution onto students. Smidekova et al. (2020, p. 13) previously raised a concern that the Gini coefficient has been an inconsistent indicator of expertise. We assume that the (un)evenness of the distribution of attention greatly depends on the complexity of the classroom context (e.g., relevant events, number of students). In our study, a more uneven distribution of attention goes hand in hand with a higher noticing accuracy for salient events. (Over-)focusing on relevant students might thus be helpful for noticing relevant events or attending to them more accurately (earlier and in connection with the right person). In this line, one might discuss the limited relevance of an equal attention distribution for theoretical conceptualizations of noticing as part of teachers' professional competence (Blömeke et al., 2015) and an indicator of teaching quality.

The different findings by type of event (salient vs. slight) allow us to draw further conclusions. It seems to be important to distinguish between events with different levels of salience when studying teachers' noticing. Our results indicate that prompting and training did not affect noticing of salient events. As already noted in previous on-action studies (Grub et al., 2022b, p. 13), salient events (e.g., a student throwing a paper ball across the room) might trigger more bottom-up attention; hence, the effects of activating knowledge as a top-down driver might be minimal here. Our results support this assumption in an in-action context. Noticing salient events might require less knowledge about classroom management, which increases with experience (Stahnke and Blömeke, 2021; Grub et al., 2022b). Whether this difference is also evident with regard to PSTs' reactions to these events remains unclear at this point. Novice and expert teachers are argued to differ profoundly not only in their perception and interpretation but also in their responses to classroom management-related events (Wolff et al., 2021). In a future study, it might be promising to examine how teachers react to salient and slight events. In this line, there is potential to explore a possible direct connection between noticing and teaching quality with our data. For this, established measures such as the CLASS rating (Pianta et al., 2012) could be used.

6.1. Strengths, limitations, and significance for future research

Our study examined differences in PSTs' noticing in-action between two experimental groups that were both attending a training, one of which received additional cognitive prompting, and one control group. The results suggest a positive influence of our training, which aimed to impart classroom management knowledge, on event-related noticing accuracy during teaching.

Our study includes several individual strengths that should be emphasized. To our knowledge, there are few studies using mobile eye tracking, thus, providing such insight into effects on teachers' noticing in-action. The quasi-experimental design, direct training of knowledge offered to investigate group differences and the relevance of knowledge as a top down driver, separately from teaching experience. The standardized teaching simulation ensured comparability between the groups of PSTs and made it possible to obtain insights into event-related noticing during teaching. We used several sources of information to assess teachers' noticing and present a novel approach that links verbal data with eye-tracking records captured in teachers' gaze videos to assess PSTs' event detection by means of trained observers. In addition, our sample focused on PSTs to obtain concrete possibilities and ideas for teacher education. Previous studies looking into noticing during teaching have so far mainly involved expertise comparisons.

Being able to notice classroom management-related events (van Es and Sherin, 2021) is regarded as a crucial and challenging skill for beginning and expert teachers alongside actually managing a classroom effectively. Based on our results, we conclude that we were able to improve PSTs' event-related noticing accuracy and influence knowledge as a top down driver of noticing. The further development of teaching-learning environments such as our seminar and the simulation environment are thus of particular importance. Our standardized teaching simulation can be used for assessment and practice of PSTs' noticing skill in teacher education.

Of particular relevance are our null findings regarding fixation/visit count and average duration on students. We acknowledge that experience and specific knowledge parts might influence global noticing in different ways, which should be examined separately in future expertise studies. This result is also of particular interest when it comes to the added value of eye-tracking technology and teacher gaze videos. Analysis of mobile eye-tracking data is time-consuming, and eye movements alone might not be as revealing in an in-action context. Our coding process for PSTs' event-related noticing offers an alternative way of assessing teachers' event-related noticing in a standardized learning environment.

Our study has strengths, but the results must also be interpreted in light of several limitations.

First, we examined effects on PSTs' noticing of the pre-defined classroom management events. Thus, the results cannot be transferred to other (e.g., more complex and less salient) events in the classroom or associated with other instructional quality characteristics. Current on-action studies also focus on classroom management. Future research should include more observation foci in in-action settings.

Secondly, we looked at selected eye-tracking measures (i.e., fixation/visit count, average fixation/visit duration) and areas of interests. The eye movements were examined with respect to the global area of interest of all students in order to establish links to previously found expertise differences in in-action studies. We did also not include classroom events as event-related areas of interests. As our trained observers' coding revealed qualitative differences, (other) eye movement measures onto event-related areas of interest (see Stahnke and Blömeke, 2021) might reveal different results. This might include the time to first fixation or the gaze relational index (see Grub et al., 2022b).

Thirdly, we find no significant differences with regard to PSTs' classroom management and general pedagogical knowledge as assessed by the PUW test (König and Blömeke, 2010) between experimental groups and control. We assessed PSTs' knowledge after the training and before the simulation. In this way, we hoped to detect classroom management knowledge differences between the control group and experimental groups. However, the students did not differ significantly in the overall number of points they achieved in the test. Nor did they differ in the dimension of classroom management knowledge. We, though, do not attribute this to a lack of knowledge increase, but rather a misfit between the type and number of test items and the specific knowledge imparted in the seminars. Our results show strong effects on noticing classroom management events. In addition the three classroom management items used in the test also focus on planning aspects of concrete teacher behavior and the use of rules and routines during instruction. As the second part of the course on classroom management together with the prompts distinctively focused behavioral strategies during instruction (e.g., monitoring, group activation), it is therefore reasonable to assume that the used test items may not have captured the specific knowledge facets that contribute to PSTs' noticing of classroom management events. Because of this we analyzed one of the open response items in more detail. We also looked at PSTs' handed in lessons plans. There we found significant differences with regard to the experimental groups and control. Both experimental group more frequently noted down classroom management strategies in the test item and their lesson plan. It supports the claim that both experimental groups gained knowledge about classroom management during the training. In subsequent studies, we plan to use self-developed instruments to capture specific classroom management knowledge, and pre-post measurement will be carried out for the experimental groups. In this way, it will be possible to trace developments in classroom management knowledge over the course of the seminar.

Fourth, due to COVID-19 restrictions and for economic reasons, think-aloud protocols were conducted online and thus not under standardized conditions. Also the stimulated recall of the simulation occurred not directly after TeachEyeClasS and the collection of the eye-tracking data and we had a notably longer delay for the control group. All this may have influenced PSTs' retrospective commenting and, respectively, coding of PSTs' noticing performance. For this reason, we did not use the PSTs' retrospective reports alone, but had trained coders assess event-related noticing based on PSTs' videos and reports. Both sources of information were used to objectively evaluate event-related noticing. Solely assessing subjective reports by PSTs might elicit different results. To further rule out the influences of delay, we asked observers during the scoring procedure, to note down and comment for each event, whether PSTs' video or think aloud commentary indicated different noticing score than the think aloud commentary. There were in general few events, where this was the case ($N = 10$). In addition, those instances were not significantly more common for control group participants. In future studies, it seems promising to examine to what extent retrospective think-aloud protocols alone or in combination with other methods (e.g., hand signaling by van Driel et al., 2021) can provide valid measurement and comparable results.

Fifth, our study uses a simulated classroom environment. Although the simulated and highly standardized classroom environment forms a strength of our study, we must note the limitation of transferability to real or more diverse classroom settings. This limitation draws upon several design choices we made to reduce cognitive load during the simulation for our PSTs. The class size of seven pupils, familiarity with the learning group and also the standardized events. These aspects might impact teachers noticing (for classroom events see Huang et al., 2021b) and teachers' stress (for class size see Huang et al., 2022). To mimic real classroom practice we situated the simulation within a field practicum and gave the PSTs a written description of the learning group. In a previous study we also found good results with regard to PSTs reported authenticity and task load of the simulation (see Telgmann and Müller, in preparation). Thus, we conclude that the standardized classroom simulation and the tasks PSTs face during the simulation approximate real classroom practice and can in some degree be transferred to real classroom practice. In this line, it would be interesting to follow up on the PSTs during their real field practicum to assess their noticing skills during regular classroom teaching.

Finally, our study had a small sample size, which particularly limits the broader implications that can be drawn from the findings. We did not reach the "preferred" sample size of our *a priori* power analysis. Although, for event-related noticing we find significant large effects similar to previous studies (Schreiter et al., 2022). Future research should work with larger samples. This might also be promising as we are then able to conduct further investigation of different PST groups in our sample. Statistical control of the PSTs' degree (special education vs. secondary education) was not possible due to the small sample size. We randomly divided all PSTs to the groups, though, the study program might influence noticing indirectly. Certain attitudes and expectations of students behavior that are worth attending might be an influencing factor.

7. Conclusion

The aim of the present study was to gain further insight into the effects of a classroom management training and prompting on PSTs' event- and global noticing. By examining the direct training of knowledge in a quasi-experimental study our results suggest that prompting noticing during teaching is possible. We were not able to find differences in global noticing between our two experimental groups and control group. However, we showed that prompting and training can affect PSTs' event-related noticing in that more knowledge might have helped PSTs to notice classroom management events earlier and more accurately. Our study represents only a first step toward understanding the influence of knowledge and the relevance of interventions for PSTs' noticing. Further studies in this field are needed to clarify how to design interventions to help PSTs be aware of classroom events. This research specifically emphasizes the potential of (standardized) reduced-complexity classroom simulations for practicing and assessing the skill of noticing. In addition, we advocate a targeted use of suitable measures to explore PSTs' noticing in teacher education.

Data availability statement

The datasets presented in this article are not readily available because of legal and privacy restrictions. The minimal data set supporting the conclusions of this article will be made available by the authors upon request, without undue reservation. Requests to access the datasets should be directed to LT, leonie.telgmann@iew.uni-hannover.de.

Ethics statement

Ethical approval was not required for the studies involving humans because consents for data collection were obtained from individuals on the legal basis for the collection and processing of personal data in accordance with the General Data Protection Regulation (GDPR) and German national data protection laws and regulations. The data protection officer of Leibniz University Hannover reviewed the consent forms as part of the data collection for this study. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LT: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Writing – original draft. KM: Conceptualization, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1266800/full#supplementary-material

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