Attention Distribution and Gaze Patterns of In-Service and Pre-Service Teachers with a Particular View on Student Diversity

Evidence from a Meta-Analytic Review and Eye-Tracking Studies

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… To

Anne, Baba,

Öykü, Özgü, Önür,

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List of Original Papers

Keskin, Ö., Seidel, T., Stürmer, K., & Gegenfurtner, A. (2024). Eye-tracking research on teacher professional vision: A meta-analytic review. *Educational Research Review*, *42*, 100586. https://doi.org/10.1016/j.edurev.2023.100586

Keskin, Ö., Gabel, S., Kollar, I., & Gegenfurtner, A. (2023). Relations between pre-service teacher gaze, teacher attitude, and student ethnicity. *Frontiers in Education*, *8*, 1272671. https://doi.org/10.3389/feduc.2023.1272671

Keskin, Ö., Kosel, C., Stahnke, R., Gabel, S., Alijagic, A., & Gegenfurtner, A. (submitted). Students' gender and engagement in teachers' scanpaths. *Learning & Instruction.*

Zusammenfassung

Professionelle Unterrichtswahrnehmung gilt als eine wichtige Kompetenz, die Lehrpersonen beherrschen sollten. Bisherige Untersuchungen konnten mit der Eye-Tracking Technologie in Bereichen wie Unterrichtstörung und Klassenmanagement einige Forschung betreiben. Jedoch gibt es weitere Herausforderungen, mit denen Lehrpersonen täglich konfrontiert sind. Vor diesem Hintergrund war es Ziel der vorliegenden Dissertation, vertiefende Fragen zur professionellen Unterrichtswahrnehmung von Lehrpersonen bezüglich des Migrationshintergrunds und Geschlechts von Lernenden in drei Studien zu erforschen.

In Studie 1 wurden zunächst 98 empirische Studien zur professionellen Unterrichtswahrnehmung mit Eye Tracking zusammengefasst, synthetisiert und meta-analytische erforscht.

Für Studie 2 wurden mit der Eye-Tracking Technologie die Augenbewegungen von 83 Lehramtsstudierenden aufgenommen, während diese ein authentisches Unterrichtsvideo im Fach Kunst der Unterstufe mit verschiedenen Migrationshintergründen betrachteten. Lehramtsstudierende zeigten eine häufigere und längere Fixation auf Lernende mit Migrationshintergründen, welche mit der Notwendigkeit an Förderung und Unterstützung begründet werden kann.

Für Studie 3 wurden mit der Eye-Tracking Technologie die Blickmuster von 20 Lehramtsstudierenden und 20 Lehrpersonen analysiert, während diese ein authentisches Unterrichtvideo im Fach Mathematik der Mittelstufe mit Mädchen und Jungen und verschiedenen Graden an Engagement betrachteten. Lehrpersonen zeigten ein gleichmäßig verteiltes Blickmuster, wohingegen Lehramtsstudierende eher ungleichmäßig verteilte Blickmuster zeigten.

Zusammenfassend kann festgehalten werden, dass das Blickverhalten von Lehrpersonen eine entscheidende Bedeutung für das Lehren und Lernen hat. Studien zur professionellen Unterrichtswahrnehmung mit der Eye-Tracking Technologie ermöglichen eine reflexive Auseinandersetzung mit dem eigenen Blickverhalten, sodass Lehrpersonen effektiver lehren und den Lernenden gleichberechtigen Unterricht ermöglichen.

Abstract

Teacher professional vision is considered a crucial competence that teachers should master. Previous research has employed eye-tracking technology to explore areas such as classroom disruptions and classroom management. However, teachers face additional daily challenges that require further investigation. Against this backdrop, the present dissertation seeks to deepen the understanding of teachers' professional classroom perceptions, particularly regarding the ethnicity and gender of students.

Sub-study 1 synthesized, summarized, and conducted a meta-analytic investigation of 98 empirical studies on teacher professional vision with eye tracking. This comprehensive review laid the foundation for further research into the nuances of classroom perception.

Sub-study 2 employed eye-tracking technology to analyze the gaze behavior of 83 pre-service teachers as they viewed an authentic classroom video featuring lower-secondary art students from diverse ethnic backgrounds. The findings revealed that pre-service teachers exhibited more frequent and prolonged fixations on ethnic minority students, a pattern that may be attributed to a perceived need for additional support and attention.

In sub-study 3, the gaze patterns of 20 pre-service and 20 in-service teachers were examined using eye-tracking technology while they watched an authentic classroom video in a middle-secondary mathematics setting featuring both boys and girls with varying levels of engagement. In-service teachers demonstrated evenly distributed gaze patterns, whereas per-service teachers exhibited uneven distribution.

The findings underscore the pivotal role of teachers' gaze behavior in shaping teaching and learning processes. Research on teacher professional vision using eye-tracking technology offers valuable opportunities for teachers to reflect on their gaze behavior. Such reflection can enhance teaching effectiveness and support equitable classroom practices, ensuring that all students receive fair and inclusive instruction.

1 Introduction

Teachers are confronted with different challenges throughout their career. These challenges are distinguished on an organizational (e.g., creating a lesson plan; Oktafiyani et al., 2021), a personal (e.g., low level of self-efficacy) and/or a student level (e.g., student heterogeneity; Skaalvik & Skaalvik, 2010; Zeng et al., 2024). A remaining difficult challenge to manage is heterogeneity in classrooms (Markic, 2014). In late 2023, the global number of forced displacements reached nearly 120 million (UNHCR, 2023). Due to more wars worldwide (e.g., in Ukraine, Syria, Palestine), climate change in countries (e.g., in Somalia), and human rights violations (e.g., in Haiti), families are forced to leave their countries for safety reasons (UNHCR, 2023). This leads to more foreign children in countries such as Germany or Turkey (UNHCR, 2023) and new challenges for teachers. Moreover, persistent gender gaps in school remain a significant challenge in many countries, limiting opportunities for women and girls (Evans et al., 2021). Therefore, teachers are expected to mitigate behavioral disparities and promote equitable participation and outcomes for all students, regardless of gender. These, among other challenges, are more difficult to overcome for pre-service teachers than for in-service teachers (Wolff et al., 2015), as in-service teachers bring more experience and knowledge into the classroom. Essentially, mastering such challenges requires the development of professional vision (Sherin & van Es, 2009).

Teacher professional vision is characterized by the knowledge-based ability of teachers to notice and interpret classroom situations and act subsequently (König et al., 2022; Seidel & Stürmer, 2014; van Es & Sherin, 2002). Both, Noticing and Reasoning are dimensions describing teachers' knowledge and actions (Blömeke et al., 2015). However, teachers' professional vision has various definitions in the literature, which will be discussed in chapter

2. Nonetheless, authors agree on one thing: professional vision is a key competence which can lead to successful learning and instruction (Stürmer et al, 2013; Blömeke et al., 2015) and, therefore, has a great impact on student academic performance and achievement (Stahnke & Gegenfurtner, 2025).

Previous research shows a wide range of measures for professional vision such as interviews, questionnaires, or video analysis (Seidel et al., 2011). Another prominent option is to use eye tracking. Prior studies employing eye-tracking technology related to teachers' professional vision are based on the expert-novice paradigm (Gegenfurtner et al., 2020; Keller et al., 2022; van den Bogert et al., 2014; Wolff et al., 2016). Eye tracking has been used on the one hand in controlled settings, such as laboratory settings involving screen-based eye tracking, where teachers watched classroom videos (Stahnke & Blömeke, 2021; Kosel et al, 2021; Wolff et al., 2016; Grub et al., 2022; Seidel et al., 2021). On the other hand, eye tracking has also been employed in uncontrolled settings, such as face-to-face classroom situations involving mobile eye tracking, where teachers taught in authentic environments (Dessus et al., 2016; Goldberg et al., 2021; Haataja et al., 2019; Huang et al., 2021b; McIntyre & Foulsham, 2018).

In sum, the present thesis provides novel addition to the limited literature on teacher noticing in terms of visual focus of attention in authentic classroom settings. In the sub-studies, the associations between teachers' visual focus of attention and teacher- and student-related factors were investigated in depth with the help of meta-analytical, quantitative, and qualitative methods. This thesis has three main aims: first, to meta-analytically study previous eye-tracking studies in a theoretical, methodological, and outcome-related manner; second, to examine the association between teachers' visual focus of attention in a heterogeneous classroom on ethnic minority and majority students as well as their attitudes towards these student groups; and third, to explicate the association between teachers' visual focus and the gender of the student as well

as how their scanpath patterns change in response to students with different levels of engagement.

2 Conceptual Framework

In the following, the most important theoretical background for my research is introduced. There are chapters regarding in-service and pre-service teachers (2.1. teacher professional vision as a key competence of teachers, 2.3. teacher attitudes as an opportunity or threat for students) and chapters regarding students (2.2. student heterogeneity as a challenge in classrooms, 2.4. student engagement as an interactive process). These are examined more closely and framed to produce a synthesized thesis. Based on this outline, the concepts underlying the published articles should gain context and synthesis.

2.1. Teacher Professional Vision as a Key Competence of Teachers

Teacher professional vision has been defined as teachers' noticing of classroom events and their knowledge-based reasoning about the identified classroom events (Seidel & Stürmer, 2014). Noticing is the "ability to notice features of a practice that are valued by a particular social group" (van Es & Sherin,2008; p. 244). According to van Es and Sherin (2021), noticing is not only a passive process of deciphering students, but rather an active process that facilitates the shaping of classroom interactions for teachers to access more information for in-depth observation and interpretation of student thinking during lessons. Propositions to model teacher professional vision differ according to their understanding and conceptualize facets of the phenomenon (Barth, 2017). Out of the existing models of teacher professional vision in the literature, a distinction can be made between procedural models (CTVE; Cognitive Theory of Visual Expertise; Gegenfurtner et al., 2023; Modeling Competence as a Continuum; Blömeke et al., 2015) and structural models (Noticing and Reasoning as Two Components of

Professional Vision; Seidel & Stürmer, 2014; (Revised) Learning to Notice Framework; van Es & Sherin, 2002; 2021).

The *CTVE model* (Gegenfurtner et al., 2023) describes the visual information processing of experts. The theory presents three basic assumptions of professional vision: extended capacity, knowledge-based processing, and practice-based interactions. Moreover, the model is based on eight processes in the visual register and long-term memory: selecting and ignoring visual information, knowledge-based noticing, extending the visual field through parafoveal processing, organizing image chunks, integrating, using visual practices to interact with the environment, and monitoring.

The *Modeling Competence as a Continuum* (Blömeke et al., 2015) posits that situational and behavioral factors serve as intermediaries between cognitive dispositions and performance in specific contexts. Therefore, competence is to be understood as a continuum where (1) behavioral approaches, which use behavioral analyses to create competence profiles and (2) competence is understood as a totality of cognitive and motivational resources. This emphasizes that individuals have all the necessary resources at their disposal and can perform well through combination and performance. The cognitive dispositions (professional knowledge; Casale et al., 2016) and affective-motivational dispositions (self-efficacy; Schunk & DiBenedetto, 2021) are considered to be learnable but relatively stable. In order to manifest competent behavior as situational performance, situation-specific skills in the areas of perception, interpretation, and decision-making are used (Shavelson, 2013).

In the *Noticing and Reasoning as Two Components of Professional Vision*, Seidel and Stürmer (2014) describe noticing as paying attention to important classroom events and focus on goal clarity and orientation, teacher support and guidance, and learning climate as relevant

components of teaching. Reasoning is described as interpreting the noticed classroom events with focus on description, explanation, and prediction.

The *(Revised) Framework of Noticing* (van Es & Sherin, 2002; 2021) in professional vision, describes a distinction between three interacting processes: attending, interpreting, and shaping. According to this model, attending refers to the ability of teachers to recognize events that are relevant for teaching and learning while ignoring irrelevant events through processes of selective attention. Furthermore, interpreting describes the ability of teachers to apply knowledge of teaching and learning and draw appropriate conclusions and predictions. Shaping, as a third process in noticing, describes the ability of teachers to entail constructing interactions and contexts to gain access to additional information and supports in-depth noticing.

In this thesis, "noticing" will be defined as the ability of teachers to selectively attend events in the classroom (Sherin, 2007). The "reasoning"- component is not a primary focus of my investigations.

2.2. Eye Tracking as a Tool in Teacher Education

In recent years, eye tracking became more and more relevant in educational science research (Jarodzka et al., 2017), research on teacher professional vision (Grub et al., 2020, Cortina et al., 2018, McIntyre et al., 2020; Keskin et al., 2023a), and expertise research (Beach & McConnel, 2018).

In expertise research, eye-tracking technology is a widespread tool to record and analyze eye movements. Its use has been applied in different domains such as reading (Rayner, 2009), chess (Chase & Simon, 1973), sports (Mann et al., 2007), and medicine (Ashraf et al., 2018). Eye movements rely on two classified events: fixations and saccades. Fixations are described

as a period of time where the eye is nearly motionless and focuses on a certain spot (Holmqvist et al., 2011). Saccades are described as the eyes' fast motion from one fixation to the next (Holmqvist et al., 2011). Furthermore, scanpath analyses might be a crucial method for investigating gaze patterns. Noton and Stark (1971a, b) point out how to evaluate eye movements and gaze behavior of individuals with scanpath analysis. This theory suggests that when individuals observe an image, they encode both the visual features of the scene and the particular gaze patterns used while viewing it.

Previous research relies on the assumption that the position of the eye is associated with the position of attention. Just and Carpenter (1976, 1980) were the first to propose the eye-mind hypotheses. They assumed that a person fixates on those areas that are being processed at a given moment and that the duration of fixation is a direct indicator of the duration of the cognitive processing of the fixated area. However, this assumption is relatively contradictory in the literature, as there are studies showing results weakening this hypothesis (Anderson et al., 2004). In addition, it is noteworthy that eye-tracking studies should make assumptions about the link between gaze and attention when triangulating eye tracking data with other data sources (e.g. verbal data) (Orquin & Holmqvist, 2018).

2.3. Student Heterogeneity as a Challenge in the Classroom

Students differ in multiple ways. Thus, there are differences which are visible to the eye and differences that are not visible to the eye. Differences which are visible to the eye might be student characteristics such as gender, ethnicity, physical disability (Weinert, 2001). Differences which are not visible to the eye might be beliefs, motivation, emotion, intelligence.

However, teachers are not prepared for these challenges and have to learn to manage and overcome them on their own (teaching experience, challenges). Their ability to succeed in

fulfilling these challenges depends on their skill to visually perceive and process all the information aggregated from the classroom (Wolff et al., 2016). Moreover, teachers must develop strong interpersonal skills to effectively communicate with and engage their students. This involves understanding the individual needs and learning styles of each student and creating an inclusive and supportive classroom environment that fosters collaboration and mutual respect (Marzano & Marzano, 2003). One of the most significant aspects of this challenge is the inherent heterogeneity within modern classrooms. Students come from diverse backgrounds and bring a wide range of experiences and perspectives. This diversity includes differences in gender, ethnicity, disability, sexual orientation, or cultural background. Each of these factors can influence a student's learning process and classroom dynamics (Banks & Banks, 2019). For example, students from different cultural backgrounds might have unique perspectives and learning preferences that need to be acknowledged and integrated into teaching practices. Additionally, gender and sexual orientation can impact student interactions and participation in various ways (Espelage & Swearer, 2008; Asplund & Orday, 2018). Recognizing and addressing these diverse needs is essential for fostering an equitable learning environment where all students have the opportunity to succeed.

For this thesis, ethnicity and gender are relevant dimensions of heterogeneity as the studies were conducted to investigate these dimensions of heterogeneity. Gender is a dimension of heterogeneity, influencing student characteristics. In classrooms, male students are often stereotyped as disruptive, bad achievers (Kulinna, 2007), while female students are perceived as attentive, motivated, good achievers (Krkovic et al., 2014). However, these perceptions can shift dramatically in STEM education, where male students are typically viewed as motivated

and good achievers, contrasting with the perception of female students as unmotivated and struggling (Fleischmann et al., 2010).

In terms of ethnicity, the differentiation between the two groups (ethnic minority and ethnic majority) seems similar. Studies have shown that teachers may unconsciously exhibit lower expectations for ethnic minority students, which can impact their academic performance and long-term educational outcomes (Ferguson, 2003). Ethnic minority students face greater disadvantages compared to their majority counterparts (Vieluf & Sauerwein, 2018).

These stereotypes and biases on gender and ethnicity highlight significant challenges within the educational environment. Research has shown that these biases not only affect students' self-perceptions and aspirations, but also influence teachers' expectations and instructional practices (Hulleman & Harackiewicz, 2009; Rattan et al., 2015).

To sum up, female students in STEM education experience disadvantages due to their gender, while ethnic minority students face disadvantages due to their ethnicity. However, questions persist regarding whether these disadvantages are influenced by educational factors such as engagement level and classroom management strategies or teacher characteristics like attitudes and experience.

2.4. Teacher Attitudes as an Opportunity or Threat for Students

Attitudes are cognitive associations when assessing or evaluating targets (Fazio, 2007). As outlined in Eagly and Chaiken's (2007) attitude theory, teacher attitudes toward a student group can be interpreted as psychological tendencies reflected in the evaluations of student groups, showing varying degrees of favor or disfavor.

For an educational reform, it is now more important than ever (Savolainen et al., 2020). In a wide range, *inclusion* means to build learning environments where all learners are accepted and embraced, regardless of their ethnicity and gender (Göransson & Nilhom, 2014). In inclusive education, teachers' attitudes are responsible for how students feel included and perceived. In diverse classrooms, the gap in academic achievements and academic expectations differ highly. This sense is also aligned with teachers' judgments and behavior (Van den Bergh et al., 2010; Kumar et al., 2015) – mostly negative. Regarding ethnicity, teachers' beliefs tend to be lower and influence students' academic self-report, self-efficacy, self-consciousness, and self-esteem (McElvany et al., 2023). Moreover, misbehavior shown by ethnic minority students is more likely to be judged by the teacher than misbehavior shown by ethnic majority students (Ebright et al., 2021) and ethnic minority students are more likely to be verbally attacked and discriminated against by their teachers than their ethnic majority peers (Weber, 2003). Regarding gender, teachers' attitudes differ depending on the subject. In STEM education, teachers tend to be more positive towards boys than girls (Lee, 2007) and in language education, teachers tend to be more positive towards girls than boys (Krkovic et al., 2014). This might also influence students' academic achievement in the subjects, as boys are more likely to perform successfully in STEM (Fleischmann et al., 2010) and girls are more likely to perform successfully in languages (Driessen & van Langen, 2013). However, generally, teachers believe that boys show more distracting behavior (Kulinna, 2007) while girls show more active contributions in class (Spilt et al., 2012).

2.5. Resumé of Theoretical Derivation

In this section, a summary of the main components of the conceptual framework will be emphasized including a graphical representation (fig. 1).

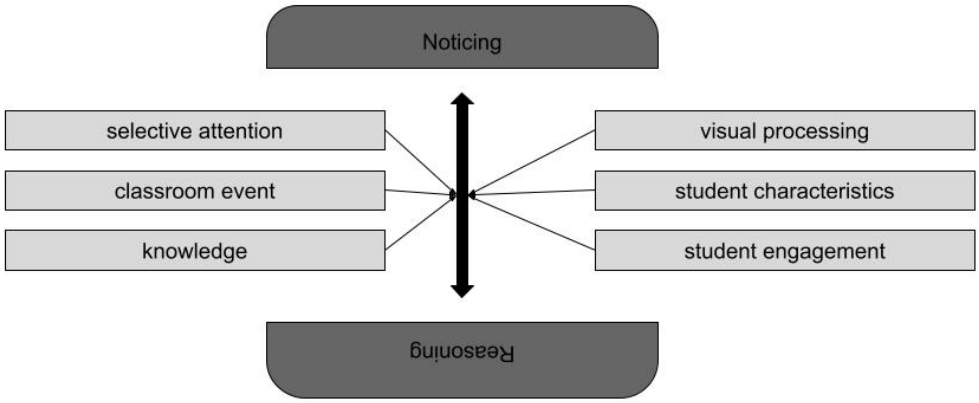

Figure 1. Model summarizing the theoretical derivation based on the presented theory.

Teacher professional vision, defined as the ability to notice and interpret relevant classroom events, serves as a crucial skill for effective classroom management and instruction (Seidel & Stürmer, 2014; van Es & Sherin, 2021). This thesis adopts a refined understanding, focusing exclusively on the noticing component, as it aligns with the study's emphasis on teachers' visual attention and its implications for heterogenous student groups.

The present dissertation draws on several key models to frame teacher professional vision and guide its investigation. The Cognitive Theory of Visual Expertise (CTVE; Gegenfurtner et al., 2023) provides a detailed understanding of how expert teachers prove classroom visual information through mechanisms such as selective attention, parafoveal processing, and integration of visual chunks. This theory highlights the role of knowledge-based and practice-driven interactions in navigating complex classroom events. Complementing this, the Noticing and Reasoning Framework (Seidel & Stürmer, 2014)

distinguishes between noticing (focusing on critical classroom events) and reasoning (interpreting those events). Similarly, the (Revised) Framework of Noticing refines this process into three dynamic components – attending, interpreting, and shaping – showing how teachers actively construct and adapt their focus during classroom interactions. Finally, the Competence as a Continuum (Blömeke et al., 2015) models noticing within a broader framework of teacher competencies, linking cognitive and motivational dispositions to practical teaching performance through perception and interpretation. Together, these models provide a comprehensive foundation for exploring how teachers' visual attention interacts with classroom diversity, particularly in relation to gender and ethnicity.

Based on this theoretical foundation, a number of open research questions were identified, which will be addressed in this dissertation. The first step was to determine the state of research on professional vision and the extent to which it can be compared and synthesized (sub-study 1).

Moreover, it is unclear to what extent the distribution of teachers' attention (Sub-study 2) and scanpath patterns (sub-study 3) differs in a heterogenous (in terms of ethnicity and gender) classroom.

In addition, it is also relevant to determine whether there are expertise differences in the noticing abilities of pre-service and in-service teachers (sub-study 3).

3 Aim of the Thesis

This thesis seeks to shed more light on studies on teachers' professional vision using eye tracking. Research gaps were identified through a meta-analytic review (sub-study 1), which is referenced in this thesis. The research questions followed in this study were to investigate methodological differences in eye tracking studies on teacher professional vision, to analyze differences in the eye movements of novice and expert teachers, to examine outcome-related differences in eye tracking studies on teacher professional vision, and to explore the use of eye-tracking technology in reflection and training in teacher education and teacher professional development.

Furthermore, it was also unclear whether there are any relations between teachers' gaze, student ethnicity, and teacher attitudes. This matter is investigated and discussed in sub-study 2, referenced in this thesis. Research questions followed in this study were to investigate differences in pre-service teachers' gaze on ethnic minority and majority students, and to examine associations between pre-service teachers' gaze movement on ethnic minority and majority students with teachers' attitudes.

In addition, it was unclear whether there are any relations between teachers' gaze, student gender, and student engagement in STEM education. This matter is investigated and discussed in sub-study 3, referenced in this thesis. Research questions followed in this study are to examine scanpath patterns of in-service and pre-service teachers observing engaged and disengaged students of different genders in a STEM subject.

4 Summary of Sub-Studies

In the following, each study will be briefly presented to contribute to the overall aim of this dissertation. The vision was to enhance the research field of teachers' professional vision. More specifically, each study investigated teachers' professional vision either through a meta-analytic review of the research field or an experimental study design. I was the first author in each study and developed the most and essential parts of the study myself. In this section, the main findings of the studies included in this dissertation will be outlined.

4.1. Sub-Study 1

The subsequent is a summary of the journal publication "Eye-tracking studies on teacher professional vision: a meta-analytic review" (see Keskin et al., 2024).

To get an overview of the literature on teacher professional vision with eye tracking, it was necessary to summarize and meta-analytically analyze the current state of research. For this purpose, a meta-analytic review was conducted, which included all publication types reporting original research (journal article, book chapter, thesis, conference paper). Hence, it was possible to present similarities and differences of the included study. The aim was (a) to examine sample, stimulus, and eye movement characteristics of existing research, (b) to present meta-analytically differences in expertise regarding eye-tracking metrics, (c) to aggregate results of existing research, and (d) to find about the usage of eye tracker as a self-reflection and feedback tool. With the results of the meta-analytic review, it was possible to discover desiderata and consequently pose further research questions.

Teacher professional vision, often referred to as teacher noticing (van Es & Sherin, 2021), encompasses the ability to observe, interpret, and respond to classroom situations

effectively. It is a key component of teacher expertise, bridging knowledge and actionable insight in teaching contexts. Drawing from the cognitive theory of visual expertise (Gegenfurtner et al., 2023), sub-study 1 explored how in-service and pre-service teachers process visual information in classrooms. This framework emphasizes three key assumptions: extended capacity in long-term working memory, knowledge-driven processing, and interaction with the environment through visual practices.

The meta-analytical review synthesized findings from 98 eye-tracking studies (see fig. 2), focusing on methodological characteristics, such as sample compositions, visual stimuli, and eye-tracking measures. Inclusion criteria encompassed studies using eye-tracking methods with in-service and pre-service teachers in classroom contexts. Data were aggregated to examine expertise-related differences in gaze patterns and the use of eye-tracking tools for education.

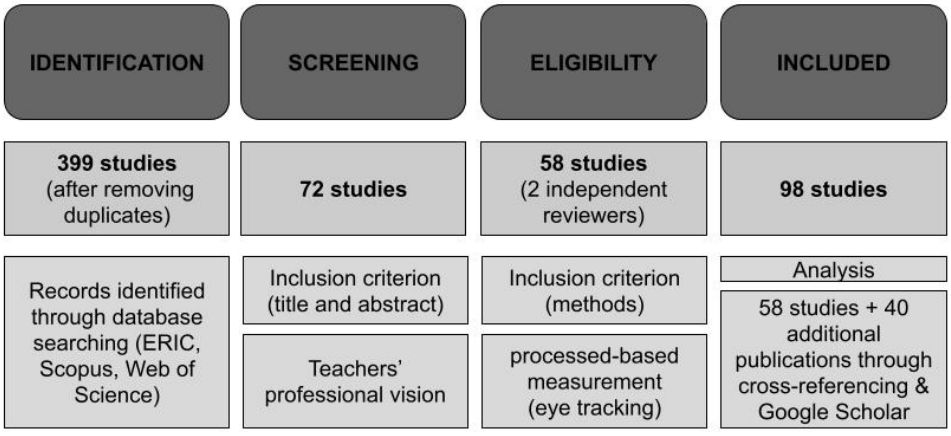

Figure 2. Overview of systematic literature search and procedure following PRISMA (Page et al., 2021).

Sub-study 1 revealed that most studies used video-based or mobile eye-tracking techniques to analyze teachers' gaze behaviors, providing a mix of dynamic and controlled contexts for examining professional vision. Video-based eye tracking allowed researchers to

evaluate teacher gaze in standardized scenarios, while mobile eye tracking captured real-time interactions in classroom settings, adding ecological validity. Despite these advantages, the studies were often constrained by small sample sizes, typically including only a limited number of in-service and pre-service teachers. This highlights the value of meta-analytic synthesis in providing a broader understanding of the patterns observed. The meta-analysis identified significant differences in how in-service and pre-service teachers allocate their attention regarding gaze proportions and gaze distribution. In-service teachers devoted a significantly larger proportion of their gaze to students (g=0.92), demonstrating their ability to focus on critical classroom interaction. In contrast, pre-service teachers were more likely to direct their attention to instructional material and other peripheral objects, reflecting their limited capacity to prioritize key elements of classroom dynamics. In addition, in-service teachers displayed a more balanced distribution of gaze across students (g=0.50), indicating a refined ability to manage their attention equitably among students. Pre-service teachers, on the other hand, tended to focus disproportionately on certain areas or individuals, potentially missing broader classroom patterns. The findings were interpreted through the lens of the cognitive theory of visual expertise (Gegenfurtner et al., 2023), which provided a structured framework for understanding these differences. In-service teachers were shown to combine real-time visual inputs with their extensive long-term working memory, enabling a deeper understanding of classroom events, and employing self-regulation techniques to monitor and adjust their gaze behavior. This ensures that their attention aligns with instructional goals. These abilities reflect a shift from pre-service teachers' bottom-up, stimulus-driven gaze patterns to top-down, knowledge-driven approaches characteristic of in-service teachers.

The meta-analytical review also explored practical applications for enhancing professional vision through training. Tools such as gaze replays and eye movement modelling

examples were highlighted as promising strategies (Van Gog et al., 2024). These methods allow teachers to visualize and reflect on their own or others' gaze patterns, helping them identify areas for improvement. By focusing on equitable attention distribution and prioritizing student engagement, these tools can bridge the gap between in-service and pre-service teachers' visual expertise, fostering more effective classroom management and teaching strategies.

All in all, the sub-study 1 provided valuable insights into the visual expertise of teachers and its implications for teacher education. While experienced teachers demonstrate superior gaze allocation and distribution, integrating eye-tracking technology into training programs can help pre-service teachers enhance their professional vision. Future research should address limitations, including small sample sizes and methodological inconsistencies, to further refine the understanding of gaze behavior in teaching contexts.

4.2. Sub-Study 2

The subsequent is a summary of the journal publication "Relations between pre-service teacher gaze, teacher attitude, and student ethnicity" (see Keskin et al., 2023b).

Ethnicity is a widespread dimension of heterogeneity in classrooms. However, it is still not extensively investigated in the field of teacher professional vision with eye tracking. Therefore, the aim of sub-study 2 was to conduct a study focusing on teachers' visual focus of attention on ethnic minority and majority students.

The aim was (a) to investigate fixations of in-service and pre-service teachers on ethnic minority students, and (b) to investigate correlations of fixations with teacher attitudes, self-efficacy, and stereotypes.

Ethnic minority students often face disadvantages in education, including lower academic achievement (Gomolla, 2006), negative teacher attitudes (Glock & Krolak-Schwerdt, 2013), and limited teacher recognition (Vieluf & Sauerwein, 2019). Drawing on critical race theory (Ledesma & Calderón, 2015) and intersectional theory (Zinn et al., 1986), this sub-study 2 explores how teacher attitudes and stereotypes may influence visual attention and recognition of ethnic minority students. The concept of professional vision, which involves teachers' ability to notice and reason about significant classroom events (Seidel & Stürmer, 2014), forms the basis for analyzing the role of gaze in teacher-student interactions. Prior studies have shown that visual attention often reflects implicit attitudes, making eye-tracking a valuable tool for understanding teacher behavior in diverse classrooms.

The study employed an explanatory sequential mixed-methods design. A total of 83 pre-service teachers from a German university participated. Pre-service teachers watched a 10-minute authentic classroom video while their eye movements were recorded. Four students (two ethnic minority and two ethnic majority students) were identified as Areas of Interest (AOIs) for tracking gaze metrics, including fixation number, fixation duration, and time to first fixation. After the video, participants completed a survey measuring explicit attitudes, self-efficacy, and stereotypes toward ethnic minority students. Written reflections were also collected to provide qualitative insights into participants' perceptions and experiences.

The quantitative findings show that, contrary to the initial hypothesis, pre-service teachers demonstrated longer fixation durations on ethnic minority students compared to ethnic majority students. This visual preference was independent of student behavior or AOI characteristics. Moreover, positive correlations were observed between explicit attitudes toward ethnic minority students and both fixation number (r=0.26, p<0.05) and fixation duration (r=0.31, p<0.05). Stereotypes and self-efficacy did not show significant correlations with gaze

behavior. The qualitative findings show that participants' written reflections revealed a mix of positive, negative, and neutral perceptions. Positive comments highlighted teacher effort to include ethnic minority students, while negative comments noted neglect or bias in interactions. In addition, created themes included motivation, stereotypes, language difficulties, and personal experience, with many participants reflecting on the complexity of classroom diversity. These findings suggest that gaze behavior is influenced by explicit attitudes and can serve as an indicator of teachers' professional vision in multicultural classrooms.

All in all, sub-study 2 provides insights into the relationship between teacher attitudes and gaze behavior in diverse classrooms. While pre-service teachers' visual attention appears to be positively correlated with favorable attitudes towards ethnic minority students, the findings highlight the complexity of interpreting gaze behavior in terms of recognition versus bias. The results underscore the importance of integrating eye-tracking into teacher education programs to foster awareness and reflection on implicit attitudes and professional vision. Future research should explore gaze patterns in real classrooms and examine how implicit attitudes influence visual attention.

4.3. Sub-Study 3

The subsequent is a summary of the journal publication "The role of student gender and student engagement in teachers' scanpath patterns" (see Keskin et al., submitted).

Given the lack of research on heterogeneity in the field of teacher professional vision with eye tracking, the aim of sub-study 3 was to conduct a study focusing on teachers' visual focus of attention on female and male students and their engagement level in STEM subjects. The emphasis was on discovering whether teachers distribute their attention evenly between

male and female students in STEM education and whether gaze patterns emerge in different students' engagement levels in the classroom.

The aim was (a) to investigate associations between teacher experience, student engagement, and student gender, and (b) to investigate gaze patterns of teachers in attention distribution.

Student gender and engagement are key factors influencing teacher perceptions and interactions in classrooms (Huang et al., 2021b), particularly in STEM education. Previous research highlights persistent gender stereotypes, with boys often perceived as more disruptive and engaged in STEM education (Kulinna, 2007), while girls face biases regarding their abilities (Wang et al., 2023). These stereotypes may unconsciously shape teachers' gaze allocation during classroom interactions. Drawing from the cognitive theory of visual expertise (Gegenfurtner et al., 2023), sub-study 3 explores how in-service and pre-service teachers differ in their visual attention strategies when observing students in STEM education. In-service teachers are thought to exhibit more balanced and strategic gaze patterns, integrating both foveal and parafoveal processing (Gegenfurtner et al., 2023), enabling them to monitor classrooms effectively and equitably.

40 teachers (20 in-service teachers, 20 pre-service teachers) participated in this eye-tracking study. Participants watched an 80-second video of an authentic mathematics classroom while their eyes were recorded. The video, set from the teachers' perspective, showed engaged and disengaged boys and girls. Areas of Interest (AOIs) were manually defined to track fixation counts, transitions, and hit proportions for engaged boys, engaged girls, and disengaged boys. Post-video survey captured participants' demographic and cognitive data, including perceived mental effort (Zijlastra & Van Doorn, 1985). Data analysis included hit proportion for each AOI, transition probabilities between AOIs, and scanpath clustering to identify distinct

attention strategies. Transition matrices and heatmaps visualized differences between in-service and pre-service teachers.

The findings show that in-service teachers significantly focused more on engaged girls (t=4.51, p<0.001) and less on disengaged boys (t=-3.12, p<0.003) compared to pre-service teachers. Pre-service teachers, in contrast, focused more on disengaged boys (M=0.59, SD=0.09) and engaged boys (M=0.32, SD=0.07), reflecting attention patterns influenced by classroom management challenges. Moreover, pre-service teachers exhibited frequent transitions to disengaged boys, often shifting from engaged girls or engaged boys. This reactive pattern indicates a struggle with prioritizing relevant information. In-service teachers, in contrast, displayed a more balanced transition pattern, transitioning evenly between engaged and disengaged students. In addition, sub-study 3 identified three clusters that relate to the visual attention strategies of teachers. Teachers in cluster 1 focused on disengaged boys (dominated by pre-service teachers), teachers in cluster 2 balanced across all categories (exclusive to in-service teachers), and teachers in cluster 3 emphasized engaged students (a mix of pre-service and in-service teachers). The results support the cognitive theory of visual expertise (Gegenfurtner et al., 2023), demonstrating that in-service teachers use knowledge-based processing and metacognitive strategies to distribute their attention effectively, whereas pre-service teachers tend to rely on reactive, stimulus-driven patterns.

All in all, sub-study 3 reveals significant differences in gaze behavior between in-service and pre-service teachers, shaped by their level of expertise. In-service teachers' ability to focus on engaged girls and balance attention across students aligns with their expertise in classroom management and stereotypes awareness. In contrast, pre-service teachers' disproportionate focus on disengaged boys underscores the need for training programs emphasizing balanced visual attention and stereotypes reduction. Future research should incorporate more diverse

classroom settings, longer observation durations, and measures of implicit attitudes to deepen understanding of gendered gaze behaviors and foster equitable teaching practices.

5 General Discussion of the Results

In this chapter, I outline the main findings of this thesis, draw conclusions about the overall research of this thesis and discuss its limitations. I then relate these findings to previous findings and conclusions and suggest new directions for research and practice.

5.1. Limitations

Publication bias is a recurring concern in meta-analytic reviews. Studies with significant or favorable results are more likely to be published, leaving out potentially valuable insights from studies with non-significant findings. This imbalance can lead to an incomplete understanding of the research field. Although sub-study 1 addresses this issue by including a wide range of publication types (e.g., journal articles, conference papers, theses) and studies in various languages, the meta-analysis may still reflect a bias towards positive outcomes. This limitation underscores the need for caution when interpreting findings, as they might not represent the full range of research conducted on teacher professional vision and eye-tracking.

Due to constraints in available research, only a subset of the identified studies could be included in the meta-analysis. Many potentially relevant studies were excluded because they did not meet inclusion criteria, such as using specific eye-tracking measures or reporting results for direct comparison. This limitation restricts the generalizability of the findings. As more studies in this field become available, future research could expand the meta-analysis to include a broader dataset, offering comprehensive insight into the field. Future research could address publication bias by systematically including unpublished studies to ensure a more

comprehensive representation of the field. Additionally, efforts to standardize reporting practices across studies and encourage the publication of non-significant results would help mitigate this limitation and provide a more balanced view of the evidence.

Eye-tracking studies in teacher professional vision employ a wide array of methodologies, including diverse sample populations (e.g., pre-service and in-service teachers), varied stimuli (videos, real classrooms, virtual reality), and different eye-tracking metrics (e.g., fixations, gaze proportions). These methodological variations make it challenging to compare results directly across studies. Discrepancies in experimental designs, theoretical frameworks, and data analysis approaches further complicate efforts to synthesize findings consistently, potentially impacting the validity of aggregated conclusions. Future research could address these difficulties in direct comparison by promoting the development and adoption of standardized protocols for study design, data collection, and reporting in eye-tracking research. This includes consistent definitions of metrics, common frameworks for categorizing sample populations, and an agreed-upon format for presenting results. Additionally, collaborative efforts across research groups could facilitate the creation of shared datasets and benchmarks, enabling more robust meta-analyses and comparisons. These steps would enhance the reliability and generalizability of findings in teacher professional vision and eye-tracking studies.

In sub-study 2, a major limitation is the sample size. The sample comprised exclusively pre-service teachers from a single university program. This homogeneity limits the diversity of perspectives and experiences within the participant pool, thereby reducing the generalizability of the findings to broader populations, including in-service teachers, educators in other regions, or those from varied educational systems. Moreover, the gender distribution in sub-study 2 reflects the general trend in Germany, where the teaching profession is predominantly female

(German Statistical Federal Office, 2023). 79.5% of the participants were female, which might potentially influence the results due to gendered differences in gaze behavior and attitudes. The lack of a balanced gender sample restricts the applicability of findings to male teachers or those in less female-dominated educational environments.

Sub-study 3 included only teachers from a single urban city in Germany. This geographic concentration limits the findings' applicability to rural areas or other cultural contexts, as urban environments may introduce unique factors influencing teacher-student interactions. Furthermore, the study design inherently includes an age gap between pre-service and in-service teachers, as in-service teachers were defined as having at least five years of teaching experience. This natural gap difference complicates conclusions about the effect of age on professional vision. Research suggests that eye movements, which reflect cognitive functions of the frontal cortical areas, may decline with age (Kramer et al., 2007; Munoz et al., 1998). Thus, observed differences in gaze patterns might be partially attributed to age-related cognitive changes rather than teaching experience alone.

Like sub-study 2, the gender distribution in sub-study 3 might not adequately reflect the diversity in the teaching profession. With 67.5% female participants, the overrepresentation of female teachers could bias the findings and reduce their relevance to more gender-balanced teaching populations.

To improve generalizability and robustness, future studies should include a more diverse sample and incorporate participants from varied geographic locations and teaching contexts. In addition, a more balanced gender representation might ensure applicable findings across male and female teachers. Also, to examine the effects of age and teaching experience independently, using age-matching samples might mitigate confounding variables.

In sub-study 2, the measurement of teacher attitudes toward ethnic minority students was limited to explicit attitudes, as captured through self-report measures (e.g., feeling thermometer). While explicit attitudes provide valuable insights into conscious beliefs and perceptions, they may not fully capture the complexity of attitudes that influence behavior. Implicit attitudes, which are unconscious and automatic, can have a significant impact on teacher-student interactions, including gaze behavior and attention distribution in classrooms. By focusing only on explicit attitudes, sub-study 2 misses the influence of implicit biases, which often unconsciously shape gaze patterns and expectations. Self-reported measures are prone to social desirability bias (Satow, 2012), potentially masking true beliefs. Moreover, implicit attitudes are better predictors of spontaneous behaviors, such as gaze movements, making their exclusion a key limitation in understanding teacher interactions. To address this limitation, future research should incorporate implicit measures (e.g., use tools such as the Implicit Association Test) to assess implicit attitudes. This method can complement explicit self-reports, providing a more comprehensive understanding of teacher attitudes. In addition, investigating the relationship between implicit and explicit attitudes and how they jointly influence gaze behavior and professional vision in the classroom might provide a deeper understanding of conscious and unconscious factors, shaping teacher interactions with ethnically diverse students.

The controlled laboratory setting used in both sub-study 2 and sub-study 3 imposes significant limitations on the external and ecological validity of the findings. Real classrooms are dynamic and multifaceted environments where teachers must simultaneously manage numerous tasks, such as monitoring multiple students, addressing disruptive behaviors, and delivering instruction. This multitasking aspect, a critical component of teaching, is absent in

the laboratory setting, making it challenging to generalize results to real-world teaching scenarios.

Moreover, the use of screen-based eye tracking, as opposed to mobile eye tracking, further reduces ecological validity. Research by Minarikova et al. (2021) indicates that teachers using mobile eye trackers in real classrooms focus more on individual students, while those using screen-based settings distribute their visual attention more evenly across the classroom. This suggests that gaze behavior observed in a lab might not accurately reflect actual classroom practices. To better understand teachers' professional vision, future studies should replicate findings using mobile eye tracking in authentic classroom settings.

In both studies (sub-study 2 and sub-study 3), participants watched videos featuring students they did not know and had no prior background information about. This lack of familiarity likely influenced their gaze behavior and decision-making, as real classroom interactions are often guided by teachers' understanding of students' individual needs and behavior. Additionally, the lack of established relationships with the students may reduce the authenticity of the observed gaze behaviors and diminish the emotional and cognitive engagement typically present in real classroom situations.

In sub-study 2, AOIs were defined to capture fixations on specific students (ethnic minority and majority). While this allows for targeted analysis of gaze behavior, it also excludes non-AOI areas where significant gaze behaviors may occur. The process of defining AOIs may inadvertently bias results, as sub-study 2 defined only few ethnic minority and majority students. Future research should consider using dynamic AOI definitions or incorporate whole-scene analysis to reduce the risk of missing critical gaze data.

In sub-study 3, scanpath patterns were analyzed using AOI-based evaluation, a method that tracks gaze sequences over time and provides diachronic insights into how participants

visually process dynamic scenes (Huang, 2018; Le Meur & Baccino, 2013). While this approach aligns more closely with capturing natural vision over time compared to static fixation metrics (Ramat et al., 2013), its analysis is limited to preselected AOIs, which may not fully reflect the complexity of classroom environments where attention is distributed across multiple competing stimuli. While scanpath patterns are valuable for understanding how attention unfolds, they may oversimplify the differentiated interaction between spatial and temporal gaze dynamics in real classroom situations. Future studies could complement scanpath analysis with broader measures that account for peripheral vision and spontaneous shifts in gaze outside predefined AOIs to better simulate natural viewing conditions.

Another key limitation in sub-study 3 is the inability to analyze gaze patterns on disengaged girls. Without this data, the study cannot provide a complete comparison across all student engagement and gender categories. A core goal of professional vision research is to understand how teachers distribute attention equitably. Without data on disengaged girls, it is unclear whether teachers are equally attentive to all disengaged students regardless of gender. Future studies should ensure that disengaged students of all genders are included as AOIs, enabling more comprehensive comparisons and conclusions about gaze distribution across different student groups.

5.2. Strengths and Consideration of Core Achievements

In the following, I summarize the main findings of the meta-analytic review and the two empirical studies and arrange them in the overarching aims of this dissertation. Furthermore, I would also like to highlight the strengths of my research and what I have accomplished.

Firstly, I started with a meta-analytic review (sub-study 1) that would create the foundation for the following studies. This research showed a growing awareness of teacher professional vision over the past 23 years. This is a great indication of the relevance of the phenomenon and its impact at both teacher and student level. When analyzing the included studies, it quickly became apparent that a very heterogeneous pattern existed. Studies analyzed different stimuli (video, face-to-face classroom, synchronous online teaching) and samples (pre-service teacher, in-service teacher, adult educator, lecturer), used different devices (screen-based eye tracker, mobile eye tracker) and parameters (fixations, saccades) and accordingly came to different results. However, the meta-analytical part made it possible to determine the effect size for teacher professional vision for the first time. Overall, the meta-analytic review and its findings provide a solid foundation for determining research questions and developing advanced hypotheses.

The first screen-based eye-tracking study was the first study to investigate the attention distribution of pre-service teachers on ethnic minority and majority students in a heterogenous classroom (sub-study 2). The study showed that pre-service teachers are aware of the disadvantages ethnic minority students are confronted with and therefore, were more fixated on identifying those students and watching closely how the teacher was in exchange with them. This suggests that pre-service teachers are able to recognize and identify relevant events in the classroom – which means that noticing is not necessarily based on experience, but in particular on knowledge.

Contrary to our theoretically based hypothesis that ethnic minority students are disadvantaged compared to their ethnic majority counterparts regarding teachers' attention distribution and the associated teacher attitudes, we discovered that pre-service teachers are

likely to have positive attitudes towards ethnic minority students and consequently also fixate more and longer on those students. However, for the first time, attitudes towards ethnic minority students were measured in an eye-tracking study. Overall, the first screen-based eye tracking study has provided insight into pre-service teachers' attention distribution and attitudes in heterogeneous classrooms. This made an important contribution to research.

The second screen-based eye-tracking study was the first study to investigate the attention distribution of pre-service and in-service teachers on student gender in STEM education (sub-study 3). The study showed that there is a difference in pre-service and in-service teachers' gaze patterns when observing girls and boys and their level of engagement in STEM education. In-service teachers are more likely to balance their attention distribution, due to their experience, but are also more likely to prioritize engagement over disengagement, compared to pre-service teachers.

Contrary to our hypotheses, pre-service teachers' attention was more guided by engaged boys. It might be the case that pre-service teachers correspond to the stereotype that boys are more interested in STEM that girls and are therefore more likely to focus their attention on this group of students. However, for the first time, gender in STEM education and teachers' scanpath patterns were measured in an eye-tracking study. Overall, the second screen-based eye tracking study enabled a valuable experimental attempt to investigate gaze patterns on student gender and engagement level and differences teacher expertise, which can generate further research questions.

5.3. Overall Contribution of the Research to Advancing the Understanding of Professional Vision

When reviewing the studies conducted for this dissertation, it becomes clear that they make a further contribution to research and knowledge about professional vision which is

widely known in research as a “black box” (Huang et al., 2021a). The meta-analytic review provides a deep insight into the existing research on professional vision in terms of methods, settings, characteristics, and results. The first screen-based experimental study provides answers to teachers’ professional vision when it comes to ethnic minority and majority students. And the second screen-based experimental study provides answers to teachers’ scanpath patterns when it comes to girls and boys in STEM education.

Results from the first screen-based experimental study challenge common assumptions that pre-service teachers may actually spend more time fixating on ethnic minority students, which could indicate increased monitoring or positive recognition. This is also the case for those who guide their gaze on relevant events in the classroom due to their theoretical knowledge rather than their experience. As Palmer et al., (2005) and Grub et al., (2022) show in their studies, experience is only promotive with knowledge and both aspects are key competences of teachers. Furthermore, by combining eye-tracking data with qualitative insights from written reflections, the study provides a nuanced understanding of how attitudes and self-efficacy influence teacher gaze behavior. Through this, the study provides direct insight into pre-service teachers’ attentional focus, which is a core component of professional vision. In addition, by correlating explicit attitudes with gaze behavior, the study advances understanding of how cognitive and affective factors influence teachers’ attention distribution.

Results from the second screen-based experimental study show a link between teachers’ gaze patterns and student gender and engagement, emphasizing how in-service teachers actively focus on engaged girls – a potentially stereotype-countering behavior. The study employs advanced methods like scanpath analysis and gaze metrics, providing a detailed understanding of how teachers allocate visual attention in dynamic classroom settings. By focusing on how gender influences teachers’ gaze behavior, the study sheds light on implicit

biases that can affect student outcomes in STEM education. The inclusion of engagement levels provides a nuanced understanding of how teachers prioritize their attention based on student behavior, emphasizing the complexity of classroom dynamics.

To summarize, it can be said that the studies in this dissertation have uncovered a further strand of research on professional vision and have partially answered so far unanswered questions. For future research it is still relevant to investigate the cause of such gaze patterns and attention distributions and to find out about what a "fair" gaze behavior in classrooms is. The present studies provide initial evidence that teachers exhibit different gaze behavior regarding heterogeneous student groups. This suggests that research on professional vision with eye-tracking needs further and in-depth investigation for teachers to live out equality and equity and improve their professional vision.

5.4. Implications and Future Directions

The aim of this dissertation is to contribute to research on teacher professional vision. Professional vision is a research field which has gained great respect, especially in recent years, and is being researched more and more. Nevertheless, it has to be said that the phenomenon covers a very broad area and therefore also requires research. Hence, with this dissertation, I was able to make a valuable contribution to this field of research, regarding a comprehensive and systematic summary of the current state of research and experimentally investigate in a heterogenous classroom context. Despite this, it must be borne in mind that there are still unanswered questions, and some have even been added.

5.4.1.Implications for Theory Development

Eye-tracking data provide valuable insights into the cognitive and attentional processes underlying professional vision. Incorporating eye-tracking technologies in teacher training programs could allow pre-service and in-service teachers to reflect on their gaze behavior and develop strategies for more equitable and effective attention allocation (Ashraf et al., 2018).

Teacher training programs can use eye-tracking data to showcase expert gaze patterns as models for pre-service teachers to analyze and emulate those patterns and improve their classroom management and noticing skills. Furthermore, eye movement modeling examples (Jarodzka et al., 2017) can be integrated into teacher simulations or classroom training environments. By providing immediate feedback, eye tracking can help teachers develop more equitable and affective attention distribution strategies.

Understanding and addressing both implicit and explicit attitudes is critical for fostering equitable and effective teaching practices. Both forms of attitudes influence teacher decision-making, interactions, and ultimately, student outcomes. Therefore, teacher training programs should employ both self-reported measures (for explicit attitudes) and implicit attitudes (for unconscious biases). Tools such as the Implicit Association Test provide measures of implicit biases towards specific student groups and enable the identification of discrepancies between what teachers consciously report and their unconscious behavior, fostering deeper awareness.

Additionally, by comparing implicit and explicit attitude measures, teachers can identify patterns of alignment and misalignment. Such awareness might be a crucial step towards a meaningful change. Incorporating guided discussions and reflective activities alongside these measures can help teachers process these insights constructively, fostering strategies for more equitable classroom interactions. This dual approach not only enhances self-awareness but also

equips teachers with the tools to actively challenge and overcome unconscious biases in their professional vision and decision-making.

Promoting equity in classrooms involves fostering environments where all students, regardless of gender, ethnicity, or engagement level, receive equal opportunities for attention and recognition. In this regard, it is important that teachers learn to monitor and balance their visual attention across all students, develop strategies for recognizing quieter, engaged learners who may be overlooked, and reflect on why certain students receive disproportionate attention and how this impacts classroom equity.

Culturally responsive teaching involves recognizing and valuing the diverse backgrounds and needs of students (van Es et al., 2022). Teacher training programs should integrate cultural competence seminars, helping teachers to understand how stereotypes (e.g., about gender, ethnicity) influence their attention and expectations, develop inclusive instructional practices that ensure all students feel recognized and valued, and use reflective exercises to uncover and address biases impacting their professional vision.

5.4.2.Implications for Future Research

Future research should expand the scope of teacher professional vision by incorporating diverse classroom contexts, such as rural and urban settings, and various cultural and subject-specific environments to enhance generalizability. Integrating implicit attitudes measures alongside explicit attitudes will provide a more comprehensive understanding of how biases influence gaze behavior and classroom interactions.

Longitudinal studies are needed to examine how teacher professional vision develops over time, tracking teachers from pre-service stages to expertise. Additionally, combining gaze

data with multimodal measures, such as physiological responses and verbal protocols, can provide richer insights into the cognitive and emotional dimensions of teacher professional vision. Finally, future studies should focus on developing and testing interventions, such as real-time feedback systems, to improve gaze distribution and reduce biases in teacher behavior.

5.4.3.Implications for Educational Practice

Teacher education programs can incorporate eye-tracking tools to provide real-time insights into visual attention patterns (Ashraf et al., 2018). Tools like gaze replay allow teachers to identify their focus areas, reflect on blind spots, and develop more balanced gaze strategies. Eye-tracking feedback systems can also offer personalized recommendations, helping teachers improve attention distribution across all students.

Teacher training should offer seminars on both implicit and explicit attitudes, utilizing tools like the Implicit Association Test to measure unconscious attitudes. Reflective activities, such as analyzing gaze behavior and linking them to biases, can help teachers become more intentional in their classroom interactions. These strategies are crucial for addressing inequities in attention and recognition

Mobile eye-tracking technology should be integrated into real-world classroom settings to provide teachers with dynamic, ad-hoc feedback on their professional vision. This technology can simulate realistic multitasking demands and help teachers develop the ability to manage complex classroom interactions while maintaining equitable attention.

Addressing biases and improving professional vision require sustained efforts. Schools and institutions should implement long-term professional development programs that include periodic re-evaluation of gaze behavior and attitudes, continuous reflection and coaching to

refine equitable teaching practices, and assessment of interventions to ensure they result in improved student experience and outcomes.

5.5. Conclusion

The findings from the meta-analytical review (sub-study 1) and the two empirical studies (sub-study 2 and 3) offer crucial insights into the development of teacher professional vision. The meta-analysis highlights the overall differences in gaze behavior between expert and novice teachers, providing evidence for the systematic ways experienced teachers allocate their attention. Sub-study 2 reveals how explicit attitudes influence teachers' visual attention towards ethnic minority students, while pointing out the need for addressing implicit biases. Sub-study 3 explores student gender and engagement patterns in STEM classrooms, demonstrating how pre-service teachers disproportionally focus on disengaged boys compared to their in-service counterparts, who display more balanced strategies.

Together, these studies emphasize the role of gaze behavior as both a reflection of professional vision and a potential indicator of unconscious biases. They provide a strong foundation for actionable strategies, such as integrating eye-tacking technology, reflective practices, and culturally responsive teaching into teacher education. By addressing these key areas, future teacher training can foster equitable classroom practices, improve teacher expertise, and ultimately create more inclusive learning environments.

In conclusion, advancing research and practice in teacher professional vision requires a holistic approach that bridges cognitive, affective, and behavioral dimensions. Combining innovative tools like eye-tracking with targeted interventions will empower teachers to become more reflective, equitable, and effective teachers, ensuring all students receive the recognition and opportunities they need.

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7 Appendix

Publication I

Keskin, Ö., Seidel, T., Stürmer, K., & Gegenfurtner, A. (2024). Eye-tracking research on teacher professional vision: A meta-analytic review. *Educational Research Review*, *42*, 100586. https://doi.org/10.1016/j.edurev.2023.100586

Publication II

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Publication III

Keskin, Ö., Kosel, C., Stahnke, R., Gabel, S., Alijagic, A., & Gegenfurtner, A. (submitted). Students' gender and engagement in teachers' scanpaths. *Learning & Instruction.*