PRONOEA

Professional Vision of Novice and Expert Teachers

Dissertation

zur Erlangung des akademischen Grades eines

Doktors der Philosophie

der Fakultät HW

Bereich Empirische Humanwissenschaften

der Universität des Saarlandes

vorgelegt von

Ann-Sophie Grub

aus Kaiserslautern

Saarbrücken, 2023

Der Dekan

Prof. Dr. Peter Loose, Universität des Saarlandes

Berichterstatter:innen

Prof. Dr. Roland Brünken, Universität des Saarlandes

PD Dr. Sarah Malone, Universität des Saarlandes

Prof. Dr. Andreas Gegenfurtner, Universität Augsburg

Tag der Disputation: 04.05.2023

"[…] τό τε εὖ [ἄρχεσθαι] μικρὸν μὲν μὴ εἶναι κτλ, παρὰ μικρὸν δέ · καὶ εἰδέναι μὲν μηδὲν πλὴν αὐτὸ τοῦτο [εἰδέναι] […]" [1]

Socrates

Some things will always be stronger
than time and distance.
Deeper than languages and ways.
Like following your dreams,
and learning to be yourself.
Sharing with others,
the magic you have found …

Sergio Bambaren [2]

[1] "*that to make a good start was no trifling advantage, but a trifle turned the scale; and that he knew nothing except just the fact of his ignorance*"; Translation from: Diogenes Laertius (1925). *Lives of Eminent Philosophers* (pp. 163). Harvard University Press.

[2] Bambaren, Sergio F. (2014). *The Dolphin: Story of a dreamer* (pp. 78). CreateSpace Independent Publishing Platform.

Acknowledgements

I would like to take this opportunity to thank all those who have contributed to the success of this PhD thesis and who have supported and motivated me during its preparation.

First and foremost, I would like to thank my chief advisor, *Prof. Dr. Roland Brünken*, for giving me the opportunity to grow and earn my doctorate under his guidance. You were always available as a reference, supportive and inspiring me with your expertise.

My special thanks go to *PD Dr. Antje Biermann* for supervising my thesis. Through constructive criticism she helped me to achieve a well-thought-out manuscript. Without her tireless positivity and patience, I would not have managed to overcome what I believe was my biggest hurdle—learning to be patient with myself. Thank you very much for making my time at the university an experience that enriched my life in so many ways and that I will never forget!

In addition, I would like to thank *Prof. Dr. Doris Lewalter* from the School of Social Sciences and Technology of the Technical University of Munich for the opportunity to cooperate on the use of classroom videos and her always rapid and constructive feedback and follow-up on joint publications.

I would also like to thank *Prof. Dr. Andreas Gegenfurtner*, whose research has paved the way for many generations to come, and who kindly agreed to review this dissertation and serve on the examining committee. I am honored to have you read and evaluate my work.

My supervisors and (former) colleagues also played a major role in making it possible for me to write this PhD thesis. Many thanks to all of you—especially to *PD Dr. Sarah Malone* and *Dr. Andreas Korbach*, who shared their expertise and advice on the eye-tracking method—for your patience, confidence and especially your extraordinary understanding.

I would also like to thank *Tobias Gall*, without whom the technical implementation and data preparation would hardly have been possible. He always took the time to work out a solution for my technical special cases and problems.

I would also like to take this opportunity to thank all the *student assistants and research interns* who supported me in the project and relieved me of some of the workload. I would like to mention in particular Eva Mayer, Annika Huse, and Julia Simons.

Furthermore, I would like to thank the "*Jungen Wilden*"—especially *Kristin Altmeyer* and *Dr. Marie Weißenfels*—from the bottom of my heart for the many helpful comments, corrections, and answered questions, without which I would not have been able to complete my work on schedule. Thank you very much for all your patience and assistance. It's a pleasure to have colleagues who have become friends for life!

I would also like to thank *Sandra Bell*, who spent many hours proofreading. She pointed out weaknesses and, as a non–specialist in educational research, was always able to point out where additional explanations were needed.

Without a doubt, my parents—*Susanne Gäckle-Grub and Thomas Grub*—deserve thanks for supporting me so warmly not only during my school years, but also during my PhD.

Last but not least, I would like to thank *Alexander Hauck*. He was a tireless discussion partner during every phase of the work and always motivated me—he deserves my special thanks.

Table of Contents

List of Figures

List of Abbreviations

AOI	area of interest
ANOVA	analysis of variance
ANCOVA	analysis of covariance
CVTE	Cognitive Theory of Visual Expertise
EMME	eye-movement modeling examples
GDPR	General Data Protection Regulation
GPA	grade point average
GRI	Gaze Relational Index
SAGAT	Situation Awareness Global Assessment Technique
SAM	Self-Assessment Manikin
WLST	Würzburg Reading Strategy Knowledge Test
PPHW-K	Pädagogisch-psychologisches Handlungswissen in Bezug auf Klassenführung [pedagogical-psychological knowledge test]
PUW	*Pädagogisches Unterrichtswissen* [pedagogical teaching knowledge]

List of Original Publications

This thesis is based on one systematic review, two empirical studies, and a methodological book chapter that have all been submitted to peer-reviewed journals or publishers. Three articles have already been published and can be accessed online. The fourth article is accepted but not yet published. All articles are included in the Appendix (Section 7.1).

(1) **Grub, A.-S**., Biermann, A., and Brünken, R. (2020). Process-based measurement of professional vision of (prospective) teachers in the field of classroom management: a systematic review. Journal for Educational Research Online, *12*(3), 75–102. https://doi.org/10.25656/01:21187

(2) **Grub, A.-S**., Biermann, A., Lewalter, D., and Brünken, R. (2022a). Professional knowledge and task instruction specificity as influencing factors of prospective teachers' professional vision. Teaching & Teacher Education, *109*, 1–14. https://doi.org/10.1016/j.tate.2021.103517

(3) **Grub, A.-S.**, Biermann, A., Lewalter, D., and Brünken, R. (2022b). Professional vision and the compensatory effect of a minimal instructional intervention: A quasi-experimental eye-tracking study with novice and expert teachers. Frontiers in Education, *7*: 890690, 1–17. https://doi.org/10.3389/feduc.2022.890690

In addition, as part of the doctorate, a fourth article—a book chapter for an anthology to which I was invited to contribute by the editors—was prepared. I incorporated material from that book chapter at appropriate points in the synopsis but did not devote an independent chapter to it in the present work.

(4) **Grub, A.-S.**, Biermann, A., and Brünken, R. (in press). Eye Tracking as a Process-Based Methodology to Examine Teachers' Professional Vision. In A. Gegenfurtner and R. Stahnke (Ed.), *Teacher Professional Vision: Theoretical and Methodological Advances (Part 1)*. Routledge.

Summary

A (prospective) teacher needs certain competencies to meet the multitasking requirements of teaching in a classroom, especially knowledge about proactive, effective classroom management and a good eye for everything that is happening in the classroom. Only by quickly recognizing relevant cues to potentially disruptive events can a teacher deal with them adequately. Yet the teacher must be able to block out events that are irrelevant to the lesson.

Competence in professional vision, which links knowledge and action in teaching, involves two sub-processes: *noticing*, a basal process of perception that involves identifying relevant events, and *reasoning*, a process that builds on noticing and can be described as the ability to use knowledge about learning and teaching to derive adequate conclusions from what is seen.

Most research on (prospective) teachers' professional vision based on subjective tests (e.g., video analysis, questionnaires, or interviews) has focused on the process of reasoning, whereas few studies have addressed the basal process of noticing, i.e., recognizing potential confounding events. Process-based methods such as eye tracking are particularly suitable for the direct and continuous recording of the basal process of perception. Eye tracking enables conclusions to be drawn about the cognitive perception processes of (prospective) teachers and integrates both spatial and temporal information on the allocation of attention. The methodological book chapter forthcoming in *Teacher Professional Vision: Theoretical and Methodological Advances* provides more detail on how eye tracking can be used and the challenges it presents.

Eye-tracking studies in other domains have shown that novices and experts differ in their gaze behavior. Preliminary educational research regarding (novice) teachers also suggests that novice and expert teachers differ in their ability to detect potential classroom disruptions. The knowledge base underlying perception is better organized in experts and thus positively influences perception. Knowledge influencing professional vision is stored in so-called schemata and can be triggered and influenced by factors such as prior knowledge. For example, professional vision may vary depending on the schema activated or depend on a given task instruction focusing on a particular aspect of the material. Therefore, it can be assumed that professional

vision can be positively influenced by training and feedback interventions. Although effective programs exist to train and support (prospective) teachers in the use of professional vision, they consume considerable time and resources.

The aim of the thesis was to investigate teachers' professional vision, especially in the area of classroom management, in two ways: implementing an online experiment within the framework of the restrictions on scientific activities due to the COVID-19 pandemic and using eye tracking as a process-based measurement method in a laboratory setting. I performed the work as follows. First, I conducted a systematic literature review to assess the state of the research on (prospective) teachers' professional vision based on process-based eye-tracking studies. For this purpose, I performed a literature search for the period from 1999 to 2019, identifying a total of 12 studies were identified. These studies were aggregated and integrated and showed relatively stable differences between experts and novices for most of the parameters investigated but used very heterogeneous methods and samples.

Based on this, two empirical studies were designed to shed more light on the competence of professional vision. Study I, conducted online, examined the extent to which knowledge as an objective measure of expertise affects student teachers' professional vision. I assessed both noticing (the accuracy and velocity of the perception of potential classroom disruptions) and reasoning (the depth of analysis revealed by verbalizations related to detected disruptions). The results of Study I showed that expertise tested by an economical knowledge test as a performance-based criterion affects prospective teachers' professional vision of (potential) teaching disruptions. The more knowledge the students had, the faster and more accurately they detected potential disturbances in the video vignettes (noticing). However, being more knowledgeable about pedagogical-psychological action did not lead to a deeper analysis (reasoning) of the events.

In Study II I used eye tracking as a process-based method to assess whether the differences reported in previous studies in professional vision expertise between student teachers and experienced teachers in monitoring and/or disruption-specific gaze behavior (noticing) could be replicated. Contrary to our hypotheses, I could not replicate expertise differences in eye-tracking parameters in a quasi-randomized experiment. Parameters measuring classroom monitoring gaze behavior regarding the whole classroom scene and event-based gaze behavior (especially that related to potential or actual teaching disruptions) were similar in student teachers and experienced teachers.

In both Study I and Study II, I investigated how effectively an economical, independent, task-specific instructional method could replicate the results of efficient but costly and resource-intensive training or feedback interventions. I hypothesized that minimal instructional support could positively influence novices' gaze behavior and thus possibly compensate for differences in expertise in professional vision. Study I found no effect of a minimal intervention on students' professional vision, whereas Study II—which used the process-based recording method of eye tracking—showed that specific instruction led to changes in gaze behavior in both students and experienced teachers. Novice and expert teachers exhibited more fixations, suggesting more effective scanning and monitoring behavior.

Overall, the results show that reinforcing the teaching of knowledge about relevant aspects of classroom management at the university is important, as it helps novice teachers take their first steps in the process of teaching and learning, which are often perceived as particularly challenging (Study I). In addition, Study II shows that further studies and research projects are needed to determine the extent to which and, especially, under which conditions differences in expertise-dependent looking behavior in the classroom can be found. Only a plausible, theoretically based research landscape in which studies produce homogeneous results will permit the development of meaningful interventions for teacher education and training in the medium term and their establishment in the university learning setting.

Zusammenfassung

Lehrkräfte lehren tagtäglich Unterrichtsinhalte, agieren mit Schüler:innen und bemühen sich deren Lernerfolg zu maximieren. Dies ist jedoch nur bei möglichst störungsarmem Unterricht möglich. Gerade im Hinblick auf die Multitasking-Anforderungen sind vor allem angehende, unerfahrene Lehrkräfte schnell überfordert. Deswegen benötigt eine (angehende) Lehrkraft bestimmte Kompetenzen, insbesondere Wissen über proaktive, effektive Klassenführung und ein gutes Auge für alles, was in ihrem/seinem Klassenraum von statten geht. Denn nur durch ein schnelles Erkennen relevanter Hinweisreize, wie beispielsweise potenzielle Störereignisse, kann mit diesen adäquat umgegangen werden. Gleichzeitig muss eine Lehrkraft aber auch fähig sein, für den Unterrichtsverlauf irrelevante Ereignisse ausblenden zu können.

Eben diese Kompetenz der professionellen Wahrnehmung, welche als Bindeglied zwischen dem Wissen und Handeln einer Lehrkraft angesehen wird, kann in zwei Teilprozesse untergliedert werden: Noticing, als basaler Wahrnehmungsprozess, bei dem es um das Identifizieren von relevanten Ereignissen geht, und Reasoning, als darauf aufbauender Prozess, der die Fähigkeit beschreibt, Wissen über Lernen und Unterrichten zu nutzen, um aus dem Gesehenen adäquate Schlussfolgerungen abzuleiten.

Bisherige Forschung zur professionellen Wahrnehmung von (angehenden) Lehrkräften, die sich auf subjektive Testverfahren wie z. B. Videoanalyse, Fragebögen oder Interviews stützen, haben sich vor allem auf den Prozess des Reasonings konzentriert, während sich nur wenige Studien mit dem basalen Prozess des Noticings, d. h. dem Erkennen potenzieller Störereignisse, befasst haben. Für die direkte und kontinuierliche Erfassung des basalen Wahrnehmungsprozesses eignen sich besonders prozessbasierte Verfahren wie das Eye-Tracking. Diese Methode ermöglicht Rückschlüsse auf kognitive Wahrnehmungsprozesse der (angehenden) Lehrkräfte und integriert sowohl räumliche als auch zeitliche Informationen der Aufmerksamkeitsallokation.

Aus der auf Eye-Tracking Studien basierenden Expertiseforschung in anderen Domänen weiß man, dass sich Noviz:innen und Expert:innen in ihrem Blickverhalten

unterscheiden. Erste bildungswissenschaftliche Forschungsbefunde hinsichtlich (angehender) Lehrkräfte legen ebenfalls nahe, dass sich angehende und erfahrene Lehrkräfte in ihrer Fähigkeit unterscheiden, potenzielle Unterrichtsstörungen zu detektieren. Diese Annahme ist darauf zurückzuführen, dass die der Wahrnehmung zugrunde liegende Wissensbasis bei Expert:innen besser organisiert ist und so die Wahrnehmung positiv beeinflusst.

Dieses die professionelle Wahrnehmung beeinflussende Wissen ist in sogenannten Schemata gespeichert und kann durch bestimmte Faktoren wie z. B. Vorwissen getriggert und beeinflusst werden. So kann die professionelle Wahrnehmung beispielsweise je nach aktiviertem Schema variieren oder auch von einer vorgegebenen, einen bestimmten Aspekt fokussierenden, Instruktion abhängen. Des Weiteren kann davon ausgegangen werden, dass die professionelle Wahrnehmung durch Interventionen positiv beeinflusst werden kann. So gibt es bereits effektive, aber gleichzeitig zeit– und ressourcenaufwendige Trainingsprogramme zur Schulung und Unterstützung professioneller Wahrnehmung für (angehende) Lehrkräfte.

Ziel der Dissertation ist es, die professionelle Wahrnehmung von Lehrkräften, insbesondere im Bereich des Classroom Managements, mit prozessbasierten Messmethoden (Eye-Tracking) zu untersuchen. Dabei wurden mehrere Ziele verfolgt: Zuerst wurde der aktuelle Forschungstand zur professionellen Wahrnehmung von (angehenden) Lehrkräften basierend auf prozessbasierten Eye-Tracking Studien in einem systematischen Literaturreview aggregiert und integriert. Dafür wurde eine Literaturrecherche für den Zeitraum von 1999 bis 2019 durchgeführt. Insgesamt konnten dabei 12 Studien identifiziert werden, die relativ stabile Unterschiede zwischen Expert:innenen und Noviz:innen bei den meisten untersuchten Parametern, bei gleichzeitig sehr heterogener Methoden- und Stichprobenauswahl, aufweisen.

Darauf aufbauend wurden zwei empirische Studien entwickelt, die dazu dienen sollten, den erst wenig erforschten Kompetenzbereich der professionellen Wahrnehmung näher zu beleuchten. Daher wurde in Studie I überprüft, inwieweit sich Wissen als objektives Maß für Expertise auf die professionelle Wahrnehmung von Lehramtsstudierenden auswirkt (Noticing: Genauigkeit und Geschwindigkeit der

Wahrnehmung potentieller Unterrichtsstörungen, Reasoning: Analysetiefe der Verbalisierungen hinsichtlich der erkannten Störungen). Ergebnisse dieser Onlinestudie zeigen, dass Expertise, operationalisiert mittels eines ökonomischen Wissenstests, als perfomanzbasiertes Kriterium einen relevanten Faktor der professionellen Wahrnehmung von angehenden Lehrkräften darstellt. Je mehr Wissen die Studierenden aufwiesen, desto schneller und mit höherer Akkuratheit entdeckten diese potentielle Störsituationen in den Videovignetten (Noticing). Gleichzeitig führte mehr Wissen über pädagogisch-psychologisches Handlungswissen jedoch nicht zu einer tieferen Analyse (Reasoning) der relevanten Ereignisse.

Darüber hinaus wurde in Studie II untersucht, ob sich die in bisherigen Forschungsbefunden aufgezeigten Expertiseunterschiede hinsichtlich der professionellen Wahrnehmung zwischen erfahrenen Lehrkräften und Lehramtsstudierenden in Bezug auf das Monitoring- und/oder störungsspezifische Blickverhalten (Noticing) in einem standardisierten Studiendesign replizieren lassen. Im Gegensatz zu unseren Hypothesen konnten wir keine Expertiseunterschiede hinsichtlich der Eye-Tracking Parameter in einem quasi-randomisierten Versuchsdesign replizieren. Studierende und erfahrene Lehrkräfte zeigten sowohl im Hinblick auf ihr globales Monitoringverhalten als auch ihr störungsspezifisches Blickverhalten, ähnliche Ausprägungen der Parameter.

Zusätzlich wurde sowohl in Studie I als auch Studie II beleuchtet, inwieweit eine ökonomische, eigenständige aufgabenspezifische Instruktion ähnliche Effekte erzielen kann wie effiziente, aber kosten- und ressourcenaufwendige Trainings- oder Feedbackinterventionen. Hierfür wurde untersucht, ob durch eine minimale instruktionale Unterstützung das Blickverhalten von Novizen positiv beeinflussten werden kann und es somit möglicherweise eine Kompensation von Expertiseunterschieden erreicht werden kann. Studie I konnte jedoch keinen Einfluss der minimalen Intervention auf die professionelle Wahrnehmung der Studierenden feststellen, wohingegen Studie II—bei der die prozessbasierte Erfassungsmethode des Eye-Trackings verwendet wurde—zeigen konnte, dass eine spezifische Instruktion sowohl bei Studierenden als auch erfahrenen Lehrkräften zu einem veränderten Blickverhalten führt. Noviz:innen und Expert:innen wiesen mehr Fixationen auf, was für ein effektiveres Scan- und Monitoringverhalten spricht.

Insgesamt sprechen die Ergebnisse dafür, dass die Vermittlung von Wissen über relevante Aspekte des Classroom Managements an der Universität gestärkt werden sollte, da dies den angehenden Lehrkräften die ersten Schritte im Prozess des Lehrens und Lernens erleichtert, der oft als besonders herausfordernd empfunden wird (Studie I). Außerdem zeigt Studie II, dass es bezüglich expertiseabhängigem Blickverhalten im Klassenraum weiterer Studien und Forschungsprojekte bedarf, um herauszufinden, inwieweit und vor allem unter welchen Bedingungen, Unterschiede hinsichtlich der Expertise zu finden sind. Nur mit einer plausiblen, theoretisch begründeten homogenen Ergebnislandschaft lassen sich mittelfristig sinnvolle Interventionen für die Aus- und Fortbildung von Lehrkräften ableiten und im universitären Lernsetting etablieren.

1 Introduction

Classrooms are characterized by the high complexity, simultaneity and dynamics of the events taking place in them (Doyle, 1985). Teachers must cope with many types of tasks at the same time. As an additional challenge, the people involved (the teacher and the students) sometimes have different goals (Wolff, 2016). In this context, proactive classroom management is considered one of the most important core competencies of a teacher (Barth, 2017). Classroom disruptions occur in every class, regardless of the school type (Meyer, 1990). According to Keller et al. (2021), an estimated 35% of the school year's teaching time is lost because disruptions prevent learning (more than 20 disruptions occur per lesson; Krause, 2004). Effective classroom management requires the early recognition of potential disruptions (Sherin & van Es, 2005; van den Bogert et al., 2014). Especially for beginning teachers, it is often challenging to perceive every critical moment and deal effectively with threatening or emerging disruptions, given the multidimensionality and the simultaneity of classroom interactions and events and the need for immediate responses (Wolff et al., 2015). The basis of effective classroom management is possessing professional vision of critical events in complex professional interaction situations (Goodwin, 1994; Sherin & van Es, 2009). Hence, the earlier a teacher perceives and anticipates situations relevant to classroom management, the better the proactive control of the teaching process—a process that can be summarized by the term "monitoring" (Gold et al., 2016). This competency has received increasing attention in research on teachers' professional vision (e.g., Barth, 2017; Gold et al., 2016; Seidel & Stürmer, 2014).

Professional vision is defined as a teacher's ability to recognize critical events and interactions in the classroom and interpret them in a theory-based manner while ignoring irrelevant events (Sherin & van Es, 2009). Professional vision, including noticing and reasoning, links the teacher's knowledge and actions (Blömeke et al., 2015). However, several more or less different definitions and uses of the term exist (see e.g., Stahnke, 2021); a few will be discussed in more detail later. Empirical studies show that competent teachers' professional vision is associated with higher quality teaching (Roth et al., 2011; Santagata & Yeh, 2016; Sherin & van Es, 2009) and better student performance (Kersting et al., 2012; Roth et al., 2011). The basal noticing process of professional vision, that is, identifying (potentially) disruptive events, is increasingly being captured by eye tracking, as technological innovations in research increase (Riedl et al., 2008). Previously, video analyses, interviews, or questionnaires were widely used as qualitative measurement methods for the early detection of situations, especially for the reasoning process (cf. Seidel et al., 2011).

The use of the process-based method of eye tracking has several advantages over verbal methods. First, recording eye movements allows for inferences about participants' attentional processes, which are usually unconscious and therefore difficult to verbalize (van Gog et al., 2009). Moreover, eye tracking integrates both spatial and temporal information (Wolff et al., 2015), whereas other methods may focus on only one of these two levels. In summary, the advantage of eye tracking can be seen in the direct and objective recording of visual processing (Wolff, 2016). Furthermore, eye tracking can be used to capture cognitive perceptual processes (Gegenfurtner et al., 2011) and to assess perceptual processes in classroom management observations (Stürmer et al., 2017; van den Bogert, 2016).

Expertise research suggests that experts and novices differ in their ability to detect potential instructional interference. The knowledge base underlying perception (Blömeke et al., 2015) is better organized in experts (Wolff, 2016) and thus influences their perception (Stahnke et al., 2016). This knowledge is stored in the form of schemata (Wolff et al., 2021) and can be triggered by certain factors (e.g., prior knowledge; Gilboa & Marlatte, 2017). For example, professional vision may vary depending on the schema that is activated or may depend on an instruction identifying which aspect of a task to focus on (e.g., Schreiter et al., 2022a; Tatler et al., 2010; Yarbus, 1967).

Professional vision, in education and other fields, is influenced by various factors (Gold et al., 2016; König & Kramer, 2015; Treisch, 2018) and can be positively influenced by interventions (Blomberg et al., 2013; Gold et al., 2013; Roth McDuffie et al., 2014). Thus, effective but time- and resource-consuming educational methods have been introduced for training professional vision (cf. Roth McDuffie et al., 2014). These include lesson analyses (e.g., Santagata et al., 2007), support through prompting tools (e.g., van Es, 2011), didactic interventions (e.g., Seidel et al., 2013), and video-based training (e.g., Gold et al., 2013).

On the one hand, I aimed in this thesis to summarize and integrate the current state of research on professional vision, especially in the field of classroom management, by conducting a systematic review. On the other hand, I aimed to investigate the extent to which knowledge as an objective measure of expertise affects student teachers' professional vision of (potential) teaching disruptions; I considered their ability to notice (accuracy and velocity) and reason (describe, explain, and guide; Study I). In addition, I aimed to investigate whether previously reported expertise-dependent differences in professional vision between experienced teachers and student teachers in global classroom monitoring and/or disruption-specific visual behavior could be replicated in a standardized study design (noticing; Study II). Moreover, I investigated to what extent an economical, stand-alone, task-specific instructional method could replicate the effects of prompting, which is often embedded in a larger training or feedback context. That is, I examined whether minimal instructional support could change the gaze behavior of novices in particular and whether more specific instructions could compensate for the differences in expertise between novice and expert teachers.

2 Conceptual Framework [3]

The following section introduces the most important theoretical background for my research. I introduce important models and explain their interrelationships. Based on this overview, it should be possible to consider the concepts underlying the published articles in context.

2.1 Classroom Management

Classroom incidents occur daily and can be caused by learners, teachers, or even external sources (Wettstein & Scherzinger, 2019). Regardless of their cause, such incidents are stressful for both sides (Pfitzner & Schoppek, 2000). Therefore, the efficient management of a classroom is both a challenge for teachers and a prerequisite for successful teaching (Ophardt & Thiel, 2013). Successful mastery of this requirement not only results in low-disturbance teaching and thus more learning time (Helmke & Schrader, 2009; Kounin, 2006) but also active relationship building between the teacher and the class (Ophardt & Thiel, 2013).

To be able to handle this complex task in the classroom—a place in which multidimensional, simultaneous, and immediate events happen (Doyle, 1985)—teachers must be able to *withitness* and *overlap* (Kounin, 2006). They should be aware of as many classroom events as possible and able to handle multiple demands simultaneously, such as maintaining the flow of instruction and responding to unavoidable discipline problems. Achieving this requires the ability to *monitor*, that is, to constantly track and register relevant processes and demonstrate that they are doing so to students (Gold & Holodynski, 2017). Teachers, then, should ideally have "eyes in the back of their heads" (Seidel, 2020).

[3] Please note that the thesis follows a classical structure. First, I discuss the theoretical basis of relevant topics such as classroom management, professional competence, professional vision, differences in expertise in professional vision of classroom disruptions, methods for examining professional vision. Then I discuss possible ways to support (prospective) teachers in developing their professional vision. This is followed by a presentation of the research aims and a summary of the articles on which the thesis is based (a systematic review and two empirical studies). The fourth article, namely, the methodological book chapter, is not summarized in one place like the other article, but is referenced at appropriate places throughout the thesis. At the end of the thesis, there is a global discussion.

The early noticing of relevant events enables teachers to address emerging classroom disruptions in a timely and subtle fashion. Thus, sometimes a glance, a gesture, or a change in position can be sufficient to proactively shape and maintain order in a classroom situation (Ophardt & Thiel, 2013), avoiding the need for an elaborate intervention after activity in a trouble spot in the classroom has escalated (van den Bogert, 2016). Proactive classroom management thus allows for the maximization of learning time, which can have a positive impact on student learning according to Helmke's (2006) model of instructional provision and uptake (see also De Jong & Westerhof, 2001). Fauth et al. (2014) note that student ratings of classroom management can predict student achievement. The clearer and more carefully structured the instruction,—that is, the more successful the classroom management is—the better students' school performance. The ability to manage classes successfully is thus part of the professional skill set of successful teachers and and an element of teaching competence and expertise (Kunter et al., 2011).

Although classroom disruption is one of the factors that plagues teachers the most, there seems to be no uniform definition of the term. For Biller (1979), Winkel (2021), and Lohmann (2003), teaching disruptions are events that interfere with, interrupt, or make the teaching-learning process impossible by partially or completely overriding the conditions under which teaching and learning can take place. In addition, classroom disruptions can be categorized variously and have different degrees of importance (Borich, 2014; Lugrin et al., 2016; Rattay & Wensing, 2011; Thomas, 2013). They can be triggered by students as well as teachers or by the interaction of the two (Nolting, 2012). The thesis focuses exclusively on the former. Someone who associates disruptive behavior with students might cite noise, restlessness, oppositional and provocative behavior, aloofness, and overt and covert aggression (Eckstein, 2018). However, the actuality and degree of (potential) disruptions is more or less in the eye of the beholder, his/her current mental and physical condition and, especially, his/her previous experience, knowledge, and competence.

2.2 Teachers' Professional Knowledge

Professional competence is the basis for successful action in job-specific situations and is a multidimensional construct. There are a wide variety of models that emphasize and highlight different aspects of competence (see Stahnke, 2021). For example, in their model of teachers' professional competence (COACTIV), Baumert and Kunter (2006) describe professional knowledge as a core aspect of a teacher's competence, along with beliefs/values, motivational orientation, and self-regulatory skills. Professional knowledge is described as consisting of different knowledge areas composed of knowledge and skills, including general pedagogical knowledge, subject-matter content knowledge, and pedagogical content knowledge. More recent approaches to assessing teacher competencies have increasingly addressed situation-specific skills (Stahnke, 2021). This broadening of the concept of competence has been motivated by the fact that effective teachers need not only knowledge but also context-specific cognitive skills that are more directly related to practice (Blömeke et al., 2015).

A conceptualization of competence as a continuum (Blömeke et al., 2015) assumes situational and behavioral characteristics that mediate between cognitive dispositions and situation-specific performance. This understanding of competence integrates behavioral definitions of competence, which create competence profiles from requirements analyses, and dispositional definitions of competence, which understand competence as the totality of all underlying cognitive and motivational resources. It explains how individuals who possess all the resources belonging to a competence construct can combine and apply them and thus perform well. Starting from cognitive dispositions (e.g., professional knowledge; Casale et al., 2016) and affective-motivational dispositions (e.g., self-efficacy; Schunk & DiBenedetto, 2021) as learnable but relatively stable components, situation-specific skills in the area of perception, interpretation, and decision-making are used to indirectly manifest competent action as situational performance (Shavelson, 2013).

In summary, knowledge is an important aspect of a teacher's ability to fulfill the demands of teaching in the classroom. Mediation processes are involved in the connection between knowledge and the ability to cope with situation-specific teaching demands (e.g., teaching disruptions); among other processes, the change in acquired knowledge structures triggered by professional experience influences the visual perception processes (Blömeke et al., 2014).

Knowledge of classroom management is part of the general dimension of general pedagogical knowledge (Voss et al., 2015) that is relevant for effective teaching (Voss et al., 2011). It is also an aspect of competence (Baumert & Kunter, 2006) and is one of the cognitive dispositions necessary for professional competence. It refers to both conceptual knowledge about the teaching and learning process (Jahn et al., 2014; Seidel et al., 2011) and the ability to apply this knowledge in a practice-oriented manner (Sherin & van Es, 2009). Professional knowledge of classroom management is considered an implicit prerequisite for the use of professional vision in teaching situations (Blömeke et al., 2015) and can affect the ability to perceive and anticipate potentially disruptive behavior and thus the implementation of a disruption-free classroom (Wolff et al., 2015). For a teacher to respond appropriately to a situation and reflect on his/her teaching, an appropriate perception of the situation is necessary. But it is often challenging, especially for beginning teachers, to perceive every critical moment and effectively manage threatening or emerging disruptions due to the multidimensionality as well as the simultaneity of classroom interactions and events and the need for an immediate response (Wolff, 2015). More about the cognitive processes such as schemata that underly these expertise differences will be discussed in Section 2.4.

As described in the following section, the structural model developed by Blömeke et al. (2015) will form the basis of the concept of competence in this thesis. It presents a holistic picture of competence as a continuum by integrating a cognitive and situated perspective (see also Stahnke, 2021).

2.3 Teachers' Professional Vision of Teaching Disruptions

The term and concept of professional vision is based on cross-disciplinary anthropological research by Goodwin (1994). Nowadays, professional vision is generally understood as the ability to identify, interpret, and evaluate features related to one's profession (König et al., 2022; Mischo et al., 2020). In teaching, professional vision is thus understood as the competence to filter out the relevant aspects of complex classroom events and interpret and evaluate them in a theory-based manner to derive action decisions for classroom management (Mason, 2011; Schoenfeld, 2011).

Approaches to modeling professional vision consider and weight the different facets of competence variously (Barth, 2017). Among existing models of professional vision, a distinction can be made between discipline-independent generic modeling approaches (e.g., situation awareness; Endsley, 1995; Cognitive Theory of Visual Expertise, CVTE; Gegenfurtner, 2020) and modeling approaches designed to explain teachers' perceptions in the context of teaching (e.g., Professionelle Unterrichtswahrnehmung [professional teaching perception]; Seidel et al., 2010; van Es & Sherin, 2002). For example, Gegenfurtner's (2020) generic theory of professional vision is based on three basic assumptions (extended capacity, knowledge-based processing, and practice-based interaction) and is devoted to understanding how to skillfully perceive, interpret, and evaluate visual information in work tasks. Eight processes in the visual register and long-term memory play a role in selecting and ignoring visual information, knowledge-based perception, expanding the visual field through parafoveal processing, organizing parts of images, integration, using visual practices to interact with the environment, and monitoring.

According to Sherin (2001), who adapted Goodwin's concept (1994) to the teaching context, a distinction can be made between two interacting processes in instructional perception (Sherin, 2007; Sherin & van Es, 2009): noticing and (knowledge-based) reasoning. "Noticing" (resp. attending, identification) describes the ability of teachers to recognize events that are relevant for teaching and learning and ignore irrelevant events via selective attention processes. "Reasoning" (resp. interpreting, making connections and reasoning) describes the ability to apply knowledge of teaching and learning and draw appropriate conclusions and predictions. This process can be seen as an indicator of the quality of the application of knowledge to the classroom situation. Van Es and Sherin (2021) extend their model with a third process, "shaping," which entails constructing interactions and contexts to gain access to additional information and supports further noticing. According to Seidel and Stürmer (2014), reasoning comprises three steps: description, explanation, and prediction. In this schema, "describing" is identifying and limning observed events based on professional knowledge without evaluating them. "Explaining" is combining and elucidating observed events with recourse to stored schemata, integrating conceptual knowledge about teaching. "Predicting" is drawing consequences from observed events using knowledge and previous teaching and learning experience in similar or comparable situations.

To maintain clarity throughout this thesis, "noticing" will be defined as teachers' attending to events in a classroom in the sense of selective attention (Sherin, 2007), and "reasoning" will cover the three skills of description, explanation, and prediction (Seidel & Stürmer, 2014).

2.4 Expertise Differences in Teachers' Professional Vision

Expertise research in different domains shows that experts and novices differ in visual perception depending on their competence and knowledge level (Gobet, 2015). According to Berliner (2001), expertise is domain-specific, that is, experts' knowledge in a particular domain (e.g., classroom management) is better structured than novices' (cf. classroom management scripts; Wolff et al., 2021). Process-based studies of prospective and experienced teachers' visual expertise show that, generally, experts have more, but shorter fixations, whereas novices have less, but longer fixations (e.g., Huang, Miller, et al., 2021; Wolff, 2016). This is in line with the assumption of fast encoding processes by various experts (Chi & Glaser, 1988). Experts fixate on relevant areas (e.g., disruptive students) more often and for a longer duration than irrelevant areas (e.g., non-instructional material) compared to novices, who look more frequently at irrelevant areas (e.g., Huang, 2018; Huang, Miller, et al., 2021; van den Bogert et al., 2014). The focus on important areas implies deeper cognitive processes (Kuperman et al., 2008; Reingold & Sheridan, 2011). Experts distributed their attention more evenly among students and spent, on average, less time looking at single areas of the classroom (e.g., Huang, 2018; McIntyre et al., 2019), which was indicative of expertise-dependent observation behavior of monitoring (Brophy, 1988). The results suggested that novice teachers are less able to differentiate and interpret salient features of classroom situations and recognize the relevant aspects than expert teachers, who have greater knowledge (Carter et al., 1987; Livingston & Borko, 1989).

These differences in visual expertise stem from the circumstance that professional vision is knowledge- or theory-based (Seidel et al., 2011). This professional knowledge is stored in form of so-called schemata [4] and can influence the process of perceiving potentially disruptive classroom events (Sherin & van Es, 2009; classroom management scripts; Wolff et al., 2021). In addition, knowledge about classroom management and corresponding schemata can influence which events are deemed relevant to proactive classroom management through top-down processes (Sherin, 2007; Wolff et al., 2016). Bidirectional relationships can be assumed between cognitive dispositions (schemata) and situation-specific abilities (professional vision) (Blömeke et al., 2015; McIntyre & Foulsham, 2018; Meschede et al., 2017; Sabers et al., 1991; Santagata & Yeh, 2016). Schemata can therefore serve as filters for professional vision (Borko & Putnam, 1996), allowing teachers to select the amount and complexity of information they need based on specific situations, such as the occurrence of events relevant to classroom management (Treisch, 2018). Amidst multidimensional, simultaneous, and immediate classroom events (Doyle, 1980), unfiltered perception due to insufficiently developed schemata quickly reaches its limits, leading to incomplete recognition of important processes, naïve interpretations, and delayed or erroneous decisions to act (Wolff et al., 2021). However, previous research has shown that perception can be guided and influenced by bottom-up and top-down processes (Catherwood et al., 2014; Durso & Gronlund, 1999; Durso & Sethumadhavan, 2008). Experienced teachers in particular show top-down processing of visual information, in which knowledge-based, activated schemata influence the perception of events (Kopp & Mandl, 2005; McVee et al., 2005; Nassaji, 2007; Wolff et al., 2015). In contrast, teach-

---

[4] Example: In contrast to student teachers, who tend to perceive and describe individual aspects of teaching separately and independently (e.g., students sit there, they talk to each other), experienced teachers can use the seating arrangement to identify social forms and the challenges and potential difficulties associated with them and interpret classroom events in context (e.g., group work is taking place; students know the rules).

ers with less experience and knowledge, whose immature schemata are more influenced by salient features (e.g., a single noisy student; Navalpakkam & Itti, 2005), are more likely to exhibit so-called bottom-up processes. Instead of being influenced by knowledge-based schemata (see Section 2.6), they are much more likely to be influenced by specific stimuli from the environment (Kopp & Mandl, 2005). For instance, prospective teachers tend to have more difficulty maintaining a view of the big picture in the classroom than more experienced teachers who have more solid schemata (cf. Clarridge & Berliner, 1991; Peterson, 1987; Treisch, 2018).

In sum, teachers' knowledge organization can influence their perception of classroom situations and their resulting situational awareness. To distinguish experienced teachers from novices, previous studies were guided by Palmer et al.'s (2005) criteria: that experts should be selected according to their years of experience (at least three to five years), social recognition (by two or more socially recognized individuals from the relevant field), membership in a professional or social group and performance-related criteria (e.g., student performance). But until now, expertise differences regarding professional vision have often been made by equating expertise with experience. Although expertise research depends on the fact that experts have outstanding and well-organized knowledge bases, this component of expertise has not yet been directly illuminated with regard to teachers' professional perceptions. Objective, performance-based assessment of expertise using knowledge tests, for example, has been rather neglected. However, determining expertise solely using criterion-based measures (e.g., years of teaching experience) can be problematic. The development of expertise is not always linear but instead often has an inverted U-shape (Gobet, 2015; van den Bogert, 2016), and expertise can vary greatly despite comparable lengths of experience (van den Bogert, 2016). In summary, teachers’ knowledge schemata can influence their professional vision of classroom management-related events, especially the perception and identification of relevant events (i.e., noticing).

2.5 Eye Tracking to Assess Teachers' Professional Vision

In recent years, the research field of teachers' professional vision has increasingly become the focus of scientific attention, particularly in light of technological advances in process-based data collection methods. Previously, researchers often used high-inference or subjective measurement methods such as the analysis of observational data, videos, or interviews (Cortina et al., 2015) to assess professional vision. These methods are used to identify perceptual and interpretive processes of visual expertise relating to reasoning but cannot adequately account for noticing in professional vision (Sherin, 2007). To capture and visualize this more basal visual skill and continuous perceptual process, process-based methods such as eye tracking are required (Wolff et al., 2016). This technology makes it possible to assess visual perception processes—in particular, information intake and processing (Jarodzka et al., 2017)—and to observe and analyze teachers' gaze behavior. It allows the identification and recognition of potentially disruptive events or other relevant classroom situations (Goldberg et al., 2019).

Eye tracking is an established research tool in many research fields where visual expertise is required, including not only medicine (e.g., Ashraf et al., 2018) and traffic psychology (e.g., Alberti et al., 2014) but also educational sciences (e.g., Jarodzka et al., 2017) and, increasingly in the last 20 years, teacher perception and instruction (Huang, Miller, et al., 2021; Keskin et al., 2022). By assessing eye movements of (prospective) teachers, reliable quantitative data on visual expertise are recorded. Fixations and saccades, among other eye movements, are used to investigate attentional behavior. For example, fixations, that is, times when the eye rests largely motionless on one spot, are considered indicators of cognitive processes (Holmqvist et al., 2011) and mark areas to which attention is paid and through which information is processed (see the eye-mind hypothesis; Just & Carpenter, 1980). Fixations were used in almost all of the studies published to date (see the systematic review).

Due to the high spatial and temporal sensitivity of eye tracking (Carter & Luke, 2020; Huang, 2018), this process-based method has long time been used to study selection and attention patterns (Bucher & Schumacher, 2012). Furthermore, eye tracking serves to measure cognitive processes online (Lachner et al., 2016; Tatler et al., 2014) and can be considered a low-interference objective record of eye movements as a behavioral indicator of cognitive function (Gegenfurtner, 2020). Attention and attentional shifts, for example, can be reflected in fixation data (van Gog et al., 2009) and used to assess and analyze the attentional allocation of novice and expert teachers in the classroom (Beach & McConnel, 2018; Jarodzka et al., 2017). Due to the multidimensionality and complexity of classroom situations that need to be processed simultaneously (Doyle, 1985), the way a teacher distributes his/her fixations in the classroom may determine which areas appear relevant given his/her experiential and knowledge framework, and thus be targeted in the context of top-down experience-guided processes and unmediated bottom-up processes (Huang, 2018; Wolff, 2016). As an objective measurement of perceptual and attentional processes, eye tracking can therefore be used in educational studies to analyze teachers' professional vision in the classroom (Wolff, 2016) and investigate the quantitative evidence underlying visual processes (Mele & Federici, 2012).

Because eye-tracking procedures allow the recording of a wide range of features, various aspects of teaching can be analyzed. Regarding the relevance of low-interference teaching to maximize learning time, both the current research field and the thesis focus on an aspect relevant to classroom management, namely (potential) classroom disruptions. However, to plan and conduct eye-tracking research on the professional vision of (prospective) teachers, theory-based parameters have to be chosen to detect differences in expertise. This requires the aggregation and integration of previous research on this topic to identify valid parameters that can differentiate between novices and experts in professional vision (the aim of the systematic review). The current eye-tracking research relating to teachers' professional vision is aggregated and accumulated in the methodological book chapter and therefore is not described in more detail here.

2.6 Fostering (Prospective) Teachers' Professional Vision

Professional vision is a core teaching competency. It allows proactive classroom management to reduce disruptions and ensure an adequate teaching-learning environment (see Section 2.2). However, identifying relevant characteristics of situations (e.g., potential teaching disruptions; cf. noticing) and making schema-based interpretations and predictions of action from them (cf. reasoning), is often a challenge for (prospective) teachers (Aloe et al., 2013; Feldon, 2007; Melnick & Meister, 2008). Thus, research and practice interests go beyond capturing perception in classroom situations. Given the "real-life shock" experienced by young prospective teachers (Dicke et al., 2016), researchers and practitioners are increasingly focused on the training of their professional vision. Supporting prospective but also experienced teachers in improving their professional vision offers a valuable opportunity to encourage effective and proactive classroom management. If (potential) classroom disruptions are recognized in time and events are proactively controlled, the learning time can be maximized and learning opportunities can be maintained. Thus, professional vision combined with classroom management is crucial to achieve and maximize effective learning outcomes (cf. Helmke & Schrader, 2009; Kounin, 2006).

Educational research has shown that teachers' professional vision can be facilitated (e.g., Gold et al., 2013; Seidel et al., 2013) by different types of training (Roth McDuffie et al., 2014): group discussions supported by prompting tools (e.g., van Es, 2011), instructional interventions (e.g., Seidel et al., 2013), pedagogical training (e.g., Södervik et al., 2022), lesson analysis frameworks (e.g., Santagata et al., 2007), and video-based training (e.g., Gold et al., 2013). Van Es (2011) used video clubs that met 10 times during the school year to improve professional vision. Videos of the participating teachers' lessons were viewed and discussed together. During the discussion, general prompts (e.g., "What did you notice?" van Es, 2011) and specific prompts (e.g., "Let's take a look at how Lindsey solved the problem!" van Es, 2011) were used to direct the teachers to analyze student thinking. Södervik et al. (2022) evaluated a pedagogical training program that used a six-week online training (consisting of self-study, reflective essays, and small-group discussions of the essays with feedback by a teacher). In the lesson analysis framework (Santagata et al., 2007), the professional vision of student teachers was enhanced by systematically structuring a video analysis in the context of the sixteen-hour training program. Gold et al. (2013) also draw on a video-based training program to promote professional vision in classroom management in the elementary classroom. This intervention totaled 60 hours (13 weekly seminar sessions plus self-study in the form of homework with feedback).

Although these methods are effective, they are not very efficient, because they are time and resource intensive and usually integrated into a larger-scale training program. A less costly and more minimal intervention —for example, in terms of a specific task instruction or prompt (defined as cues to stimulate productive learning activities)—would be particularly helpful in teacher education (see e.g., Beilstein et al., 2017, or van Es & Sherin, 2006, for the helpful use of prompts in teacher education). In this regard, previous studies have shown that general and specific prompts can support novices in their professional vision (van Es, 2011). The use of prompts can help novices recall knowledge or skills that they would not be able to retrieve spontaneously (cf. Hilbert et al., 2008). However, it is unclear to what extent the specific prompt alone affects professional vision as opposed to the additional training content such as group discussions (Roth McDuffie et al., 2014; Star & Strickland, 2008). It is also unclear whether not only prompts presented during the task and embedded in a larger training or feedback context (e.g., Pichert & Anderson, 1977; Pressley et al., 1992) but also stand-alone task instructions that are embedded before the task can influence professional vision.

In this regard, process-based research suggests that gaze behavior and thus professional vision can be purposefully altered by an activated schema or influenced by specific task instruction focusing on a particular aspect of the task material (Buswell, 1935; Castelhano et al., 2009; DeAngelus & Pelz, 2009; Farnand & Fairchild, 2012; Gobet, 2015, p. 15; Vaidyanathan et al., 2016; Yarbus, 1967). According to Gilboa and Marlatte (2017), schemata are context-sensitive: different schemata are stimulated by different situations and tasks and can be triggered by factors such as prior knowledge or attention. An activated schema can influence incoming information processing, functioning like a kind of template that represents relevant knowledge structures and influences information processing (Ghosh et al., 2014; Thorndyke & Yekovich, 1980). It can have a priming effect by helping an individual to identify relevant details and guiding selective attentional processes (Johnston & Dark, 1986; cf. noticing). Furthermore, (activated) schemata influence how events are perceived, interpreted, and remembered (Gilboa & Marlatte, 2017; Teufel & Nanay, 2017). Thus, early perceptual processes can be influenced by providing specific types of information (generating top-down approaches, see also Section 2.6). For example, Yarbus (1967) was able to show evidence for top-down control by demonstrating qualitative differences in eye movement and fixation patterns depending on the instructions for a visual task (e.g., "state the ages of the subjects" vs. "remember the subjects' clothing" vs. free inquiry). Replications by DeAngelus and Pelz (2009) and Tatler et al. (2010) also showed that participants focused more on certain parts of the task material depending on the aspect triggered by the instruction.

Given the dynamic and multidimensional nature of the classroom and the associated recognition of relevant events, classroom management cannot be described as a passive process. Rather, perceiving, detection, identifying, reacting, and interacting in classroom management-relevant situations involve more-or-less conscious decision-making about what to pay attention to (Simpson et al., 2018). Knowledge of relevant aspects of a classroom situation, operationalized as specific instructions, can accelerate their recognition. The human visual system is biased toward tasks based on known information when it highlights what is relevant—for example, a potential teaching disruption (Navalpakkam & Itti, 2005). Thus, knowledge about the target of attention (operationalized as specific instruction) plays a crucial role in selecting the focus of attention (top-down processes). Through a specific instruction, the more-or-less conscious decision on what to focus attention on is externally determined (cf. knowledge-activating external cues; Herold-Blasius, 2021). The instruction facilitates the perception of certain aspects of a situation and leads to deepened attention to these aspects (Roth McDuffie et al., 2014).

Especially for those with less knowledge, this type of external facilitation is beneficial. Looking through a defined frame allows an individual's limited attention to be focused on relevant aspects of a task rather than being overwhelmed by the many complexities of the classroom (Roller, 2016). This in turn leads to a performance advantage (see processing prompts; Gerjets et al., 2008) as the identification of potential problems (e.g., a potential classroom disruption) is directly related to the activation of corresponding schemata (e.g., for classroom management) that were activated by the specific task instruction (e.g., potential classroom disruption). For novices, specific instructions are easier to understand than more general instructions because specific instructions require less inference (Bouxsein et al., 2008; Catrambone, 1990; Rosenshine et al., 1996). A general or nonspecific instruction does not provide details for each specific case, so the relevance of task aspects must be deduced by the individual. It can be argued that even minimal task-related instructional support in the implementation of a specific task can lead to an increase in performance because certain schemata are activated, and attention is directed to relevant aspects of the task.

Research shows that without specific instruction, prospective teachers struggle to focus their attention on visual cues relevant to teaching-learning (Star & Strickland, 2008), are quick to follow their often intuitive and naïve conceptions of teaching (Hammerness et al., 2002), and are at risk of making hasty judgments and overgeneralizations (Schwindt, 2008). High complexity makes perception difficult for prospective teachers. Those who receive specific task instruction that emphasizes certain aspects of the task can more easily focus their attention on relevant visual cues of situations (Star & Strickland, 2008; cf. noticing), more accurately describe observed cases (Santagata & Guarino, 2011; cf. reasoning), and better use their expertise to explain and instruct (Stürmer et al., 2013; cf. reasoning).

In conclusion, there is evidence that certain tasks or prompts can activate specific knowledge (triggering and activating schemata, resp. top-down-processes) that supports professional vision, especially in the setting of time-intensive training formats. However, it is not yet clear whether a minimal intervention would also ease the complex, multidimensional challenge of classroom management—whether specific instructions could help to activate specific knowledge and apply appropriate strategies.

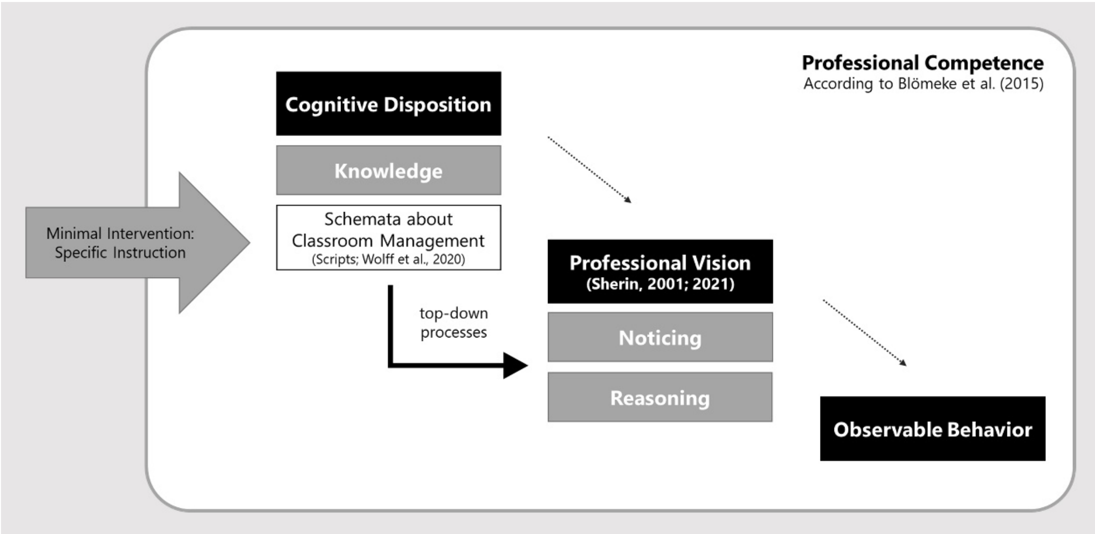
2.7 Résumé of the Theoretical Derivation

This section summarizes the main components of the theoretical derivation with an emphasis on the research gaps. It also offers a graphical representation—

simplified and reduced to essentials—of the interrelationships between cognitive dispositions, perception processes, interventions, and the resulting teacher (gaze) behavior (see Figure 1).

Figure 1

Résumé of the Theoretical Derivation



To effectively cope with the unique circumstances of a classroom and teach adequately, proactive classroom management to prevent teaching disruption is important. Early detection and identification of potentially disruptive events can only be ensured through teachers' anticipatory monitoring and scanning behavior, namely, their professional vision. This ability to perceive and observe the classroom can be described as one of the core areas of professional competence. Cognitive dispositions, including knowledge of classroom management, influence professional vision, including both its noticing and reasoning processes. Depending on the situation and individual's level of competence, one can distinguish between top-down and bottom-up based perception. Thus, existing knowledge about similar classroom situations can foster more targeted expertise-dependent perceptions. This knowledge-based perception can be triggered by external support, such as a specific instruction (schema activation). Thus, differences in perception are based on differences in knowledge-based expertise, and perception can be seen as an indicator of the application of competencies in professional situations.

Based on the existing research landscape, I identified several open research questions:

(1) What is the status quo of research on prospective and experienced teachers' professional vision of classroom management events? (Article 1: Systematic Review)
(2) Are there knowledge-based expertise differences among student teachers in their ability to notice and reason about (potential) classroom disruptions in an online experiment that uses video vignettes? (Article 2: Study I)
(3) Are there expertise differences between student teachers and experienced teachers in their ability to notice (potential) classroom disruptions in an eye-tracking experiment that uses a variety of process-based measurement parameters (eye-tracking data)? (Article 3: Study II)
(4) Can the professional vision of (a) student teachers in an online experiment and (b) student teachers in an eye-tracking experiment be supported by a minimal intervention aimed at a specified task? (Articles 2 and 3: Study I and Study II)
(5) How can eye tracking be used as a process-based method of recording teachers' professional vision? (Article 4: Book chapter)

As the first step, the current research landscape on process-based capture of professional vision of prospective and experienced teachers was to be established by means of a systematic literature review following a methodological formal approach to minimize bias due to selective literature selection (see Tranfield et al., 2003). The aim was to systematically identify the factors for which there were heterogeneous study results and thus a need for further research and derive further, original research ideas from this knowledge (Article 1: Systematic Review). Two studies were then to be conducted to investigate professional vision in more detail: an online study to capture the noticing and reasoning processes of student teachers and the influence of experience (as a "classical" measurement of expertise) and knowledge (an objective, standardized measurement of expertise) on their perception processes (Article 2: Study I) and an eye-tracking study to capture the professional vision of classroom-management-relevant events of prospective and experienced teachers (Article 3: Study II). In each study, the influence of a minimal intervention (a specific or a general instruction) was examined to determine if such interventions can support prospective teachers in their classroom management, supplementing or replacing successful but inefficient perceptual training options. The book chapter (Article 4) presents and discusses obstacles and challenges relating to methodology, stimuli, parameters, interpretation, and the triangulation of eye movement data. It also addresses future areas of research for process-based assessment of professional vision and thus represents a continuation of the existing literature on the recording of teachers' professional vision.

3 Research Aims

Guided by the theoretical background provided in the previous sections, the aim of this thesis is to investigate teachers' professional vision in the field of classroom management, because early noticing, that is, effective professional vision, is necessary for the establishment of an adequate teaching and learning atmosphere in the classroom, especially the control of classroom disruptions. Research gaps were identified in the current literature and addressed in a systematic review as well as two empirical studies: No overview existed of the literature on prospective and experienced teachers' professional vision of classroom management issues and the parameters used to discuss differences in expertise (systematic review). Also, it was unclear whether there are expertise differences among student teachers regarding professional vision of (potential) teaching disruptions when knowledge is used as a proxy for expertise (Study I). Furthermore, it is unclear 1) under what conditions expertise differences between novice and expert teachers in classroom-relevant professional vision, especially the perception of teaching disruptions, can be replicated in an eye-tracking study and 2) whether an inexpensive, minimal intervention—a specific task instruction—can support professional vision (Study I and II). The book chapter, in turn, aggregates and elaborates on the existing knowledge of eye tracking as a process-based method of capturing teachers' professional vision; it can serve as a guide for other researchers in this topic area. The concrete research aims for the systematic review and empirical studies follow are set out below.

3.1 Systematic Review

To be able to create and develop theory-based hypotheses and adequate study designs for studies, it was necessary to summarize and integrate the current state of research on (differences between novice and expert) teachers' professional vision in the field of classroom management to draw conclusions from the individual studies by taking an aggregate approach. For this purpose, a systematic literature review was conducted, which filtered all peer-reviewed journal articles published at the time and processed them appropriately. In this way, commonalities and differences between the individual studies could be identified. I used the systematic review to consider research gaps and derive research questions.

3.2 Study I

Since previous studies were mainly based on expertise comparisons between experienced teachers and prospective teachers, and expertise was used synonymously with experience, we wanted to explore how knowledge plays a (crucial) role in professional vision, specifically in identifying potential classroom disruptions. Therefore, we first aimed to investigate in an online study [5] whether differences in professional vision in both noticing and reasoning processes could be found among novice teachers—a group which is usually considered to be homogenous. We used a knowledge test as an economical, performance-based expertise indicator. Previous research showed that external factors support perception processes during acquisition (Gold et al., 2013; Stockero & Stenzelbarton, 2017) and didactic interventions can be effective in promoting perception (Roth McDuffie et al., 2014). Based on this research, we aimed to examine whether the competence of perceiving—especially noticing but also reasoning processes—could be fostered by minimal instructional support (activating knowledge schemata to promote top-down processes). Previously, similar questions had only been studied in time- and resource-heavy video-based interventions.

3.3 Study II

Study II, based on the systematic review and the results of Study I, investigated a gap in the literature: whether expertise differences between novice and expert teachers could be replicated in a quasi-randomized standardized experimental setting using scripted video vignettes. This study would extend previous research findings; expertise effects would be re-examined and generalized. By using eye-tracking parameters that had not been used before in the context of teachers' professional vision of classroom-management-related events (e.g., Gaze Relational Index), new insights into the sensitivity of eye-tracking parameters for identifying expertise differences could

[5] Due to the Covid-19 pandemic occurring in Germany at that time and the associated restrictions, no eye-tracking study could be performed. Therefore, other parameters had to be used, which prompted us to plan this online study that would address the predetermined topic.

be obtained. Compared to Study I, which focused on disturbance-specific perceptions, Study II distinguished between global monitory gaze behavior across the entire classroom and an event-related gaze behavior related to (potential) classroom disturbances. Although the results of Study I showed that minimal intervention in an online setting did not support novice teachers' professional vision, Study II examined how specific versus general instruction could influence gaze behavior based on—compared to online data—temporal and spatial high-resolution eye-tracking parameters, and potentially support novices in their professional vision of disruptive events. Thus, Study II extends Study I, in which student teachers' professional vision was captured only indirectly via verbal data (a relatively imprecise measurement) and introduces the possibility of using a similar study design to collect and analyze process-based eye movement data to directly capture the basal perceptual process of teachers' professional vision.

4 Summary Report of the Systematic Review and the Empirical Studies

In light of the overarching purpose of this thesis—to investigate and examine prospective and experienced teachers' professional vision relative to classroom management—I conducted a systematic review and to empirical studies and will briefly summarize them here. I was the first author of each study. This chapter outlines the context and aims of the systematic review and the two empirical studies and briefly explains the individual data collection procedure for the different parts of the thesis. I also provide an overview of the instruments, details of the results, and a brief discussion. Elements of Study I and Study II that are similar because of the similarities in their designs will be discussed in more detail in the description of Study I. The explanation of Study II only details the changes and special features that differentiate it from Study I. In both studies, additional parameters were collected to use as possible control variables that will not be discussed in detail in this thesis (for example, self-efficacy and cognitive load in Studies I and II, and selective attention in Study II) as they do not directly relate to the research question. An overview of these parameters can be found in the Appendix (Section 7.2).

4.1 Systematic Review

Grub, A.-S., Biermann, A., and Brünken, R. (2020). Process-based measurement of professional vision of (prospective) teachers in the field of classroom management: a systematic review. *Journal for Educational Research Online*, *12*(3), 75–102. https://doi.org/10.25656/01:21187

4.1.1 Theoretical Background

Professional vision of classroom-management-relevant events as a core competence of teachers includes perceptual performance and underlying cognitive processes of perception (Blömeke et al., 2015; see Section 2.2). The earlier a teacher perceives (noticing) and anticipates (reasoning) situations that are relevant for classroom management, the better the proactive control of the teaching process. Over the past decade, an increasing number of researchers have assessed and analyzed novice and expert teachers' professional vision (see Section 2.3). They have often used highly interferential or subjective measurement methods such as analyses of observational data, videos, or interviews (Cortina et al., 2015) to identify differences in the perception and interpretation of situations at the reasoning level. However, process-based methods such as eye tracking are needed to investigate differences in the basic perceptual processes that are used to identify events and form the basis of reasoning (Sherin, 2007; Wolff, 2016). Eye tracking allows the assessment of eye movement as a behavioral indicator of cognitive function (Gegenfurtner, 2020; see Section 2.5). In recent years, this technique has gained increasing attention in the field of educational research. It can be used to capture many aspects of professional vision, including the early detection of (potential) teaching disruptions (van den Bogert, 2016). Different indicators can be used to assess, for example, the areas on which a teacher's eyes are fixed or how his/ her attention is distributed in the classroom (Holmqvist et al., 2011). Previous studies that used eye-tracking methods to measure classroom-management-related professional vision employed a variety of indicators, of which some are sensitive to differences in expertise (e.g., Gegenfurtner et al., 2011).

To construct a theory-driven foundation for further research on prospective and experienced teachers' professional vision of classroom management situations, the status quo of the research must be assessed. Therefore, my first step in this thesis was to conduct a systematic literature search to identify, evaluate, summarize, and aggregate the findings of all studies of teachers' professional vision that have used eye tracking, especially those that examined noticing in the context of classroom management, and examine which parameters could be used to identify differences in expertise.

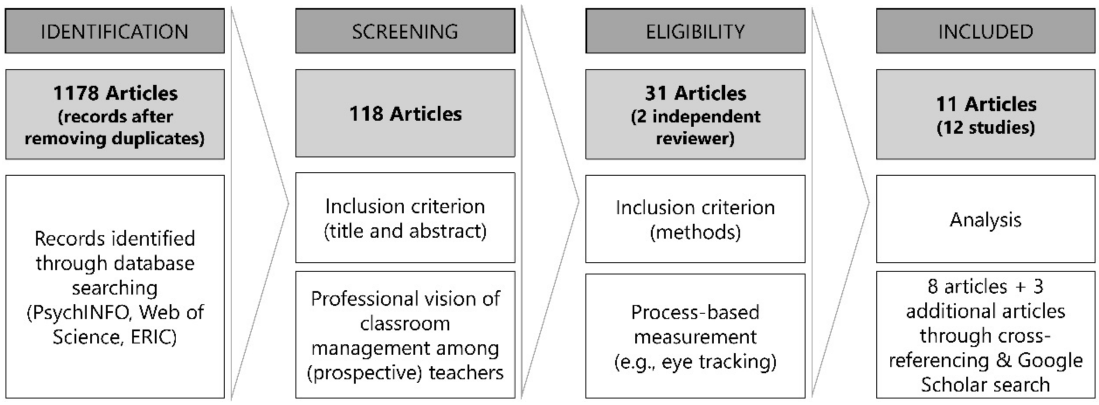
4.1.2 Methods

A systematic literature search (Van Wee & Banister, 2015; Wee & Banister, 2015) was carried out in August 2019 by searching and cross-referencing the databases EbscoHost, PsycInfo and Web of Science for the period from 1999 to 2019.

Eleven articles containing a total of 12 studies dealt with the direct recording of teachers' professional vision in classroom management situations via process-based methods such as eye tracking. For a brief overview of the search procedure, see Figure 2.

Figure 2

Overview of the Systematic Literature Search and Procedure Following PRISMA (Page et al., 2021).



4.1.3 Results and Discussion

The 12 studies were characterized by varying degrees of standardization and different technical conditions (e.g., sampling rate varies between 30 Hz and 250 Hz depending on the study). Nevertheless, the gaze behavior of experts and novices differed significantly in most of the studies, which suggests that—under certain instances—eye tracking can be sensitive to expertise differences.

Several of the studies that compared experts and novices distinguished them only by years of experience, whereas others used at least one of the criteria suggested by Palmer et al. (2005) as well. These criteria included social recognition and professional or social group membership, although only for experts. Researchers should apply the criteria suggested by Palmer et al. (2005) and control professional knowledge for the investigated aspects of professional vision (cf. Lachner et al., 2016). Some of the studies used relatively small samples with limited power for inferential statistics (e.g., Dessus et al., 2016; van den Bogert et al., 2014).

The following paragraphs describe the aggregated results on the parameters, including their sensitivity to expertise. Experts generally had more fixations but shorter fixation durations, whereas novices had fewer but longer fixations. These findings are in line with the assumption of fast encoding processes by various experts (Chi & Glaser, 1988). Also, experts fixed their gazes on relevant areas (e.g., disruptive students) more often than on irrelevant areas (e.g., non-instructional material) compared to novices and spent longer looking at the relevant areas. Focusing on important areas indicates deeper cognitive processes (e.g., Kuperman et al., 2008). Fixation dispersion differed between experts and novices as well. Experts distributed their attention more evenly among students and spent, on average, less time with single areas of interest (AOIs). This is characteristic expertise-dependent monitoring behavior (cf. Brophy, 1988).

Results of the systematic review demonstrated that research on teachers' professional vision of classroom management events is heterogeneous in terms of the methods used (e.g., mobile vs. stationary eye tracking, differences in sampling frequencies, degree of standardization, length of video vignettes used resp. teaching duration), and sample characteristics (e.g., differences in selection criteria used to distinguish novices from experts, sample size). Comparing the studies—for example, comparing studies using mobile versus stationary eye tracking—is risky because both observing and teaching (the latter as a secondary task) are performed during mobile eye tracking so it better reflects the real-life classroom teaching experience than stationary eye tracking (Wade & Tatler, 2005).

In addition, the systematic review identified some commonly used parameters (fixation count, fixation duration) but found that attention distribution was measured with different parameters in many studies (e.g., Gini-coefficient; difference coefficients). Using dispersion measures can lead to inappropriate data aggregation (Orquin & Holmqvist, 2018) because there are various reasons for a stronger focus on one area (e.g., saliency relative to bottom-up processes; Itti & Koch, 2001; or complexity of the object; Just & Carpenter, 1976; or higher relevance recognized by top-down processes; Orquin & Mueller Loose, 2013). Given this problem and also the eye-mind hypothesis (Just & Carpenter, 1980), a methodological triangulation in subsequent studies would be important in order to make statements about *why* something was given special attention (e.g., salience/bottom-up processes or knowledge schemata about disruptive behavior/top-down processes). Finally, we should also briefly mention limitations regarding the expertise-sensitivity: Expertise is not the only influence on teachers' visual processing; their cultural backgrounds and the subjects they teach (see the book chapter) are also significant. For example, cognitive models of teachers depend on shared culture (Blömeke et al., 2016; Hofstede, 1986), and didactical strategies, teachers' gaze behavior, and the relevance of stimuli differ according to the aims of the teaching subject (König et al., 2011).

In summary, the studies assessed in the systematic review identified differences between experts and novices on most of the parameters studied, but the use of different stimuli and methodologies limits study comparability and generalizability. Therefore, further studies that use standardized experimental settings, adequate sample sizes, and select expertise not only on the basis of teaching experience but also through performance-based criteria such as Palmer et al.'s (2005) are desirable. Furthermore, some parameters seem more valid than others for revealing differences in expertise, based on the homogenous results they produced (e.g., fixation count, fixation duration). In addition, the systematic review showed that there are parameters for which little research is available (e.g., scanpath length; van den Bogert, 2016), although other research groups have now taken up these methods of analysis (e.g., Kosel et al., 2021). Teachers' professional vision should be further researched to identify and differentiate the factors besides expertise that can influence, both positively and negatively, gaze behavior in the classroom. This is where Studies I and II as well as research from other researchers (e.g., Kosel et al., 2021; Stahnke & Blömeke, 2021a; Wyss et al., 2020) play a role.

4.2 Empirical Study I

Grub, A.-S., Biermann, A., Lewalter, D., and Brünken, R. (2022a). Professional knowledge and task instruction specificity as influencing factors of prospective teachers' professional vision. *Teaching & Teacher Education*, *109*, 1–14. https://doi.org/10.1016/j.tate.2021.103517

4.2.1 Theoretical Background

Professional vision, that is, the accuracy of teachers' perceptions of relevant (potentially disruptive) events in classroom, is influenced by their knowledge of classroom management (Blömeke et al., 2014; see also Section 2.4; Calderhead, 1979; Gold et al., 2013; Krauss et al., 2011; Meschede et al., 2017). Blömeke et al. (2014), for example, postulate that both perceptual performance (accuracy) and perceptual speed (velocity) of professional vision of specific teaching events depend on corresponding knowledge. Teachers with less knowledge are less able to differentiate and interpret salient features of classroom situations and recognize relevant aspects of such situations later than teachers with more knowledge (Carter et al., 1987; Livingston & Borko, 1989). Moreover, novices give more descriptions and fewer predictions (e.g., Sabers et al., 1991) when recognizing and verbalizing an event; their analyses are more superficial.

In education research and teacher education, there has been widespread interest during the last decade in expertise differences between novice and expert teachers in classroom-management-related professional vision. Some of the studies in the systematic review that examined teachers' professional vision differentiated between teachers with less teaching experience (mostly student teachers) and those with more than five years of teaching experience. Only one study (Stürmer et al., 2017) focused solely on novice teachers (see Section 4.1). However, scarcely any of the studies considered performance-based, objective parameters to distinguish expertise as advised by Palmer et al. (2005); instead, they relied only on criterion-based criteria such as teaching experience. This approach can be problematic because the development of expertise is not always linear and there can be a high degree of variability in expertise despite comparable lengths of experience (Gobet, 2015; van den Bogert et al., 2014).

Previous research has shown that professional vision can be supported by external factors such as prompting tools in the frame of time- and resource-consuming training programs (Gold et al., 2013; Roth McDuffie et al., 2014). However, it is unclear whether the effects perceived are due to instructional specificity per se or rather to additional training content such as group discussions.

In summary, there are still several open questions regarding expertise operationalization and the potential of minimal instructional interventions. Study I was based on the systematic review and the research gaps it revealed, namely, that the professional vision of teachers should be examined more closely and the factors that could influence it considered in a differentiated manner. Therefore, we investigated whether differences could be detected in professional vision (both in noticing and reasoning) among novice teachers, using a knowledge test as an economical, performance-based expertise indicator following the recommendations of Palmer et al. (2005). Furthermore, we examined if solely a specific, compared to a more general, instruction can support novice teachers' professional vision, activating knowledge schemata to promote top-down processes (see also Section 2.6). We also analyzed whether the recognition of relevant classroom management events could be facilitated by activating instruction-dependent schemata by directing attention to single, essential aspects of classroom environment by providing more specific, compared with less specific, instructions (Rosenshine et al., 1996).

4.2.2 Procedure and Methods

4.2.2.1 Participants.

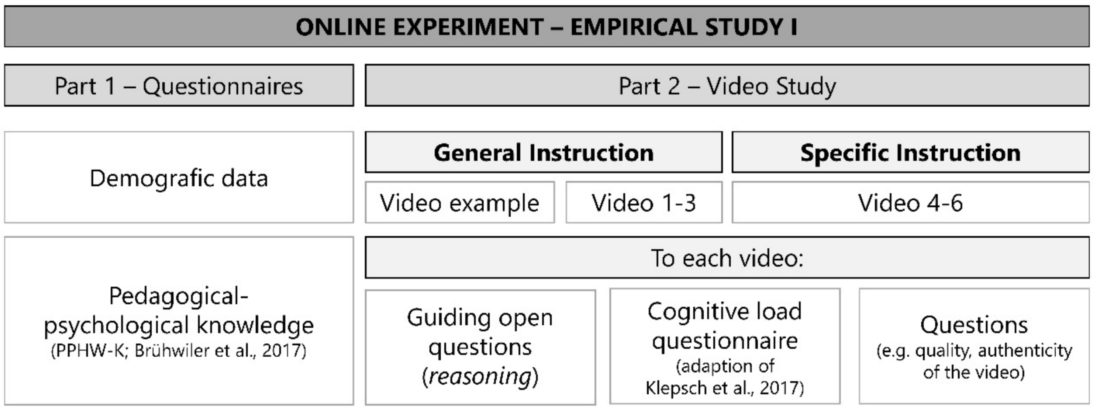
We recruited 116 prospective teachers with a maximum of 40 hours of teaching experience from 13 different German universities in nine federal states via email lists and social networks responsible for educational institutions (teaching experience: M = 23.12 hours, SD = 52.28). A total of 31 participants were excluded from all of the calculations for one or more of the following reasons: not completing the study, very low engagement scores, already working in education, or using a smartphone instead of PC. The remaining 89 participants (age: M = 23.38 years, SD = 3.44) were all student teachers with a maximum of 40 hours teaching experience from German universities. The gender distribution was as follows: 62 female, 21 male, one diverse, one unspecified. More than half of the participants were in work training to become secondary school teachers (65.9%), 22.4% were student teachers for primary schools, 9.4% for special schools, and 2.4% for vocational schools.

4.2.2.2 Design.

Data collection for Study I started in April 2020 and ended in September 2020. The data were collected online using questionnaires and video vignettes created with Questback Unipark Software. The study consisted of two parts (Figure 3) separated by an average of 1.24 days.

Figure 3

Design of Empirical Study I



In the first part, participants completed questionnaires that collected demographic data and measured pedagogical-psychological knowledge, which was assessed with an objective, standardized questionnaire based on six text vignettes (PPHW-K; Brühwiler et al., 2017). In the second part, the participants watched six short video vignettes of different teaching situations. The participants were randomly assigned to one of six video sequences, and the presentation order of the videos was systematically randomized using a Latin square design (see Figure 4). The task assigned to the participants was to identify classroom-management-relevant events and subsequently describe what they saw in response to in-depth questions. Participants were allowed to pause the video as many times as they wanted. For each identified event, they were asked what they noticed, why they noticed it, and to what extent the event could be classified as relevant for teaching, [6] with the opportunity to discuss up to 10 events per video.

To investigate the hypothesis that a minimal intervention in the form of specific instruction could have an impact on professional vision, the instruction was differentiated when the videos were presented. The sample video as well as the first three videos were companied by a general instruction [7] and the last three videos by a specific instruction. [8]

Figure 4

Video Randomization in Empirical Studies I and II

Video Sequence	General Instruction				Specific Instruction		
A1	Video example	Video 2a	Video 1a	Video 3a	Video 1b	Video 2b	Video 3b
A2	Video example	Video 3a	Video 2a	Video 1a	Video 3b	Video 1b	Video 2b
A3	Video example	Video 1a	Video 3a	Video 2a	Video 2b	Video 3b	Video 1b
B1	Video example	Video 1b	Video 2b	Video 3b	Video 2a	Video 1a	Video 3a
B2	Video example	Video 3b	Video 1b	Video 2b	Video 3a	Video 2a	Video 1a
B3	Video example	Video 2b	Video 3b	Video 1b	Video 1a	Video 3a	Video 2a

4.2.2.3 Materials (used in Study I and Study II).

The materials relevant to this thesis and their use are described in more detail below except for the procedures already described in detail in the articles. Materials

[6] (a) What did you see? (b) Why did you notice it? and (c) How is what you saw relevant for the lesson?

[7] General Instruction: "In the following, a video will be played; take a closer look at it. If you notice something relevant, stop the video and answer the questions about what you saw."

[8] 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, stop the video and answer the questions about what you saw."

used in both Study I and Study II are explained in this chapter. Deviations and special features relating to Study II are discussed in more detail in Section 4.3.2.2

The *pedagogical-psychological knowledge test* (PPHW-K; Brühwiler et al., 2017) was used as a performance-based, objective measure of expertise in Studies I and II. Through the use of text vignettes, both procedural and conditional knowledge of classroom management of prospective and experienced teachers could be recorded. Due to the closed-response format, the PPHW-K was very economical to administer and evaluate. The maximum score that can be achieved is 28. The procedure is described in more detail in both articles; hence reference is made to them for more information.

The *video vignettes* that are described in more detail below were used in Studies I and II. They were provided by the *Toolbox Lehrerbildung* (Lewalter et al., 2020) of the Technical University of Munich (TUM) as part of a collaboration. The video segments were extracted from scripted 10th- and 11th-grade mathematics and informatics lessons at a German secondary school and were selected based on classroom management events, audiovisual quality, and the authenticity of the situations by three people working independently (the first author of the publications and two students of educational psychology). Seven video vignettes with an average length of 1.43 min (SD = 0.16 min) were selected, of which one served as an example for the task. They exhibit different quality types and numbers of disruptions (one, two, or more potential disruptions) such as students throwing a paper ball at one another or a student putting his head on the table during class and apparently going to sleep. In total, the six videos used for later analysis contained 16 disruptions.

4.2.2.4 Dependent variables.

The dependent variables of noticing—accuracy and velocity—and the dependent variables of reasoning were collected during the online experiment using a master rating developed by the first author of the article about Study I and an educational psychology student. Both raters looked at the video vignettes individually and coded (potential) classroom disruptions in terms of onset, duration, and type or content of the disruption as well as the students involved in it. Subsequently, the codings were compared for each video. The only video vignettes used in the study were those for which the raters agreed on the time of onset, duration, and content of the disruption.

Following the instruction they received, participants were tasked with selecting the appropriate timestamp for each detected event or potential instructional disruption from a given list of timestamps representing the discovery time of the participant of the corresponding detected event. These timestamps were provided in one-second increments depending on the length of the video. Theoretically, participants could note up to 10 disturbance events per video. After a participant had used a timestamp to identify a relevant classroom event, he or she was asked to answer three open questions in written form (see Section 4.2.2.2). Questions targeted what was identified, why it was discovered, and to what extent it was considered relevant or a (potential) teaching disruption. This written information was analyzed for both noticing (accuracy) and reasoning (depth of analysis). Participants were also instructed to watch the video a maximum of two times (except for briefly rewinding it to note timestamps). This was also checked by a control question after each video. These two steps (selecting a timestamp and answering the three questions in writing) had to be performed by the participants independently for each relevant event in each video.

4.2.2.4.1 Noticing.

The correctness of the specified recognized events was evaluated by assigning one point for each accurately recognized event. The master rating, used to determine whether an event was recognized accurately, was part of the written information collected for each participant (*accuracy*; range 0-16 points). The two raters coded the open responses for each video vignette. The mean interrater reliability of Cohen's kappa was .74.

The time that elapsed until the identification of the event (duration) was a continuous, dependent variable. It was recorded as the time interval between the detection of the event by the participant and the timestamp of the master rating (*velocity*; difference acceleration $\text{time}_{\text{masterrating}}$ - acceleration $\text{time}_{\text{participant}}$; theoretical score 0 – -30). Velocity was calculated only for correctly detected events. Disturbances that were detected later than 30 seconds after the beginning of the disturbance were not considered. A velocity value of 0 corresponds to perfect detection performance.

4.2.2.4.2 Reasoning.

To clarify the reasoning hypotheses, the answers to the three open questions for each correctly recognized classroom management event were analyzed by summarizing and evaluating the verbal answers qualitatively in MAXQDA 2020. The depth of the analysis was assessed using inductively and deductively generated categories, distinguishing between descriptive, explanative, and guiding statements (Seidel & Stürmer, 2014; Sherin, 2007).

Descriptive statements were based only on what was perceived by sensoria and were value-free: statements were classed as descriptive when an observable event or an observable fact was named or depicted and did not contain any evaluations or reasons. In contrast, a statement was classed as *explanative* when an observed situation was not simply named but rather cause-effect relationships were explained, judging comments were made about the quality of the observed teaching interaction, or teaching situations were explained in a theoretically sound manner. If a statement included suggestions for improvement and/or other options for handling an event, it was classed as a *guiding statement*.

After several rounds of conceptualization and piloting of the coding scheme, all statements were coded by the two independent raters (the first author of the publications and an educational psychology student). The interrater reliability of Cohen's Kappa was .71. The qualitative data was then quantified. The proportion of the individual code category number to that of the participant's total number of codes was put into relation to ensure that differences between the respective code categories were not due to differences in the number of correctly identified events or statements.

4.2.3 Results

4.2.3.1 Knowledge and Noticing.

Linear regressions analyses for each criterion (accuracy and velocity), with knowledge as predictor, showed that professional vision varies at an early stage of a teacher's career, depending on the level of knowledge. The number of accurately recognized, relevant events depended on the level of knowledge of the prospective teacher, $F(1, 83) = 4.30$, $p = .021$, $\beta = .222$. Participants with a higher level of knowledge recognized significantly more potential teaching disruptions. In addition, knowledge contributed to a faster perception of relevant events, $F(1, 83) = 3.22$, $p = .039$, $\beta = .193$.

4.2.3.2 Knowledge and Reasoning.

Linear regression analyses for each criterion (descriptive, explanatory, and guiding statements), with knowledge as predictor, revealed that prospective teachers' knowledge could not significantly predict the proportion of descriptive statements about a relevant teaching event, $F(1, 83) = 0.50$, $p = .241$, $\beta = .077$, the proportion of explanatory statements, $F(1, 83) = 0.04$, $p = .421$, $\beta = -.022$, or the proportion of statements containing modification suggestions (guidance), $F(1, 83) = 0.87$, $p = .178$, $\beta = -.102$.

4.2.3.3 Effect of Minimal Intervention. [9]

One-way repeated measured analysis of covariances (ANCOVA) was performed, with task instruction as within-subject variable for each dependent variable, video sequence as a between-subject variable (based on preliminary analysis finding a confounding influence), and knowledge as a covariate. Omega was used as an effect size measure as it is less susceptible to positive bias than, for example, eta (e.g., Okada, 2013).

The results for the noticing variables suggested that instruction (general vs. specific) had no significant effect on professional visions' accuracy, $F(1, 82) = 0.31$, $p = .255$, $\omega^2 = .00$, or velocity, $F(1, 75) = 1.15$, $p = .243$, $\omega^2 = .00$.

Also, the results for the reasoning variables indicated that instruction (general vs. specific) did not significantly influence the proportion of descriptive, $F(1, 82) = 0.47$, $p = .249$, $\omega^2 = .00$, or explanatory comments, $F(1, 82) = 0.27$, $p = .303$, $\omega^2 = .00$. However, instruction did significantly affect the proportion of guiding statements, $F(1, 82)$

[9] To ensure that the results of the study were comparable despite the different maximum values of the video blocks under the different tasks, the absolute values of the accuracy were relativized block by block to the total performance of the respective video block for the calculations of the differences in task performance. For the speed calculations, this intermediate step was not necessary because this measure already contained mean values.

= 7.29, p = .004, ω^2 = .03; specific instruction resulted in a smaller proportion of leading statements.

Knowledge was not a significant covariate in the calculations for any of the dependent variables ($p \geq .05$), except for velocity, $F(1, 75) = 4.58$, p = .036, ω^2 = .02. Likewise, there was no significant interaction between instruction and knowledge (p > .05).

4.2.4 Discussion

The results suggest that pedagogical-psychological knowledge is a significant predictor of the accuracy and velocity of professional vision. More knowledge contributes to greater accuracy: the proportion of correctly recognized potential teaching disruptions is greater and relevant classroom management events are recognized earlier (i.e., more quickly). Thus, our results, which fit into the previous research frame (Gegenfurtner, Lewalter, et al., 2020), strengthen the hypothesis that there are expertise-dependent differences in the perception of events. Furthermore, our online study showed that expertise identified through a performance-based, proximal parameter (the participant's score on a knowledge test) rather than the criterion-based, distal indicator (years of experience) used in previous studies can differentiate novices and experts, even in a prospective teacher sample. This indicates that knowledge is an important component of professional vision as higher knowledge can lead to more effective perception: more accurate and faster identification of potentially disruptive events.

It should be noted, however, that the effect sizes were very low. Since R^2 is always biased by the sample—which in our case was very homogeneous—this could have influenced the results. Therefore, we recommend replicating the study with a more heterogeneous sample (e.g., students with a larger variance in experience).

Prospective teachers' knowledge did not predict the proportion of descriptive, explanatory, or guiding statements. This implies that prospective teachers describe and discuss events similarly regardless of their knowledge level. One possible explanation is that knowledge acquisition and competence do not depend solely on the situation but rather also on the use of knowledge (Kunina-Habenicht et al., 2013). Thus it is conceivable that the format used for recording in our study—writing—is not an appropriate method to uncover differences in verbalization. Previous studies used transcriptions of thinking aloud for this purpose (Wolff et al., 2017; Wyss et al., 2020). It is also possible that individuals with low levels of awareness and active knowledge are less able to consciously and actively use and/or verbally articulate their knowledge than experienced teachers (Weber et al., 2020). Additionally, the quality and quantity of the written statements could have been influenced by the motivation of the participants. However, it is difficult to control for motivation because quantity could be influenced by other individual factors and preferences as well (e.g., keyboard handling, rhetorical style). We conducted post hoc analyses based on these exploratory hypotheses. The results show that engagement influences the quantity of verbalizations (r = 0.255, p = .019). But a close look at whether motivation might have decreased over the course of the experiment found no significant effect for the two video sequences (A vs. B) in terms of motivation for instruction conditions (paired t-test; video sequences A: $t(41)$ = -.469, p = .642, video sequences B: $t(42)$ = 0.223, p = .825). Another explanation of the differences between our results and those of previous studies could be the different composition of our sample, which consisted only of student teachers. The literature reports differences in knowledge facets and related reasoning processes in teachers with different levels of expertise. Studies comparable to ours have investigated differences in reasoning processes but mainly in terms of expertise differences between student teachers and experienced teachers (e.g., Gegenfurtner, Lewalter, et al., 2020; Gold et al., 2016; Stahnke & Blömeke, 2021b; Wolff et al., 2017; Wolff et al., 2016). Since verbalizing is a higher cognitive process than perceiving, and knowledge and experience are much more likely to need to be linked in our study than in previous studies to reach correct conclusions, it is conceivable that the lack of effect in our study is due to a lack of variance.

The results of the present study suggest that more detailed instructions do not foster professional vision more than less detailed instructions: There were no significant differences in accuracy and velocity of professional vision as a function of instruction: the minimal intervention failed to show a significant effect. Further studies would be desirable to rule out the possibility that this nonsignificant effect was due to the small sample, relatively large variance of the variable, or even the conservatism of the procedure (due to the inclusion of a covariate; Huitema, 2011).

Similarly, more specific instruction did not lead to deeper analysis as measured by descriptive, explanatory, and guiding statements. There is even an effect contrary to the hypotheses on guiding statements, although it should be interpreted with caution for several reasons (small effect size; cf. Kirk 1996; small proportion of guiding statements, and large variance).

The hypothesized effects of task specificity were not observed. The instructions may not have been differentiated or disjunctive enough to capture differences among novice teachers on such a rather low-threshold and less objectifiable online study or the prospective teachers may have intuitively judged possible potential instructional disruptions to be most relevant even when they received merely a general instruction. Further research is needed to explore this question.

Limitations affecting both Study I and Study II (e.g., study design, use of video vignettes, inaccuracy of the parameters measured online) are addressed further in the general discussion in this thesis. However, it should be emphasized that despite the unsophisticated nature of the study design and the simplicity of the online parameter, it was possible to uncover differences in expertise among students as a function of knowledge. Similarly, Schreiter et al. (2022b) showed that knowledge enables preservice teachers to recognize difficulty-generating task features more frequently and evaluate them correctly, leaving to a more efficient judgement process in teaching situations.

In summary, the outcomes of Study I reinforce the importance of knowledge transfer during university education. The more knowledge with which prospective teachers are equipped about relevant features of classroom events, the better they will be able to recognize, identify and cope with such classroom scenarios later on (Ballantyne, 2007). The transfer of knowledge can ease what is often perceived as a difficult entry into the process of teaching and the acquisition of teaching skills. This study showed for the first time that knowledge, measured using a performance-based expertise criterion, could reveal differences in professional vision among student teachers. This finding emphasizes the necessity of considering not only professional experience in expertise studies but also including other factors as control variables. It remains unclear whether a minimal intervention in the form of a specific task has no benefit in helping prospective teachers perceive teaching disruptions or if an effect might not have been detected due to the online setting. Study II further explored this question in an eye-tracking study that offered higher temporal and spatial resolution.

4.3 Empirical Study II

Grub, A.-S., Biermann, A., Lewalter, D., and Brünken, R. (2022b). Professional vision and the compensatory effect of a minimal instructional intervention: A quasi-experimental eye-tracking study with novice and expert teachers. *Frontiers in Education*, *7*:890690, 1–17. https://doi.org/10.3389/feduc.2022.890690

4.3.1 Theoretical Background

Because no explicit measurement of the basal perceptual process (noticing) was possible in the online setting of Study I, Study II used the same study design but combined it with on-site eye tracking. Eye tracking, a process-based methodology, permitted finer-grained and more accurate measurements of the noticing process than the online assessment used in Study I. Its higher temporal and spatial accuracy also allowed the gathering of information about the cognitive functions underlying perception. Additionally, the sample used in Study II was broader than the sample used in Study I. In addition to novice teachers, it included teachers with at least 5 years of teaching experience to capture expertise differences and wide variability in expertise, experience, and knowledge. This eye-tracking study addressed two different aims to close research gaps, as described below.

As shown in the systematic review, differences between expert and novice teachers' gaze behavior relative to classroom events are evident in certain instances. For example, experts exhibit more but shorter fixations than novices (Huang, Miller, et al., 2021; Wolff, 2016) and their gaze roams over the entire classroom (monitoring). In addition, Study I suggested that there are also expertise differences in professional vision among student teachers that are dependent on their knowledge of classroom management. On the one hand, Study II constituted a replication and extension of previous research on teachers' professional vision. It examined whether previously reported expertise differences in eye movements could be shown with video vignettes, a sample of novice and experienced teachers, and eye-tracking equipment in a quasi-randomized standardized experimental setting. Expertise differences were re-examined, generalized, and related to further eye-tracking parameters, and global monitoring gaze behavior across the classroom and event-specific gaze behavior relating to (potential) teaching disruptions were distinguished.

Previous research has shown that external factors facilitate professional vision (Gold et al., 2013; Stockero & Stenzelbarton, 2017) and didactic interventions can be effective in promoting perception (Roth McDuffie et al., 2014). As the interventions that have been used previously are very extensive and time-consuming (e.g., video clubs or similar development settings; Sherin, 2007; Sherin & Han, 2004; van Es & Sherin, 2008), we focused on a minimal, economical version of instructional support. Study I, however, failed to show an effect of a minimal intervention on student teachers' professional vision of (potential) teaching disruptions (global monitoring gaze behavior was not recorded in Study I, see Section 4.2.2.4). Thus, Study II investigated whether instructional support changed prospective teachers' gaze behavior compared to experienced teachers and whether this minimal support could compensate for expertise differences. Hence Study II extended Study I, in which only student teachers' professional vision was investigated, and the assessment was indirect (achieved by collecting written information, which is not a highly accurate way of measuring professional vision). The design of Study II was similar to that of Study I, but process-based eye movement data were collected and analyzed to directly capture the basal noticing process of teachers' professional vision.

4.3.2 Procedure and Methods

Empirical Studies I and II were similar in study design but different in the way that they recorded professional vision and addressed the associated research questions. As the study design was already presented in detail in Study I, it is only briefly touched upon here. Instead, I have focused on the differences between the studies.

4.3.2.1 Participants.

We recruited 71 teachers (34 prospective teachers and 37 experienced teachers). Following Palmer et al. (2005), pedagogical knowledge was additionally measured as an objective measure of expertise. Only data from 29 novices (83% female; age: M = 24 years, SD = 6.63) and 35 experts (46% female; age: M = 46 years, SD =

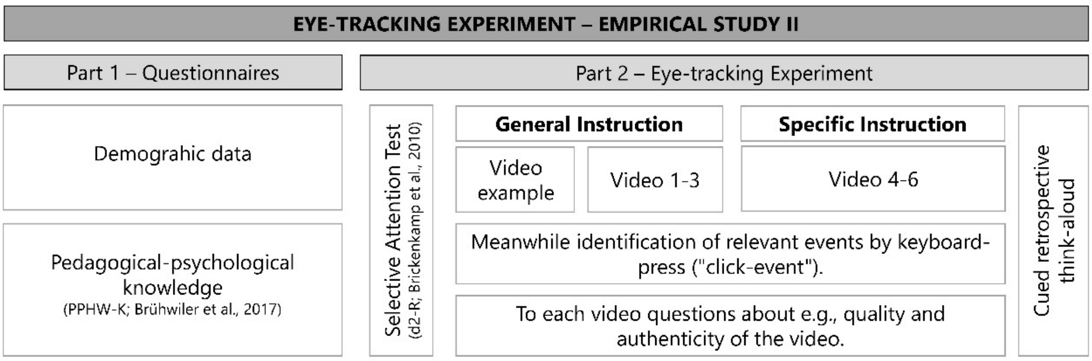
9.94) were included in the analyses (*N* = 64); low-quality eye-tracking data and non-performing participants were excluded. Novices had very little teaching experience (*M* = 4.48 hours, *SD* = 9.20), whereas experts had been teaching for an average of 15.71 (*SD* = 8.62) years. Participation was voluntary. Participants who completed the study were monetarily rewarded (experienced teachers) or given Versuchspersonenstunden (student teachers). All data were handled according to the ethical standards of the Ethics Committee of the Faculty for Empirical Human Sciences and Economical Sciences (Saarland University).

4.3.2.2 Design & Material.

Preregistration for Study II took place in November 2020. Data collection started in December 2020 and ended in April 2021. Data was collected from an eye-tracking study consisting of an online questionnaire (that requested demographic data and measured pedagogical-psychological knowledge; see Section 4.2.2.3) and an eye-tracking experiment in the laboratory (Figure 5). The completion of the questionnaire and the laboratory experiment were separated by an average of ten days.

Figure 5

Design of Empirical Study II



The design of the eye-tracking experiment corresponded to the design of the professional vision assessment in Study I. The same seven video vignettes from the *Toolbox Lehrerbildung* were used in a quasi-randomized design, with the order of presentation balanced using a Latin square; see Figure 4 in Section 4.2.2. Likewise, the first three videos (as well as the example video) were accompanied by the general instruction and the last three videos by the specific instruction. The video-viewing task was similar to that in Study I, that is, the videos were to be watched very closely and a button was to be pressed (a "click-event") if something relevant was discovered (general instruction) or explicit attention was to be paid to potential teaching disruptions (specific instruction); see Section 4.2.2.2. Unlike in Study I, however, the eye movements of the participants were recorded during the task by a static binocular eye tracker (Tobii Pro Fusion, sampling frequency up to 250 Hz). The test situation was standardized, and a 9-point calibration was performed.

After the eye tracking was completed, a cued retrospective think-aloud phase was conducted. The participants were asked to comment further on the previously identified events to assess their thought processes (triangulation of eye movement data). The analysis of the verbal data is not part of this dissertation. The experiments took approximately two hours (approximately 45 minutes for the eye tracking and 75 minutes for the think-aloud phase).

4.3.2.3 Dependent Variables.

Various AOI-based eye-tracking parameters were collected as part of the eye-tracking study. We distinguished between the two types of AOIs used to aggregate the eye-tracking data into parameters: *global AOIs*, for which the eye-tracking data captured global monitoring gaze behavior, and *event-based AOIs,* for which the eye-tracking data related to disruption-specific areas and was collected during the duration of the disruption (Figure 6). Figure 7 provides an overview of the definitions of each parameter and the expected direction of expertise differences (hypotheses).

Figure 6

Areas of Interest in Empirical Study II

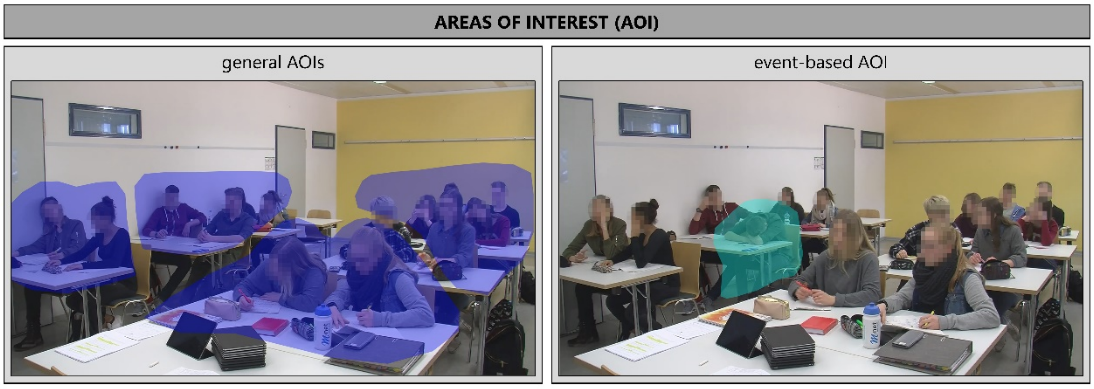


Figure 7

Eye-Tracking Parameters Utilized in Study II

	Parameter	Definition	Hypothesis
Global Monitoring Gaze Behavior	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)	Ratio of mean fixation duration (in milliseconds) to fixation count	E < N
Event-related Gaze Behavior	Response accuracy	Number of correctly recognized events; possible range between 0 – 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 disruption 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

Note. AOI = area of interest; E = experts, N = novices.

Global monitoring gaze behavior was assessed using five selected eye-tracking parameters shown to be stable, expertise-sensitive variables in previous, comparable studies (cf. the systematic review). These parameters were fixation count, fixation duration, visit count, visit duration, and Gaze Relational Index [10] (GRI; cf. Gegenfurtner, Boucheix, et al., 2020). They were evaluated based on global AOIs (see Figure 6).

Event-related gaze behavior was operationalized by time to first fixation, and the number of fixations before the "click-event" (the number of fixations before the participant decides that a given event is relevant). Furthermore, the response accuracy and the decision time (the time elapsed between the first fixation and the "click-event") were used as indicators (see Figure 7). These parameters were evaluated based on specific AOIs that include teaching disruptions caused by students.

Compared to Study I, noticing of relevant classroom situations in Study II was not recorded by self-report but rather was assessed using (relatively unbiased, temporally and spatially high-resolution) eye movement data. The counterpart of accuracy in Study I (whether written information contained appropriate content-related interference, see Section 4.2.2.4) is response accuracy in Study II. We looked at whether a "click-event" occurred during a disruption as an indicator of the detection of a relevant event by the participant (with the assumption that there was also a fixation in the corresponding AOI during the disruption). The velocity of noticing in Study I corresponded to the time to first fixation in Study II.

4.3.3 Results

Independent t-tests were calculated for the individual parameters with expertise as between-subjects factor for the gaze behavior hypotheses. No significant effects were found in the *global monitoring gaze behavior* of (prospective) teachers for

[10] The GRI is a measure of gaze dispersion representing differences in processing depth. It is defined as the ratio of the mean fixation duration (in milliseconds) and the fixation count (Gegenfurtner, Boucheix, et al., 2020). Smaller values are more likely than larger values to be associated with relational processing (that is, to be related to knowledge-driven, top-down processes). Larger values point to exploratory processing, which is related to quick, bottom-up processes. Unlike the Gini coefficient, the GRI has no fixed comparative value. The range over which it deviates is study- and data-dependent. However, it is important for the calculation that fixation duration and fixation count are relativized on the same level, that is, when using the mean fixation duration, the total fixation count cannot be used; instead, the mean fixation count must be applied.

the five parameters: fixation count, *t*(55) = -0.30; *p* = .384, *d* = -0.08; visit count, *t*(55) = -0.28, *p* = .390, *d* = -0.08; mean fixation duration, *t*(55) = 0.24, *p* = .404; *d* = 0.07; visit duration, *t*(55) = 0.27, *p* = .393, *d* = 0.07; and GRI, *t*(55) = 0.06, *p* = .478, *d* = 0.02.

No significant effects on *event-related gaze behavior* of (prospective) teachers were found for the six parameters: response accuracy, *t*(55) = 1.20, *p* = .117, *d* = 0.32; decision time, *t*(55) = -0.44, *p* = .331, *d* = -0.12; number of fixations before response, *t*(55) = -1,09, *p* = .142, *d* = -0.29; time to first fixation, *t*(55) = 0.62, *p* = .271, *d* = 0.16; and first fixation duration, *t*(55) = -0.26, *p* = .398, *d* = -0.07.

Repeated measured analyses of variance (ANOVAs) were computed with instruction as a within-subject factor. Contrary to the hypotheses, there were no expertise-dependent differences. No significant effects on global monitoring gaze behavior were shown for instructional expertise or instructional expertise interaction. But we found significant effects of instruction on the parameter's fixation count, visit count, and GRI. When both experts and novices receive specific instructions, they show more fixations, more visits, and a smaller GRI. No significant effects for instruction variation, expertise, or the interaction of instruction and expertise were found in event-related gaze behavior.

4.3.4 Discussion

The results suggest—contrary to our hypotheses and some prevailing research findings (e.g., van den Bogert, 2016)—that there are no significant differences between novices' and experts' eye-tracking parameters in global monitoring gaze behavior. However, the research findings in the area of professional vision have been enriched by new empirical data recently and are much more heterogeneous than they were during the planning period of the study (preregistration took place in November 2020). Future hypotheses should take in the updated state of the literature and be formulated as specifically as possible given the heterogeneous findings on the effects of professional knowledge, experience, and other factors that can influence teachers' professional vision. Possibly the studies discussed in this thesis overestimated the effects of the experiments on professional vision given that other studies failed to find expertise differences (despite a large sample; Shinoda et al., 2021) or confirm that a teacher's perception follows a stable pattern (Smidekova et al., 2020; Seidel et al., 2021; Shinoda et al., 2021; Smidekova et al., 2020; Stahnke & Blömeke, 2021a). Thus it is evident that a teacher's gaze can vary considerably. Of note, there seem to be factors besides expertise that influence perception and thus professional vision—for example, the instructional mode (e.g., Seidel et al., 2021; Stahnke & Blömeke, 2021a). Maybe scenes that encompass an entire classroom are especially likely to trigger bottom-up perception processes because they feature more salient visual impressions and cues such as movements, whereas seatwork scenes rely more heavily on top-down processes (Seidel et al., 2021). Thus, knowledge and experience play different roles in different formats. This could explain why we were unable to uncover expertise differences in the video vignettes we used as the aspects of the scenes used were salient throughout the classroom (bottom-up perception) and top-down processes played a minor role; neither knowledge nor experience were needed to identify the salient disruptions. In summary, internal validity may be limited. This finding highlights the fact that teachers' professional vision seems to be multifaceted, multifactorially affected and driven, and domain specific (cf. Steffensky et al., 2015), and thus vary depending on the pedagogical content, pedagogical-psychological aspects of teaching, the instructional format, and/or subject topic form.

Contrary to our hypothesis and some prevailing research findings (e.g., Wolff et al., 2021; Wolff et al., 2015), our results suggest that there are no expertise differences between novices' and experts' professional vision in event-related gaze behavior. However, recent studies make the results collected in prior studies seem more contradictory (e.g., Keller et al., 2021). Differences in the number of perceived teaching events are not necessarily expertise-dependent (Keller et al., 2021), teaching experience does not automatically lead to better perception (Bastian et al., 2021), and putative experts do not show equal identification accuracy (Shinoda et al., 2021; Wyss et al., 2020). This evidence hints that not only expertise or experience should be used as indicators of a good "seer." There are presumably many additional factors (e.g., situational awareness, parafoveal perception; see Gegenfurtner, 2020), including internal factors (e.g., stress, attentional focus; see Chaudhuri et al., 2021) that can contribute to professional vision.

We uncovered no expertise effect or interaction effect between expertise and instruction. Contrary to the hypothesis, the specific instruction not only supported novices but also influenced the visual perception of experts. However, the results suggest that instruction influences global monitoring gaze behavior independent of expertise. Both novice and expert teachers demonstrated sharper focus after receiving the specific instruction, improving their scanning and observing behavior in the classroom by increasing the number of fixations and gaze shifts between individual student groups (see also Stahnke & Blömeke, 2021a; Wolff et al., 2015). The ability to let one's gaze wander in the classroom (monitoring behavior) permits quicker detection of potential classroom disruptions. In practice, this results in more proactive classroom management and less disruption of the flow of instruction, thus positively impacting student learning (Emmer & 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 (Field, 2013).

There is no instruction effect or even an interaction effect between expertise and instruction for event-related gaze behavior. Most previous studies relating to cognition during classroom disruptions focused on larger and more elaborate interventions to develop prospective teachers' cognition (Gold et al., 2013; Seidel et al., 2013). In contrast, we examined a minimal intervention.

Only Study I also examined whether specific instruction affects teachers' professional vision of classroom disruptions. That study was conducted without eye tracking and included only students. Again, there was no supporting effect of minimal intervention in favor of novices. There are several possible reasons why the predicted effects could not be found. The difference between the general and the specific instructions may have been too small and therefore hardly perceived; focusing on classroom management may not have been ideal as it is one of the most relevant and therefore most present topics for novice teachers (Gage & MacSuga-Gage, 2017), or the schemata of novices may not have been sufficient and/or sufficiently networked to offer relief (Wiścicka, 2014).

5 General Discussion

In this chapter, I provide an overview of the main findings of the empirical studies, draw conclusions regarding the overall research aim of this dissertation, and address its limitations. I then contextualize the outcomes in the context of previous findings and conclusions and suggest new directions for research and practice.

5.1 Strengths and Appraisal of Pivotal Achievements

First, I briefly summarize the main findings of the systematic review and the two empirical studies in light of the overall goals of the dissertation. Furthermore, I outline the strengths of the research and what I have achieved. Subsequently, I discuss the limitations and necessary restrictions of the research and interpret the findings, concluding by summarizing their scientific and practical implications.

5.1.1 Systematic Review

I began this research by conducting a systematic review that would serve as the foundation for subsequent studies. This review showed that interest in eye-tracking-based research on professional vision in (prospective) teachers has increased over the past 20 years. This is underlined by the nature of the literature that has been published since the completion of my review. Overall, the research published between 1999 and 2019 paints a heterogeneous picture in terms of the choice of the sample, associated differences in prerequisites (knowledge, experience, etc.), the technology used (mobile and stationary eye tracking, different sampling frequencies, etc.), and the parameters used to analyze professional vision and their interpretation. The results of expertise differences are not consistent. One measure of expertise, the Gini-coefficient, is a measure of fixation dispersion and thus monitoring; the larger the value, the more unevenly attention is distributed over the targets. Cortina et al. (2015) showed that novices had a higher value than experts. In contrast, Dessus et al. (2016) reported the reverse (experts > novices). But overall, the review and its findings served as a stable foundation for further developing the research on professional vision and deriving new, more advanced hypotheses. Of course, it should be kept in mind that a systematic review represents only the status quo at the time of publication. It also has other limitations as often only peer-reviewed articles are used to ensure the quality of the research that is reviewed. When sufficient published studies are available, a meta-analysis would provide an interesting starting point for future research.

5.1.2 Empirical Study I

The online study—which was the first study to investigate the influence of knowledge about classroom management as an objective, standardized variable of influence on professional vision—showed that such knowledge of classroom management can have a positive influence on the basal perception processes of noticing by student teachers. Student teachers with more knowledge were able to identify potentially disruptive events more quickly and adequately. This suggests that the recognition and identification of relevant events in the classroom is based not just on experience but also by knowledge. This should be considered in the context of teacher training. However, an influence of knowledge on reasoning processes cannot be assumed. Possible reasons for this were discussed in Section 4.2.4.

Contrary to our theoretically based hypothesis that a minimal intervention would affect both the noticing and reasoning processes of perception, specific instruction had no effect on professional vision (except for an effect contrary to the hypotheses for guiding statements). Further research should clarify whether more sophisticated and/or detailed instructions may be needed (for possible starting points, see Section 5.3.5).

Conducting the study in an online setting made it possible for the first time to conduct a study on professional vision based on a comparatively broad sample spanning multiple federal states. The associated disadvantages are discussed under Limitations (Section 5.2.2.2).

5.1.3 Empirical Study II

The eye-tracking study was the first process-based assessment of professional vision in a quasi-randomized study design with video vignettes in which intervention effects were systematically investigated. It showed no effect of differences in expertise on professional vision—neither on global monitoring gaze behavior nor event-based gaze behavior (Section 4.3.3). These results, which were contrary to the hypotheses, extend the heterogeneous research landscape and suggest that professional vision is more complex and multifaceted than previously assumed. The results reported in this thesis as well as findings published by other national and international research groups indicate that there are factors besides knowledge and experience that influence professional vision (e.g., instructional mode; Stahnke & Blömeke, 2021a). Future research should consider potential moderating and mediating influencing variables besides expertise.

However, this study provided initial evidence that both prospective and experienced teachers can benefit from a minimal intervention: a specific instruction. Teachers at both levels of expertise showed more pronounced monitoring behavior due to the schematic activation evoked by the more precise instructions for the task and the frame of reference it provided.

5.1.4 Overall Benefit of the Research for the Understanding of Professional Vision

Despite the heterogeneous results of the three published research papers, they provide new knowledge about the "black box" of professional vision (Huang, Miller, et al., 2021) and a foundation for future research. The systematic review provides a clear presentation of the methods, indicators, possible influencing factors, and results used in previous studies. From this knowledge (and taking into account the research results published since then), new, further research hypotheses can be generated and tested to shed even more light on the "black box."

Results from the online and eye-tracking study show that the selection of the sample and expert comparisons should consider not only experience but also the participants’ levels of knowledge about the topic under investigation. In this, I follow Palmer et al. (2005), who call for the use of both experience and performance-based criteria in selecting experts and novices for studies of expertise. As shown in Study I, knowledge without experience is also conducive to professional vision and thus part of the core competence of prospective teachers. This finding supports the relevance of theoretical knowledge transfer in teacher education.

It can be deduced from Studies I and II that minimal interventions can be helpful under certain conditions to both experts and novices. Since Study II found instructional effects, whereas Study I identified only a small effect on reasoning processes (guiding statements), the way in which professional vision is captured must play a role. Compared to an online study without eye tracking, a process-based eye-tracking recording offers a temporally and spatially higher-resolution possibility of recording professional vision. Eye-tracking studies thus have added value compared to classical observational studies. Future eye-tracking studies could be conducted to determine how specific instructions need to be to enhance professional vision and identify further possibilities for supporting the acquisition of professional vision. The present studies provide initial evidence that minimal interventions may be helpful in addition to existing time- and resource-intensive training methods.

Although the results of the two studies are different, they are not mutually exclusive but rather, taken together, provide a nuanced view of (novice) teachers' professional vision. In summary, in students, knowledge has a positive impact on professional vision, but differences in process-based eye movement data between experts and novices can only be found under certain conditions. This suggests that the research field needs further, detailed investigations to meaningfully distinguish among the members of both heterogeneous and homogeneous groups of students and teachers and, ultimately, assist them in improving professional vision.

5.2 Limitations

The limitations of the systematic review and empirical studies are presented below.

5.2.1 Limitations of the Systematic Review

One of the major limitations of systematic literature reviews is publication bias (Nelsen et al., 2017; Zawacki-Richter et al., 2020). We attempted to minimize this influence by using three different databases (ERIC, PsycINFO, and Web of Science), not restricting search criteria (except for content), and conducting supplemental searches via Google Scholar and additional referencing. Nevertheless, the search cannot be all-inclusive, so there could be additional literature that was not identified. The quality of a systematic review is only as good as the articles that it includes. Ideally, the articles that are included should reflect the current research landscape regardless of the significance of the results. Often, however, it is not possible to say whether all the studies conducted on a given topic were published and thus available for review. In addition, it is often difficult to make direct comparisons between different studies because of missing information that has not been reported (e.g., the exact wording of instructions, the duration of a survey, etc.). Due to the limited number of studies available and the heterogeneity in their samples, parameters, and method of analysis, the present systematic literature review could not provide information on overall statistical effects. Similarly, the limited number of studies made it difficult to offer exact interpretations of the findings for each parameter. Once sufficient data are available, a meta-analysis would be useful in addressing this limitation.

5.2.2 Limitations Regarding the Empirical Studies I and II

Results can only be generalized to a limited extent due to the study designs, samples collected, and the instruments used—as is usual in empirical field research. That, of course, also applies to this dissertation and the research work and studies on which it is based. The most important limitations are critically examined below.

5.2.2.1 Sample.

A major limitation, as with many empirical studies, is the sample. Our sample had an uneven distribution in terms of residence, school type, and gender that limited the generalizability of the results and should be considered when interpreting them.

In Study I, students were recruited nationwide. The participants came from 13 different universities in nine federal states. A sample that is as broad as possible is an advantage for generalizability, but not all states are represented in our sample (e.g., Schleswig-Holstein, Hamburg) and some are represented by only a few people (e.g., Lower Saxony: three people, Saxony-Anhalt: one person). This could have distorted the results due to the north-south divide in Germany, which includes educational inequalities between certain federal states (Ditton, 2007, pp. 251-252). Differences in university curricula can also lead to limitations in such a heterogeneous sample if the curricular differences mean that the participants did not experience comparable university educations. Only those students who had access to the forums and social media on which the study was advertised (teacher-related Facebook groups) were even aware of it. To investigate these possible effects, follow-up studies with larger samples and multilevel analyses would be useful.

For Study II, both novices and experts were recruited exclusively in Saarland and at some schools in Rhineland-Palatinate. This type of recruitment decreases generalizability. While it can be assumed that the students have all experienced the same university education, the (presumable) homogeneity of the sample limits generalizability.

Although we attempted to reduce biased selection in Study II by using a modified procedure in the selection and identification of expert teachers (experience and knowledge as criteria), bias cannot be excluded. Due to the naturally occurring age differences between student teachers and teachers with at least 5 years of teaching experience in Study II, no conclusion can be drawn about the influence of age on professional vision. This is a general problem in expert studies because experts are often older than novices. It is particularly relevant to eye-tracking studies as eye movements reflect cognitive functions of frontal cortical areas (Kramer et al., 2007) that decline with age (Munoz et al., 1998). In our Study II, the experts were naturally on average 22 years older than the novices due to the recruitment criteria that we used (criteria suggested by Palmer et al., 2005). One way to address this potential confounder in future studies (Huang, Richter, et al., 2021) would be to implement a baseline test for age-related eye movement characteristics (e.g., pro- and anti-saccade task; Peltsch et al., 2011).

The gender distribution of the present studies was also uneven as 73% of participants in Study I and 84% of novices in Study II were female (whereas there was a fairly even ratio among experts). However, the proportion of women among teachers in general education schools was approximately 73.4% in the 2020/2021 school year (Statista Research Department, 2022), so this minimally limits generalizability.

In Study I, more than half of the participants were secondary student teachers (66%). Similarly, in Study II, 83% of the teachers and 59% of the student teachers were or were going to be teaching, respectively, at the secondary school level. Different grade levels (e.g., elementary vs. secondary grade level) have different requirements and present different challenges. In elementary school, for example, the educational mission plays a greater role, and within-class performance tends to be more heterogeneous than in secondary school. This limits generalizability because elementary and secondary school teaching may entail different cognitive schemata. In follow-up studies, the extent to which the school type of the observer and the students to be observed (mutually) influence each other should be questioned and examined using multilevel analyses and larger samples.

Even though participation in Studies I and II was voluntary, the samples were selective: The participants had to be interested in participating in the follow-up research that involved eye tracking. In both the online and laboratory experiments, real engagement could have been lower than self-assessed engagement, biasing the results (a classic disadvantage of depending on self-disclosure).

In summary, despite our best efforts, the sample was selective and localized, limiting the generalizability of the results and increasing the probability of misestimating effects—that is, overestimating or underestimating them (Bortz & Schuster, 2010).

5.2.2.2 Questionnaires.

The PPHW-K, which was used in both Studies I and II for objective, standardized recording of knowledge as an indicator of expertise in addition to experience, is not yet a published and established procedure in research, although the PPHW (Brühwiler et al., 2017) has been published and evaluated. The objectivity of the PPHW is ensured by standardized instructions. Based on the at least acceptable internal consistency with Cronbach's alpha of .76 (Oser et al., 2008), the reliability of the measurement instrument can be assumed to be satisfactory (Field, 2018; Nunnally, 1978). Higher test scores on the PPHW among teachers are related to positive teaching evaluations by their students, suggesting that it has predictive validity. However, the results of the PPHW do not correlate with those produced by the Pädagogisches Unterrichtswissen [pedagogical teaching knowledge] (PUW; König & Blömeke, 2010) or the Professionelle Unterrichtswahrnehmung [professional teaching perception]

(Seidel et al., 2010), which also measure classroom-related knowledge (Brühwiler et al., 2017), indicating a rather low convergent validity.

Critically, however, the PPHW-K has not yet been published and evaluated. Although the values for Cronbach's alpha in both Study I (α = .83) and Study II (α= 80), showed that good reliability was achieved (Blanz, 2021), internal and external validation assessment for the PPHW-K is essential.

It is also possible that different types of knowledge (e.g., pedagogical content knowledge, pedagogical-psychological knowledge, content knowledge; Baumert & Kunter, 2006, p. 482) affect gaze behavior and professional vision differently (Newen & Vetter, 2017). In our studies, we only recorded pedagogical-psychological action knowledge in relation to classroom management, so it is conceivable that our results—in particular from Study I—do not apply to general pedagogical knowledge.

5.2.2.3 Online and Laboratory Settings.

Online surveys present special difficulties: it is not possible to perfectly control which medium (e.g., smartphone, tablet, computer) is used to conduct them (e.g., screen size can affect how a survey is perceived; see Maniar et al., 2008). Online studies also have higher dropout rates than in-person studies; this requires special attention (Arechar et al., 2018). Our dropout rate of 25% is within the normal range, judging from comparisons with other studies (cf. Dandurand et al., 2008).

In Study I, due to the online setting, some participants could have pretended to be student teachers and falsified information (e.g., about the subjects studied or the university). However, if this occurred, it was probably rare as participants were acquired exclusively through networks of educational institutions. Biases due to external influences (e.g., credibility, distraction factors) cannot be excluded.

In our eye-tracking experiment, we opted for a laboratory setup with a stationary eye tracker and third-party video vignettes because we wanted to keep the number of possible confounding and influencing variables on the actual effect as low as possible. However, this limited the external and ecological validity because the complexity of real classrooms and the necessity of multitasking while teaching is missing in laboratory settings (see the book chapter for further discussion). In follow-up studies, mobile eye tracking could be used to better capture the complexity of real classrooms and the need for multitasking. Initial studies comparing in-action (mobile eye tracking) and on-action (stationary eye tracking) recordings (Minarikova et al., 2021) have shown that in mobile eye tracking, teachers focus their attention mainly on the student with whom they are interacting. In contrast, on-action recordings show that most students are scanned equally. This indicates that gaze behavior can differ depending on the method used. Therefore, whether the minimal intervention can improve monitoring behavior in the real classroom must be verified.

The use of video (vignettes) offers many possibilities for systematic research on professional vision (Seidel & Stürmer, 2014; Sherin, 2007). Videos depicting realistic, authentic classroom situations can support investigations to link theory and practice that are essential to professional vision (Brophy, 1988; Koc et al., 2009) and can be used as prompts to determine teachers' knowledge (Kersting et al., 2010). Although they can be used to illustrate exemplary teaching practices for handling routine, at the same time, video recordings contain only a fraction of what happens in classroom (van Es & Sherin, 2010); they cannot depict the entire complexity of the lesson or teaching, only a reduced section (Sherin, 2001). As a result, the use of video vignettes can only provide a limited statement and only a part can be contributed to the creation of the theory. They can only be used to examine situations that can be seen on videos, whereas in the classroom, teachers in their real-life situation have background information about the students, lesson, and school, which can help them to assess and handle different teaching situations (Sherin, 2001). In summary, various tasks such as observing, teaching, and watching videos influence what one sees and hears and, consequently, where one focuses one's attention in the classroom. [11]

Slight but salient disruptions appear in the videos (e.g., a student throwing a paper ball, another student putting his head on the table and seeming to sleep; Rattay & Wensing, 2011). This limits generalizability (see the book chapter also). It could be that the obviousness of the disruptions led to novices recognizing as many disruptions

[11] "Professional vision in relation to video is simply not the same as professional vision in relation to teaching. And in general, researchers’ professional vision is for observing and for watching video, whereas teachers’ professional vision is for teaching. Therefore, researchers’ and teachers’ professional vision are by their nature two very different perspectives" (Sherin, 2001).

as the experts (the results of Study II showed no expertise differences regarding accuracy; cf. Section 4.3.3). These events are likely to have been perceived more through bottom-up-based gaze control rather than top-down-based gaze control and required little experience or prior knowledge of classroom disruptions. Yet no study to date has examined the influence of the salience of relevant events on professional vision in more detail. It should also be noted that not all of the videos used in the studies indicate the number of students in the classroom and not all show student-teacher interaction. These factors may influence professional vision because the complexity of classroom situations increases when there are more students and interactions. Gender effects could also influence perception (see Section 5.3.2), as could lesson content (computer science, mathematics; Huang, 2018). For example, (prospective) mathematics teachers may have divided their attention between the mathematic-related aspects of the video lessons and the pedagogical-psychological focus of attention (see the book chapter).

Participants watched videos of students they did not know in Studies I and II. This may have influenced the observation process. Typically, teachers have background information about students, their achievement levels, difficulties, and potential for disruption. This knowledge can improve professional vision as it enriches the cognitive schemata. Although the (prospective) teachers received brief informational texts on grade level and content before watching the videos, this cannot substitute for several weeks, months, or years of knowledge about the students and their interactions. This may underestimate the performance of experienced teachers in particular as they are used to having and being able to use this kind of background information (van den Bogert, 2016). It can lead to an overestimation of the student teachers because they only had to process an excerpt from a lesson through the use of the video vignettes and the focus was on pure observation. In real lessons, teachers must pay attention to the content and delivery of the lesson, answer unplanned questions, etc. This multitasking, which is normally mentally stressful for prospective teachers, cannot be duplicated in a laboratory experiment.

5.2.2.4 Minimal Intervention (Specific Instruction).

To specify a research question relevant to classroom management, especially the management of classroom disruptions, it is necessary to reduce the complexity of a classroom situation. Yet that may mean ignoring other aspects of the real-life classroom such as classroom climate and student-teacher interactions. Therefore, the results presented in this thesis are limited in terms of their informative value about the complex fabric of teaching. They refer only to one aspect of classroom management, potential classroom disruptions.

Another point of concern about the instructions is that the general and specific instructions may not have been adequately differentiated or disjunctively so that the difference was barely recognizable to the participants and the different task focus was not apparent. It is also conceivable that (prospective) teachers, without prompting, had classroom disruptions in mind as an important aspect of classroom management and concentrated on this (Levin et al., 2009; Schaffert, 2022) even after receipt of the general instruction, which focused on relevant events. Another possibility is that the specific instruction could have activated corresponding classroom management-relevant cognitive schemata about teaching disruptions but due to the videos used and their content and structure, the focus was automatically on (potential) instructional disruptions. Thus, possibly due to the camera perspective and the seating arrangement and the accompanying focus on the students, identical visual perceptions for general as well as specific instruction occurred through both bottom-up- and top-down-based perceptions. Because the disruptions were salient, they received attention through bottom-up processes as well as expertise- and schemata-triggered (based on the specific instruction) top-down processes. Thus, novices, via bottom-up processes, and experts, via bottom-up and top-down processes, might have demonstrated similar professional vision.

5.2.2.5 Evaluation of Online- and Eye-Tracking Data.

We assessed the dependent variables for professional vision (accuracy and velocity; Study I). The assessment was relatively inaccurate with respect to the self-disclosures (see Section 4.2.2.4). For example, measuring velocity is not as accurate as measuring reaction time in the laboratory or employing process-based measures such as eye tracking.

There are also limitations with respect to the master rating underlying the data (identification of disruptions and time of disruptions; accuracy and velocity) because it was developed by theorists (first author of Study I and an educational psychology student) and not practitioners (experienced teachers). In future studies, it would be helpful if the master rating were assessed by experienced teachers and compared with the inter-rater reliability of the corresponding variables, considering the same practitioners from the schools. The reasoning data (verbal data; Study I) also had limitations. The retrospective measurement methods used to detect differences in subject knowledge within a group of students considered typically homogeneous may not be sensitive enough to detect differences in performance due to differentiated task instruction. Process-based methods, such as eye tracking (see Study II), may be better suited to capture the accuracy and velocity of professional vision than online measurements as eye tracking provides high-resolution data in both time and space. Nevertheless, it should be noted that the noticing data collected online also showed knowledge-based differences between students. Eye tracking might show the same supportive effect of specific task instruction compared to a generalized version, although it has not yet been significantly demonstrated in quantitative data (Nückles, 2020).

Comparisons between the parameters of noticing used in Study I (accuracy and velocity) and the corresponding parameters in Study II (response accuracy and time to first fixation) are only possible to a limited extent because they are based on different measurement methodologies (self-reported data in Study I and eye movement data and click events in Study II) and thus have different levels of precision. Furthermore, accuracy in Study I and response accuracy in Study II differ somewhat because response accuracy only provides information about whether the disturbance was fixed, not whether it was also classified as relevant. To determine the latter would require consulting the corresponding verbal data because it is theoretically possible that a participant marked another event as relevant using keystrokes. A measurement error of this kind cannot be excluded and can only be reduced by methodological triangulation (see Section 5.3.5).

We had a variety of options for evaluating the eye-tracking data (Study II). We chose an AOI-based evaluation to distinguish gaze behavior directed at general areas such as groups of students and that aimed at potential areas of teaching disruptions. This method of analysis has drawbacks as the way AOIs are designed can influence the results (Hessels et al., 2016; Kosel, 2022; Pappa et al., 2020). Using AOI allows the aggregation of data across different temporal regions, time frames, and individuals (Ylitalo, 2017), resulting in the oversimplification of variation between and within individuals (Huang, 2018). Additionally, AOI-based analysis breaks the natural connection between spatial and temporal information and artificially creates a unitary measure such as fixation duration (temporal) or AOIs (spatial). In light of this, Huang (2018), following Le Meur & Baccino (2013), suggested the use of diachronic indicators (e.g., scanpath analyses) as an alternative to synchronic indicators (e.g., fixations) to better capture the living and processual nature of vision over time (Ramat et al., 2013).

In our study, the disruptions to be detected were determined by a panel of psychologists and educational scientists. The differing perspectives of theorists/scientists and practitioners/teachers (cf. van Es, 2011) may have biased the design, selecting and defining the disruptions. Furthermore, the corresponding AOIs were developed deductively based on master ratings. In future studies, an ex-post approach such as AOI grid analysis (e.g., Wolff et al., 2016) could be used to extract and analyze salient features more objectively.

Kaakinen (2020) expresses criticism of the classical analysis of eye-tracking data using static analysis of variance. Because a person's eye movements are not independent of each other (i.e., the left and right eye cannot look in different directions simultaneously), the author suggests analysis methods that better take into account the correlative structure of the data: linear mixed models (Judd et al., 2017) or mixed logit models (Jaeger, 2008) as these allow the modeling of random variance between persons. Further advantages and disadvantages of different analysis methods are discussed in the book chapter. They should be taken into account in further studies (e.g., scanpath analyses).

A method that is used frequently in multimedia research, namely, the investigation of transitions between certain areas of learning material, could also be applied to the field of teachers' professional vision. However, the complex data source (instructional videos) and the lack of a theory about correct transitions of gaze among different components of instruction (e.g., students, tables, materials, windows) pose a hurdle that would necessitate beginning with exploratory studies.

5.3 Implications and Future Directions

The individual publications and the thesis do not claim to be exhaustive or even discuss the entire complexity and diversity of teachers' professional visions based on the underlying research. The thesis serves to shed some light on professional vision, especially regarding classroom management and, helped by technologies developed in the last decades, helps to narrow the large gaps in the research. It represents only a small contribution to a large research universe. Yet it is an important step in the right direction—namely, the differentiated and precise consideration of teachers' professional vision. Nevertheless, many questions remain unanswered, and the existing research opens the door to further research, studies, and reflections.

5.3.1 Expertise as a Between-Subject Factor

The following conclusions can be drawn from the present studies. Sample and expertise development should be modified to distinguish between novices (students) and experts (experienced teachers) as participants. Also, at least one more group, for example, trainee teachers, should be surveyed. Since the development of expertise is not necessarily linear (Gobet, 2015; van den Bogert, 2016), surveying the professional vision of intermediate-level teachers could provide new insights. The first step would be to find out which eye-tracking parameters are sustainably sensitive to differences across different levels of expertise. Likewise, a longitudinal study of individual developmental trajectories and the potential of professional vision would also be exciting in this frame. A nationwide and/or cross-national study with multilevel evaluation would also be desirable. A profile analysis could also provide further insight into the professional vision of (prospective) teachers. Even though we obtained a fairly large, broad-based sample in Studies I and II in comparison to comparable studies, a larger, representative sample would be desirable in future studies.

5.3.2 Expand the Scope of the Topic

Previous studies of teachers' professional vision have focused mainly on classroom management issues (Keskin et al., 2022). Since eye tracking allows a broad spectrum of professional vision characteristics to be captured, different elements of classroom situations should be investigated. In addition to classroom management (e.g., Study II; Stahnke & Blömeke, 2021a; Wolff et al., 2016; Wyss et al., 2020), global teaching situations (e.g., Huang, Miller, et al., 2021; Smidekova et al., 2020), diagnostic accuracy (e.g., Kosel et al., 2021; Seidel et al., 2021), cultural differences, communicative gaze behaviors (e.g., McIntyre & Foulsham, 2018; McIntyre et al., 2017), and teacher-student interactions (e.g., Haataja et al., 2019; Pouta et al., 2020) as well as inclusive teaching aspects (Grub et al., in preparation; Keskin, 2022) deserve attention (Keskin et al., 2022).

Preliminary findings regarding these aspects of classroom events or interactions are already available. For example, Huang, Miller et al. (2021) examined subject differences in attention focus and allocation in real classroom situations. Kosel et al. (2021) used eye tracking to examine the relationship between teachers' visual strategies and judgment accuracy related to student profiles relevant to learning (see Seidel et al., 2021). Seidel et al. (2021) focused on teachers' diagnostic skills, including their ability to assess student engagement and detect underlying situations (e.g., overconfidence or difficulty). McIntyre et al. (2017) demonstrated that professional vision not only involves perceiving but also communicating. They analyzed the "communicative gaze" (gaze during conversation) and the "attentive gaze" (gaze during questioning). Pouta et al. (2020) used eye movement data to study how (prospective) teachers interact with students.

5.3.3 (Co-)Variables in Further Research Studies

Eye tracking thus offers many opportunities to examine different facets of professional vision, although—until now—professional vision related to classroom management events has been the focus of most of the published studies (Keskin et al., 2022). In the context of the thesis, several data relating to additional variables were collected for control purposes (e.g., self-efficacy, cognitive load; see Appendix, Section 7.2), but no specific hypotheses were made in advance with these variables, and they were not used in further analyses. Future studies of professional vision should include (other) control and influencing variables such as different types of knowledge (e.g., content knowledge, pedagogical content knowledge). Because knowledge and noticing are interrelated, subskills can play an important role in noticing processes (Barth et al., 2019). As explained in Section 2.2, knowledge is multifaceted and different facets could vary in their effects on different aspects of the classroom; future studies should investigate the effect of this. For example, the findings of Huang et al. (2018) suggest that the different demands of different subjects and possibly knowledge associated with the subjects, lead to different gaze behaviors (e.g., fixation count and fixation duration: literacy > math).

The influence of cognitive load on professional vision could also be included as a (co)variable because some studies suggest that greater knowledge can be related to a lower cognitive load and, consequently, higher performance (e.g., Kalyuga, 2007). Initial results indicate that novice teachers experience a heavier cognitive load than more experienced teachers (Dessus et al., 2016). For this reason, we also examined cognitive load in Study I and II. Knowledge was not a significant predictor of cognitive load in our samples. However, it is conceivable that cognitive load could play a role in other studies, especially in profile analyses, which is why mental load should not be left out of the equation.

Student characteristics and teacher stereotypes may also influence professional vision (see e.g., Kosel et al., 2021; Schnitzler et al., 2020; Seidel et al., 2021). For example, Seidel et al. (2021) examined teachers' diagnostic abilities when observing student engagement and inferred underlying student characteristics. They showed that teachers assessed incoherent profiles more accurately than novice teachers and expert teachers focused more on students who might require adaptive pedagogical interventions (e.g., struggling students). This indicates that teacher gaze could supplement the perceptual component of professional vision (Seidel et al., 2021).

Teachers should ideally assess and evaluate students as objectively as possible. Nevertheless, teachers—like all people—have stereotypes that can be activated automatically and thus unconsciously and can unintentionally influence student assessment and teacher behavior (e.g., Glock, 2016; Glock & Kleen, 2021; Kleen & Glock, 2018). Stable negative stereotyping of a group in a performance domain can lead to particularly unfavorable attribution patterns and inadequate teacher behavior (Kleen & Glock, 2020). For example, gender stereotypes exist with regard to classroom disruptions. Teachers are more likely to associate disruptions with male students (Arbuckle & Little, 2004; Glock & Kleen, 2017; Kulinna, 2007), especially male students with an immigrant background (Ferguson, 1998; Glock, 2016). Investigating the influence of student performance on the gaze behavior of (prospective) teachers could identify individual support possibilities in the context of inclusive teaching and heterogeneity.

5.3.4 Assessment Methods Transferred From Other Domains

A new approach in teacher education would be to experiment with assessment methods used for the visual observation of action spaces in traffic psychology. Many events, including hazards, occur simultaneously in traffic. As in a classroom, attention processes have to be directed to relevant things, whereas unimportant aspects must be ignored. Vertical and horizontal dispersion measures (e.g., Melin et al., 2018) and the Situation Awareness Global Assessment Technique (SAGAT; Endsley, 1995) are used to assess the professional vision of (prospective) drivers relative to hazard perception (e.g., Malone & Brünken, 2016). For example, in the latter, participants watch traffic videos and press a reaction button when they perceive an emerging hazard, with reaction times logged as performance indicators. Newer process-based SAGAT methods use eye tracking to differentiate recognition and reaction (e.g., Malone & Brünken, 2020).

5.3.5 Further Research Recommendations

To improve the possibilities for systematic literature reviews and meta-analyses, which can contribute to the expansion of knowledge on specific topics such as professional vision by summarizing and aggregating the current state of research, several points should be considered when publishing new articles. As part of the Open Science Collaboration, the focus should be on publishing preregistered studies to minimize publication bias and target theory-based research. In addition, publications should be described following certain guidelines (e.g., Holmqvist et al., 2022) so that replications of and/or comparisons between studies can be made. The calculation and specification or provision of effect sizes are also extremely important for future meta-analyses. Publishing raw data is challenging due to General Data Protection Regulation (GDPR), but a paper by van Driel et al. (2022) is a good example of how the gap between privacy and open science can be bridged.

To account for possible differences between theorists and practitioners, future studies should include an exploratory pre-analysis by experienced teachers or an inductive evaluation to confirm that events shown in videos are relevant. Possibly the instruction should include an extended definition of the term "disruption" (i.e., a brief explanation of what is meant by "disorder") because different people may see and perceive the same situation but evaluate it differently based on their previous experience, opinions, and attitude. The definition of "disorder" may be very individual and subjective. Likewise, further research should examine the extent to which the salience of potential disruptions or relevant events in the classroom affects expertise differences or, more generally, the gaze behavior of (prospective) teachers.

Given the specificity of the instruction and the related problem regarding the possible lack of disjunctivity or automatic focus on (potential) instructional disruptions, further studies should investigate the extent to which different disjunctive instructions affect the gaze behavior of (prospective) teachers or at least ask the subjects what they were thinking about during the general instruction (control variable). Furthermore, it would be interesting to investigate the effects of other instructions, such as requesting teachers to distribute monitoring attention evenly or educating novices about their deficits and expertise-dependent monitoring behavior.

To aid in the critical discussion of the eye-mind hypothesis (Just & Carpenter, 1980), triangulation, that is, the joint analysis of eye-tracking and verbal data, is recommended (Orquin & Holmqvist, 2018); it could permit the mapping of the underlying cognitive processes. Although some studies have used both data sources (Muhonen et al., 2021; Pouta et al., 2020; Wolff et al., 2015), direct triangulation has only been used twice up to now. First, Wyss et al. (2020) linked eye-tracking data and retrospective annotation of what was seen in a video. Second, Biermann et al. (in preparation) triangulated eye-tracking and verbal data using a mixed methods approach to investigate the professional vision of classroom disruptions among (prospective) teachers. In our research, we examined whether the events that were judged to be relevant during the viewing of a classroom video were also mentioned in the subsequent stimulated recall. In addition, we examined whether there were expertise-dependent differences in the eye-movement data (student teachers vs. experienced teachers) and differences between individuals who perceived the critical incidents in the videos and those who did not (responders vs. non-responders). Future studies should collect and evaluate data for triangulation because this could offer deeper insight into professional vision and reduce the limitations of the eye-mind hypothesis. Such a procedure might, for example, reveal whether fixating on a specific student for a long time is a sign of ambiguity, close observation, or perhaps even nonverbal communication. Such conclusions cannot be drawn purely from eye-tracking data but rather only be conjectured.

The use of digital teaching has been spreading in Germany, and its use was given new impetus by the COVID-19 pandemic (Meinokat & Wagner, 2022). Teaching online places different demands on teachers than teaching in the physical classroom, and the handling of disruptions is different. Research on disruptions in digital teaching in the context of professional vision does not yet exist, but the subject deserves investigation due to the increasing pace of digitization in the 21st century.

Research on professional vision in relation to university teaching and higher education also holds promise for the future (e.g., Södervik et al., 2022). For example, initial studies comparing classrooms with auditoriums (Coskun & Cagiltay, 2020) show that the focus of attention of teachers in the classroom shifts over time from the back to the front rows, whereas the distribution of attention in the auditorium remains stable over time (front > back).

5.3.6 Practical Implications

In the long term, training and monitoring skills might be developed for (prospective) teachers based on this and future research. This could reduce or counteract the "real-life shock" (Dicke et al., 2016) experienced by new teachers. Encouraging teachers to shift their focus to some aspects of monitoring that researchers have identified as important might support teachers' efforts to implement educational reforms (Sherin, 2001) and help them actively practice and improve professional vision. Different approaches to fostering monitoring skills would be possible.

One possibility would be to use recorded eye-movement data as a reflection and feedback tool (Ashraf et al., 2018). For example, student teachers could view their recorded eye movements to reflect on their perceptions, much as video clubs are used in teacher education. Santagata et al. (2021) provide a review of video-based programs focused on teacher perceptions in mathematics. Recording eye movements would go beyond video clubs to allow visualization of cognitive processes, potentially stimulating deeper processing.

Eye-tracking methods offer many possibilities to capture the professional vision of teachers, including in-action recording with mobile eye trackers and on-action recording in standardized, (quasi-)experimental laboratory settings with stationary eye trackers. These opportunities, as well as methods of analysis, are discussed in detail in the methodological book chapter and are therefore only touched upon here.

The use of immersive technologies such as augmented reality (AR; in medical education: e.g., Heinrich et al., 2021), mixed reality (XR), virtual reality (VR; e.g., Huang, Richter, et al., 2021; Mikhailenko et al., 2022), and immersive simulated reality (e.g., simulated classrooms; e.g., Dalgarno et al., 2016; Theelen et al., 2019) is becoming more and more popular. The disadvantages that arise from the use of video vignettes (see Section 5.2.2.3), could be eliminated by using immersive simulated reality; standardization is still possible in the latter (Goldberg & Fütterer, accepted). Early evidence suggests that evidence collected in VR environments is as good as that obtained from real-world experiments (Richter et al., 2022). Research on professional vision combined with methods such as eye tracking, offers opportunities to complement professional vision training and develop training environments in which (prospective) teachers can improve their professional competencies. Augmented and artificial reality provide high-immersion laboratory environments that closely resemble the dynamic reality of the classroom (Clay et al., 2019).

It would also be possible to test the use of eye-movement modeling examples (EMME; Jarodzka et al., 2017; van Gog et al., 2009) as it is already applied in other domains. However, this raises the question of whether there is a single professional view or several paths that lead to the goal of professional vision. Assuming that it is empirically confirmed that there are valid differences between the gaze behavior of experts and novices and that expert gaze behavior turns out to be homogeneous, EMME could be used as a method for training (prospective) teachers (see the book chapter). The method involves recordings of an expert's eye movements, with the data presented as scanpaths or spotlights, with unimportant information blurred. Such recordings are often used in conjunction with eye movement explanations provided by the person being recorded (Nyström & Holmqvist, 2008). Previous research from the field of medicine has shown that novices can learn from EMME (e.g., Gegenfurtner et al., 2017; Gegenfurtner & Seppänen, 2013). However, there are conflicting findings on the effects of EMME (e.g., Eder et al., 2021; van Gog et al., 2009; Wright et al., 2022). Before using EMME in teacher education and training, further research should be conducted to determine its limitations and the extent to which this way of representing expert visual behavior can be used to train novices. As indicated previously, there may be many effective visual strategies for observing classrooms, so the utility of EMME is questionable at this time.

5.4 Conclusion

At first glance, we found a fairly consistent picture of expertise differences between prospective and experienced teachers, despite the use of a wide variety of methods and consideration of different parameters (see the systematic review). However, more recent studies, published since 2019, indicate that professional vision is not a unitary skill but rather a multifaceted and diverse core competency of teachers that can be influenced by diverse internal and external abilities, skills, and influences. It seems questionable whether there is actually the *one and only* professional vision of teachers. Our online and eye-tracking studies broaden this approach and support and extend equally important research findings from other research groups. Based on the research underlying this thesis, we know that knowledge has a positive effect on student teachers' identification of potential classroom disruptions (Study I) and that the gaze behavior of prospective and experienced teachers does not necessarily differ but that certain conditions must be met for the gaze behavior of the two groups to coincide. A first step towards support of both prospective and experienced teachers with a minimal intervention could be taken by showing that specific instructions can lead to a change in gaze behavior.

The professional vision of (prospective) teachers continues to be a varied and multifaceted subject for research. In the future, given the constantly developing technologies for increasing immersion, it should offer new possibilities for research almost daily.

6 References

Alberti, C. F., Shahar, A., and Crundall, D. (2014). Are experienced drivers more likely than novice drivers to benefit from driving simulations with a wide field of view? *Transportation Research Part F: Traffic Psychology and Behaviour*, *27*(Part A), 123–132. https://doi.org/https://doi.org/10.1016/j.trf.2014.09.011

Aloe, A. M., Amo, L. C., and Shanahan, M. E. (2013). Classroom management self-efficacy and burnout: A multivariate meta-analysis. *Educational Psychology Review*, *26*(1), 101–126. https://doi.org/10.1007/s10648-013-9244-0

Arbuckle, C., and Little, E. (2004). Teachers' perceptions and management of disruptive classroom behaviour during the middle years (years five to nine). *Australian Journal of Educational and Developmental Psychology*, *4*, 59–70.

Arechar, A. A., Gächter, S., and Molleman, L. (2018). Conducting interactive experiments online. *Experimental Economics*, *21*(1), 99-131. https://doi.org/10.1007/s10683-017-9527-2

Ashraf, H., Sodergren, M. H., Merali, N., Mylonas, G., Singh, H., and Darzi, A. (2018). Eye-tracking technology in medical education: A systematic review. *Med Teach*, *40*(1), 62–69. https://doi.org/10.1080/0142159X.2017.1391373

Ballantyne, J. (2007). Documenting praxis shock in early-career Australian music teachers: The impact of pre-service teacher education. *International Journal of Music Education*, *25*(3), 181–191. https://doi.org/https://doi.org/10.1177/0255761407083573

Barth, V. L. (2017). *Professionelle Wahrnehmung von Störungen im Unterricht* (1st ed.). Springer VS.

Barth, V. L., Piwowar, V., Kumschick, I. R., Ophardt, D., and Thiel, F. (2019). The impact of direct instruction in a problem-based learning setting. Effects of a video-based training program to foster preservice teachers' professional vision of critical incidents in the classroom. *International Journal of Educational Research*, *95*, 1–12. https://doi.org/10.1016/j.ijer.2019.03.002

Bastian, A., Kaiser, G., Meyer, D., Schwarz, B., and König, J. (2021). Teacher noticing and its growth toward expertise: an expert–novice comparison with pre-service and in-service secondary mathematics teachers. *Educational Studies in Mathematics, 110*, 205–232. https://doi.org/10.1007/s10649-021-10128-y

Baumert, J., and Kunter, M. (2006). Stichwort: Professionelle Kompetenz von Lehrkräften. *Zeitschrift für Erziehungswissenschaft*, *9*(4), 469–520. https://doi.org/10.1007/s11618-006-0165-2

Beach, P., and McConnel, J. (2018). Eye tracking methodology for studying learning: A review of research. *International Journal of Research and Method in Education*, *42*(5), 485-501. https://doi.org/doi/10.1080/1743727X.2018.1496415

Beilstein, S. O., Perry, M., and Bates, M. S. (2017). Prompting meaningful analysis from pre-service teachers using elementary mathematics video vignettes. *Teaching and Teacher Education*, *63*, 285–295. https://doi.org/https://doi.org/10.1016/j.tate.2017.01.005

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research*, *35*(5), 463–482. https://doi.org/https://doi.org/10.1016/S0883-0355(02)00004-6

Biller, K.-H. (1979). *Unterrichtsstörungen* (1st ed.). Klett.

Blanz, M. (2021). *Forschungsmethoden und Statistik für die Soziale Arbeit: Grundlagen und Anwendungen* (2nd ed.). Kohlhammer.

Blomberg, G., Sherin, M. G., Renkl, A., Glogger, I., and Seidel, T. (2013). Understanding video as a tool for teacher education: investigating instructional strategies to promote reflection. *Instructional Science*, *42*(3), 443–463. https://doi.org/10.1007/s11251-013-9281-6

Blömeke, S., Gustafsson, J.-E., and Shavelson, R. J. (2015). Beyond dichotomies. *Zeitschrift für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Blömeke, S., König, J., Busse, A., Suhl, U., Benthien, J., Döhrmann, M., and Kaiser, G. (2014). Von der Lehrerausbildung in den Beruf – Fachbezogenes Wissen als Voraussetzung für Wahrnehmung, Interpretation und Handeln im Unterricht. *Zeitschrift für Erziehungswissenschaft*, *17*(3), 509–542. https://doi.org/10.1007/s11618-014-0564-8

Blömeke, S., Olsen, R. V., and Suhl, U. (2016). Relation of student achievement to the quality of their teachers and instructional quality. In T. Nilsen and J.-E. Gustafsson (Eds.), *Teacher quality, instructional quality and student outcomes* (pp. 21–50). Springer Nature. https://doi.org/10.1007/978-3-319-41252-8_2

Borich, G. D. (2014). Classroom management II. Promoting student engagement. In G. D. Borich (Ed.), *Effective Teaching Methods. Research-Based Practice* (8th ed., pp. 102–129). Pearson.

Borko, H., and Putnam, R. T. (1996). Learning to teach. In D. C. Berliner and R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). Macmillan Library Reference USA; Prentice Hall International.

Bortz, J., and Schuster, C. (2010). *Statistik für Human- und Sozialwissenschaftler* (7th ed.). Springer-Verlag GmbH.

Bouxsein, K. J., Tiger, J. H., and Fisher, W. W. (2008). A comparison of general and specific instructions to promote task engagement and completion by a young man with Asperger syndrome. *Journal of Applied Behavior Analysis*, *41*(1), 113–116. https://doi.org/10.1901/jaba.2008.41-113

Bradley, M. M., and Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49–59. https://doi.org/https://doi.org/10.1016/0005-7916(94)90063-9

Brickenkamp, R., Schmidt-Atzert, L., and Liepmann, D. (2010). Test d2 – Revision. Aufmerksamkeits und Konzentrationstest (1st ed.). [Manual]. Hogrefe.

Brophy, J. (1988). Educating teachers about managing classrooms and students. *Teaching and Teacher Education*, *4*(1), 1–18. https://doi.org/https://doi.org/10.1016/0742-051X(88)90020-0

Brühwiler, C., Hollenstein, L., Affolter, B., Biedermann, H., and Oser, F. (2017). Welches Wissen ist unterrichtsrelevant?. *Zeitschrift für Bildungsforschung*, *7*(3), 209–228. https://doi.org/10.1007/s35834-017-0196-1

Bucher, H.-J., and Schumacher, P. (2012). Aufmerksamkeit und Informationsselektion: Blickdaten als Schlüssel zur Aufmerksamkeitssteuerung. In H.-J. Bucher and P. Schumacher (Eds.), *Interaktionale Rezeptionsforschung: Theorie und Methode der Blickaufzeichnung in der Medienforschung* (pp. 83–107). Springer Fachmedien. https://doi.org/10.1007/978-3-531-93166-1_3

Buswell, G. T. (1935). *How people look at pictures: A study of the psychology and perception in art*. University Chicago Press.

Calderhead, J. (1979). *Teachers' classroom decision-making: its relationship to teachers' perceptions of pupils and to classroom interaction*. [Doctoral dissertation]. [Stirling]: University of Stirling. http://hdl.handle.net/1893/2093

Carter, B. T., and Luke, S. G. (2020). Best practices in eye tracking research. *Int J Psychophysiol*, *155*, 49–62. https://doi.org/10.1016/j.ijpsycho.2020.05.010

Carter, K., Sabers, D. S., Cushing, K. S., Pinnegar, S., and Berliner, D. C. (1987). Processing and using information about students: A study of expert, novice, and postulant teachers. *Teaching and Teacher Education*, *3*(2), 147–157. https://doi.org/https://doi.org/10.1016/0742-051X(87)90015-1

Casale, G. S., Sarah, Hennemann, T., and König, J. (2016). Wie lässt sich Klassenführungsexpertise messen? Überprüfung eines videobasierten Erhebungsinstruments für Lehrkräfte unter Anwendung der Generalisierbarkeitstheorie. *Empirische Sonderpädagogik*, *2*, 119–139. https://doi.org/10.25656/01:12300

Castelhano, M. S., Mack, M. L., and Henderson, J. M. (2009). Viewing task influences eye movement control during active scene perception. *Journal of Vision*, *9*(3), 1–15. https://doi.org/10.1167/9.3.6

Catherwood, D., Edgar, G. K., Nikolla, D., Alford, C., Brookes, D., Baker, S., and White, S. (2014). Mapping brain activity during loss of situation awareness: An EEG investigation of a basis for top-down influence on perception. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *56*(8), 1428–1452. https://doi.org/10.1177/0018720814537070

Catrambone, R. (1990). Specific versus general procedures in instructions. *Human-Computer Interaction*, *5*(1), 49–93. https://doi.org/10.1207/s15327051hci0501_2

Chaudhuri, S., Muhonen, H., Pakarinen, E., and Lerkkanen, M.-K. (2021). Teachers' focus of attention in first-grade classrooms: exploring teachers experiencing less and more stress using mobile eye-tracking. *Scandinavian Journal of Educational Research*, *66*(6), 1076–1092. https://doi.org/10.1080/00313831.2021.1958374

Chi, M. T. H., and Glaser, R. (1988). Overview. In M. T. H. Chi, R. Glaser, and M. J. Farr (Eds.), *The nature of expertise*. Lawrence Erlbaum Associate. https://doi.org/10.4324/9781315799681

Clarridge, P. B., and Berliner, D. C. (1991). Perceptions of student behavior as a function of expertise. *The Journal of Classroom Interaction*, *26*(1), 1–8. https://www.jstor.org/stable/23869663

Clay, V., Konig, P., and Konig, S. (2019). Eye Tracking in Virtual Reality. *J Eye Mov Res*, *12*(1), 1–18. https://doi.org/10.16910/jemr.12.1.3

Cortina, K. S., Miller, K. F., McKenzie, R., and Epstein, A. (2015). Where low and high inference data converge: Validation of CLASS assessment of mathematics instruction using mobile eye tracking with expert and novice teachers. *International Journal of Science and Mathematics Education*, *13*(2), 389–403. https://doi.org/10.1007/s10763-014-9610-5

Coskun, A., and Cagiltay, K. (2020). Investigation of classroom management skills by using eye-tracking technology. *Education and Information Technologies, 26,* 2501–2522. https://doi.org/10.1007/s10639-020-10368-0

Dalgarno, B., Gregory, S., Knox, V., and Reiners, T. (2016). Practising teaching using virtual classroom role plays. *Australian Journal of Teacher Education*, *41*(1), 123–154. https://doi.org/10.14221/ajte.2016v41n1.8

Dandurand, F., Shultz, T. R., and Onishi, K. H. (2008). Comparing online and lab methods in a problem-solving experiment. *Behavior Research Methods*, *40*(2), 428–434. https://doi.org/10.3758/brm.40.2.428

De Jong, R., and Westerhof, K. J. (2001). The quality of student ratings of teacher behaviour. *Learning Environments Research*, *4*, 51–85. https://doi.org/10.1023/A:1011402608575

DeAngelus, M., and Pelz, J. B. (2009). Top-down control of eye movements: Yarbus revisited. *Visual Cognition*, *17*(6–7), 790–811. https://doi.org/10.1080/13506280902793843

Dessus, P., Cosnefroy, O., and Luengo, V. (2016). Keep your eyes on 'em all!": a mobile eye-tracking analysis of teachers' sensitivity to students. In K. Verbert, M. Sharples, and T. Klobuĉar (Eds.), *Adaptive and adaptable learning* (pp. 72–84). Springer International Publishing. https://hal.archives-ouvertes.fr/hal-01362185

Dicke, T., Holzberger, D., Kunina-Habenicht, O., Linninger, C., Schulze-Stocker, F., Seidel, T., . . . Kunter, M. (2016). "Doppelter Praxisschock" auf dem Weg ins Lehramt? Verlauf und potenzielle Einflussfaktoren emotionaler Erschöpfung während des Vorbereitungsdienstes und nach dem Berufseintritt. *Psychologie in Erziehung und Unterricht*, *63*, 244–257. https://doi.org/10.2378/peu2016.art20d

Ditton, H. (2007). Der Beitrag von Schule und Lehrern zur Reproduktion von Bildungsungleichheit. In R. Becker and W. Lauterbauch (Eds.), *Bildung als Privileg* (2nd ed., pp. 243–471). VS Verlag für Sozialwissenschaften. https://doi.org/https://doi.org/10.1007/978-3-531-90339-2_9

Doyle, W. (1980). *Classroom Management*. Kappa Delta Pi.

Doyle, W. (1985). Recent research on classroom management: implications for teacher preparation. *Journal of Teacher Education*, *36*(3), 31–35. https://doi.org/10.1177/002248718503600307

Durso, F. T., and Gronlund, S. D. (1999). Situation awareness. In F. T. Durso, R. S. Nickerson, S. T. Schvaneveldt, D. S. Lindsay, and M. T. H. Chi (Eds.), *Handbook of applied cognition* (pp. 283–314). John Wiley and Sons Ltd.

Durso, F. T., and Sethumadhavan, A. (2008). Situation awareness: Understanding dynamic environments. *Human Factors*, *50*(3), 442–448. https://doi.org/10.1518/001872008X288448

Eckstein, B. (2018). *Gestörter Unterricht. Wie Lehrpersonen, Schülerinnen und Schüler Unterrichtsstörungen wahrnehmen, deuten, bewerten und beschreiben.* [Doctoral dissertation]. [Zurich]: University of Zurich. https://doi.org/10.5167/uzh-158353

Eder, T. F., Scheiter, K., Richter, J., Keutel, C., and Hüttig, F. (2021). I see something you do not: Eye movement modelling examples do not improve anomaly detection in interpreting medical images. *Journal of Computer Assisted Learning, 38*, 379–391. https://doi.org/10.1111/jcal.12619

Emmer, E. T., and Stough, L. M. (2001). Classroom management: A critical part of educational psychology, with implications for teacher education. *Educational Psychologist*, *36*(2), 103–112. https://doi.org/10.1207/s15326985ep3602_5

Endsley, M. R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors*, *37*(1), 32–64. https://doi.org/10.1518/001872095779049543

Farnand, S., and Fairchild, M. (2012). *The effect of experimental instructions on the number of areas identified as important in photographic images [conference session]*. Conference on Colour in Graphics, Imaging, and Vision (IS&T) 6th CGIV Proceedings, Amsterdam, 290–294. Retrieved January, 17, 2023, from http://markfairchild.org/PDFs/PRO40.pdf

Fauth, B., Decristan, J., Rieser, S., Klieme, E., and Büttner, G. (2014). Student ratings of teaching quality in primary school. Dimensions and prediction of student outcomes. *Learning and instruction*, *29*, 1–9. https://doi.org/10.25656/01:18135

Feldon, D. F. (2007). Cognitive load and classroom teaching: The double-edged sword of automaticity. *Educational Psychologist*, *42*(3), 123–137. https://doi.org/10.1080/00461520701416173

Ferguson, R. F. (1998). Teachers' perceptions and expectations and the Black–White test score gap. In C. Jencks & M. Phillips (Eds.), *The Black–White test score gap*. (pp. 273–317). Brookings Institution Press.

Field, A. (2013). *Discovering statistics using IBM SPSS Statistics* (4th ed.). SAGE.

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE.

Gage, N. A., and MacSuga-Gage, A. S. (2017). Salient classroom management skills: Finding the most effective skills to increase student engagement and decrease disruptions. *Report on emotional and behavioral disorders in youth*, *17*(1), 13–18. Retrieved January, 17, 2023, from https://www.ncbi.nlm.nih.gov/pubmed/30686938

Gegenfurtner, A. (2020). *Professional vision and visual expertise*. [Habilitation treatise]. [Regensburg]: University of Regensburg. Retrieved January, 17, 2023, from https://www.researchgate.net/profile/Andreas-Gegenfurtner/publication/356613436_Professional_Vision_and_Visual_Expertise/links/61a4fcb5c6494c310e78e15c/Professional-Vision-and-Visual-Expertise.pdf

Gegenfurtner, A., Boucheix, J.-M., Gruber, H., Hauser, F., Lehtinen, E., and Lowe, R. (2020). The Gaze Relational Index as a measure of visual expertise. *Anim. Proc. Model.* *3*(1), 32–40. Retrieved January, 17, 2023, from https://www.journalofexpertise.org/articles/volume3_issue1/JoE_3_1_Gegenfurtner.pdf

Gegenfurtner, A., Lehtinen, E., Jarodzka, H., and Säljö, R. (2017). Effects of eye movement modeling examples on adaptive expertise in medical image diagnosis. *Computers and Education*, *113*, 212–225. https://doi.org/10.1016/j.compedu.2017.06.001

Gegenfurtner, A., Lehtinen, E., and Säljö, R. (2011). Expertise differences in the comprehension of visualizations: A meta-analysis of eye-tracking research in professional domains. *Educational Psychology Review*, *23*(4), 523–552. https://doi.org/10.1007/s10648-011-9174-7

Gegenfurtner, A., Lewalter, D., Lehtinen, E., Schmidt, M., and Gruber, H. (2020). Teacher expertise and professional vision: Examining knowledge-based reasoning of pre-service teachers, in-service teachers, and school principals. *Frontiers in Education*, *5:59*. https://doi.org/10.3389/feduc.2020.00059

Gegenfurtner, A., and Seppänen, M. (2013). Transfer of expertise: An eye tracking and think aloud study using dynamic medical visualizations. *Computers and Education*, *63*, 393–403. https://doi.org/10.1016/j.compedu.2012.12.021

Gerjets, P., Scheiter, K., and Schuh, J. (2008). Information comparisons in example-based hypermedia environments: supporting learners with processing prompts and an interactive comparison tool. *Educational Technology Research and Development*, *56*(1), 73–92. https://doi.org/10.1007/s11423-007-9068-z

Ghosh, V. E., Moscovitch, M., Melo Colella, B., and Gilboa, A. (2014). Schema representation in patients with ventromedial PFC lesions. *The Journal of Neuroscience*, *34*(36), 12057–12070. https://doi.org/10.1523/JNEUROSCI.0740-14.2014

Gilboa, A., and Marlatte, H. (2017). Neurobiology of schemas and schema-mediated memory. *Trends in Cognitive Sciences*, *21*(8), 618–631. https://doi.org/10.1016/j.tics.2017.04.013

Glock, S. (2016). Stop talking out of turn: The influence of students' gender and ethnicity on preservice teachers' intervention strategies for student misbehavior. *Teaching and Teacher Education*, *56*, 106–114. https://doi.org/10.1016/j.tate.2016.02.012

Glock, S., and Kleen, H. (2017). Gender and student misbehavior: Evidence from implicit and explicit measures. *Teaching and Teacher Education*, *67*, 93–103. https://doi.org/https://doi.org/10.1016/j.tate.2017.05.015

Glock, S., and Kleen, H. (2021). The role of preservice teachers' implicit attitudes and causal attributions: a deeper look into students' ethnicity. *Current Psychology*. https://doi.org/10.1007/s12144-021-02000-2

Gobet, F. (2015). *Understanding expertise: A multi-disciplinary approach*. Palgrave Macmillan.

Gold, B., Förster, S., and Holodynski, M. (2013). Evaluation eines videobasierten Trainingsseminars zur Förderung der professionellen Wahrnehmung von Klassenführung im Grundschulunterricht. *Zeitschrift für Pädagogische Psychologie*, *27*(3), 141–155. https://doi.org/10.1024/1010-0652/a000100

Gold, B., Hellermann, C., and Holodynski, M. (2016). Professionelle Wahrnehmung von Klassenführung - Vergleich von zwei videobasierten Erfassungsmethoden.. In K. Schwippert and D. Prinz (Eds.), *Der Forschung - Der Lehre - Der Bildung: Aktuelle Entwicklungen der Empirischen Bildungsforschung* (pp. 103–118). Waxmann.

Gold, B., and Holodynski, M. (2017). Using digital video to measure the professional vision of elementary classroom management: Test validation and methodological challenges. *Computers and Education*, *107*, 13–30. https://doi.org/10.1016/j.compedu.2016.12.012

Goldberg, P., and Fütterer, T. (in press). Virtual reality as a tool in research on teachers' professional vision. In A. Gegenfurtner and R. Stahnke (Eds.), *Teacher Professional Vision: Theoretical and Methodological Advances (Part 1)*. Routledge.

Goldberg, P., Sümer, Ö., Stürmer, K., Wagner, W., Göllner, R., Gerjets, P., . . . Trautwein, U. (2019). Attentive or not? Toward a machine learning approach to assessing students' visible engagement in classroom instruction. *Educational Psychology Review*, *33*(1), 27–49. https://doi.org/10.1007/s10648-019-09514-z

Goodwin, C. (1994). Professional vision. *American Anthropologist*, *96*(3), 606–633. https://doi.org/10.1525/aa.1994.96.3.02a00100

Grub, A.-S., Biermann, A., and Brünken, R. (2020). Process-based measurement of professional vision of (prospective) teachers in the field of classroom management: A systematic review. *Journal for Educational Research Online*, *12*(3), 75–102. https://doi.org/10.25656/01:21187

Grub, A.-S., Biermann, A., and Brünken, R. (in press). Eye tracking as a process-based methodology to examine teachers' professional vision. In A. Gegenfurtner and R. Stahnke (Eds.), *Teacher Professional Vision: Theoretical and Methodological Advances (Part 1)*. Routledge.

Grub, A.-S., Biermann, A., Lewalter, D., and Brünken, R. (2022a). Professional knowledge and task instruction specificity as influencing factors of prospective teachers' professional vision. *Teaching and Teacher Education*, *109,* 1–14. https://doi.org/10.1016/j.tate.2021.103517

Grub, A.-S., Biermann, A., Lewalter, D., and Brünken, R. (2022b). Professional vision and the compensatory effect of a minimal instructional intervention: A quasi-experimental eye-tracking study with novice and expert teachers. *Frontiers in Education*, *7*:890690, 1–17. https://doi.org/10.3389/feduc.2022.890690

Grub, A.-S., Selisko, T., Biermann, A., Perels, F., and Brünken, R. (in preparation). A quasi-experimental eye tracking study investigating professional vision of inclusive teaching situations.

Haataja, E., Garcia Moreno-Esteva, E., Salonen, V., Laine, A., Toivanen, M., and Hannula, M. S. (2019). Teacher's visual attention when scaffolding collaborative mathematical problem solving. *Teaching and Teacher Education*, *86,* 1–15. https://doi.org/10.1016/j.tate.2019.102877

Hammerness, K., Darling-Hammond, L., and Shulman, L. (2002). Toward expert thinking: How curriculum case writing prompts the development of theory-based professional knowledge in student teachers. *Teaching Education*, *13*(2), 219–243. https://doi.org/10.1080/1047621022000007594

Heinrich, F., Huettl, F., Schmidt, G., Paschold, M., Kneist, W., Huber, T., and Hansen, C. (2021). HoloPointer: a virtual augmented reality pointer for laparoscopic surgery training. *Int J Comput Assist Radiol Surg*, *16*(1), 161–168. https://doi.org/10.1007/s11548-020-02272-2

Helmke, A. (2006). *Unterrichtsqualität: Erfassen, Bewerten, Verbessern* (4th edition). Kallmeyersche Verlagsbuchhandlung.

Helmke, A., and Schrader, F.-W. (2009). Qualitätsmerkmale "guten Unterrichts". In S. Hellekamps, W. Plöger, and W. Wittenbruch (Eds.), *Handbuch für Erziehungswissenschaft* (Vol. Band II/1: Schule, pp. 701–712). Schöningh.

Herold-Blasius, R. (2021). Prompts. In R. Herold-Blasius (Ed.), *Problemlösen mit Strategieschlüsseln: Eine explorative Studie zur Unterstützung von Problembearbeitungsprozessen bei Dritt- und Viertklässlern* (pp. 25–34). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-32292-2_4

Hessels, R. S., Kemner, C., van den Boomen, C., and Hooge, I. T. (2016). The area-of-interest problem in eyetracking research: A noise-robust solution for face and sparse stimuli. *Behav Res Methods*, *48*(4), 1694–1712. https://doi.org/10.3758/s13428-015-0676-y

Hilbert, T. S., Nückles, M., Renkl, A., Minarik, C., Reich, A., and Ruhe, K. (2008). Concept Mapping zum Lernen aus Texten. *Zeitschrift für Pädagogische Psychologie*, *22*(2), 119–125. https://doi.org/10.1024/1010-0652.22.2.119

Hofstede, G. (1986). Cultural diff erences in teaching and learning. *International Journal of Intercultural Relations*, *10*(3), 301–320. https://doi.org/10.1016/0147-1767(86)90015-5

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R. J., H. , and Van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. OUP Oxford.

Holmqvist, K., Orbom, S. L., Hooge, I. T. C., Niehorster, D. C., Alexander, R. G., Andersson, R., . . . Hessels, R. S. (2022). Eye tracking: empirical foundations for a minimal reporting guideline. *Behav Res Methods*. https://doi.org/10.3758/s13428-021-01762-8

Huang, Y. (2018). *Learning from teacher´s eye movement: Expertise, subject matter and video modeling*. [Doctoral dissertation]. [Michigan]: University of Michigan. ProQuest. https://www.proquest.com/docview/2167908970

Huang, Y., Miller, K. F., Cortina, K. S., and Richter, D. (2021). Teachers' professional vision in action. *Zeitschrift für Pädagogische Psychologie*, 1–18. https://doi.org/10.1024/1010-0652/a000313

Huang, Y., Richter, E., Kleickmann, T., Wiepke, A., and Richter, D. (2021). Classroom complexity affects student teachers' behavior in a VR classroom. *Computers and Education*, *163*. https://doi.org/10.1016/j.compedu.2020.104100

Huitema, B. (2011). *The analysis of covariance and alternatives: Statistical methods for experiments, quasi-experiments, and single-case studies* (2nd ed.). Wiley.

Itti, L., and Koch, C. (2001). Computational modelling of visual attention. *Nat Rev Neurosci*, *2*(3), 194-203. https://doi.org/10.1038/35058500

Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language*, *59*(4), 434–446. https://doi.org/https://doi.org/10.1016/j.jml.2007.11.007

Jahn, G., Stürmer, K., Seidel, T., and Prenzel, M. (2014). Professionelle Unterrichtswahrnehmung von Lehramtsstudierenden. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, *46*(4), 171–180. https://doi.org/10.1026/0049-8637/a000114

Jarodzka, H., Holmqvist, K., and Gruber, H. (2017). Eye tracking in Educational Science: Theoretical frameworks and research agendas. *Journal of Eye Movement Research*, *10*(3), 1–18. https://doi.org/10.16910/jemr.10.1.3

Johnston, W. A., and Dark, V. J. (1986). Selective attention. *Annual Review of Psychology*, *37*(1), 43–75. https://doi.org/10.1146/annurev.ps.37.020186.000355

Judd, C. M., Westfall, J., and Kenny, D. A. (2017). Experiments with more than one random factor: designs, analytic models, and statistical power. *Annu Rev Psychol*, *68*, 601–625. https://doi.org/10.1146/annurev-psych-122414-033702

Just, M. A., and Carpenter, P. A. (1976). Eye fixations and cognitive processes. *Cognitive Psychology*, *8*(4), 441–480. https://doi.org/https://doi.org/10.1016/0010-0285(76)90015-3

Just, M. A., and Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*(4), 329–354. https://doi.org/https://doi.org/10.1037/0033-295X.87.4.329

Kaakinen, J. K. (2020). What can eye movements tell us about visual perception processes in classroom contexts? Commentary on a special issue. *Educational Psychology Review, 33,* 169–179. https://doi.org/10.1007/s10648-020-09573-7

Kalyuga, S. (2007). Expertise reversal effect and ist implications for learner-tailored instruction. *Educational Psychology Review*, *19*(4), 509–539. https://doi.org/10.1007/s10648-007-9054-3

Keller, L., Cortina, K. S., Müller, K., and Miller, K. F. (2021). Noticing and weighing alternatives in the reflection of regular classroom teaching: Evidence of expertise using mobile eye-tracking. *Instructional Science, 50*, 251–272. https://doi.org/10.1007/s11251-021-09570-5

Kersting, N. B., Givvin, K. B., Sotelo, F. L., and Stigler, J. W. (2010). Teachers' analyses of classroom video predict student learning of mathematics: further explorations of a novel measure of teacher knowledge. *Journal of Teacher Education*, *61*(1-2), 172–181. https://doi.org/10.1177/0022487109347875

Kersting, N. B., Givvin, K. B., Thompson, B. J., Santagata, R., and Stigler, J. W. (2012). Measuring usable knowledge: Teachers' analyses of mathematics classroom videos predict teaching quality and student learning. *American Educational Research Journal*, *49*(3), 568–589. https://doi.org/10.3102/0002831212437853

Keskin, Ö. (2022, November 25). Der Blick auf Lernende: Aufmerksamkeitsallokation von Lehramtsstudierenden auf Schüler:innen mit und ohne Migrationshintergrund. [Symposium session]. 7. wissenschaftliches Symposium "Professionelle Unterrichtswahrnehmung" des Projekts "Förderung der Lehrerprofessionalität im Umgang mit Heterogenität" (LeHet), Augsburg, Germany.

Keskin, Ö., Gegenfurtner, A., Seidel, T., and Stürmer, K. (2022, April). *Teacher noticing: A meta-analytic review of eye-tracking studies.* [Conference session]. Annual Meeting of the American Educational Research Association (AERA), San Diego, USA.

Kleen, H., and Glock, S. (2018). A further look into ethnicity: The impact of stereotypical expectations on teachers' judgments of female ethnic minority students. *Social Psychology of Education*, *21*(4), 759–773. https://doi.org/10.1007/s11218-018-9451-0

Kleen, H., and Glock, S. (2020). Sag' mir, wie du heißt, dann sage ich dir, wie du bist: Eine Untersuchung von Vornamen. In S. Glock and H. Kleen (Eds.), *Stereotype in der Schule* (pp. 99–131). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-27275-3_4

Klepsch, M., Schmitz, F., and Seufert, T. (2017). Development and validation of two instruments measuring intrinsic, extraneous, and germane cognitive load. *Frontiers in Psychology*, *8:* 1997, 1–8. https://doi.org/10.3389/fpsyg.2017.01997

Koc, Y., Peker, D., and Osmanoglu, A. (2009). Supporting teacher professional development through online video case study discussions: An assemblage of preservice and inservice teachers and the case teacher. *Teaching and Teacher Education*, *25*(8), 1158–1168. https://doi.org/https://doi.org/10.1016/j.tate.2009.02.020

Kopp, B., and Mandl, H. (2005). *Wissensschemata*. [Research report]. LMU München: Lehrstuhl für Empirische Pädagogik und Pädagogische Psychologie, *177*. https://doi.org/10.5282/ubm/epub.744

Kosel, C. (2022, Oktober 24). *Wissenschaftliche Gütekriterien in Eye-Tracking Studien mit Lehrpersonen. Zentrale Herausforderungen and mögliche Lösungsansätze*. [Presentation]. Arbeitsgruppe Eye Tracking, University of Augsburg, Germany.

Kosel, C., Holzberger, D., and Seidel, T. (2021). Identifying expert and novice visual scanpath patterns and their relationship to assessing learning-relevant student characteristics. *Frontiers in Education*, *5:*612175, 1–16. https://doi.org/10.3389/feduc.2020.612175

Kounin, J. S. (2006). *Techniken der Klassenführung*. Waxmann.

Kramer, J. H., Mungas, D., Reed, B. R., Wetzel, M. E., Burnett, M. M., Miller, B. L., . . . Chui, H. C. (2007). Longitudinal MRI and cognitive change in healthy elderly. *Neuropsychology*, *21*(4), 412–418. https://doi.org/10.1037/0894-4105.21.4.412

Krause, A. (2004). Erhebung aufgabenbezogener psychischer Belastungen im Unterricht - ein Untersuchungskonzept. *Zeitschrift für Arbeits- und Organisationspsychologie A and O*, *48*(3), 139–147. https://doi.org/10.1026/0932-4089.48.3.139

Krauss, S., Blum, W., Brunner, M., Neubrand, M., Baumert, J., Kunter, M., . . . Elsner, J. (2011). Konzeptualisierung und Testkonstruktion zum fachbezogenen Professionswissen von Mathematiklehrkräften. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, and M. Neubrand (Eds.), *Professionelle*

Kompetenz von Lehrkräften: Ergebnisse des Forschungsprogramms COACTIV (pp. 135–161). Waxmann.

Kulinna, P. H. (2007). Teachers' attributions and strategies for student misbehavior. *Journal of Classroom Interaction*, *42*(2), 21–30. Retrieved, January 17, 2023, from https://files.eric.ed.gov/fulltext/EJ829002.pdf

Kunina-Habenicht, O., Schulze-Stocker, F., Kunter, M., Baumert, J., Leutner, D., Förster, D., . . . Terhart, E. (2013). Die Bedeutung der Lerngelegenheuten im Lehramtsstudium und deren individuelle Nutzung für den Aufbau des bildungswissenschaftlichen Wissens. *Zeitschrift für Pädagogik*, *59*, 1–23. https://doi.org/https://doi.org/10.25656/01:11924

Kunter, M., Kleikmann, T., Klusmann, U., and Richter, D. (2011). Die Entwicklung professioneller Kompetenz von Lehrkräften. In M. Kunter, J. Baumert, W. Blum, U. Klusman, S. Krauss, and M. Neidbrand (Eds.), *Professionelle Kompetenz von Lehrkräften – Ergebnisse des Forschungsprogramms COACTIV* (pp. 55–68). Waxmann.

Kuperman, V., Bertram, R., and Baayen, R. H. (2008). Morphological dynamics in compound processing. *Language and Cognitive Processes*, *23*(7–8), 1089–1132. https://doi.org/10.1080/01690960802193688

König, J., and Blömeke, S. (2010). Pädagogisches Unterrichtswissen (PUW); Dokumentation der Kurzfassung des TEDS-M Testinstruments zur Kompetenzmessung in der ersten Phase der Lehrerausbildung. [Berlin]: Humbold-Universtität.

König, J., Blömeke, S., Paine, S., Schmidt, W. H., and Hsieh, F.-J. (2011). General pedagogical knowledge of future middle school teachers: On the complex ecology of teacher education in the United States, Germany, and Taiwan. *Journal of Teacher Education*, *61*(2), 188–201. https://doi.org/http://dx.doi.org/10.1177/0022487110388664

König, J., and Kramer, C. (2015). Teacher professional knowledge and classroom management: on the relation of general pedagogical knowledge (GPK) and classroom management expertise (CME). *Zdm*, *48*(1–2), 139–151. https://doi.org/10.1007/s11858-015-0705-4

König, J., Santagata, R., Scheiner, T., Adleff, A.-K., Yang, X., and Kaiser, G. (2022). Teacher noticing: A systematic literature review of conceptualizations, research designs, and findings on learning to notice. *Educational Research Review*, *36*, 1–18. https://doi.org/10.1016/j.edurev.2022.100453

Lachner, A., Jarodzka, H., and Nückles, M. (2016). What makes an expert teacher? Investigating teachers' professional vision and discourse abilities. *Instructional Science*, *44*(3), 197–203. https://doi.org/10.1007/s11251-016-9376-y

Le Meur, O., and Baccino, T. (2013). Methods for comparing scanpaths and saliency maps: strengths and weaknesses. *Behavior Research Methods*, *45*(1), 251–266. https://doi.org/10.3758/s13428-012-0226-9

Levin, D. M., Hammer, D., and Coffey, J. E. (2009). Novice teachers' attention to student thinking. *Journal of Teacher Education*, *60*(2), 142–154. https://doi.org/10.1177/0022487108330245

Lewalter, D., Titze, S., Bannert, M., and Richter-Gebert, J. (2020). Lehrer*innenbildung digital und disziplinverbindend. Die Toolbox Lehrerbildung. *Journal für LehrerInnenbildung jlb*, *20*(2), 76–84. https://doi.org/10.35468/jlb-02-2020_06

Livingston, C., and Borko, H. (1989). Expert-novice differences in teaching: A cognitive analysis and implications for teacher education. *Journal of Teacher Education*, *40*(4), 36–42. https://doi.org/https://doi.org/10.1177/002248718904000

Lohmann, G. (2003). *Mit Schülern klarkommen. Professioneller Umgang mit Unterrichtsstörungen und Disziplinkonflikten*. Cornelsen Scriptor.

Lugrin, J.-L., Latoschik, M. E., Habel, M., Roth, D., Seufert, C., and Grafe, S. (2016). Breaking Bad Behaviors: A new tool for learning classroom management using virtual reality. *Frontiers in ICT*, *3*:26, 1–21. https://doi.org/10.3389/fict.2016.00026

Malone, S., and Brünken, R. (2016). The role of ecological validity in hazard perception assessment. *Transportation Research Part F: Traffic Psychology and Behaviour*, *40*, 91–103. https://doi.org/doi:10.1016/j.trf.2016.04.008

Malone, S., and Brünken, R. (2020). Studying gaze behavior to compare three different hazard perception tasks. *Human factors*, *62*(8), 1286–1303. https://doi.org/https://doi.org/10.1177/0018720819873462

Maniar, N., Bennett, E., Hand, S., and Allan, G. (2008). The effect of mobile phone screen size on video based learning. *Journal of Software*, *3*(4), 51–61. https://doi.org/https:// doi.org/10.4304/jsw.3.4.51-61

Mason, J. (2011). Noticing: Roots and branches. In M. G. Sherin, V. Jacobs, and R. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (1st ed., pp. 35–50). Routledge. https://doi.org/https://doi.org/10.4324/9780203832714

McIntyre, N. A., and Foulsham, T. (2018). Scanpath analysis of expertise and culture in teacher gaze in real-world classrooms. *Instructional Science*, *46*(3), 435–455. https://doi.org/10.1007/s11251-017-9445-x

McIntyre, N. A., Jarodzka, H., and Klassen, R. M. (2019). Capturing teacher priorities: Using real-world eye-tracking to investigate expert teacher priorities across two cultures. *Learning and Instruction*, *60*, 215–224. https://doi.org/10.1016/j.learninstruc.2017.12.003

McIntyre, N. A., Mainhard, M. T., and Klassen, R. M. (2017). Are you looking to teach? Cultural, temporal and dynamic insights into expert teacher gaze. *Learning and Instruction*, *49*, 41–53. https://doi.org/10.1016/j.learninstruc.2016.12.005

McVee, M. B., Dunsmore, K., and Gavelek, J. R. (2005). Schema theory revisited. *Review of Educational Research*, *75*(4), 531–556. https://doi.org/https://doi.org/10.3102/00346543075004531

Meinokat, P., and Wagner, I. (2022). Causes, prevention, and interventions regarding classroom disruptions in digital teaching: A systematic review. *Education and Information Technologies*, *27*(4), 4657–4684. https://doi.org/10.1007/s10639-021-10795-7

Mele, M. L., and Federici, S. (2012). Gaze and eye-tracking solutions for psychological research. *Cogn Process*, *13* (Suppl 1), 261–265. https://doi.org/10.1007/s10339-012-0499-z

Melin, M. C., Peltomaa, E., Schildt, L., and Lehtonen, E. (2018). Where do people direct their attention while cycling? A comparison of adults and children. *Transportation Research Part F: Traffic Psychology and Behaviour*, *58*, 292–301. https://doi.org/https://doi.org/10.1016/j.trf.2018.06.017

Melnick, S. A., and Meister, D. G. (2008). A comparison of beginning and experienced teachers' concerns. *Educational Research Quarterly*, *31*(3), 39–56. Retrieved, January 1, 2023, from https://www.proquest.com/scholarly-journals/comparison-beginning-experienced-teachers/docview/61942447/se-2?accountid=13637

Meschede, N., Fiebranz, A., Möller, K., and Steffensky, M. (2017). Teachers' professional vision, pedagogical content knowledge and beliefs: On its relation and differences between pre-service and in-service teachers. *Teaching and Teacher Education*, *66*, 158–170. https://doi.org/10.1016/j.tate.2017.04.010

Meyer, H. (1990). *Unterrichtsmethoden*. Scriptor.

Mikhailenko, M., Maksimenko, N., and Kurushkin, M. (2022). Eye-tracking in immersive virtual reality for education: A review of the current progress and applications. *Frontiers in Education*, *7*:697032, 1–13. https://doi.org/10.3389/feduc.2022.697032

Minarikova, E., Smidekova, Z., Janik, M., and Holmqvist, K. (2021). Teachers' professional vision: Teachers' gaze during the act of teaching and after the event. *Frontiers in Education*, *6* :716579, 1–18. https://doi.org/10.3389/feduc.2021.716579

Mischo, C., Wolstein, K., Tietze, S., and Peters, S. (2020). Professionelle Wahrnehmung bei Kita-Fachkräften. Erfassung, Generalisierbarkeit und Zusammenhänge.

Journal for educational research online, *12*(3), 23–49. https://doi.org/10.25656/01:21185

Muhonen, H., Pakarinen, E., and Lerkkanen, M.-K. (2021). Do teachers' professional vision and teaching experience always go hand in hand? Examining knowledge-based reasoning of Finnish Grade 1 teachers. *Teaching and Teacher Education*, *106*:103458, 1–12. https://doi.org/https://doi.org/10.1016/j.tate.2021.103458

Munoz, D. P., Broughton, J. R., Goldring, J. E., and Armstrong, I. T. (1998). Age-related performance of human subjects on saccadic eye movement tasks. *Experimental Brain Research*, *121*(4), 391–400. https://doi.org/10.1007/s002210050473

Nassaji, H. (2007). Schema theory and knowledge-based processes in second language reading comprehension: A need for alternative perspectives. *Language Learning*, *57*, 79–113. https://doi.org/https://doi.org/10.1111/j.1467-9922.2007.00413.x

Navalpakkam, V., and Itti, L. (2005). Modeling the influence of task on attention. *Vision Research*, *45*(2), 205–231. https://doi.org/10.1016/j.visres.2004.07.042

Nelsen, L. D., Simmons, J., and Simonsohn, U. (2017). Psychology's renaissance. *Annual Review of Psychology*, *69*, 511–534. https://doi.org/https://doi.org/10.1146/annurev-psych-122216-011836

Newen, A., and Vetter, P. (2017). Why cognitive penetration of our perceptual experience is still the most plausible account. *Consciousness and Cognition*, *47*, 26–37. https://doi.org/https://doi.org/10.1016/j.concog.2016.09.005

Nolting, H.-P. (2012). *Störungen in der Schulklasse* (10th ed.). Beltz Verlag.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). McGraw-Hill.

Nyström, M., and Holmqvist, K. (2008). Semantic override of low-level features in image viewing – both initially and overall. *Journal of Eye Movement Research*, *2*(2), 1–11. https://doi.org/10.16910/jemr.2.2.2

Nückles, M. (2020). Investigating visual perception in teaching and learning with advanced eye-tracking methodologies: Rewards and challenges of an innovative research paradigm. *Educational Psychology Review*, *33*(1), 149–167. https://doi.org/10.1007/s10648-020-09567-5

Ophardt, D., and Thiel, F. (2013). *Klassenmanagement. Ein Handbuch für Studium und Praxis*. Kohlhammer.

Orquin, J. L., and Holmqvist, K. (2018). Threats to the validity of eye-movement research in psychology. *Behav Res Methods*, *50*(4), 1645–1656. https://doi.org/10.3758/s13428-017-0998-z

Orquin, J. L., and Mueller Loose, S. (2013). Attention and choice: a review on eye movements in decision making. *Acta Psychol (Amst)*, *144*(1), 190–206. https://doi.org/10.1016/j.actpsy.2013.06.003

Oser, F., Biedermann, H., Brühwiler, C., Krattenmacher, S., and Steinmann, S. (2008). Test zum Pädagogischen Handlungswissen von Lehrpersonen. Erhebungsinstrument aus dem Projekt TEDS-M Schweiz. [St. Gallen]: Pädagogische Hochschule St. Gallen.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., . . . Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*:89, 1–11. https://doi.org/10.1186/s13643-021-01626-4

Palmer, D. J., Stough, L. M., Burdenski, T. K., and Gonzales, M. (2005). Identifying teacher expertise: An examination of researchers' decision making. *Educational Psychologist*, *40*(1), 13–25. https://doi.org/10.1207/s15326985ep4001_2

Pappa, C. I., Kosel, C., Schnitzler, K., and Seidel, T. (2020). Using eye-tracking to investigate teacher gaze: Data accuracy and drawing of meaningful dynamic areas of interest in video stimuli. *Pedagogická orientace*, *29*, 401–423. https://doi.org/10.5817/PedOr2019-4-401

Peltsch, A., Hemraj, A., Garcia, A., and Munoz, D. P. (2011). Age-related trends in saccade characteristics among the elderly. *Neurobiol Aging*, *32*(4), 669–679. https://doi.org/10.1016/j.neurobiolaging.2009.04.001

Peterson, P. L. C., M. A. (1987). Teachers' schemata for classroom events: The mental scaffolding of teachers' thinking during classroom instruction. *Teaching and Teacher Education*, *3*(4), 319–331. https://doi.org/10.1016/0742-051X(87)90024-2

Pfitzner, M., and Schoppek, W. (2000). Gemeinsamkeiten und Diskrepanzen in der Bewertung von Unterrichtsstörungen durch Lehrer und Schüler - eine empirische Untersuchung [Commonalities and discrepancies in the evaluation of classroom disruptions by teachers and students - an empirical investigation]. *28*(4), 350–378. https://doi.org/10.25656/01:5478

Pfitzner-Eden, F. (2016). STSE. Scale for Teacher Self-Efficacy - deutsche adaptierte Fassung [Procedure documentation and questionnaire]. In Leibniz-Institut für Psychologie (ZPID) (Ed.), *Open Test Archive*, [Trier]: ZPID. https://www.testarchiv.eu/de/test/9007043

Pichert, J. W., and Anderson, R. C. (1977). Taking different perspectives on a story. *Journal of Educational Psychology*, *69*(4), 309–315. https://doi.org/https://doi.org/10.1037/0022-0663.69.4.309

Pouta, M., Lehtinen, E., and Palonen, T. (2020). Student teachers' and experienced teachers' professional vision of students' understanding of the rational number concept. *Educational Psychology Review, 33*, 109–128. https://doi.org/10.1007/s10648-020-09536-y

Pressley, M., El-Dinary, P. B., Gaskins, I., Schuder, T., Bergman, J. L., Almasi, J., and Brown, R. (1992). Beyond direct explanation: Transactional instruction of reading comprehension strategies. *The Elementary School Journal*, *92*(5), 513–555. https://doi.org/https://doi.org/10.1086/461705

Ramat, A. G., Mauri, C., and Molinelli, P. (2013). *Synchrony and diachrony: A dynamic interface*. John Benjamins Publishing Company. https://doi.org/10.1075/slcs.133

Rattay, C., and Wensing, R. (2011). Fünf Eskalationsstufen von Unterrichtsstörungen und mögliche Gegenmassnahmen. In C. Rattay, J. Schneider, R. Wensing, and O. Wilkes (Eds.), *Unterrichtsstörungen souverän meistern – Das Praxisbuch. Profi-Tipps und Materialien aus der Lehrerfortbildung* (pp. 59–74). Auer.

Reingold, E. M., and Sheridan, H. (2011). Eye movements and visual expertise in chess and medicine. In S. P. Liversedge, I. D. Gilchrist, and S. Everling (Eds.), *Oxford Handbook on Eye Movements* (pp. 528–550). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199539789.013.0029

Richter, E., Hußner, I., Huang, Y., Richter, D., and Lazarides, R. (2022). Video-based reflection in teacher education: Comparing virtual reality and real classroom videos. *Computers and Education*, *190*: 104601, 1–12. https://doi.org/https://doi.org/10.1016/j.compedu.2022.104601

Riedl, R., Brandstätter, E., and Roithmayr, F. (2008). Identifying decision strategies: A process- and outcome-based classification method. *Behavior Research Methods*, *40*(3), 795–807. https://doi.org/10.3758/brm.40.3.795

Roller, S. A. (2016). What they notice in video: A study of prospective secondary mathematics teachers learning to teach. *Journal of Mathematics Teacher Education*, *19*(5), 477–498. https://doi.org/10.1007/s10857-015-9307-x

Rosenshine, B., Meister, C., and Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research*, *66*(2), 181–221. https://doi.org/10.2307/1170607

Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., and Wickler, N. I. Z. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal of Research in Science Teaching*, *48*(2), 117–148. https://doi.org/10.1002/tea.20408

Roth McDuffie, A., Foote, M. Q., Bolson, C., Turner, E. E., Aguirre, J. M., Bartell, T. G., . . . Land, T. (2014). Using video analysis to support prospective K-8 teachers' noticing of students' multiple mathematical knowledge bases. *Journal of Mathematics Teacher Education*, *17*(3), 245–270. https://doi.org/10.1007/s10857-013-9257-0

Sabers, D. S., Cushing, K. S., and Berliner, D. C. (1991). Differences among tachers in a task characterized by simulatenity, multidimensionality, and immediacy. *American Educational Research Journal*, *28*(1), 63–88. https://doi.org/10.2307/1162879

Santagata, R., and Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *ZDM*, *43*(1), 133–145. https://doi.org/10.1007/s11858-010-0292-3

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A.-K., Yang, X., and Kaiser, G. (2021). Mathematics teacher learning to notice: a systematic review of studies of video-based programs. *ZDM – Mathematics Education*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

Santagata, R., and Yeh, C. (2016). The role of perception, interpretation, and decision making in the development of beginning teachers' competence. *ZDM*, *48*(1–2), 153–165. https://doi.org/10.1007/s11858-015-0737-9

Santagata, R., Zannoni, C., and Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: an empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Mathematics Teacher Education*, *10*(2), 123–140. https://doi.org/10.1007/s10857-007-9029-9

Schaffert, U. (2022). Professionswissen von Lehrkräften. In U. Schaffert (Ed.), *Erwerb Diagnostischer Kompetenz im Sachunterricht: Wissensvernetzung durch Unterstützung bei der Wissensreorganisation* (pp. 11–73). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-39063-1_2

Schnitzler, K., Holzberger, D., and Seidel, T. (2020). Connecting judgment process and accuracy of student teachers: differences in observation and student engagement cues to assess student characteristics. *Frontiers in Education*, *5*: 602470, 1–28. https://doi.org/10.3389/feduc.2020.602470

Schoenfeld, A. H. (2011). Noticing matters. A lot. Now what? In M. G. Sherin, V. Jacobs, and R. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (1st ed., pp. 223–238). Routledge. https://doi.org/https://doi.org/10.4324/9780203832714

Schreiter, S., Vogel, M., Rehm, M., and Dörfler, T. (2022a). Die Rolle des Wissens angehender Mathematiklehrkräfte beim Diagnostizieren schwierigkeitsgenerierender Aufgabenmerkmale. Erkenntnisse aus Eye-Tracking Stimulated Recall Interviews. *Journal für Mathematik-Didaktik*, *43*(1), 101–133. https://doi.org/10.1007/s13138-022-00203-z

Schreiter, S., Vogel, M., Rehm, M., and Dörfler, T. (2022b). *Improving pre-service teachers' diagnostic judgments regarding task difficulties in the domain of fractions and angles - A process-oriented investigation with eye-tracking* [Conference session]. Twelfth Congress of the European Society for Research in Mathematics Education (CERME12), Bozen-Bolzano, Italy. https://hal.archives-ouvertes.fr/hal-03744869

Schunk, D. H., and DiBenedetto, M. K. (2021). Self-efficacy and human motivation. In A. J. Elliot (Ed.), *Advances in Motivation Science* (8th ed., pp. 153–179). Elsevier. https://doi.org/https://doi.org/10.1016/bs.adms.2020.10.001

Schwindt, K. (2008). *Lehrpersonen betrachten Unterricht: Kriterien für die kompetente Unterrichtswahrnehmung*. Waxmann.

Seidel, T. (2020). Klassenführung. In E. M. J. Wild (Ed.), *Pädagogische Psychologie* (pp. 119–131). Springer. https://doi.org/10.1007/978-3-662-61403-7_5

Seidel, T., Blomberg, G., and Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, *34*, 56–65. https://doi.org/10.1016/j.tate.2013.03.004

Seidel, T., Blomberg, G., and Stürmer, K. (2010). "Observer" – Validierung eines videobasierten Instruments zur Erfassung der professionellen Wahrnehmung von Unterricht. Projekt OBSERVE. In E. Klieme, D. Leutner, and M. Kenk (Eds.), *Kompetenzmodellierung. Zwischenbilanz des DFG-Schwerpunktprogramms und Perspektiven des Forschungsansatzes* (pp. 296–306). Beltz. https://doi.org/10.25656/01:3438

Seidel, T., Schnitzler, K., Kosel, C., Stürmer, K., and Holzberger, D. (2021). Student characteristics in the eyes of teachers: Differences between novice and expert teachers in judgment accuracy, observed behavioral cues, and gaze. *Educational Psychology Review*, *33*(1), 69–89. https://doi.org/10.1007/s10648-020-09532-2

Seidel, T., and Stürmer, K. (2014). Modeling and measuring the structure of professional vision in preservice teachers. *American Educational Research Journal*, *51*(4), 739–771. https://doi.org/10.3102/0002831214531321

Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., and Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others? *Teaching and Teacher Education*, *27*(2), 259–267. https://doi.org/10.1016/j.tate.2010.08.009

Shavelson, R. J. (2013). On an approach to testing and modeling competence. *Educational Psychologist*, *48*(2), 73–86. https://doi.org/10.1080/00461520.2013.779483

Sherin, M. G. (2001). Developing a professional vision of classroom events. In T. L. Wood, B. S. Nelson, and J. Warfield (Eds.), *Beyond classical pedagogy: Teaching elementary school mathematics* (pp. 75–93). Lawrence Erlbaum Associates.

Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, and S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 383–395). Routledge, Taylor and Francis Group.

Sherin, M. G., and Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/https://doi.org/10.1016/j.tate.2003.08.001

Sherin, M. G., and van Es, E. A. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education*, *13*(3), 475–491. Retrieved, January 17, 2023, from https://www.researchgate.net/profile/Miriam-Sherin/publication/254840333_Using_Video_to_Support_Teachers'_Ability_to_Notice_Classroom_Interactions/links/53ff942a0cf2194bc29a943d/Using-Video-to-Support-Teachers-Ability-to-Notice-Classroom-Interactions.pdf

Sherin, M. G., and van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, *60*(1), 20–37. https://doi.org/10.1177/0022487108328155

Shinoda, H., Yamamoto, T., and Imai-Matsumura, K. (2021). Teachers' visual processing of children's off-task behaviors in class: A comparison between teachers and student teachers. *PLoS One*, *16*(11), 1–18. https://doi.org/10.1371/journal.pone.0259410

Simpson, A., Vondrová, N., and Žalská, J. (2018). Sources of shifts in pre-service teachers' patterns of attention: the roles of teaching experience and of observational experience. *Journal of Mathematics Teacher Education*, *21*(6), 607–630. https://doi.org/10.1007/s10857-017-9370-6

Smidekova, Z., Janik, M., Minarikova, E., and Holmqvist, K. (2020). Teachers' gaze over space and time in a real-world classroom. *Journal of Eye Movement Research*, *13*(4), 1–20. https://doi.org/10.16910/jemr.13.4.1

Stahnke, R. (2021). *Teachers' Situation-Specific Skills With a Particular Focus on Classroom Management. Evidence From a Systematic Review and Novice-Expert Studies*. [Berlin]: Humboldt-Universität. Retrieved, January 17, 2023, from https://edoc.hu-berlin.de/bitstream/handle/18452/23703/dissertation_stahnke_rebekka.pdf?sequence=3&isAllowed=y

Stahnke, R., and Blömeke, S. (2021a). Novice and expert teachers' noticing of classroom management in whole-group and partner work activities: Evidence from teachers' gaze and identification of events. *Learning and Instruction*, *74,* 1–12. https://doi.org/10.1016/j.learninstruc.2021.101464

Stahnke, R., and Blömeke, S. (2021b). Novice and expert teachers' situation-specific skills regarding classroom management: what do they perceive, interpret and suggest? *Teaching and Teacher Education*, *98,* 1–14. https://doi.org/10.1016/j.tate.2020.103243

Stahnke, R., Schueler, S., and Roesken-Winter, B. (2016). Teachers' perception, interpretation, and decision-making: a systematic review of empirical mathematics education research. *ZDM*, *48*(1-2), 1–27. https://doi.org/10.1007/s11858-016-0775-y

Star, J. R., and Strickland, S. K. (2008). Learning to observe: using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*(2), 107–125. https://doi.org/10.1007/s10857-007-9063-7

Statistica Research Department (November 2, 2022). *Anteil der weiblichen Lehrkräfte an allgemeinbildenden Schulen in Deutschland im Schuljahr 2021/2022 nach Schulart*. Retrieved January 17, 2023, from https://de.statista.com/statistik/daten/studie/1129852/umfrage/frauenanteil-unter-den-lehrkraeften-in-deutschland-nach-schulart/

Steffensky, M., Gold, B., Holdynski, M., and Möller, K. (2015). Professional vision of classroom management and learning support in science classrooms—Does professional vision differ across general and content-specific classroom interactions? *International Journal of Science and Mathematics Education*, *13*(2), 351–368. https://doi.org/10.1007/s10763-014-9607-0

Stockero, S. L., and Stenzelbarton, A. D. (2017). An exploration of how aspects of a noticing intervention supported prospective mathematics teacher noticing [Conference session]. Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Indianapolis, IN. Retrieved January 17, 2023, from https://files.eric.ed.gov/fulltext/ED581343.pdf

Stürmer, K., Könings, K. D., and Seidel, T. (2013). Declarative knowledge and professional vision in teacher education: effect of courses in teaching and learning. *British Journal of Educational Psychology*, *83*(3), 467–483. https://doi.org/10.1111/j.2044-8279.2012.02075.x

Stürmer, K., Seidel, T., Müller, K., Häusler, J., and S. Cortina, K. (2017). What is in the eye of preservice teachers while instructing? An eye-tracking study about attention processes in different teaching situations. *Zeitschrift für Erziehungswissenschaft*, *20*(S1), 75–92. https://doi.org/10.1007/s11618-017-0731-9

Södervik, I., Vilppu, H., and Boshuizen, H. E. M., Mari. (2022). Development of university teachers' professional vision of students' prior knowledge during a short pedagogical training. *International Journal of Teaching and Learning in Higher Education*, *34*(1), 7–24. Retrieved January 17, 2023, from https://www.isetl.org/ijtlhe/pdf/IJTLHE4229.pdf

Tatler, B. W., Kirtley, C., Macdonald, R. G., Mitchell, K. M. A., and Savage, S. W. (2014). The active eye: perspectives on eye movement research. In *Current Trends in Eye Tracking Research* (pp. 3–16). https://doi.org/10.1007/978-3-319-02868-2_1

Tatler, B. W., Wade, N. J., Kwan, H., Findlay, J. M., and Velichkovsky, B. M. (2010). Yarbus, eye movements, and vision. *i-Perception*, *1*(1), 7–27. https://doi.org/10.1068/i0382

Teufel, C., and Nanay, B. (2017). How to (and how not to) think about top-down influences on visual perception. *Consciousness and Cognition*, *47*, 17–25. https://doi.org/10.1016/j.concog.2016.05.008

Theelen, H., van den Beemt, A., and den Brok, P. (2019). Classroom simulations in teacher education to support preservice teachers' interpersonal competence: A systematic literature review. *Computers and Education*, *129*, 14–26. https://doi.org/https://doi.org/10.1016/j.compedu.2018.10.015

Thomas, L. (2013). *Unterrichtsstörungen mit System begegnen. Flexible Stategien für schwierige Situationen* (1st ed.). Raabe.

Thorndyke, P. W., and Yekovich, F. R. (1980). A critique of schema-based theories of human story memory. *Poetics*, *9*(1-3), 23–49. https://doi.org/https://doi.org/10.1016/0304-422X(80)90011-X

Tranfield, D., Denyer, D., and Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*(3), 207–222. https://doi.org/https://doi.org/10.1111/1467-8551.00375

Treisch, F. (2018). *Die Entwicklung der Professionellen Unterrichtswahrnehmung im Lehr-Lern-Labor Seminar* [Doctoral dissertation]. [Würzburg]: Julius-Maximilians-Universität. ProQuest. https://www.proquest.com/docview/2089254784?pq-origsite=gscholarandfromopenview=true

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, *17*(7), 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Vaidyanathan, P., Prud'hommeaux, E., Pelz, J. B., Alm, C. O., and Haake, A. R. (2016, March 14-17). *Fusing eye movements and observer narratives for expert-driven* *image-region annotations* (pp. 27–34) [Conference session]. Proceedings of the Ninth Biennial ACM Symposium on Eye Tracking Research and Applications, Charleston, SC, United States. https://doi.org/10.1145/2857491.2857542

van den Bogert, N. (2016). *On teachers' visual perception and interpretation of classroom events using eye tracking and collaborative tagging methodologies* [Doctoral dissertation]. [Einhoven]: Technische Universiteit Eindhoven. https://pure.tue.nl/ws/files/12966900/20160116_Bogert.pdf

van den Bogert, N., van Bruggen, J., Kostons, D., and Jochems, W. (2014). First steps into understanding teachers' visual perception of classroom events. *Teaching and Teacher Education*, *37*, 208–216. https://doi.org/10.1016/j.tate.2013.09.001

van Driel, S., Jarodzka, H., Crasborn, F., van Strien, J., and Brand-Gruwel, S. (2022). Capturing and characterizing teachers' noticing as basis for their classroom management in different career stages: a data paper. *International Journal of Research and Method in Education*, 1–13. https://doi.org/10.1080/1743727X.2022.2110230

van Es, E. A. (2011). A framework for learning to notice student thinking. In M. G. Sherin, V. R. Jacobs, and R. A. P. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 134–151). Taylor and Francis.

van Es, E. A., and Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571–596. Retrieved January 17, 2023 from https://www.learntechlib.org/primary/p/9171/

van Es, E. A., and Sherin, M. G. (2006). How different video club designs support teachers in "learning to notice". *Journal of Computing in Teacher Education*, *22*(4), 125–135. Retrieved January 17, 2023, from https://files.eric.ed.gov/fulltext/EJ876909.pdf

van Es, E. A., and Sherin, M. G. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education*, *24*(2), 244–276. https://doi.org/10.1016/j.tate.2006.11.005

van Es, E. A., and Sherin, M. G. (2010). The influence of video clubs on teachers' thinking and practice. *Journal of Mathematics Teacher Education*, *13*(2), 155–176. https://doi.org/10.1007/s10857-009-9130-3

van Es, E. A., and Sherin, M. G. (2021). Expanding on prior conceptualizations of teacher noticing. *ZDM – Mathematics Education*, *53*(1), 17–27. https://doi.org/10.1007/s11858-020-01211-4

van Gog, T., Jarodzka, H., Scheiter, K., and Paas, F. (2009). Attention guidance during example study via the model's eye movements. *Computers in Human Behavior*, *25*(3), 785–791. https://doi.org/10.1016/j.chb.2009.02.007

Van Wee, B., and Banister, D. (2015). How to write a literature review paper? *Transport Reviews*, *36*(2), 278–288. https://doi.org/10.1080/01441647.2015.1065456

VERBI Software. (2019). MAXQDA 2020 [Computer software]. [Berlin, Germany]: VERBI Software, available from: https://www.maxqda.com/de/

Voss, T., Kunina-Habenicht, O., Hoehne, V., and Kunter, M. (2015). Stichwort Pädagogisches Wissen von Lehrkräften: Empirische Zugänge und Befunde. *Zeitschrift für Erziehungswissenschaft*, *18*(2), 187–223. https://doi.org/10.1007/s11618-015-0626-6

Voss, T., Kunter, M., and Baumert, J. (2011). Assessing teacher candidates' general pedagogical/psychological knowledge: Test construction and validation. *Journal of Educational Psychology*, *103*(4), 952–969. https://doi.org/10.1037/a0025125

Wade, N. J., and Tatler, B. W. (2005). *The moving tablet of the eye: The origins of modern eye movement research*. Oxford University Press.

Weber, K. E., Prilop, C. N., Viehoff, S., Gold, B., and Kleinknecht, M. (2020). Fördert eine videobasierte Intervention im Praktikum die professionelle Wahrnehmung von Klassenführung? – Eine quantitativ-inhaltsanalytische Messung von Subprozessen professioneller Wahrnehmung. *Zeitschrift für Erziehungswissenschaft*, *23*(2), 343–365. https://doi.org/10.1007/s11618-020-00939-9

Wee, B. V., and Banister, D. (2015). How to write a literature review paper? *Transport Reviews*, *36*(2), 278–288. https://doi.org/10.1080/01441647.2015.1065456

Wettstein, A., and Scherzinger, M. (2019). *Unterrichtsstörungen verstehen und wirksam vorbeugen* (1st ed.). Kohlhammer Verlag.

Winkel, R. (2021). *Der gestörte Unterricht. Diagnostische und therapeutische Möglichkeiten* (12th ed.). Schneider Verlag.

Wiścicka, E. (2014). Expertise in Teaching. *Annales Neophilologiarum*, *8*, 203–217. Retrieved January 17, 2023, from https://bazhum.muzhp.pl/media/files/Annales_Neophilologiarum/Annales_Neophilologiarum-r2014-t-n8/Annales_Neophilologiarum-r2014-t-n8-s203-217/Annales_Neophilologiarum-r2014-t-n8-s203-217.pdf

Wolff, C. E. (2016). *Revisiting "withitness": Differences in teachers´s representations, perceptions, and interpretations of classroom management* [Doctoral dissertation]. [Heerlen]: Open University of the Netherlands. https://research.ou.nl/ws/files/33374782/E_book_Dissertatie_Charlotte_Wolff_2016.pdf

Wolff, C. E., Jarodzka, H., and Boshuizen, H. P. A. (2017). See and tell: Differences between expert and novice teachers' interpretations of problematic classroom management events. *Teaching and Teacher Education*, *66*, 295–308. https://doi.org/10.1016/j.tate.2017.04.015

Wolff, C. E., Jarodzka, H., and Boshuizen, H. P. A. (2021). Classroom management scripts: A theoretical model contrasting expert and novice teachers' knowledge and awareness of classroom events. *Educational Psychology Review*, *33*(1), 131–148. https://doi.org/10.1007/s10648-020-09542-0

Wolff, C. E., Jarodzka, H., van den Bogert, N., and Boshuizen, H. P. A. (2016). Teacher vision: expert and novice teachers' perception of problematic classroom management scenes. *Instructional Science*, *44*(3), 243–265. https://doi.org/10.1007/s11251-016-9367-z

Wolff, C. E., van den Bogert, N., Jarodzka, H., and Boshuizen, H. P. A. (2015). Keeping an Eye on Learning. *Journal of Teacher Education*, *66*(1), 68–85. https://doi.org/10.1177/0022487114549810

Wright, A. M., Salas, J. A., Carter, K. E., and Levin, D. T. (2022). Eye Movement Modeling Examples guide viewer eye movements but do not improve learning. *Learning and Instruction*, *79,* 1–9. https://doi.org/10.1016/j.learninstruc.2022.101601

Wyss, C., Rosenberger, K., and Bührer, W. (2020). Student teachers' and teacher educators' professional vision: Findings from an eye tracking study. *Educational Psychology Review*, *33*(1), 91–107. https://doi.org/10.1007/s10648-020-09535-z

Yarbus, A. L. (1967). *Eye movements and vision*. Plenum Press.

Ylitalo, A.-K. (2017). *Statistical inference for eye movement sequences using spatial and spatio-temporal point processes*. [Doctoral dissertation]. [Jyväskylä]: University of Jyväskylä, Department of Mathematics and Statistics. http://urn.fi/URN:ISBN:978-951-39-7064-2

Zawacki-Richter, O., Kerres, M., Bedenlier, S., Bond, M., and Buntins, K. (2020). *Systematic reviews in educational research*. Springer Nature. https://doi.org/10.1007/978-3-658-27602-7

7 Appendix

7.1 Publications

Publication I

Grub, A.-S., Biermann, A., and Brünken, R. (2020). Process-based measurement of professional vision of (prospective) teachers in the field of classroom management: a systematic review. *Journal for Educational Research Online*, *12*(3), 75–102. https://doi.org/10.25656/01:21187

Publication II

Grub, A.-S., Biermann, A., Lewalter, D., and Brünken, R. (2022a). Professional knowledge and task instruction specificity as influencing factors of prospective teachers' professional vision. *Teaching & Teacher Education*, *109*, 1–14. https://doi.org/10.1016/j.tate.2021.103517

Publication III

Grub, A.-S., Biermann, A., Lewalter, D., and Brünken, R. (2022b). Professional vision and the compensatory effect of a minimal instructional intervention: A quasi-experimental eye-tracking study with novice and expert teachers. *Frontiers in Education*, *7*: 890690, 1–17. https://doi.org/10.3389/feduc.2022.890690

Publication IV

Grub, A.-S., Biermann, A., and Brünken, R. (in press). Eye Tracking as a Process-Based Methodology to Examine Teachers' Professional Vision. In A. Gegenfurtner and R. Stahnke (Ed.), *Teacher Professional Vision: Theoretical and Methodological Advances (Part 1)*. Routledge.

7.2 Extended Summary of Collected Variables

In addition to the variables already described in detail in Sections 4.2.2 and 4.3.2, further parameters were measured for consideration as possible control variables. As they were not relevant to the previously published articles and the present doctoral thesis, they were not discussed in the thesis. However, the table below provides a brief overview of all of the parameters measured in Studies I and II.

Questionnaire	Information about the Questionnaire	Study I	Study II
Self-created questionnaire about **demographic data**	Gender, age, grade point average (GPA), teaching experience (in years for teachers and hours for students), teaching subjects, instructional level, type of school, federal state, semester and, for teachers, type of employment (part-time/full-time)	X	X
PPHW-K (unpublished survey on the pedagogical-psychological knowledge of teachers in the field of classroom management; Brühwiler et al. 2017)	Nine text vignettes (only 7 vignettes used for analysis; V4 und V12 excluded based on test quality criteria) Available from the authors	X	X

STSE (German adaptation [Pfitzner-Eden, 2016] of the Teacher's Sense of Efficacy Scale from Tschannen-Moran & Woolfolk Hoy, 2001).	12 items Availability: Pfitzner-Eden, F. (2016). STSE. Scale for Teacher Self-Efficacy - deutsche adaptierte Fassung [Verfahrensdokumentation und Fragebogen]. In Leibniz-Institut für Psychologie (ZPID) (Hrsg.), Open Test Archive. Trier: ZPID. https://doi.org/10.23668/psycharchives.6585	X	X
Adapted version of Klepsch et al.'s (2017) **Cognitive Load Questionnaire**	Cognitive Load (Intrinsic Cognitive Load, Extraneous Cognitive Load) Four items: [12] (1) To recognize relevant situations in the video, you had to keep many things in mind at the same time. (ICL) (2) Recognizing relevant situations was very complex. (ICL) (3) When searching for relevant situations in the video it was tedious to pick out the most important information. (ECL) (4) The presentation was unfavorable for spotting relevant situations. (ECL)	X	X
Self-Assessment Manikin (SAM; Bradley & Lang, 1994)	Two items: arousal, pleasure Available at https://csea.phhp.ufl.edu/media.html	X	X

[12] Original items:
(1) Um relevante Situationen im Video zu erkennen, musste man viele Dinge gleichzeitig im Kopf behalten. (ICL)
(2) Relevante Situationen zu erkennen war sehr komplex. (ICL)
(3) Bei der Suche nach relevanten Situationen im Video war es mühsam, die wichtigsten Informationen zu entdecken. (ECL)
(4) Die Darstellung war ungünstig, um relevante Situationen zu entdecken. (ECL)

Self-created questions relating to the **video vignettes**	Six items [13] about engagement, authenticity, quality, observation, and seriousness: (1) When working on the task, I worked hard. (engagement) (2) Did you work on the video task to the best of your ability? (seriousness video) (3) How realistic did you feel the video was? (authenticity) (4) Was the quality of the video good enough for you to do the task? (quality) (5) How easy did you find it to identify relevant situations? (observation) (6) Did you answer the questions to the best of your ability? (seriousness questions)	X	X
d2-R (Brickenkamp et al., 2010)	Test of Attention Revised (paper-pencil version)	/	X

[13] Original items:
(1) Bei der Bearbeitung der Aufgabe habe ich mich angestrengt.
(2) Haben Sie die Videoaufgabe nach bestem Wissen und Gewissen bearbeitet?
(3) Wie realitätsnah haben Sie das Video empfunden?
(4) War die Qualität des Videos gut genug, um die Aufgabe zu bearbeiten?
(5) Wie einfach ist es Ihnen gefallen, relevante Situationen zu identifizieren?
(6) Haben Sie die Fragen nach bestem Wissen und Gewissen beantwortet?