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A quasi-experimental eye-tracking study investigating the relationship between professional vision and the dispositions for inclusive teaching

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Inclusive education aims to provide equal learning opportunities for all students by addressing their diverse needs. Teachers must identify and respond to the physical and psychological requirements of individual learners to deliver adaptive and differentiated instruction. Professional vision plays a critical role in managing inclusive classrooms, which demands more nuanced approaches than homogeneous groups. This study explores key factors that influence professional vision for inclusive teaching, focusing on pedagogical knowledge, attitudes, and self-efficacy. Attitudes toward inclusive education influence a teacher's willingness to implement inclusive practices, while self-efficacy reflects confidence in managing diverse classrooms. The study analyzed professional vision among 80 pre-service teachers using eye-tracking technology. Participants were presented with four teaching video vignettes designed to assess student orientation (fixation count and duration), and verbal recognition performance of inclusive events. Predictors included pedagogical knowledge, attitudes toward inclusive education, and self-efficacy beliefs on adaptive teaching. The results showed that attitudes, self-efficacy, and pedagogical knowledge could not significantly predict total fixation duration or fixation count. Similarly, these predictors were unrelated to the verbal recognition performance of critical incidents, even when analyzed at the video level. The study emphasizes the need to enhance teacher training to prepare pre-service teachers to identify critical classroom situations. Such improvements aim to foster professional vision and adaptive teaching strategies in inclusive education.

KEYWORDS

professional vision, self-efficacy, eye tracking, mixed methods, inclusive education, stimulated retrospective think aloud, student teachers

1 Introduction and theoretical background

1.1 Inclusive education

Inclusion describes the process of dismantling barriers to ensure the equal participation of all members of society (Ainscow, 2007). As a formative site of socialization, schools have historically created barriers that either excluded certain children from the school system entirely or segregated them into special educational institutions. Inclusive education advocates for the joint education of all children as a foundation for full participation in society (Göransson and Nilholm, 2014).

The implementation of inclusive education faces several challenges. The field is currently divided between traditional perspectives, which support the role of special education alongside regular education, and inclusionist perspectives, which call for an individualized educational system and highlight the negative effects of grouping children based on a single defining characteristic (Ainscow, 2007).

With the United Nations Convention on the Rights of Persons with Disabilities (CRPD, 2006), along with national legislation, schools and teachers face increasing pressure to teach a diverse range of children within mainstream classrooms. While the previous external differentiation in special classes and special schools provided necessary assurance of homogeneity, inclusive education requires internal differentiation to address greater heterogeneity. One way to meet these demands is the use of differentiated instruction (DI; Coubergs et al., 2017; Pozas et al., 2020; Tomlinson, 2001).

DI is based on the idea that all learners are different (Roose et al., 2022) and is considered an effective method in heterogeneous classrooms (Gheyssens et al., 2021). In their meta-analysis, Deunk et al. (2018) showed that DI has a small to moderate effect on student achievement. DI does not refer to a single teaching method; rather, it encompasses a wide variety of effective methods (Bondie et al., 2019). In this context, DI refers to a teacher's ability to design adaptive lessons that challenge and support diverse students according to their individual needs, all within a single classroom (Coubergs et al., 2017; Fogarty and Pete, 2011; Gheyssens et al., 2021). For example, the DI taxonomy of Pozas and Schneider (2019) aims to close the gap between educational theory and everyday instructional practice by providing a toolbox for teachers and practitioners. Rather than referring to a specific classroom practice, DI describes a set of practices and preconditions concerning effective learning in heterogeneous groups (Pozas et al., 2020). Depending on the DI framework, this may include beliefs about learning and teaching, selected content, individual preferences (e.g., learning profiles), pre-assessment, formative assessment, mastery learning (i.e., self-efficacy), and more (Pozas and Schneider, 2019). However, in practice, DI requires a prompt perception and adequate as well as effective identification of individual learning opportunities (Gheyssens et al., 2021), which requires a clear overview of the classroom, the students, and their learning and support needs. To recognize and respond appropriately to these increasingly diverse requirements, professional vision is a crucial skill in inclusive classrooms (Roose et al., 2019). As a precondition for inclusive education, we view DI as a set of practices aimed at supporting effective learning processes for all children.

To apply inclusive practices like DI, teachers must have positive attitudes toward inclusive education (Mertoglu, 2020; Van Mieghem et al., 2020). Therefore, attitudes are a fundamental precondition for recognizing individual differences in today's classrooms, as they determine the basic willingness to include children perceived as different. Unlike traditional approaches to education that rely on external differentiation to form homogeneous groups, inclusive classrooms actively embrace the differences of individual students (Tomlinson et al., 2003). Therefore, teachers are required to adopt methods and classroom practices that account for student diversity. Therefore, not only attitudes toward inclusive education but also strong self-efficacy beliefs regarding the implementation of these practices are needed (Savolainen et al., 2012). In education, teachers' self-efficacy generally refers to the belief in their ability to positively impact student learning (Guskey and Passaro, 1994). Specifically, self-efficacy for adaptive teaching in heterogeneous classrooms is both linked to attitudes toward inclusive education and serves as a precondition for applying inclusive classroom practices (Meschede and Hardy, 2020).

1.2 Teachers' professional vision as a link between knowledge, beliefs, and inclusive classroom practices

Classrooms are highly complex environments due to the interplay of multifaceted, simultaneous processes and events (Doyle, 1985). This complexity is heightened by diverse student characteristics, which pose a significant challenge, especially for prospective teachers (Kunter et al., 2013). Effective teaching requires appropriate and proactive management of this heterogeneity for successful teaching (Helmke and Schrader, 2010). However, to be able to react adequately to learning-relevant events in this complex environment, they must be perceived early on and interpreted correctly (Wolff et al., 2021). For example, if a student's attention wanes because the subject or task is too simple or unchallenging, this should be recognized as early as possible through cues such as posture, facial expressions, or other behavior. This allows a more suitable DI method to be applied, helping the student stay engaged with subject matter and experience an appropriate learning opportunity.

Professional vision (Sherin, 2001, 2007) refers to the ability to accurately identify, interpret, and make decisions in teaching situations. It is a key component of professional competence and a critical factor in teaching quality (Wolff et al., 2021). Professional vision comprises two distinct processes (Sherin, 2007; van Es and Sherin, 2021): noticing and reasoning. Noticing is defined as identifying relevant features of classroom interactions for learning (van Es and Sherin, 2008) and effective instructional practice (Stürmer et al., 2013) while simultaneously ignoring irrelevant events. Reasoning describes the use of one's knowledge and experience to understand and interpret what is seen, adopting

an inquiring attitude. For example, a teacher in an inclusive classroom should be able to perceive and identify students with individual learning support needs through their verbal and non-verbal behavior (noticing) and simultaneously interpret these cues in the context of DI and derive specific individualized interventions (reasoning).

Applying and adapting Blömeke et al.'s (2015) competence model, which integrates different theoretical approaches to teachers' professional competence, professional vision, as a situation-specific skill, serves as a bridge between cognitive dispositions (e.g., knowledge and beliefs) and affective-motivational dispositions (e.g., attitudes) on one side, and classroom practice on the other.

Previous research on professional vision in the classroom has primarily focused on classroom management, particularly handling teaching disruptions (Grub et al., 2024; Keskin et al., 2024). However, alongside classroom management, inclusive education and the associated need for individual support are becoming increasingly important in teachers' daily practice (Ainscow and Messiou, 2018; Keppens et al., 2019) and should therefore be investigated.

Professional vision in inclusive situations is influenced by cognitive dispositions, such as pedagogical knowledge of individual learning processes and learning environments (Baumert and Kunter, 2006), self-efficacy beliefs (Keppens et al., 2021), and affective-motivational disposition (i.e., attitudes toward inclusive education) (see Figure 1). Although attitudes toward inclusive education have been shown to significantly influence the success of diverse students, their connection to professional vision has not yet been established. To date, research has predominantly focused on beliefs about educating a diverse student body rather than on attitudes toward inclusive education (i.e., Roose et al., 2022).

Pedagogical knowledge and *self-efficacy beliefs* are thought to influence professional vision in a specific way, as "teachers' existing knowledge and beliefs serve as filters through which they, like people in general, view and interpret their experiences" (Borko and Putnam, 1996, p. 699). Professional vision is assumed to be an indicator of "integrated knowledge," reflecting the integration of theory and practice (Seidel and Stürmer, 2014). Previous research, particularly on differences in expertise in professional vision, has attributed these differences to specific knowledge structures known as schemata (cf. Berliner, 2001). The more efficient these schemata—meaning the more interconnected, detailed, and experience-based they are—the more likely they are to enable a holistic view of classroom events. This enables rapid information processing and differentiation between relevant and less relevant events (Carter et al., 1988; Grub et al., 2020). Research on professional vision has shown that prospective teachers with greater procedural knowledge are not only more accurate and quicker at identifying relevant aspects (Grub et al., 2022a) but also demonstrate more effective monitoring behavior, such as scanning the classroom, by showing an increased number of brief fixations (Grub et al., 2020). Student teachers with greater knowledge also demonstrate stronger reasoning skills, offering more interpretations of classroom events rather than merely providing descriptions (Wolff et al., 2016).

Beliefs provide a cognitive framework that guides teachers' attention toward relevant aspects of inclusive classrooms, such as indicators of student needs (Keppens et al., 2021; Roose et al., 2022). Self-efficacy beliefs, in turn, contribute to the confidence necessary to interpret and act upon these perceptions, particularly in the context of DI (Meschede et al., 2017). Research has shown that teachers with stronger beliefs in inclusive practices and higher self-efficacy beliefs are more proficient in identifying and responding to individual learning needs in classroom settings (Keppens et al., 2021). Moreover, beliefs have been found to mediate the relationship between professional vision and the actual implementation of inclusive teaching strategies (Roose et al., 2022). To understand the extent to which teachers' beliefs and knowledge actually influence professional vision, correlational studies using standardized instruments to assess professional vision are recommended (e.g., Blömeke et al., 2015; Huang et al., 2021; Santagata and Yeh, 2016). For example, in an online study of perceptions of classroom disruptions, Grub et al. (2022a) found that student teachers with more knowledge were able to identify relevant events in video vignettes more quickly and with higher accuracy than their peers with less knowledge. Additionally, Schreiter et al. (2022) demonstrated that knowledge enables student teachers to more quickly recognize relevant task features and accurately assess them, resulting in a more efficient judgment process in teaching situations. However, empirical studies examining the relationship between cognitive dispositions (knowledge and beliefs) and affective-motivational dispositions (e.g., attitudes toward inclusive education) on situation-specific skills (professional vision) remain scarce. One exception is the study by Meschede et al. (2017), which explored the relationship between teachers' professional vision, pedagogical content knowledge, and beliefs using a video-based assessment approach focusing on instructional support in elementary science classrooms to investigate the structure of teacher cognition. They found that all three constructs—professional vision, knowledge, and constructive beliefs—are positively intercorrelated. Keppens et al. (2021) investigated the extent to which Flemish student teachers' beliefs and self-efficacy are related to inclusive teaching practices in the context of teacher–student interactions and DI. They used a video-based comparative judgment instrument to assess professional vision and found that higher self-efficacy beliefs correspond to greater skill at identifying aspects of inclusive education related to DI (noticing). Roose et al. (2022) investigated whether teachers' professional vision of DI mediates between their beliefs about teaching diverse learners and their practice of DI, using survey data, self-reports, and video-based judgment assessment (Roose et al., 2018) in secondary Flemish schools. They found that teachers with greater professional vision capacity—measured using the e-Pic instrument (cf. Gheyssens et al., 2017), which compares participants' performance with expert performance (see Roose et al., 2019)—hold beliefs about teaching diverse learners that explain the positive association between implementing DI in classrooms and professional vision.

In summary, previous research using video-based assessments of professional vision combined with qualitative data analysis of reasoning processes suggests that knowledge and beliefs affect professional vision. What remains unclear, and to our knowledge as yet unexplored, is how cognitive dispositions (knowledge

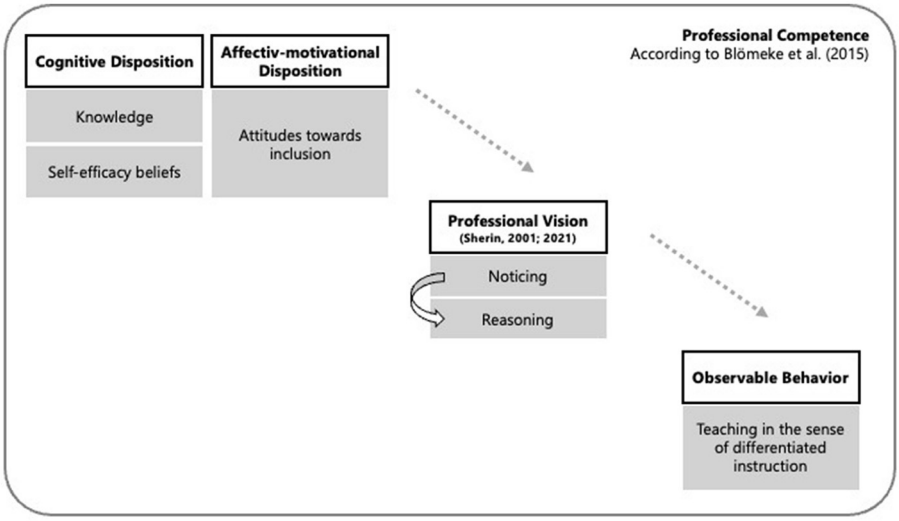

FIGURE 1
Competence model according to Blömeke et al. (2015).

and self-efficacy beliefs) and affective-motivational dispositions (attitudes) toward inclusive teaching influence professional vision when measured through process-based methods such as eye tracking, which provides temporal and spatial information on perceptual processes.

1.3 A Multi-method approach to assess teachers' professional vision

To capture the continuous process of teachers' professional vision, we used a multi-method approach to explore both noticing and reasoning processes. For noticing, quantitative eye movement data were recorded using process-based eye-tracking methods, which provide information on participants' fixation areas, including number and duration. To observe and analyze teachers' gaze behavior, eye tracking provides access to the identification and recognition of relevant classroom situations, such as DI (Goldberg et al., 2021; Keppens et al., 2019). For reasoning, qualitative verbal data were collected using a cued retrospective think-aloud (RTA) method to investigate the depth of analysis and for triangulation purposes (Biermann et al., 2023; Grub et al., 2024; Wolff et al., 2016).

1.4 Research aim and research questions

For teachers, acting competently and effectively addressing student heterogeneity are daily challenges, and recent advances in inclusive education have increased the pressure to adopt inclusive teaching practices.

Therefore, this study aims to explore inclusivity-related aspects of prospective teachers' professional vision and examine potential interactions between gaze behavior and attitudinal characteristics relevant to inclusive education, such as beliefs and knowledge (De Boer et al., 2011). For this purpose, we adapt the approach of Wyss et al. (2021), who used a mixed method design combining eye-tracking data and *post-hoc* think-aloud verbalizations to examine perceptions of critical incidents (CI)—in our case, teaching aspects referring to DI, especially heterogeneity/diversity—at both the noticing and reasoning levels.

1.5 Research questions and hypotheses

As this study is, to the best of our knowledge, the first to examine professional vision using process-based eye-tracking methods combined with knowledge and self-efficacy beliefs about inclusive education, Research Questions 1–3 were formulated exploratively.

(1) Does noticing gaze behavior (based on eye-tracking data) in inclusive teaching situations depend on attitudes toward inclusive education, self-efficacy on adaptive teaching, and/or pedagogical teaching knowledge?

It is hypothesized that individuals with more positive self-efficacy beliefs on adaptive teaching and attitudes toward inclusive education and higher pedagogical teaching knowledge will exhibit a more differentiated and attentive perception of relevant gaze patterns in inclusive classroom settings. Specifically, both predictors are expected to explain unique variance in professional vision, as measured through gaze-based indicators of noticing (fixation count, fixation duration).

(2) Does recognition performance (noticing based on verbal data) of CIs depend on self-efficacy beliefs on adaptive teaching and attitudes toward inclusive education and/or pedagogical knowledge?

It can be assumed that individuals with self-efficacy beliefs on adaptive teaching, attitudes toward inclusive education, and/or higher pedagogical teaching knowledge are more likely

to accurately recognize CIs in inclusive classroom settings (cf. Grub et al., 2022a).

(3) Mixed-method analysis: What is the relationship between eye-tracking data and recognition performance? The assumption underlying exploratory Research Question 3 is that student teachers who mention the CI are more attentive to the corresponding scene (total fixation duration) and observe the persons of interest in the relevant time window more frequently (fixation count). This assumption is supported by research on professional vision, which indicates that relevant classroom situations are scanned or looked at more frequently (i.e., have more fixations) and are typically viewed for longer durations, either due to automatic attention allocation or because relevant areas naturally attract more prolonged attention (i.e., higher fixation duration; see Grub et al., 2020; Holmqvist et al., 2011). This gaze behavior is assumed to reflect the greater relevance of areas to which attention is directed.

2 Materials and methods

As part of open science research, the study was preregistered. Detailed information can be found at https://osf.io/7f8dp/.

2.1 Participants

A total of $N = 80$ student teachers ($M_{Age} = 24.00$, $SD_{Age} = 6.03$) participated in the study. They were recruited via university seminars, e-mail lists, and flyers at Saarland University and had an average of 1.91 years of teaching experience. Data from two participants were excluded from the analyses due to insufficient (eye-tracking) data quality (e.g., outlier with more than three standard deviations for at least one of the relevant variables). This left $N = 79$ student teachers for analysis. Of the final sample ($n = 44$) participants identified as female ($n = 34$), identified as male, and one identified as diverse. Participants attended on average the fifth semester. The sample included 15 primary school student teachers, 10 lower secondary school student teachers, 43 lower and higher secondary school student teachers, and 11 business education student teachers. Informed consent was obtained from all participants.

2.2 Design and procedure

The study consisted of three sequential parts and was performed entirely under standardized conditions in a laboratory between April and July 2023 (see Figure 2). In the first part, an upstream demographic questionnaire asking questions about age, gender, teaching experience, school subjects, and type of school was presented online on Unipark. In the second phase, eye tracking was conducted, with participants quasi-randomly assigned to one of four video sequences. The order of presentation was balanced using a Latin square design to control for sequence effects. Participants watched a total of four video vignettes while their gaze was recorded. They were instructed to identify CIs (see Biermann et al., 2023; Wyss et al., 2021) in each video by pressing a key.[1] This approach generated both process-based eye-tracking data and quantitative data on participants' awareness of CIs during the video observations.

Immediately after watching the videos, an RTA based on individual gaze data was conducted, in which eye movements, presented as scanpaths, served as a cue for verbalization. During this phase, participants were asked to elaborate on the previously identified events in greater detail to assess their reasoning processes related to professional vision and to triangulate the eye-tracking data.

In the third part, participants were asked to complete three questionnaires on their attitudes toward inclusive education (Lüke and Grosche, 2018), self-efficacy beliefs on adaptive teaching in heterogeneous classrooms (Meschede and Hardy, 2020), and about pedagogical teaching knowledge (König and Blömeke, 2009). The entire experiment lasted about 90 min.

In summary, the experiment collected both quantitative data (eye movements and CI keypress) and qualitative data (verbal data within the RTA) related to the same CIs, allowing for a comprehensive examination and triangulation of professional vision.

2.3 Material

2.3.1 Eye tracking

In the eye-tracking phase, a binocular stationary eye tracker (Tobii Pro Fusion, 120 Hz)[2] was used to assess professional vision. Eye movements were recorded under standardized environmental conditions. High-quality eye-tracking data are available for the participants (calibration accuracy: $M = 0.55°$, $SD = 0.18°$; calibration precision: $M = 0.31°$, $SD = 0.22°$).

2.3.2 Video vignettes

The video vignettes used in the eye-tracking experiment (see Figure 3 for an example) were based on scripted lessons in mathematics and informatics topics for 10th and 11th grade students in the advanced track at a German secondary school (Gymnasium) and had been used in previous studies (Biermann et al., 2023; Grub et al., 2022b,a). They were developed by the "Toolbox Teacher Education" ("Toolbox Lehrerbildung") at the

1 Translated from German: "It is the teacher's task to organize lessons in such a way that as many of the pupils present as possible actively participate in the lesson." In the following, pay attention to aspects that you notice in relation to the participation of all pupils in the lesson and how the teacher reacts to this. A video is played below. Watch it very carefully. If you notice anything relevant, press the "Y" button."

2 We used a 24-inch display monitor (1080 x 1920), kept the distance between the eye tracker and participants as identical as possible (~65 cm), and ensured uniform illumination. Before the record itself, we conducted a 9-point automatic calibration followed by a validation to ensure data quality. If the 9-point automatic calibration failed, it was performed again. Data were exported from Tobii using the Tobii I-VT (fixation) filter with a standard setting (I-VT classifier), i.e., a threshold of 30°/s.

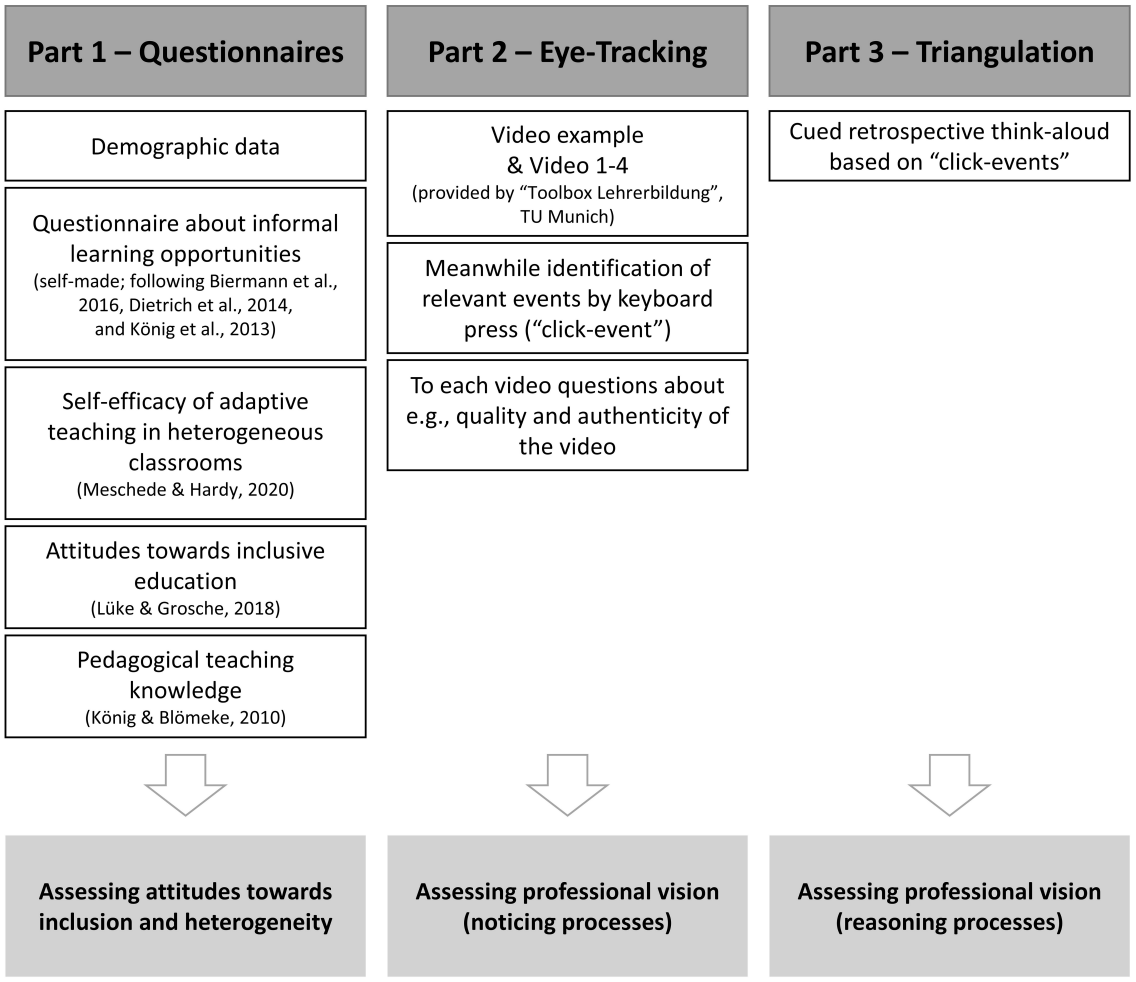

FIGURE 2
Design of the mixed methods study.

Technical University of Munich (Lewalter et al., 2020) and have an average duration of 3.18 min (SD = 0.46 min). The video vignettes were selected by three independent raters (the first and second author and an educational psychology student) based on events related to DI (especially adaptive situations in heterogeneous classes), audiovisual quality, and situational authenticity. One video was used as a sample, and the remaining four were presented in a balanced Latin square randomized manner across four conditions. Each of the vignettes was presented only once.

2.3.3 Master rating

A master rating of the inclusive teaching situations was created for the videos, with each event defined by its start time, duration, event or content type, and the students and teacher involved. The videos were viewed and analyzed by both experienced educational researchers (first authors) and two experienced teachers (JW, SA).[3] Their ratings were compared, discussed, and refined through joint discourse, then documented in a standardized master rating. A total of 29 events relevant to inclusive schooling were defined (for an overview, see Supplementary material).

2.3.4 Questionnaires

A short self-designed *questionnaire about demographic data* with seven items was used to collect demographic information—such as age, gender, and type of school studied—to provide control parameters for later analysis.

The questionnaire about *self-efficacy for adaptive teaching in heterogeneous classrooms* (Selbstwirksamkeitserwartungen zum adaptiven Unterrichten in heterogenen Lerngruppen, SAUL; Meschede and Hardy, 2020) included 22 items aimed at assessing self-efficacy in terms of both diagnosing learning requirements and potential for teaching differentiation and support. Three subscales

3 JW (39 years old; male; 14 years of teaching experience, mathematics, physics and informatics; grammar school) and SA (33 years old; female; 5 years of teaching experience; mathematics and English; secondary and comprehensive school).

FIGURE 3
Example illustration of the AOIs for one of the videos (Source: "Toolbox Teacher Education" [[Toolbox Lehrerbildung], 2020]. The AOIs were active only for the duration of the events and are only visible for analysis.

were recorded: diagnosis of learning prerequisites (eight items), teaching differentiation (eight items), and promotion and use of heterogeneous learning prerequisites in the context of cooperative learning (six items). Items were assessed on a four-point Likert scale (1: I do not agree at all, 4: I fully agree; for sample items, see Supplementary Table 8).

We applied the PREIS attitude scale by Lüke and Grosche (2018) to measure *attitudes toward inclusive education in the population*. This instrument has demonstrated reliability and validity for measuring one-factor construct attitudes toward inclusive education. It contains a total of 14 items and applies a broad definition of inclusive education (Ainscow, 2007; Göransson and Nilholm, 2014; Lüke and Grosche, 2018). It adds value to the current discourse on inclusive teacher education by providing a more holistic view on hindrances and potential within the field (Roose et al., 2022). Items were assessed on a five-point Likert scale (1: I do not agree at all, 5: I totally agree; for sample items, see Supplementary Table 8).

Pedagogical teaching knowledge (Pädagogisches Unterrichtswissen, PUW; König and Blömeke, 2009) was developed within the framework of TEDS-M (see König and Blömeke, 2009) and serves as an achievement test for prospective teachers across all school types. The questionnaire contained a total of 18 test items, ten closed and eight with an open response format. It covered three dimensions of cognitive demand (remembering, understanding/analyzing, creating) and five content dimensions (dealing with heterogeneity, structuring, classroom management, motivation, and performance assessment).

TABLE 1 Eye-tracking parameters used in the study.

Parameter	Definition
Total fixation duration	Sum of all individual fixation durations on the AOI
Fixation count	Number of fixations on an AOI

2.4 Dependent variables and data analysis

The two most well-known parameters—*fixation count* and *total fixation duration*—were used to measure professional vision, providing detailed insight into gaze behavior (Grub et al., 2020, 2024). For an overview and definition of the parameters, see Table 1.

An *area of interest (AOI)–based evaluation* of the eye-tracking data was performed, aggregating the aforementioned parameters within the predefined AOIs (see Figure 3). Polygonal dynamic AOIs were determined deductively corresponding to the CI, including individual students, groups of students, or the teacher. For the following calculations, the parameters were averaged across all AOIs for each video, and an overall value was calculated across all videos.

The verbal data from the RTA were transcribed and analyzed with MAQXDA 24 (VERBI Software, 2019). To assess recognition performance, two experienced researchers rated the participants' statements using the master rating. One point was awarded for each

situation contained in the master rating that was verbalized by the students. A total score was then calculated across all videos (range: 0–17 points, see Supplementary material—master rating).

3 Results

The analyses were calculated using R software (RStudio 2024.04.2 and R 4.4.1). An alpha level of 0.05 was used for the statistical tests. In accordance with the principles of open science, the data used will be made available by the authors, without undue reservation.

3.1 Research question 1

Does noticing gaze behavior (based on eye-tracking data) of inclusive teaching situations depend on attitudes toward inclusive education, self-efficacy beliefs, and/or pedagogical teaching knowledge?

Multiple regression analyses were conducted for each parameter (total fixation duration, fixation count) as the criterion, with inclusion (attitudes toward inclusive education), self-efficacy (self-efficacy for adaptive teaching in heterogeneous classrooms), and knowledge (pedagogical teaching knowledge) as predictors. These analyses aimed to examine the relationship between noticing gaze behavior (based on the eye-tracking data) of inclusive teaching situations, attitudes toward inclusive education, self-efficacy beliefs on adaptive teaching, and/or pedagogical knowledge. Table 2 presents means and standard deviations, and detailed results are shown in Table 3.

The results suggest that none of the predictors (attitude, self-efficacy, knowledge) significantly predict gaze behavior—neither the total fixation duration nor the fixation count—of prospective teachers. The analyses were also conducted at the video level (see Supplementary Tables 2–5), but no correlations were found.

3.2 Research question 2

Does recognition performance of CIs depend on self-efficacy beliefs and attitudes toward inclusion and/or pedagogical knowledge?

Multiple regression analyses were conducted with performance (recognition performance of CIs based on the verbal data) as the criterion and inclusion (*attitudes toward inclusive education*), self-efficacy (*self-efficacy for adaptive teaching in heterogeneous classrooms*), and knowledge (*pedagogical teaching knowledge*) as predictors. The aim was to analyze the relationship between noticing behavior (based on the verbal data) in inclusive teaching situations, beliefs toward inclusive education (attitudes and self-efficacy), and/or the pedagogical knowledge. Table 2 presents the means and standard deviations, with detailed results in Table 4.

The results suggest that none of the predictors (attitude, self-efficacy, knowledge) significantly predicts the recognition performance of prospective teachers. The analyses were also conducted at the video level (see Supplementary Table 6), with no correlations identified.

3.3 Research question 3

Mixed-method analysis: What is the relationship between eye-tracking data and recognition performance?

Linear regression analyses were conducted with total fixation duration and fixation count as predictors and performance as the criterion to examine the relationship between noticing gaze behavior of inclusive teaching situations and recognition of CIs based on verbal data (see Table 5). Means and standard deviations can be found in Table 2.

The results indicate that performance significantly predicts total fixation duration as a parameter of noticing gaze behavior in prospective teachers, $\beta = 0.07$, SE $= 0.02$, 95% confidence interval [0.02–0.11], $t_{(75)} = 3.11$, $p = 0.003$, $R^2 = 0.12$.

A video-level analysis (see Supplementary Table 7) yielded significant results only for Video 2.

4 Discussion

The present study investigated the relationship between dispositions for inclusive education (cognitive and affective-motivational), pedagogical knowledge, and professional vision as assessed through eye-tracking technology and verbal recognition of CIs. The findings offer new insights into the assessment of professional vision but also challenge established assumptions in the literature. Previous findings using video-based judgment instruments (Keppens et al., 2021; Meschede et al., 2017) have identified a general relationship between professional vision and teachers' beliefs, pedagogical knowledge, and self-efficacy. Additionally, Roose et al. (2018) identified a relationship between professional vision and teachers' beliefs about teaching diverse learners.

The results for Research Question 1 indicate that none of the predictors—attitudes toward inclusive education, self-efficacy beliefs on adaptive teaching, or pedagogical knowledge—significantly predicted noticing behaviors as measured by gaze metrics (total fixation duration and fixation count). Even prospective teachers with more positive attitudes toward inclusive education, higher self-efficacy, and pedagogical knowledge did not identify and recognize CIs more accurately. Based on our results, the assumption that professional vision reflects the integration of theory and practice (Seidel and Stürmer, 2014) cannot be validated. This finding challenges previous studies, which have suggested strong links between teacher beliefs, knowledge, and professional vision (Keppens et al., 2021; Meschede et al., 2017; Roose et al., 2018).

One explanation for the divergence might lie in methodological differences. While previous studies predominantly used video-based judgment instruments, this study employed process-based eye-tracking technology. Eye tracking primarily captures attentional processes (e.g., where and how long participants focus), but it may not fully encompass the cognitive and interpretative aspects of noticing behavior (van den Bogert et al., 2014). These results suggest that professional vision, particularly in complex inclusive teaching scenarios, may not be entirely observable through gaze behavior alone.

TABLE 2 Means, standard deviations, and correlations with confidence intervals.

Variable	*M*	*SD*	1	2	3	4	5
1. Attitudes toward inclusion	3.39	0.92					
2. Self-efficacy	3.23	0.36	0.11 [−0.11, 0.33]				
3. Knowledge	34.90	6.80	0.0 1 [−0.21, 0.23]	−0.12 [−0.33, 0.11]			
4. Performance	10.74	4.27	0.17 [−0.07, 0.39]	0.05 [−0.19, 0.29]	−0.14 [−0.37, 0.10]		
5. Total fixation duration	3.83	0.81	0.03 [−0.19, 0.25]	0.05 [−0.17, 0.27]	−0.19 [−0.40, 0.03]	0.35** [0.13, 0.55]	
6. Fixation count	11.78	2.72	−0.03 [−0.25, 0.19]	−0.15 [−0.36, 0.08]	0.01 [−0.21, 0.23]	0.10 [−0.14, 0.33]	0.55** [0.37, 0.69]

$N = 79$. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). $^{**}p < 0.01$.

TABLE 3 Results of the multiple regression analysis for RQ 1 across all four videos.

Parameter	Estimate	SE	95% CI		*t*	*p*
			LL	*UL*		
Total fixation duration						
(Intercept)	4.34	1.03	2.28	6.40	4.20	0.00
Attitudes toward inclusion	0.02	0.10	−0.18	0.22	0.23	0.82
Self-efficacy	0.06	0.26	−0.46	0.58	0.24	0.81
Knowledge	−0.02	0.01	−0.05	0.00	−1.68	0.10
Fixation count						
(Intercept)	15.57	3.52	8.55	22.59	4.42	0.00
Attitudes toward inclusion	−0.03	0.34	−0.71	0.64	−0.09	0.92
Self-efficacy	−1.12	0.89	−2.88	0.65	−1.26	0.21
Knowledge	0.00	0.05	−0.09	0.09	−0.05	0.96

$N = 79$. CI, confidence interval; LL, lower limit; UL, upper limit; df_{error}, 75. Multiple R^2 (total fixation duration) = 0.39; Multiple R^2 (fixation count) = 0.22.

Furthermore, the lack of significant findings highlights a potential gap between theoretical constructs like attitudes or knowledge and their application in practice. While attitudes and self-efficacy are often considered prerequisites for inclusive teaching (Dignath et al., 2022), these constructs may not directly translate into observable noticing behaviors in controlled experimental settings. This underlines the need for professional development interventions that explicitly focus on bridging the gap between beliefs and practical skills (Guskey, 2002).

For Research Question 2, the regression analyses revealed no significant relationships between attitudes toward inclusive education, self-efficacy, or pedagogical knowledge and CI recognition performance. This finding aligns with the results for Research Question 1, further emphasizing that beliefs and knowledge alone may not predict key aspects of professional vision, such as the ability to recognize CIs. Although a correlation between the eye-tracking data and CI recognition was identified, none of the predictors significantly contributed to recognition performance, either overall or at the video level (see Table 4 and Supplementary Table 6).

This result is surprising, given earlier research identifying teacher beliefs and knowledge as influential in the noticing of classroom events (Keppens et al., 2021; Meschede et al., 2017). This raises questions about whether this study's experimental setting, task complexity, or operationalization of professional vision might have limited the visibility of such relationships. Additionally, recognition performance may involve deeper reflective processes that are not directly linked to cognitive structures like attitudes or knowledge, but instead depend on experiential factors or situational familiarity.

The inability to establish a link between predictors and CI recognition suggests that professional vision is a multifaceted construct requiring further methodological triangulation. Combining process-based measures like eye tracking with retrospective or qualitative approaches may provide a more comprehensive understanding of the pathways through which beliefs and knowledge influence professional vision.

The analysis for Research Question 3 revealed that CI recognition performance significantly predicted gaze behavior, specifically total fixation duration. This finding supports theoretical

TABLE 4 Results of the multiple regression analysis for RQ 2 across all four videos.

Parameter	Estimate	SE	95% CL		*t*	*p*
			LL	UL		
(Intercept)	10.84	5.83	−0.80	22.48	1.86	0.07
Attitudes toward inclusion	0.81	0.57	−0.32	1.94	1.43	0.16
Self-efficacy	0.08	1.46	−2.83	2.99	0.06	0.96
Knowledge	−0.09	0.07	−0.24	0.06	−1.19	0.24

$N = 79$. CI, confidence interval; LL, lower limit; UL, upper limit; df_{error}, 75. Performance, Recognition of critical incidents as—verbalized; Multiple $R^2 = 0.03$.

TABLE 5 Results of the multiple regression analysis for RQ 3 across all four videos.

Parameter	Estimate	SE	95% CL		*t*	*p*
			LL	UL		
(Intercept)	34.94	17.61	−0.12	70.01	1.99	0.05
Fixation count	−2.82	1.47	−5.75	0.10	−1.92	0.06
Total fixation duration	5.27	4.96	−4.61	15.15	1.06	0.29

$N = 79$. CI, confidence interval; LL, lower limit; UL, upper limit; df_{error}, 75. Multiple R^2 (Overall) = 0.05.

frameworks for professional vision, which propose that noticing and interpreting key classroom events are closely interconnected (Seidel and Stürmer, 2014). However, this relationship was not consistent across all videos, with only Video 1 showing significant results.

This inconsistency may reflect differences in the complexity or salience of the CIs presented in each video. Video 1 may have included CIs that were more easily recognizable or required less cognitive effort to interpret, as suggested by prior research on the situational and contextual variability of professional vision (Stahnke and Friesen, 2023). The findings underscore the importance of considering the design and content of stimuli in professional vision research, as these factors may influence both gaze behavior and recognition performance.

Although pedagogical knowledge has been previously identified as a significant predictor of noticing behavior (Grub et al., 2020), there appears to be a difference in the assessment of CIs. This highlights the importance of combining multiple methods to assess professional vision. Classroom management aspects, operationalized in terms of disruptions, appear to be recognized more accurately than student engagement and individual support, which are essential for adopting inclusive education (Ainscow and Messiou, 2018; Keppens et al., 2019).

4.1 Exploratory analysis

Exploratory analyses were also conducted in addition to the hypothesis-based calculations. These analyses considered both all AOIs (student and teacher) and only student AOIs, as well as the video level (see Supplementary material) to account for possible influencing factors from different school types and subjects (Stahnke and Friesen, 2023). The type of school (elementary school vs. grammar school) was also controlled for. None of these additional calculations yielded significant results, suggesting that they are not influencing factors in our sample.

4.2 Strengths and limitations

The study minimized study-related influences by randomizing video order within sequences using a Latin square. Standardized video vignettes ensured result comparability across samples, leading to new insights. Broad participant recruitment further enhanced generalizability by creating a larger sample size than most previous studies (Grub et al., 2020; Kosel, 2022).

In addition to the study design, our investigation is distinguished by its methodology. We employed various questionnaires, eye tracking, and RTA protocols (i.e., verbal data) to explain our observations. However, the instrument used to measure attitudes toward inclusive education, self-efficacy beliefs on adaptive teaching, and pedagogical knowledge may have influenced the study's outcomes in several ways. First, the reliance on self-report questionnaires could have introduced social desirability bias, especially for attitudes toward inclusive education, with participants potentially providing responses aligned with socially expected views rather than their true assessment. Similarly, the distal timing of these measures, taken separately from the main experimental tasks, may have weakened their predictive validity for real-time noticing behavior. Pedagogical knowledge, often assessed through declarative measures, might not fully capture procedural or situational knowledge relevant to interpreting classroom events in dynamic, heterogeneous settings.

Another strength is that the selected events and AOIs are based not only on researchers' theoretical knowledge but also on input from experienced teachers, who were consulted to design a master rating that combines theory and practical experience (Grub, 2023; Grub et al., 2022b).

While video vignettes can illustrate exemplary teaching practices and the dilemmas faced in daily routines, video recordings capture only a fraction of classroom activities (Sherin and van Es, 2009). Furthermore, the videos include slight but noticeable inclusive teaching situations, limiting generalizability. The video vignettes primarily featured notable events (e.g., a student puts their head on the table or throws a paper

ball across the room), which were likely perceived through both top-down (Orquin and Mueller Loose, 2013) and bottom-up gaze control (Itti and Koch, 2001), requiring little actual experience and prior knowledge of inclusive teaching situations. This example illustrates a limitation of the video vignettes: they include not only situations relevant to inclusive teaching but also classroom disruptions that may affect lesson flow in other ways. This overlap could be problematic, as it blurs the line between the perception of DI and classroom management. It should be considered that reduced student attention, as shown in some scenes, may indicate either under- or over-challenge, thus requiring DI, or reflect behavior disruptive to the learning environment, which would instead fall under classroom management. Hence, a clear separation between the two essential dimensions of effective teaching—DI and classroom management—is not fully achievable in the current material, nor is it likely in everyday practice. As a result, it is possible that this overlap influenced participants' perception and, consequently, the results.

On a methodological level, the simultaneous application of the PUW (König and Blömeke, 2009) and Self-Efficacy of Adaptive Teaching in Heterogeneous Classrooms (Meschede and Hardy, 2020) questionnaires warrants critical reflection. The PUW represents a broad assessment of general pedagogical knowledge across various domains (e.g., classroom management, assessment, instructional strategies) without a specific focus on heterogeneity or inclusive education. Consequently, although it captures fundamental teaching knowledge, it may not be sufficiently sensitive to detect knowledge components that are particularly relevant for inclusive practices or the perception of DI. In this respect, its construct validity for this study's specific research question is limited, especially since heterogeneity-related items are not separately identifiable or analyzable. In contrast, the self-efficacy scale developed by Meschede and Hardy (2020) explicitly targets teachers' perceived capabilities to adapt instruction in heterogeneous classrooms and appears more directly aligned with the theoretical underpinnings of inclusive education. However, despite this conceptual proximity, this study found no significant association between self-efficacy and professional vision. This lack of correlation may be partly due to the limitations of the instrument itself: while it captures general confidence in managing diversity, it does not assess domain-specific or situational self-efficacy (e.g., in actual classroom interactions). This might be more strongly associated with dynamic indicators of professional vision, such as gaze behavior. Furthermore, the scale emphasizes declarative judgments (e.g., "I feel capable of…") rather than situational or action-related efficacy beliefs, which could reduce predictive validity in process-based assessments. Future research might benefit from using more fine-grained and situationally grounded instruments, such as video-based or vignette-based self-efficacy measures, which can elicit more context-sensitive responses and better reflect the demands of inclusive teaching in real time. Alternatively, instruments that distinguish between general and inclusive self-efficacy (e.g., Sharma et al., 2015; Schwarzer and Hallum, 2008) may provide more differentiated insights. Methodologically, a multi-method approach that integrates declarative, situational, and behavioral data is recommended to more holistically capture the complexity of teacher cognition and professional vision.

4.3 Implications for further research

Future studies could consider selecting video material with a stronger emphasis on inclusive practices or heterogeneity-related classroom situations to further sharpen the analytical focus. The video vignettes used in this study offered substantial benefits by highlighting salient aspects of classroom interaction, minimizing event overlaps, and maintaining low complexity. However, these strengths also entailed limitations, as the videos inevitably represented only a fraction of the complexity and variability inherent in actual classroom practice. Future studies could pay more attention to choosing videos that focus more on inclusion or heterogeneity aspects. For example, instead of using videos from the relatively homogeneous secondary school context, future research could incorporate videos from more heterogeneous elementary school classes to offer a richer environment for examining professional vision in inclusive contexts. Elementary classrooms often display a wider range of heterogeneity in terms of developmental stages, learning needs, and socio-emotional behaviors, making them ideal for such investigations. Additionally, longer video sequences or real-life classroom recordings using mobile eye-tracking technology would enhance ecological validity and generalizability by simulating the complexities and temporal dynamics of authentic teaching environments.

Comparative studies involving both novice (e.g., student) and expert teachers could illuminate the role of experience and expertise in recognizing and interpreting heterogeneous aspects in classrooms. Such research would provide valuable insights into how professional vision evolves over time and the extent to which expertise enhances the ability to notice and address diverse learner needs. By examining developmental trajectories, researchers could identify key competencies that should be targeted in teacher education and professional development programs.

To address the limitations of the instruments used, future studies could employ implicit measures, such as the Implicit Association Test (Greenwald et al., 2003), to assess unconscious attitudes toward inclusive education and diverse learners, providing a more nuanced understanding of participants' beliefs. Implicit measures, such as assessments of stereotypical attitudes toward inclusive education or diverse learner groups, could offer valuable insights beyond the self-reported attitudes used in this study. These tools may reveal underlying biases or preconceptions that shape teachers' professional vision, even when not consciously recognized. For self-efficacy, scenario-based assessments or situational judgment tests (SJTs; Nadmilail and Mohd Matore, 2021) could offer a more contextualized and behaviorally relevant measure. Regarding pedagogical knowledge, dynamic and applied assessment formats, such as video-based or simulation-based tasks, might better reflect the knowledge required to recognize and interpret CIs in inclusive classrooms (e.g., Keppens et al., 2019; Nickl et al., 2024). Integrating these improved tools could enhance the sensitivity and ecological validity of the predictors, offering a clearer understanding of how these factors influence

professional vision. Additionally, conducting surveys of knowledge and attitudes closer to the experimental tasks (proximal measures) could yield more accurate insights into their influence on professional vision compared to the distal measures used in this study.

While this study employed a master rating based on expert knowledge, future research might benefit from incorporating a more extensive and diverse panel of experts during the creation of such ratings. By involving professionals from various educational contexts (e.g., inclusive, special education, and general teaching practitioners), researchers could generate a more comprehensive and nuanced evaluation of video content and its representation of heterogeneity. This approach would better capture the complexities of diverse classrooms and ensure that CIs reflect real-world teaching challenges.

Methodological triangulation (i.e., combining different data sources, such as eye-tracking data with verbal data; see e.g., Biermann et al., 2023), would also be desirable, as eye-tracking data alone cannot yield fully valid conclusions about the distribution of attention and underlying cognitive processes (Grub et al., 2024; Holmqvist et al., 2011; cf. eye–mind assumption; Just and Carpenter, 1980). For instance, a particular group of students may not be deemed relevant through cognitive top-do wn processes, as previously assumed, but may instead attract more fixations due to bottom-up processes. This may be due to dynamic stimuli—like specific movements or students throwing paper balls—or other factors, like certain colors, which automatically attract attention. These stimuli are inevitably and directly connected to top-down information (see Navalpakkam and Itti, 2005).

Previous eye-tracking studies on professional vision have largely focused on classroom disruptions as indicators of classroom management. Future research should broaden this focus to include dimensions critical for inclusive education, such as individualization and student engagement (Ainscow and Messiou, 2018). These aspects are essential for creating supportive and equitable learning environments, yet they remain underexplored in process-based investigations. By addressing these dimensions, future studies could offer more comprehensive insights into how teachers manage diverse classrooms effectively.

The aggregated data analysis approach used in this study may obscure important nuances in gaze behavior (Kaakinen, 2021). Future research should consider event-level or student-level analyses to capture detailed patterns of noticing and interpretation (Huang et al., 2021). For example, examining how specific classroom events or individual student characteristics (e.g., behavior, engagement level) influence gaze behavior could provide a more granular understanding of professional vision processes. Such analyses would allow researchers to explore interactions between teacher attention and contextual factors, further enriching our understanding of professional vision in diverse classrooms.

4.4 Implications for theory and practice

The findings of this study hold important implications for both theoretical understanding and practical application in the context of professional vision, particularly in inclusive education. While the exploratory nature of this research limits definitive conclusions, several key areas warrant attention and further investigation.

A central question in research on professional vision remains unresolved: *What constitutes competent perception in (inclusive) teaching situations?* This study highlights the ambiguity surrounding whether professional vision is characterized by frequent, short-duration fixations indicative of broad monitoring through knowledge-driven processes; longer, targeted fixations signaling in-depth analysis of specific events or individuals; or a combination of both, depending on situational demands. Existing frameworks suggest that professional vision integrates noticing and interpreting classroom events (Seidel and Stürmer, 2014). However, the lack of clear patterns in this study raises the possibility that "professional" vision might not be universally defined. Instead, perception may vary significantly between individuals and contexts (i.e., Stahnke and Friesen, 2023), emphasizing the situational and idiosyncratic nature of gaze behavior.

The findings suggest that professional vision may not follow a single, standardized pattern but instead reflect individual and situational factors. This challenges the notion of a universal model of professional vision and aligns with theories emphasizing teacher agency and adaptive expertise. Acknowledging such variability could encourage a shift in research paradigms to explore personalized pathways of professional vision development. Moreover, the results point to the complexity of disentangling cognitive processes driving attention. It remains unclear whether observed gaze behaviors result from top-down processes (e.g., pedagogical intentions) or bottom-up dynamics (e.g., the salience of stimuli). Future research should explore how these processes interact, particularly in diverse and inclusive classrooms where attention may be drawn to unique challenges and opportunities. The application of mobile eye tracking could possibly increase the external validity by allowing to measure representative complex situations in classrooms (Grub et al., 2025). In addition to recording professional vision using eye tracking, triangulation with situational measures of self-efficacy (e.g., through situated assessments or simulated tasks) could be used to increase the validity of the results.

In terms of practical implications, the lack of significant predictive relationships between attitudes, self-efficacy, knowledge, and professional vision underscores the need for practice-based training in teacher education programs to bridge the gap between theoretical understanding and classroom implementation. Simulated classroom environments or video-based analysis tasks could help prospective teachers develop a more refined ability to notice and interpret inclusive teaching aspects (e.g., Telgmann and Müller, 2003). Furthermore, the apparent variability in professional vision highlights the importance of flexible approaches in teacher training that account for individual differences. Teachers should be supported in developing personal strategies for managing diverse classrooms, whether through rapid monitoring or deep engagement with specific events, depending on their strengths and situational demands.

Integrating technology into teacher training could further support this development. Eye tracking and other technologies could play a significant role in fostering self-awareness among teachers about their gaze behavior and attentional patterns. By incorporating such tools into teacher education, prospective

teachers could receive feedback and reflection options on their professional vision, helping them refine their focus on CIs relevant to inclusive education. This also raises questions about how professional vision should be assessed. Current criteria often rely on generalized assumptions about what constitutes "effective" noticing. However, if professional vision is indeed individualized and context-dependent, assessment frameworks must evolve to recognize diverse strategies and their efficacy in different classroom settings.

Finally, these findings carry implications for policy and curriculum design in teacher education. The results call for policies and curricula that prioritize adaptive expertise by encouraging both theoretical grounding and practical application. This would ensure that teachers are better equipped to meet the demands of increasingly heterogeneous classrooms. The questions raised by this study, such as whether professional vision differs significantly between novice and expert teachers, how contextual factors like classroom heterogeneity influence attentional patterns and cognitive processes, and whether professional vision can be effectively trained, offer critical directions for future research. The research of practicing teachers in actual classroom situations could further add value to the discourse. Addressing these questions will not only advance the theoretical understanding of professional vision but also provide actionable insights to enhance teacher education and classroom practice.

5 Conclusion

The results of this study contribute to the ongoing discourse on professional vision and inclusive education in several ways. First, they challenge established findings by demonstrating that beliefs and knowledge do not directly predict prospective teachers' gaze behavior or recognition performance. This highlights the limitations of relying solely on self-reported attitudes or knowledge assessments to infer professional vision abilities. Second, the significant relationship between CI recognition performance and gaze behavior suggests that professional vision involves interrelated but distinct processes that require methodological triangulation for comprehensive assessment. Overall, the results suggest that aspects of differentiation and student engagement are less pronounced in professional vision and insufficiently connected to pedagogical knowledge and attitudes toward inclusive education. The development of professional vision, particularly with regard to the engagement of individual students, is a prerequisite for progress in inclusive education.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/39g7e.

Ethics statement

Ethical approval was not required for the studies involving humans because Ethical review and approval were waived for this study due to the following reasons: (1) written informed consent is obtained; (2) Collected data were anonymous and stored and processed according to the EU General Data Protection Regulation; (3) Only data relevant to the study are collected; (4) Data collection is conducted or supervised by experienced researchers. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

A-SG: Writing – review & editing, Project administration, Validation, Supervision, Data curation, Formal analysis, Methodology, Visualization, Funding acquisition, Conceptualization, Software, Investigation, Writing – original draft, Resources. TS: Software, Investigation, Supervision, Writing – original draft, Conceptualization, Project administration, Funding acquisition, Writing – review & editing, Resources, Formal analysis, Visualization, Data curation, Methodology, Validation. DL: Writing – review & editing, Resources, Validation. AB: Supervision, Methodology, Data curation, Validation, Conceptualization, Writing – review & editing.

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Conflict of interest

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

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The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1635351/full#supplementary-material

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