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Professional Vision and the Compensatory Effect of a Minimal Instructional Intervention: A Quasi-Experimental Eye-Tracking Study With Novice and Expert Teachers

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The early recognition of potential disruptions in learning environments is of great importance for the proactive control of the teaching process and maximizing learning outcomes. The professional competence of (prospective) teachers is required for successful classroom management. Teachers' professional vision (PV) serves as a link between their knowledge and classroom management behavior. Expertise research in different domains has shown that experts and novices show differences in visual perception based on their expertise level; however, research results to date are heterogeneous and often based on small samples. An eye-tracking study using a quasi-randomized experimental design was performed to investigate how German prospective (n = 29) and experienced (n = 35) teachers perceived different teaching situations. The goal of the study was to determine whether previous results from expertise research could be replicated in a standardized experimental setting. Moreover, the impact of a minimal intervention (specific instruction) on PV of potential classroom disruptions was investigated. In contrast to the hypotheses, no expertise-dependent differences on various eye-tracking parameters can be found. Furthermore, the minimal intervention does not lead to an improvement in PV for experts or novices. The results are discussed with regard to the discrepancy with previously published findings and possible explanations are offered (e.g., the salience of disruptions, internal personal factors, and external environmental influences).

Keywords: professional vision, classroom management, expertise, instructional support, eye tracking

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INTRODUCTION

Classrooms are full of complex situations due to the variety of people, goals, and activities (Wolff, 2016), and thus multidimensional, simultaneous, and dynamic processes (Doyle, 1985). Teachers must therefore perceive and interpret a large amount of visual information to effectively manage the classroom, while at the same time teaching the students the subject matter. It is not remarkable that beginning teachers are overwhelmed by the complexity of the classroom situation

(Stokking et al., 2003; Feldon, 2007). Previous research shows that professional vision, and thus the early recognition of potential disturbances as an important component of proactive classroom management, should be a crucial competence of a teacher (Sherin and van Es, 2009; Barth, 2017). However, professional vision (Goodwin, 1994; Sherin and van Es, 2005) is not straightforward—expertise research suggests that experts and novices differ in their ability to recognize potential teaching disruptions. Grub et al. (2020) summarized in their review article that there is empirical evidence for differences in the eye-movement patterns of experts and novices for different eye-tracking parameters. Nevertheless, the authors also show that the study designs are heterogeneous, especially concerning the methods used (static vs. mobile eye tracking), video vignettes (scripted vs. real, longer vs. short), and the parameters investigated. Furthermore, the studies are little standardized and include discrepancies in the number of students, lesson content, social form, among other things. We shall hence want to examine whether these expertise differences can also be found in a standardized experiment using a comparatively large sample.

Expertise research including, inter alia, process-based measurements, reveal that gaze behavior is dependent on competence, especially knowledge (Blömeke et al., 2015). This knowledge is stored in the form of schemata (see "classroom management scripts"; Wolff et al., 2021) and can be triggered by certain factors (e.g., prior knowledge or attention; Gilboa and Marlatte, 2017). Process-based research suggests that gaze behavior (and thus professional vision) may vary depending on the intended use in the form of an activated scheme or may depend on an instruction according to which a certain aspect of the task material is emphasized (e.g., Buswell, 1935; Yarbus, 1967; Tatler et al., 2010; Gobet, 2015, p. 15). Thus, it is not astonishing that research in various domains, including cognitive psychology and educational research, reveals that instructional interventions can positively influence professional vision (Blomberg et al., 2013). However, since previous interventions (Santagata et al., 2007; van Es, 2011; Gold et al., 2013; Seidel et al., 2013) are extensive and time-consuming, our focus is on a minimal, economical intervention. The study investigates whether minimal instructional support leads to changes in gaze behavior among (prospective) teachers and whether a more specific instruction can possibly compensate for differences in expertise. For this purpose, a study design with scripted video vignettes of classroom situations was developed, which makes it possible to measure the gaze behavior and reaction of experts and novices regarding potential teaching disruptions based on parameters of the eye-tracking methodology as well as a recorded reaction in the form of a keypress upon identification of a relevant event.

THEORETICAL BACKGROUND

Teachers' Professional Vision

Teachers require professional competence to ensure teaching quality (Kunter et al., 2013). The competence of teachers is characterized by the ability to continuously perceive, monitor, and adequately interpret relevant aspects of a multidimensional classroom (Wolff, 2016) and thus proactively manage teaching and instruction (Kounin, 2006). Hereby, competence is conceived as a continuum in which cognitive dispositions (knowledge) influence visual processes (Blömeke et al., 2015). In particular, a considerable value is attributed to the situation-specific ability to perceive relevant aspects of the classroom and is positively related to the teachers' level of competence (Stahnke and Blömeke, 2021). Previous research has shown that the early recognition of potential disturbances as an important component of proactive classroom management should be a key competence of teachers (Sherin and van Es, 2009; Barth, 2017). Therefore, professional vision, especially visual monitoring and scanning of the classroom, is crucial (Gold and Holodynski, 2017).

Professional vision is considered a knowledge-based process and describes the ability of teachers to rapidly notice relevant events and engage in knowledge-driven reasoning about the noticed event (van Es and Sherin, 2008; Gegenfurtner et al., 2020b). Both the ability to focus attention on critical situations while blocking out unimportant events (*noticing*) and the ability to apply knowledge about teaching and learning to draw appropriate conclusions (*reasoning*) are essential (Sherin, 2007). However, noticing and reasoning are not isolated processes but are mutually dependent: what is observed influences interpretation and vice versa (Sherin and van Es, 2009). Since the teacher is not only responsible for paying attention to classroom-management-related aspects of teaching but is also expected to concurrently educate students, it is almost impossible to pay attention to all aspects of the classroom at the same time. To be able to direct attention to important events and suppress irrelevant events (noticing), conceptual knowledge about effective teaching and learning is required (Sherin and van Es, 2009).

Expertise-Dependent Organization of Knowledge About Classroom Management

Teachers' knowledge about classroom management, as a part of the cognitive dispositions of teachers' competence, contains conceptual knowledge about what is relevant in the classroom and is stored in the form of schemata[1] (see "classroom management scripts"; Wolff et al., 2021). Among experts, these schemata are more interlinked and elaborated (Wolff et al., 2021), and can help one to perceive and organize visual information (Henderson and Hayes, 2018). Experts can retrieve meaningful schemata faster due to a qualitatively different mental representation and can change them faster, allowing them to plan flexibly. In contrast, novices are more rigid in their concepts. Experts tend to control their cognitive processes "top-down," whereas novices are more prone to "bottom-up" strategies (Hershler and Hochstein, 2009). Likewise, Wolff's model of "classroom management scripts" (2021) delineates the influence of knowledge on experts' and

[1] Schemata are superordinate mental structures in linked knowledge units (e.g., Kopp and Mandl, 2005).

novices' perception, awareness, and interpretive processing of problematic classroom situations. In summary, teachers' knowledge schemata influence their professional vision of classroom situations, especially the perception and identification of relevant events (noticing).

Eye-Movement Behavior as an Indicator of Teachers' Expertise

Process-based methods like eye tracking are particularly suitable to uncover differences in the visual perception of situations relevant for classroom management between prospective and experienced teachers because visual perception is a continuous process (Gegenfurtner et al., 2020b; Kosel et al., 2021). To assess professional vision with an eye-tracking method, several indicators are worth considering. According to the oculomotor definition, a fixation describes the period of time in which the eye is relatively motionless, that is, moves as little as possible (Holmqvist et al., 2011). Fixations indicate which areas are focused on and which stimuli are important (Just and Carpenter, 1976), whereby the degree of experience influences the number of fixations (*fixation count*), with experts having more fixations on relevant events, as well as on dynamic stimuli (Jarodzka et al., 2010). Probably the most-used eye-tracking measure is *fixation duration* (Holmqvist et al., 2011), which describes how long a fixation lasts.

Similar findings are reflected in teacher education research: for example, both Stahnke and Blömeke (2021) and Grub et al. (2022) were able to show that experienced individuals identified more relevant events than less experienced ones. Regarding eye-tracking parameters, Wyss et al. (2021) showed that those teachers who detected a critical incident were more frequently fixating on it than those who did not detect the incident. Furthermore, expertise differences are shown with respect to teachers' proportion of gaze and number of fixations (Stahnke and Blömeke, 2021). Kosel et al. (2021) also investigated the gaze behavior of experts and novices with respect to their scanpaths, or their eye-movement patterns. They reported differences between experienced and novice teachers in the sense that experts monitor the entire classroom and repeatedly let their gaze shift back to update visual information. Grub et al. (2020) summarized in their review article that there are somewhat similar differences in the eye-movement patterns of experts and novices for several eye-tracking parameters using heterogeneous methods and more or less small samples.

Referring to the expertise-dependent organization of knowledge about classroom management, it can be further noted that experts utilize their elaborated schemas when conducting school lessons to identify potential disruptions early. Therefore, they fixate on relevant areas more frequently (e.g., students who are inattentive or playing with extracurriculars). Due to their expertise and knowledge, experts can encode information more quickly (Chi and Glaser, 1988) and thus better anticipate situations in general (Jarodzka et al., 2017). Based on these eye-movement parameters (many and short fixations), experts can consistently update dynamic teaching situations, which is also described as monitoring behavior (see also "withitness"; Kounin, 2006). In general, the distribution of fixations may also be an indicator of deeper cognitive processing or the importance of a region (Reingold et al., 2001; Kuperman et al., 2008). In terms of observing behavior or perceiving what is going on in the classroom, the distribution of attention across students is more even for expert teachers (Wolff, 2016; Stahnke and Blömeke, 2021). In summary, expertise research including, *inter alia*, process-based measurements, reveals that gaze behavior is dependent on experts' competence, especially their knowledge (Blömeke et al., 2015), and thus, professional vision can be fostered through knowledge activation.

Scaffolding Teachers' Professional Vision of Classroom Management

Expertise research in other domains already suggests that instructional interventions can positively influence professional vision. For example, novices can activate and apply their knowledge better by prompting tools (e.g., Pichert and Anderson, 1977; Bereiter and Scardamalia, 1985). Even process-based research suggests that gaze behavior (and thus professional vision) may vary depending on the activated schema or may depend on a given instruction focusing on a particular aspect of the task material (e.g., Buswell, 1935; Yarbus, 1967; Tatler et al., 2010; Gobet, 2015, p. 15).

Wolff et al. (2021) describe the model of classroom management scripts (corresponding to schemata; see section "Design") that differ according to the teacher's level of competence and knowledge and thus influence the teacher's professional vision. Schemas can be triggered by certain factors (e.g., prior knowledge or attention) and are context-sensitive, and different schemas are stimulated depending on the situation or task (Gilboa and Marlatte, 2017). Once a schema is activated, it can influence the processing of incoming information by representing relevant knowledge structures and biasing information processing (Ghosh et al., 2014). Activated schemas modulate early perceptual processes by filling them with specific information instances (generating top-down approaches), which can have a priming effect on the identification of relevant aspects and can control selective attentional processes (see noticing; Johnston and Dark, 1986). Furthermore, (activated) schemas influence how events are perceived, interpreted, and remembered (see professional vision; Gilboa and Marlatte, 2017). Evidence for such top-down control was provided by Yarbus as early as 1967: depending on the instruction in a visual task (e.g., "state the age of the subjects" vs. "remember the subjects' clothing" vs. free inquiry), he was able to uncover qualitative differences in eye movement and fixation patterns. Moreover, replications of DeAngelus and Pelz (2009) and Tatler et al. (2010) suggest that participants focused more on certain parts of the task material depending on which aspect was emphasized by the instruction.

Detecting and identifying relevant events in classroom management is not a passive process but involves more-or-less conscious decisions about what to pay attention to (Simpson et al., 2018). In this context, the recognition of the relevant aspects of a teaching situation is accelerated by the teacher's knowledge. This suggests that our visual system biases attention based on known information (e.g., aspects of classroom management) to highlight what is relevant (e.g., a potential disruption; Navalpakkam and Itti, 2005). In addition, knowledge of the target of attention, operationalized as a specific instruction, plays a critical role in selecting the focus of attention. By providing a specific instruction that includes more-or-less concrete cues about where attention should be focused, awareness of certain factors is facilitated and deepened (Roth McDuffie et al., 2014).

This type of facilitation is particularly beneficial for those with less knowledge, as looking through a defined framework allows limited attention to be focused on relevant aspects of the task, rather than being overwhelmed by the many complexities in the classroom (Roller, 2016). It further provides a performance benefit (see processing prompts; Gerjets et al., 2008): the identification of potential problems (e.g., a teaching disruption) is directly related to the activation of corresponding schemas (e.g., regarding classroom management) that were activated by the specific instruction. For novices, specific instruction facilitates more focus than general instruction because specific instruction allows for a smaller amount of inference (Catrambone, 1990; Bouxsein et al., 2008). Meanwhile, general or rather unspecific instruction does not provide details for each specific case, and the relevance of certain events must be deduced by oneself. Thus, it can be deduced that minimal instructional support in providing a specific task can also lead to a performance increase.

Research shows that without specific instruction, pre-service teachers are unable to focus their attention on relevant teaching-learning components (Star and Strickland, 2008), quickly follow their intuitive and naïve ideas about teaching (Hammerness et al., 2002), and run the risk of making quick judgments and overgeneralizations (Schwindt, 2008). Thus, high complexity complicates perception for prospective teachers. Those who receive specific instruction that accentuates certain aspects of classroom management, however, can focus their attention on relevant situations (see noticing; Star and Strickland, 2008). These findings are supported by educational research that indicates that instructional interventions (specific instruction) can positively influence professional vision. However, particularly in the realm of teacher education and scaffolding methods for prospective teachers, the question of how to facilitate novices' entry into the profession as efficiently as possible and thus better promote students' learning success from the very beginning still needs to be addressed. Grub et al. (2022) were unable to reveal any effects depending on the instruction in a similar question, but they did not use a process-based methodology and only used students as research participants, which is why we want to examine here to what extent a more precise measurement of professional vision can reveal the effects of minimal instruction on expertise differences between experts and novices. Eye tracking as a method of process-based recording of eye movements thus offers the possibility to evaluate the influence of minimal instructional support.

Research Question and Hypotheses

A study design with scripted video vignettes of classroom situations was developed, in which both eye-tracking parameters and a tactile reaction (keypress upon identification of a relevant event) were recorded. The study investigates whether replication of the previous results of expertise differences can be attained in a standardized experimental setting, whether instructional support leads to changes in gaze behavior among prospective teachers, and whether the specific instruction can compensate for differences in expertise. Experienced teachers should not gain significant added value from the specific instruction since experts generally apply knowledge-based perception. In summary, the top-down processes of perception triggered by the instruction, which the experts always use, should be supportive for the novices.

Relationship Between Expertise and Professional Vision Regarding Eye-Tracking Parameters

Previous studies using various eye-tracking parameters showed that experienced teachers evince an effective expertise-dependent monitoring behavior: they distribute their fixations more widely and quickly across the entire classroom (suggesting consistency) to observe all simultaneous processes as adequately as possible and to intervene, if necessary, whereas novices tend to focus on irrelevant events (Wolff, 2016). Grub et al. (2020) summarized in their systematic review that these differences between expert and novice gaze behavior are evident in certain instances. To determine whether these differences in expertise can be shown with the available material and equipment in a quasi-randomized standardized experimental setting, the first step is to replicate and extend previous research results. In this way, the expertise effects will be re-examined, generalized, and related to further eye-tracking parameters. Thereby, we distinguish between a global monitoring gaze behavior across the entire classroom, on the one hand, and an event-related gaze behavior with regard to potential teaching disruptions, on the other hand. Extending the study by Grub et al. (2022), in which the professional vision of only students was collected indirectly via verbal data, the present study presents the possibility of collecting and analyzing process-based eye movement data with a similar study design

TABLE 1 | Demographic data.

	Experienced teachers (Experts, n = 35)	Pre-service teachers (Novices, n = 29)
	***M* (*SD*)**	***M* (*SD*)**
Age	45.66 (9.94)	23.93 (6.63)
Grade point average	2.54 (0.50)	2.01 (0.63)
Gender	♀ = 45.71%	♀ = 82.76%
(Studying to become) teacher for		
Primary school	8.57%	37.93%
Secondary School	82.86%	58.62%
Vocational school	8.57%	3.45%

in order to be able to directly capture the basal process of perception, viz. noticing.

Hypothesis 1: Global monitoring gaze behavior. Experts and novices show different eye movements operationalized by various eye-tracking parameters based on specific areas of interest (AOI) that include students and student groups in regard to a global monitoring gaze behavior.

1a. Experts show a higher fixation count and higher visit count compared to novices.

1b. Experts show a shorter mean fixation duration and visit duration compared to novices.

1c. Experts show a lower gaze relational index (GRI) compared to novices.

Hypothesis 2: Event-related gaze behavior. Eye movements operationalized by different eye-tracking parameters based on specific AOIs that include teaching disruptions differ between experts and novices with respect to an event-related gaze behavior.

2a. Experts show a higher response accuracy and a shorter decision time compared to novices.

2b. Experts show a shorter time to the first fixation in a relevant AOI and a lower number of fixations before they decide that this is a relevant event. As an additional, exploratory question, we tested whether experts and novices differ regarding the duration of the first fixation.

Impact of a Minimal Instructional Intervention on Prospective Teachers' Professional Vision

Previous research has shown that external factors can facilitate perception during acquisition (Gold et al., 2013; Stockero and Stenzelbarton, 2017); thus, instructional interventions can be effective in scaffolding noticing (Roth McDuffie et al., 2014). We want to examine if a specific instruction, compared to a general instruction (see section "Scaffolding Teachers' Professional Vision of Classroom Management"), improves prospective teachers' professional vision (Ge et al., 2005; Gerjets et al., 2008). The aim is to analyze whether activating particular schemata depending on the task and varying the specificity of instruction can facilitate the recognition of potentially relevant events by directing attention to single, essential aspects of the classroom environment through higher specificity (Rosenshine et al., 1996).

Hypothesis 3: The expertise differences between novices and experts are larger in the general instruction than in the specific instruction, that is, the instruction can compensate for differences in expertise. However, only the novices, not the experts, benefit from the minimal instruction.

MATERIALS AND METHODS

For detailed information on methods and materials, the pre-registration is available under osf.io/92f3m.

Participants

In total, *N* = 71 pre-service teachers (novices; *n* = 34) and experienced teachers (experts; *n* = 37) participated in this study. The novices had a maximum amount of 40 h of teaching experience and were recruited from the Saarland University via e-mail lists and flyers. The experts had a minimum of 5 years of teaching experience and were recruited from German schools in Saarland and Rhineland-Palatinate via e-mail, telephone, and newspaper. However, the data of seven participants (five novices, two experts) were excluded from the analyses due to insufficient data quality (for more details see pre-registration). The demographic data of the remaining 64 participants are shown in **Table 1**. Novices had been in teacher education for 2.21 (*SD* = 2.53) semesters and were not in service yet. They had an average teaching experience (e.g., through internships) of 4.48 h on average (*SD* = 9.20). Experts had been teaching for 15.71 (*SD* = 8.62) years on average. All attendees participated voluntarily and have been rewarded in monetary terms for full participation.

Design

The study consisted of an online questionnaire as well as an eye-tracking experiment in a laboratory with, on average, 10 days in between (see **Figure 1**). In the first part, the participants completed questionnaires on demographic data and pedagogical/psychological knowledge, which were presented online on Unipark. For the eye-tracking experiment, the participants visited the laboratory for an individual appointment. After taking the Selective Attention Test (D2-R; Brickenkamp et al., 2010), the eye-tracking phase started to assess professional vision. In this, seven short video vignettes of different classroom situations were shown. The participants were quasi-randomly assigned to one of six video sequences (A1, A2, A3, B1, B2, and B3), which were balanced regarding the order of presentation by Latin square (see **Figure 2**). The participants identified relevant elements in each video via keyboard-press (see below). While observing the videos, the gaze behavior of the participants was recorded. After each video, participants answered questions about the videos' quality and authenticity. Furthermore, a cued retrospective think-aloud phase, in which the participants were asked to specify the previously identified events in more detail, took place at the end of the video task to assess the participants' reasoning processes and to triangulate the eye-tracking data. The analysis of the verbal data is not part of this study. In total, the experiment lasted approximately 2 h (Part 1: approx. 45 min; Part 2: approx. 75 min).

Materials

Pedagogical/Psychological Knowledge Test

The PPHW-K (Brühwiler et al., 2017) was used to assess contextualized pedagogical/psychological knowledge. In the form of text vignettes, seven different hypothetical teaching situations were presented and two different questions were asked after each: the first refers to the teacher's possible behavior (procedural knowledge), and the second to a situation analysis (conditional knowledge). Statements relating to the

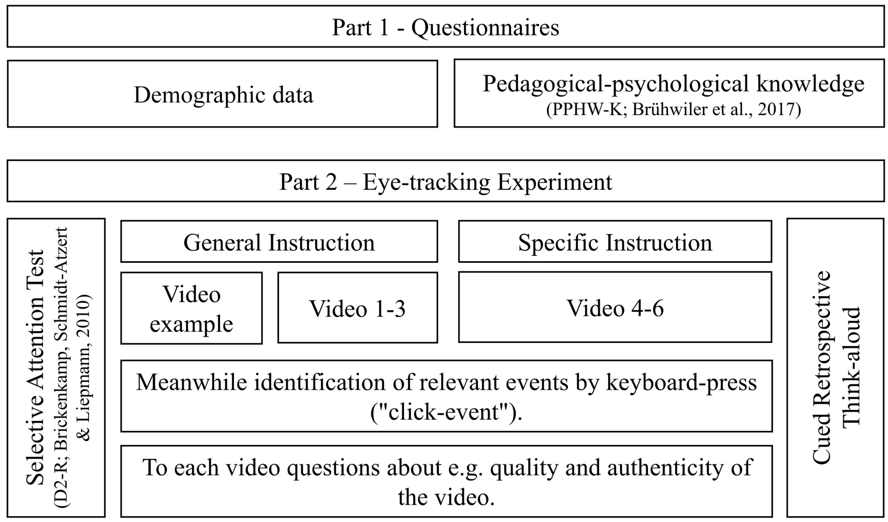

FIGURE 1 | Design of the eye-tracking study.

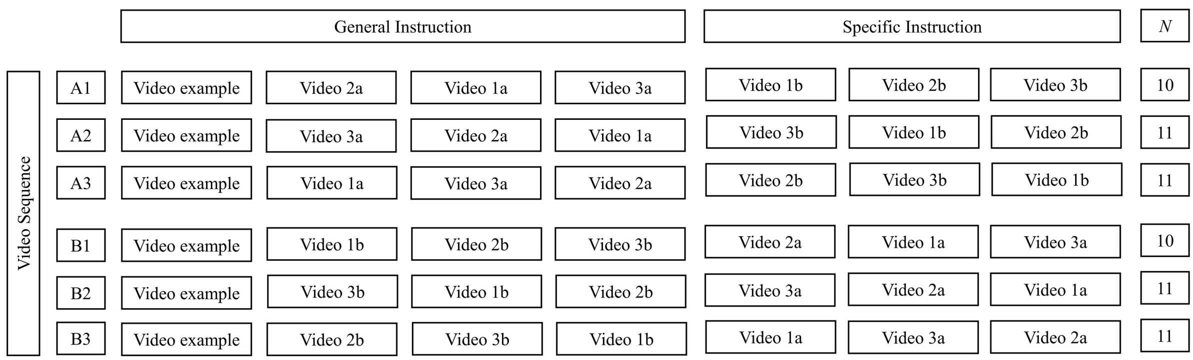

FIGURE 2 | Order of the video presentation balanced by Latin square.

TABLE 2 | Utilized eye-tracking parameters in the study.

Parameter	Definition	Hypothesis
Fixation count	Number of fixations on a general AOI	E > N
Visit count	Number of visits on a general AOI	E > N
Mean fixation duration	Average duration of fixation on a general AOI	E < N
Visit duration	Duration from the first fixation in a general AOI to the next fixation outside the corresponding AOI	E < N
Gaze relational index (GRI)[a]	Ratio of mean fixation duration (in milliseconds) to fixation count	E < N
Response accuracy	Number of correctly recognized events; possible range between 0 and 15	E > N
Decision time	Duration between first fixation in an event-based AOI until timestamp of click-event	E < N
Number of fixations before click/response	Number of fixations in an event-based AOI before click-event	E < N
Time to first fixation	Duration from onset of disturbance to first fixation in the corresponding event-based AOI	E < N
First fixation duration	Duration of the first fixation in an event-based AOI	exploratory

AOI, area of interest; E, experts; N, novices. [a]Following (Gegenfurtner et al., 2020a), the GRI is used as a marker for processing depth and visual expertise.

two knowledge components for each vignette were presented to then be assessed on a four-level Likert scale regarding the likelihood of acting or analyzing the situation in such a manner. Each participant could reach a maximum of 28 points in the PPHW-K.

Video Fragments

The eye-tracking experiment consists of seven different staged video vignettes of classroom situations, which are developed by "Toolbox Teacher Education" ("Toolbox Lehrerbildung") from the Technical University of Munich (Lewalter et al., 2020). They are based on scripted lessons of the 10 and 11th grades of the advanced track at a German secondary school (Gymnasium) and were already used in a preceding study (Grub et al., 2022). The fragments cover topics in mathematics and informatics and have an average length of 1.43 min (*SD* = 0.16 min). Each video was presented only once. The videos were selected by three independent persons based on classroom-management-related events, their situations' authenticity, and audiovisual quality. One video serves as an example video, whereas the remaining six videos contain one, two, or more than two instructional disruptions as a variation in complexity. Various disruptions can be seen, such as a pupil who puts his head down on the table during class and is supposedly asleep, or pupils who throw a paper ball at each other, or even minor disruptions such as a pupil not following the task. In total, the six videos consulted for later analysis contain 15 disruptions.

Apparatus

Eye movements were recorded using the static and lab-based Tobii Pro Fusion binocular eye-tracker using Tobii Pro Lab on a 24-inch display monitor (1,080 × 1,920) and at a sampling frequency of up to 250 Hz. Eye-tracking conditions were standardized for all participants (constant ceiling light, 65 cm distance to eye-tracker). Moreover, before beginning eye tracking, a 9-point automatic calibration followed by a validation was implemented to ensure data quality. The calibration was performed again if the 9-point automatic failed. High-quality eye-tracking data (see section "Results") are available for the participants.

Procedure and Dependent Variables

While watching the videos, the eye movements of the participants were recorded. The task was to identify relevant events in each video depending on the instruction via keyboard-press ("click-event"). For the first three videos, the participants had to press the keyboard as soon as they saw something relevant (general instruction[2]). However, during the last three videos, the instruction was more specific and explicitly aimed at classroom-management-related situations (specific instruction[3]). The assignment of the videos to the instructions was done considering the number of included perturbations.

In order to take a closer look at the differences between experts and novices in terms of professional vision, a number of eye-tracking parameters were selected (see **Table 2**). Some of them have already been identified as sensitive to expertise differences in other studies (e.g., fixation count; Grub et al., 2020), while others have received rather less attention in the field of teacher education (e.g., GRI). For example, the use of the GRI as a measure of visual literacy in the field of professional perception is relatively new (Gegenfurtner et al., 2020a). This index relates the mean duration of fixations (in milliseconds) and the mean number of fixations to each other as a measure of the preference on relational rather than exploratory processing. Experts should therefore have a lower GRI, which is indicative of scanning behavior, whereas novices are more likely to get attached to individual aspects and should therefore be characterized by a higher GRI.

The individual eye-tracking parameters were calculated as follows: in a first step, the data exported from Tobii was averaged for each of the six videos, i.e., the average fixation number per AOI was calculated for each video. In a second step, these values were averaged across all videos so that the value used for the analyses represents the average fixation frequency per AOI in one of the six videos.

Specific AOIs, which were developed deductively, are used to evaluate the parameters. The implementation was done using Tobii Pro Lab in the form of dynamic polygonal AOIs. These include student groups and are active over the entire video span (general AOI). Additionally, there are AOIs that are only active over the duration of the disruption (event-based AOI). In the following, AOIs are considered that refer to the frequency, length, and distribution of eye movements over the entire video, as well as AOIs that examine the eye movements, especially for the time of a teaching disruption (see **Figure 3**).

RESULTS

The analyses were calculated using JASP 0.14.1 (JASP Team, 2020). An alpha level of 0.05 was used for the statistical tests. According to the hypotheses, the *p*-value was halved for one-sided testing before comparing it with the alpha level.

An *a priori* power analysis was conducted using G*Power (Faul et al., 2007) with $\alpha = 0.05$ and power $(1-\beta) = 0.95$. Previous research obtains medium to large effect sizes for the eye-tracking parameter in regard to expertise differences in the professional vision of classroom management (Wolff et al., 2015; Seidel et al., 2021; Stahnke and Blömeke, 2021; Wyss et al., 2021). Assuming similar effect sizes, the sufficient sample size for the analysis of variances (ANOVA; $f = 0.40$) with two groups is $N = 84$. Unfortunately, however, the calculated sample size could not be achieved due to the impeded recruitment of participants caused by the COVID-19 pandemic during the survey period (winter semester 2020/2021). According to Pospeschill and Siegel (2018) and Stahnke and Blömeke (2021), non-parametric tests were also carried out for those dependent variables that fulfilled all preconditions for parametric testing to check the robustness of our results due to the relatively small sample size. The non-parametric tests (e.g., Kruskal–Wallis test for heterogeneous variances) yielded similar results unless explicitly stated otherwise. Thus, the non-parametric results are not reported.

Considering that valid and reliable eye-tracking data are particularly important in analyses with (small) AOIs (e.g., Nyström et al., 2013; Orquin and Holmqvist, 2018), we excluded a total of seven individuals (two experts, five novices) for the following analyses due to the quality of their calibration

[2]General instruction: "In the following, a video will be played, take a closer look at it. If you notice something relevant, press the keyboard."

[3]Specific instruction: "In the following, a video will be played, take a closer look at it. *Please watch it carefully and pay special attention to potential teaching disruptions*. If you notice something relevant, press the keyboard."

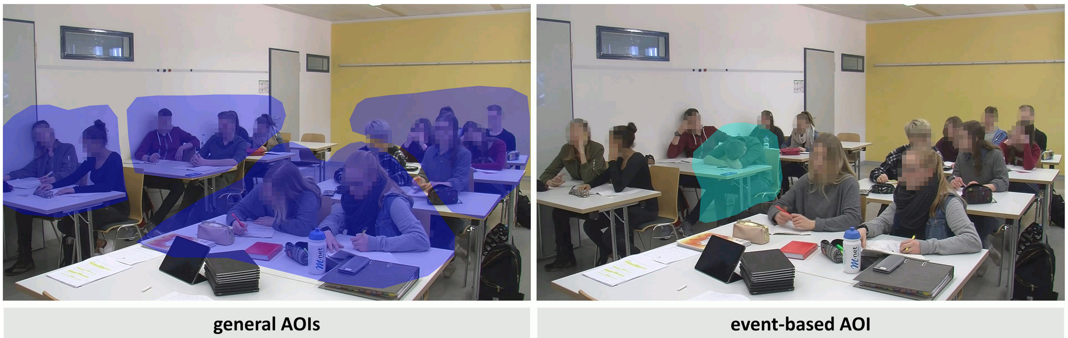

FIGURE 3 | Exemplary illustration of the AOIs for one of the videos (Source: "Toolbox Teacher Education" [Toolbox Lehrerbildung], 2020). On the left side, AOIs that include student groups and are active throughout the video (general AOI) are marked, and on the right side, the AOI that includes only the source of the disturbance and is active only for the duration of the disturbance (event-based AOI) is marked.

accuracy and precision (see preregistration). The following AOI-based analyses are therefore based on data from 64 participants (calibration accuracy: M = 0.55°, SD = 0.18°; calibration precision: M = 0.35°, SD = 0.18°).

In accordance with the principles of open science, the data used will be made available by the authors, without undue reservation.

Preliminary Analyses

Due to the study design, performance differences between instructions could not be validly interpreted in the presence of possible training effects. For this purpose, performance was compared in terms of the z-standardized accuracy of correctly-identified disruptions for the first and last videos presented, respectively, as a function of each video sequence. Results suggest no significant effect in performance improvement during the experiment (see **Table 3**). In summary, training effects can be neglected, and therefore, it can be assumed that the study results are not confounded by performance increases based on the experimental setup.

Furthermore, the comparability of the videos was checked. For this purpose, performance was compared in terms of accuracy for those videos that contained the same number of disturbances (e.g., comparison of Videos 1a and 1b under the same instruction but between participants). For both instructions, a Mann–Whitney U-test, due to the violation of normal distribution and variance heterogeneity, was calculated to check the videos' comparability concerning response accuracy performance (see **Table 4**). Therefore, the absolute values of the response accuracies were relativized block-wise to the respective video's overall performance (for detailed information, see section "Design"). The results show that performance under the general instruction as well as under the specific task instruction is comparable across the different video sequences: the participants notice a comparable number of events in Videos A1–A3 as well as in Videos B1–B3. Therefore, we did not include this condition as an additional between-subjects variable in the following analyses regarding instructional differences, as we can eliminate the presence of a systematic bias.

Since there are results that could show that more knowledge can be related to a lower cognitive load and, consequently, to higher performance (e.g., Kalyuga, 2007), we controlled whether the cognitive load was operationalized by the adapted questionnaire of Klepsch et al. (2017), which can be predicted by knowledge. Results show that knowledge is not a significant predictor of cognitive load, $F_{(1,59)}$ = 0.02, p = 0.885, R^2 = 0.00, β = −0.019, so cognitive load does not need to be included as a covariate for further analyses (for means and standard deviations see **Supplementary Material**).

TABLE 3 | Comparisons via paired t-test between the first and last video presented for each video sequence to examine training effects.

Video sequence	Comparison ($Video_{first}$ and $Video_{last}$)	Values of significance	
		t	p
A1	Video 2a and 3b	t (9) = −0.55	0.595
A2	Video 3a and 2b	t (10) = −1.03	0.327
A3	Video 1a and 1b	t (10) = −1.13	0.284
B1	Video 1b and 3a	t (9) = 0.29	0.781
B2	Video 3b and 1a	t (10) = 1.32	0.216
B3	Video 2b and 2a	t (10) = 0.46	0.654

N = 64.

TABLE 4 | Results of the independent t-test for comparability of the videos differing by the conditions within the respective instruction.

	Video sequences A1–A3	Video sequences B1–B3	Values of significance	
	M (SD)[a]	M (SD)[b]	t	p
General instruction	0.44 (0.20)	0.40 (0.28)	t (56.85) = 0.71	0.483
Specific instruction	0.45 (0.26)	0.45 (0.27)	t (62) = 0.05	0.964

[a]*N = 32,* [b]*N = 32.*

However, in line with Palmer et al. (2005), not only experience but also the level of students' or teachers' knowledge is considered in the following to further elaborate on the interaction of the two factors influencing professional vision. Grub et al. (2022) were already able to show that knowledge has a positive effect on accuracy and velocity in detecting potential disturbances: students with more experience detected disturbances more often and faster than those with less experience. In stepwise regressions for each of the eye-tracking parameters used, whether the inclusion of pedagogical/psychological knowledge as a covariate could contribute to the explanation of variance was tested in advance (for means and standard deviations see **Supplementary Material**). However, for all parameters used, knowledge was found to have no significant influence on gaze ($p > 0.05$).

Likewise, the concentration performance or working speed in the context of selective attention has no significant influence ($p > 0.05$, for means and standard deviations see **Supplementary Material**).

Hypotheses Regarding the Relationship Between Expertise and Professional Vision Based on Eye-Tracking Data

For the further hypothesis-specific analyses, three more participants (two experts and one novice) were excluded because they did not recognize a single disruption ("non-performer"). It can also be inferred from the data review (including open response formats) of the corresponding participants that the task had not been comprehended properly. Therefore, a sample size of 61 will be applied for subsequent calculations.

Hypothesis 1 Regarding Global Monitoring Gaze Behavior

An independent *t*-test for each of the eye-tracking parameters with the between-subjects factor "expertise" (experts vs. novices) was calculated for general AOIs. Means and standard deviations, as well as the detailed results, can be found in **Table 5**.

No significant effects regarding hypotheses 1a, 1b, or 1c could be revealed; there are no expertise differences between prospective and experienced teachers in terms of the different eye-tracking parameters based on the global AOIs.

TABLE 5 | Results of the *t*-test with regard to global monitoring gaze behavior based on the mean about all general AOIs.

	Experts	Novices	Values of significance		
	M (SD)	*M (SD)*	*t* (55)	*p*	*d*
Fixation count	53.01 (6.86)	53.60 (8.12)	–0.30	0.384	–0.08
Visit count	21.59 (3.76)	21.89 (4.46)	–0.28	0.390	–0.08
Mean fixation duration	0.38 (0.06)	0.38 (0.08)	0.24	0.404	0.07
Visit duration	17.39 (1.16)	17.31 (1.10)	0.27	0.393	0.07
GRI	7.47 (1.96)	7.43 (2.53)	0.06	0.478	0.02

$N_{experts} = 30$, $N_{novices} = 27$.

Hypothesis 2 Regarding Event-Related Gaze Behavior

An independent *t*-test for each of the eye-tracking parameters with the between-subjects factor "expertise" (experts vs. novices) was calculated for event-related AOIs. Means and standard deviations, as well as the detailed results, can be found in **Table 6**.

No significant effects regarding hypotheses 2a and 2b could be revealed; there are no expertise differences between prospective and experienced teachers in terms of the different eye-tracking parameters based on the event-related AOIs. Concerning the exploratory hypothesis 2b, there are no significant differences. Both prospective teachers and experienced teachers fixate on the disruption-specific AOIs for a comparable length of time during the first fixation.

Hypothesis 3 Regarding the Influence of Specific Task Instruction on Expertise-Dependent Professional Vision

A repeated measured ANOVA was performed, with "expertise" (experts vs. novices) as the between-subject variable and task instruction (general vs. specific) as the within-subject variable for each dependent eye-tracking parameter. Means and standard deviations can be found in **Table 7** and the detailed results in **Table 8**.

Regarding the global monitoring gaze behavior, no significant effects are shown for expertise or the interaction of instruction × expertise. However, there are significant effects of instruction on the parameter fixation count, visit count, and GRI ($p < 0.05$). Under specific instruction, both experts and novices show more fixations, more visits, and a smaller GRI.

Concerning event-related gaze behavior, no significant effects are shown for either instructional variation, expertise, or the interaction of these two factors.

DISCUSSION

In the last decade, eye tracking has been a very common method to measure expertise differences regarding professional vision in the field of classroom management in teacher education and educational research (Grub et al., 2020). However, there are still several open questions regarding the expertise sensitivity of eye-tracking parameters and the possibility of scaffolding professional vision through instructional support. Therefore, this study addressed whether the previous results of expertise differences could be replicated in a standardized experimental setting and whether instructional support can enhance prospective teachers' perception processes of relevant events.

Relationship Between Expertise and Professional Vision Regarding Different Eye-Tracking Parameters

Global Monitoring Gaze Behavior

The results suggest that there are no expertise differences in global monitoring behavior between prospective and experienced teachers (*hypothesis 1*), that is, novices and experts show no differences in the number of their fixations and visits, in the duration of fixations and visits, or, therefore, in GRI. These results are contrary to our hypotheses and some prevailing research findings (see van den Bogert et al., 2014; van den Bogert, 2016; Huang, 2018).

However, current research shows that the available empirical data has been enriched by novel research findings, and the impact of expertise on teachers' professional vision depicts a rather heterogeneous pattern. For example, Shinoda et al. (2021) similarly did not find expertise differences for fixation duration and fixation count in their study with a large sample regarding AOIs that contained no disruption (comparable with our global AOIs). Effects may have been overestimated in previous studies. Likewise, Smidekova et al. (2020) investigated gaze distribution over a longer time period and showed that the distribution of gaze movement patterns across the classroom itself does not follow a stable intra individual pattern, but varies substantially between lessons, and further between the investigated experienced teachers. It is thus apparent that a teacher's gaze can vary considerably. Furthermore, the authors emphasize the relevance of parameter selection considering the purpose: some eye-tracking parameters are more sensitive to expertise differences than others.

Other studies have revealed that gaze behavior can further be affected by other factors. Stahnke and Blömeke (2021), for example, were able to find expertise differences in gaze behavior only in the partner-work format, but not in the group-work format. These findings suggest that not only the expertise but also the social form of teaching can influence gaze behavior. Similarly, a study by Seidel et al. (2021), which investigates teacher diagnostic skills, only found differences in the number and duration of fixations between student teachers and experienced teachers in the individual seatwork scene, but not in the whole-classroom instruction scene. The authors explain this by pointing out that whole-classroom scenes, in particular, tend to trigger bottom-up perceptual processes, because there are more salient visual perceptual

TABLE 6 | Results of the *t*-test with regard to event-related gaze behavior.

	Experts	Novices	Values of significance		
	M (SD)	*M (SD)*	*t* (55)	*p*	*d*
Response accuracy[a]	1.33 (0.55)	1.17 (0.45)	1.20	0.117	0.319
Decision time	8633.23 (3980.39)	9087.67 (3801.09)	−0.44	0.331	−0.117
Number of fixations before response	9.26 (3.28)	10.19 (3.21)	−1.09	0.142	−0.288
Time to first fixation	40.58 (1.62)	40.29 (1.96)	0.62	0.271	0.163
First fixation duration	0.27 (0.08)	0.28 (0.10)	−0.26	0.398	−0.07

$N_{experts}$ = 30, $N_{novices}$ = 27. [a]The average number of correctly-detected disruptions per video is indicated. A total of 15 disruptions could be identified throughout all the videos. Experts detected a total of 46.43% and novices 46.13% of all disruptions in the video vignettes.

TABLE 7 | Descriptive statistics for the ANCOVA with regard to the influence of specific instruction of expertise-dependent professional vision.

	General instruction		Specific instruction	
Global monitoring gaze behavior				
	Experts	Novices	Experts	Novices
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Fixation count	156.58 (22.61)	153.92 (31.00)	161.48 (23.28)	165.85 (27.75)
Visit count	63.59 (11.78)	62.19 (16.13)	66.23 (12.47)	68.31 (13.69)
Mean fixation duration	1.17 (0.31)	1.20 (0.38)	1.13 (0.32)	1.07 (0.30)
Visit duration	52.04 (4.97)	50.94 (7.13)	52.29 (4.13)	52.34 (4.01)
GRI	7.82 (2.90)	8.46 (4.29)	7.33 (2.79)	6.88 (2.93)
Event-related gaze behavior				
	Experts	Novices	Experts	Novices
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Response accuracy	0.49 (0.25)	0.43 (0.17)	0.50 (0.23)	0.45 (0.26)
Decision time[a]	19235.67 (14056.49)	20725.89 (13084.79)	17919.09 (10763.09)	17898.32 (8625.77)
Number of fixations before response	19.02 (9.25)	22.06 (11.19)	20.52 (9.20)	20.84 (9.28)
Time to first fixation	122.05 (8.15)	119.82 (12.27)	121.43 (6.89)	120.50 (7.55)

$N_{experts}$ = 30, $N_{novices}$ = 27. [a]$N_{experts}$ = 27, $N_{novices}$ = 24.

impressions and cues such as motions, whereas seatwork scenes are based more on top-down processes. This would suggest that we were not able to uncover any differences in expertise in our video vignettes because the aspects of the whole classroom scenes used were salient, and top-down processes assumed a subordinate role. Neither knowledge nor experience was required to identify the salient disruptions, so experts and novices performed alike. In conclusion, internal validity may be limited.

This illustrates, as already postulated by Steffensky et al. (2015), among others, that professional vision is domain-specific and varies in regard to, for example, the pedagogical content or pedagogical/psychological aspects of the lesson, the social form, the grade level, or the topic under examination. Since our videos show mostly frontal teaching, it is reasonable to assume that this may have had an additional impact on the teachers' eye movements and scanning behavior of the classroom (see Stahnke and Blömeke, 2021).

Event-Related Gaze Behavior

Results suggest that there are no expertise differences in event-related gaze behavior between prospective and experienced teachers (*hypothesis 2*), that is, there are no differences between novices and experts in the number of correctly-recognized disruptions, the time until they recognize that a disruption has occurred, the time until the first fixation on the disruption, or the number of fixations before they decide that it is indeed a disruption.

These results are contrary to hypotheses and some prevailing research findings (see van den Bogert et al., 2014; Wolff et al., 2015; Wyss et al., 2021). However, there are more recent results that make the previous database more inconsistent (e.g., Keller et al., 2021).

Keller et al. (2021) showed in a mobile eye-tracking study with novice and expert teachers that novices and experts did not differ in the number of teaching events they perceived (however, there are differences concerning the interpretation and valuation of the events). Another study comparing teachers' and student teachers' visual perception of off-task behavior found an expertise effect on accuracy, but still, only about 40.7% of the experienced teachers (and 25.2% of the student teachers) detected the disruption (Shinoda et al., 2021). In our study, both experts and novices correctly identified about 46% of the disruptions (see **Table 6**). Differences in expertise regarding the eye-tracking parameters could only be found concerning the number of fixations, but not for the duration of fixations and only with respect to time period after the disruption contained in the video, not before. It is conceivable that the differences found can only be attributed to those experts who were able to identify the disruption as such (see Wyss et al., 2021), that is, the differences may not inevitably be the consequence of expertise but may be attributable to other (not yet fully researched) factors.

Moreover, recent research using video vignettes compared with open and closed questions to assess noticing also shows that teaching experience does not automatically contribute to higher achievement in noticing (Bastian et al., 2021). Furthermore, only

TABLE 8 | Results of the repeated measured ANOVA with regard to the influence of specific instruction of expertise-dependent professional vision.

	Values of significance								
Global monitoring gaze behavior									
	Main effect (Instruction)			**Between-subject variable (Expertise)**			**Interaction effect (Instruction × Expertise)**		
	F ratio	***p***	**ω^2**	***F ratio***	***p***	**ω^2**	***F ratio***	***p***	**ω^2**
Fixation count	6.46	**0.007**	0.02	0.02	0.445	0.00	1.13	0.147	0.00
Visit count	9.50	**0.002**	0.03	0.02	0.441	0.00	1.17	0.142	0.00
Mean fixation duration	1.56	0.108	0.01	0.13	0.360	0.00	0.43	0.257	0.00
Visit duration	0.76	0.194	0.00	0.28	0.298	0.00	0.37	0.274	0.00
GRI	2.96	**0.046**	0.02	0.03	0.438	0.00	0.83	0.183	0.00
Event-related gaze behavior									
	Main effect (Instruction)			**Between-subject variable (Expertise)**			**Interaction effect (Instruction × Expertise)**		
	F ratio	***p***	**ω^2**	***F ratio***	***p***	**ω^2**	***F ratio***	***p***	**ω^2**
Reponse accuracy	0.31	0.291	0.00	1.08	0.152	0.00	0.01	0.461	0.00
Decision time	0.93	0.170	0.00	0.08	0.387	0.00	0.12	0.363	0.00
Number of fixations before response	0.00	0.472	0.00	0.76	0.194	0.00	0.50	0.243	0.00
Time to first fixation	0.00	0.492	0.00	0.90	0.174	0.00	0.15	0.350	0.00

Significant values ($\alpha < 0.05$) are in bold. N = 57.

a subset of teachers achieve proficiency, and even fewer achieve expert status (see Dreyfus and Dreyfus, 1987, Berliner, 1988). For example, Wyss et al. (2021) showed that few experts do not solely fixate on a "critical incident" but also verbalize it afterward. Those experts also showed differences in eye movement data compared to the other participants, regardless of whether they were prospective or experienced teachers. These insights suggest that not only expertise or experience should be used as an indicator for a good "seer," but that there are probably many other factors (e.g., situational awareness, an ability for parafoveal vision, etc.) that contribute to noticing (Gegenfurtner, 2020). In fact, there is already preliminary evidence that internal factors, such as experienced stress, impact the focus of attention on students in the classroom (Chaudhuri et al., 2021).

Effects of Specific Instruction on Process-Based Measurements of Professional Vision

Regarding *global monitoring gaze behavior*, the results indicate that instruction affects professional vision, independent of expertise, in the sense that both prospective and experienced teachers show a higher number of fixations and a higher visit count under specific instruction than under general instruction; likewise, there is an instructional effect with respect to the GRI. These significant results suggest that more specific instruction may sharpen the focus of both experts and novices by increasing their scanning/monitoring behavior of the classroom through an augmented number of fixations and gaze shifts between individual student groups (see Wolff et al., 2015, Stahnke and Blömeke, 2021). By allowing the eye to roam around the classroom, potential classroom disruptions can be identified more quickly, which means there is better proactive classroom management and less disruption to the flow of the lesson in practice, and therefore a positive impact on student learning (Emmer and Stough, 2001; Kounin, 2006; Steffensky et al., 2015). Despite its significance, the instructional effect should be interpreted with caution because the effect size is small (see Field, 2013).

However, as might be expected based on the results of hypotheses 1 and 2, none of the analyses reveal an expertise effect. Likewise, no interaction between instruction and expertise can be found, that is, contrary to the hypothesis, the specific instruction does not support novices alone, but also influences experts' visual perception.

Concerning *event-based gaze behavior,* neither instruction nor expertise effects are evident, nor an interaction between the two. That is, the specific instruction does not lead to an improved and/or faster perception of disturbances, for novices or experts. As this was the first study of its kind with an instructional variation to improve the professional vision of prospective teachers, especially for identifying potential teaching disruptions, the non-significant results regarding the interaction of instruction and expertise can barely be compared with previous research results from the field of teacher education. Studies have focused more on larger-scale and more elaborate interventions to develop the perception of prospective teachers (Gold et al., 2013; Seidel et al., 2013), whereas we examined a minimal intervention. To the best of our knowledge, there is only one other published study dealing with a similar research question. Grub et al. (2022) also investigated whether specific instruction influences the professional vision of classroom disruptions. However, this study was conducted without eye tracking and only with students as participants. Here, too, there was no supportive effect of the minimal intervention in favor of the novices.

Multiple reasons are conceivable as to why the predicted effects could not be found. It is quite possible that participants noticed almost no difference between the general and the specific instructions, as the task instructions might not have been differentiated enough. It is equally feasible that the focus on classroom management, in the specific case of classroom disruptions, was not ideally chosen. Both prospective and experienced teachers could consider classroom disruptions by pupils to be the most relevant events in a classroom (Gage and MacSuga-Gage, 2017) so that the two task categories are therefore not disjunctive but overlap to some extent. Furthermore, schemata are formed through situations in which certain conditions and their implications are observed and interpreted (Axelrod, 1973). The interconnections are then developed in the context of the novice's own level of knowledge. Novices' schemata may not yet be sufficient and/or sufficiently networked to offer relief, as they have so far only experienced their theoretical understanding of classroom management from the student perspective and have not yet been able to put this knowledge into practice (Wiścicka, 2014). The "critical incident" study by Wyss et al. (2021) shows a similar pattern in which, in contrast to previous video vignettes used in research, the teacher is the source of disruption in the classroom: those teacher educators who identified the event that interfered with learning, disregarding irrelevant events without losing focus on other activities in the classroom, show different gaze behavior than the student teachers and those teacher educators who did not notice the critical event. The authors explain this by the fact that these experts, due to their previous experience and professional knowledge, can show a better professional vision both qualitatively (verbalizations about the event) and quantitatively (gaze behavior).

Another possibility can be considered in the presentation of the instructions by within-subject design. While no training effects were found (see section "Preliminary Analyses"), some students are seen in several videos, which may have led to familiarity or knowledge about their character, behavior, or the like. Therefore, it cannot be excluded that carryover effects may have occurred due to these factors.

Strengths and Limitations

The study design created an experimental environment that was not compromised by study-related characteristics, achieved by randomizing the order of the videos within video blocks according to the Latin square, as well as the balanced allocation of the videos to the instructional conditions. In addition, the use of standardized video vignettes allows for comparability of results across different samples, which enabled new insights to be derived from the research findings. This generalizability is further enhanced by the fact that our broad-based participant acquisition allowed us to recruit a larger sample size than in most former studies. Furthermore, we recruited a sample of teachers from different types of schools to promote the generalizability of the results (see **Table 1**). We would have liked to operationalize expertise not only in terms of experience but also in terms of pedagogical/psychological knowledge (see Palmer et al. (2005)) and to include this as a covariate in the analyses. Unfortunately, however, our sample did not show significant differences in expertise with respect to knowledge, nor was this a significant predictor of any of the parameters used.

Of course, our study also has limitations; due to the quasi-randomized assignment of students and faculty to novice and expert groups, there are also limitations regarding the sample. For example, due to the naturally occurring age differences between still students and teachers with at least 5 years of teaching experience, no statement can be made about the influence of age on professional vision. The same applies to gender, since it was mainly female students who took part in the study, whereas there was a fairly balanced ratio among teachers (see **Table 1**).

While video vignettes can be used to illustrate exemplary teaching practices and dilemmas faced by their daily routine, at the same time, video recordings contain only a fraction of what happens in the classroom (van Es and Sherin, 2010). In addition, the videos comprise slight but salient teaching disruptions (see Rattay and Wensing, 2011), limiting generalizability.

In the video vignettes used, there were mainly salient disruptions (e.g., a student puts their head on table or throws a paper ball across the room) that were presumably perceived not only purely through top-down-based but also much more bottom-up-based gaze control and required little actual experience and prior knowledge of classroom disturbances.

Implications for Further Research

Studies with video vignettes that vary in the degree of teaching disruption could provide further, complementary insights. It is conceivable that less salient disruptions require a greater level of experience and are only recognized by experts (see van den Bogert, 2016), and that in such situations the expertise-dependent, top-down based gaze behavior is first needed and becomes visible (Wyss et al., 2021). To verify this, a study would need to be conducted in which the gaze behavior of novices and experts is systematically compared as a function of differently-obvious and salient instructional disruptions. Possibly, the results could provide important information for the education and promotion of professional vision for novice teachers.

Due to the possibility that the participants are already skilled in watching videos and identifying potential disruptions due to the number of videos under the general instruction before they watched the videos under specific instruction, it would make sense to conduct a further study in which the instruction is not varied within but instead between participants. However, this would probably require a larger sample size.

It is also possible that the instructions were too similarly worded and therefore not disjunctive enough to represent a difference for the participants. It would be exciting to vary the degree of specificity of the instructions even more, to determine if an even more specific instruction might lead to more effects in the form of differentiated gaze behavior between general and more specific instructions. It is conceivable that a very specific instruction draws attention to specific aspects of the classroom and thus guides gaze behavior even more.

It would moreover be interesting to preface the video viewing with some sort of training on what is meant by teaching disruption (e.g., definitions, precursors, and examples). In this way, it would be possible to find out to what extent the knowledge of disruptions or, rather, practical experience influences the professional vision and identification of disruptions.

Some studies have been able to show that social forms (e.g., Stahnke and Blömeke, 2021), subjects taught, and cultural factors (e.g., Huang, 2018; McIntyre and Foulsham, 2018) can influence gaze movements and thereby professional vision. Although our sample is too small to examine such differences, it would still be of interest for further research to dig deeper into these differences to examine systematic variation in gaze behavior and their influencing factors.

Scanpaths are another promising method for analyzing eye movement data to explore more understanding of the processes involved in viewing a classroom. Kosel et al. (2021), for example, look at cognitive processes of expert and novice teachers in an assessment situation using eye-movement patterns. The results show, among other things, that teachers' scanpaths were idiosyncratic and more similar to teachers of the same expertise group. McIntyre and Foulsham (2018) also analyzed scanpaths to evaluate differences between expert and novice teachers in real-world classrooms in regard to culture. They found, among other things, that expert teachers have a focused gaze and constantly refer back to students and that Asian teachers scan students more compared to United Kingdom teachers. In this respect, an analysis of scanning patterns is a useful addition to eye-tracking research in the field of professional vision and should receive more attention in the future.

Since, in addition to experience, knowledge can influence perceptual ability (e.g., Wolff et al., 2015, 2021; Barth et al., 2019; Grub et al., 2022), we have additionally recorded pedagogical/psychological knowledge. However, since we were unable to find a correlation between eye movements and knowledge, in experts or novices, it seems reasonable to assume that the test used may not have captured those cognitive abilities that are necessary for the perception and identification of potential disruptions. In light of other research findings (e.g., Zaragoza et al., 2021), which could show that professional knowledge does not necessarily go hand-in-hand with good observation skills of classroom situations, it is conceivable that only specific knowledge facets have a significant influence on perception. In any case, further research should not underestimate the factor of knowledge as an influencing variable on professional vision (see Grub et al., 2022) and possibly use a more appropriate assessment, and/or should evaluate which facets of knowledge have an impact.

Implications for Theory and Practice

Importantly, there are limitations of the eye–mind hypothesis, which is the basis of eye-tracking research (Just and Carpenter, 1980). This theory assumes that the attention of the observer is wherever they are looking at that moment (fixation). Therefore, shifts in fixation are directly linked to shifts in attention (Holmqvist et al., 2011). However, the separation of fixations from the "spotlight of attention" poses a significant problem for data analysis (Duchowski, 2002). According to this separation, it is possible to fixate on a point visually, but to have one's attention on a completely different point (for example "hidden attention"; Posner, 1980). Consequently, a recorded gaze path can show which regions were viewed, but whether they were consciously processed cognitively cannot be determined without triangulation (see Wolff et al., 2015). Bente (2005) correctly adds to this approach that eye tracking is not able to explain the reason for not looking at certain regions (Rakoczi, 2012). Methodological explanations are also weak in that eye movements cannot be interpreted as selection processes *per se* since they are in principle a result of preceding cognitive processes. Conclusions regarding visual perception should therefore always be made with caution. For example, it is possible that a certain group of students in the classroom is not, as assumed, evaluated as relevant due to cognitive top-down processes and therefore viewed more frequently, but is rather increasingly fixated upon due to basal bottom-up processes, since dynamic stimuli (e.g., certain movements or students throwing paper balls), or other factors such as certain colors, automatically attract attention and are inevitably directly linked to top-down information (see Navalpakkam and Itti, 2005). Therefore, triangulation should be included in every eye-tracking study (Orquin and Holmqvist, 2018). Triangulation, the connection of eye movements with another source of information, is repeatedly mentioned in the context of eye-tracking research (Holmqvist et al., 2011, p. 95). In the future, more attention should be paid to this direct connection between eye-tracking data and the frequently recorded verbal data. Analyses should be performed that directly link the two records.

Furthermore, publication bias cannot be ruled out. Especially in specialized research, pre-registration is crucial (Burns et al., 2019) to counteract the publication of only statistically significant results and thus better reflect the actual state of research. Only when all results are available to researchers can the correct and adequate conclusions for practice be drawn from them. In the words of Altman and Bland (1995, p. 485), just because "the study has shown that there is no difference, whereas usually all that has been shown is an absence of evidence of a difference. These are quite different statements."

CONCLUSION

In summary, it can be said that we could not replicate expertise effects in a quasi-randomized eye-tracking experiment using video vignettes, but we could show that a minimal intervention in the form of a specific instruction can, under specific circumstances, influence the gaze movement regarding the fixation count of (prospective) teachers. The field of research on the process-based recording of professional vision, in particular of things relevant to classroom management such as disruptions in teaching, requires further studies to find out to what extent and, above all, under what conditions differences in expertise can be found. Only with a plausible, theoretically-founded homogeneous results landscape can meaningful interventions for teacher training and further education be derived and established in the university learning setting.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Saarland University, Ethics Committee of the Faculty of Human Sciences, Chair Cornelius König, Campus A1 3 in Saarbrücken, Germany. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

A-SG: conceptualization, methodology, formal analysis, investigation, and writing—original draft. AB: conceptualization, methodology, and writing—review and editing, and supervision. DL: resources and writing—review and editing. RB: conceptualization, methodology, resources, supervision, and writing—review and editing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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