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University teachers' professional vision with respect to their conceptions of teaching and learning: findings from an eye-tracking study

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This study investigated how university teachers' (mis)conceptions of teaching and learning are related to their ability to notice and interpret pedagogically significant incidents in the classroom, that is their professional vision. Additionally, we examined whether university teachers can be supported in their development of conceptual understanding and professional vision through a short pedagogical training. A total of 32 university teachers who participated in this study completed a teacher conception questionnaire and an eye-tracking measurement with a stimulated retrospective recall (SRR) interview. A pre-test/post-test design was utilized. The findings indicate that in general, professional vision scores and (mis) conceptions of teaching and learning did not correlate. However, with regard to classroom incidents where teachers' visual attention needed to be selectively allocated due to simultaneous interactions, university teachers with more misconceptions and less sophisticated conceptions of teaching and learning tended to focus on the teacher's actions in the classroom. By contrast, university teachers with fewer misconceptions and with more sophisticated conceptions of teaching and learning tended to focus on students' actions. University teachers' less sophisticated conceptions became more sophisticated as a result of pedagogical training. Additionally, statistically significant improvements in participants' noticing were identified, but interestingly not in their interpreting skills. The results emphasize the relevance of the need for pedagogical training and the development of conceptual understanding for university teachers in relation to learning theories in order to support their pedagogical expertise as well as their professional vision.

KEYWORDS

professional vision, selective attention, teacher gaze, misconceptions, university teachers, pedagogical expertise, pedagogical training, eye-tracking

1. Introduction

Successful teaching at universities requires that the teacher makes relevant notions in the classroom. Teaching–learning situations at universities are fraught with complex and rapidly changing situations in which university teachers must have an ability to pay attention to events that foster or constrain student learning and simultaneously ignore less important classroom interactions. To guide the limited attentional visual capacity in order to focus on these

important events requires high-quality pedagogical expertise, including professional vision (Goodwin, 1994). Professional vision means the ability to notice and interpret relevant features of teaching-learning situations to support student learning as effectively as possible (Van Es and Sherin, 2002). Nevertheless, university teachers' pedagogical expertise and professional vision development is still an understudied research area.

University teachers are often experts in their own discipline, but this does not automatically mean that they would be excellent teachers with strong pedagogical understanding. Still today, many university teachers teach without formal pedagogical education and hence have only a limited knowledge of pedagogical concepts and theories (Postareff and Nevgi, 2015). The relation of these potential naïve conceptions and other central elements of teacher expertise, such as professional vision, is a poorly known research area. Previous studies have shown that teachers' beliefs and conceptions related to teaching and learning impact on what and how teachers observe and interpret in classroom situations (Ericsson and Pool, 2016; Meschede et al., 2017; Sun and Zhang, 2022). There have been a number of studies which have focused on university teachers' conceptions of teaching and learning. In summary, the previous research seems to bear out the existence of two broad teaching orientations ranging from focusing on teacher centered activities/content focused approach to interaction with students to foster their learning (e.g., Martin and Balla, 1991; Samuelowicz and Bain, 1992; Gow and Kember, 1993; Trigwell et al., 1994; Virtanen and Lindblom-Ylänne, 2009). Previous studies also show that even university teachers tend to have less sophisticated prior conceptions about teaching and learning and may even harbor misconceptions (Heinonen et al., 2022; Södervik et al., 2022). Thus, attaining a scientific understanding of teaching and learning often requires conceptual change (Vosniadou et al., 2020), and to support university teachers' conceptual change, pedagogical training is needed (Vilppu et al., 2019; Heinonen et al., 2022; Södervik et al., 2022). Compared to primary and secondary education, university teachers often lack pedagogical education, because in many countries pedagogical education is not a prerequisite for working as a university teacher (Murtonen and Vilppu, 2020). This variation in their pedagogical background makes university teachers a special group compared to teachers in lower education levels and highlights the need for research into pedagogical expertise development within the university context. However, little is known about university teachers' professional vision with respect to their (mis)conceptions of teaching and learning, with only a few exceptions (Södervik et al., 2022). In addition, more focused research is needed on what teachers' pay attention to in the classroom, especially in events where several simultaneous events compete for the viewer's attention. These are often unconscious actions and eye-tracking is a new method for examining such actions.

This study brings together perspectives and research traditions that have previously been more or less isolated, namely conceptual understanding and professional vision, bridging the gap between university teachers' theoretical knowledge and their action in the classroom. Our study aims to understand the role of conceptual understanding with respect to professional vision as together they form the basis of university teachers' pedagogical expertise development. The purpose of this study is to examine the relationship between (mis)conceptions and professional vision using classroom video assignment, eye-tracking, questionnaire and a stimulated retrospective recall (SRR) interview. Additionally, it investigates the development of pedagogical expertise as a result of pedagogical training, i.e., the change in university teachers' (mis)conceptions about teaching and learning and about professional vision.

1.1. University teachers' professional vision

To support student learning properly in universities requires that university teachers not only know what and how to teach, but that they are able to notice and interpret meaningfully relevant processes in teaching-learning situations to support student learning as effectively as possible (Van Es and Sherin, 2002; Sherin et al., 2011; Seidel and Stürmer, 2014). This means appropriate skills in professional vision (Goodwin, 1994). Noticing involves deciding consciously or unconsciously where to attend when observing a teaching-learning situation, and interpreting concerns the ways in which teachers draw on their knowledge to draw conclusions about what has been attended to. These two components of professional vision – noticing and interpreting – are interrelated and cyclical (Sherin and van Es, 2009). Interpreting important events also requires three interrelated processes: (1) description, (2) explanation, and (3) prediction (Seidel and Stürmer, 2014). Professional vision is especially important in teaching-learning situations where several simultaneous events compete for the teacher's attention at the same time (Shin, 2021). Thus, before a teacher can interpret the situations correctly and thus support student learning, the teacher must first learn to notice which pedagogical situations are significant.

While research on teachers' professional vision has been more prevalent in primary and secondary education, the limited attention given to professional vision in university settings is a significant gap that warrants more investigation. Studying professional vision in the university context helps us to understand how university teachers navigate these distinct challenges and make informed instructional decisions, and this understanding plays a vital role in student learning outcomes. In order to direct their visual focus of attention efficiently and consciously, university teachers need an appropriate conceptual understanding that can guide their attention in the classroom, but they also need to be able to interpret the pedagogically relevant events that they notice meaningfully by verbalizing or reflecting. Therefore, there should be a stronger focus on research on university teachers' professional vision. In addition, more research is needed to investigate how university teachers' (mis)conceptions are related to their professional vision.

The methods used to study university teachers' pedagogical expertise have been previously rather limited (Berliner, 2001; Wolff et al., 2016), mainly focusing on utilizing self-reports and interviews. In our study, the use of eye-tracking adds significant value to the research of professional vision as it measures cognitive processes in complex classroom interactions (Holmqvist et al., 2011; Beach and McConnel, 2018; Jarodzka et al., 2021; Lagner et al., 2022). However, eye-tracking methodology only enables the investigation of teachers' noticing skills, and not the interpretation of the noticed events, which is a crucial part of professional vision. Thus, eye-tracking should be combined with additional data, such as interviews, to investigate what interpreting skills lie behind the observation (van den Bogert et al., 2014). Although previous studies using eye-tracking methodology have already included qualitative interview data (e.g.,

Guan et al., 2006; Hyrskykari et al., 2008; Gegenfurtner and Seppänen, 2013), in the university context this type of mixed-methods approach is still rare and therefore it is needed to gain more knowledge about university teachers' professional vision development (see, however, Murtonen et al., 2022). Therefore, in this study, we use a classroom video assignment and an SRR interview to study university teachers' professional vision. Additionally, our research focuses especially on those situations where the teachers have to choose where to focus their attention while multiple things are happening at the same time in the classroom. To study this, an eye-tracking method was used.

1.2. University teachers' conceptions of teaching and learning with respect to their professional vision

Because classrooms are complex environments where multiple events happen at the same time, teachers cannot pay attention to everything that is happening. In fact, teachers' attention is very selective, and is based on their beliefs, previous experiences, and knowledge (Mason, 2002). Teachers' professional vision and their conceptions of teaching and learning are intertwined aspects of their instructional practice (Meschede et al., 2017; Sun and Zhang, 2022). By studying these aspects together, researchers can develop a holistic understanding of the complex interplay between teachers' beliefs, their observation skills, and the instructional decisions they make.

In previous teacher education research, two underlying conceptions of teaching are often distinguished, commonly characterized as either teaching as transmitting knowledge from the teacher to students or teaching as facilitating learning, that is by constructing knowledge with the students to achieve conceptual change (Pajares, 1992; Kember and Kwan, 2000; Staub and Stern, 2002; Voss et al., 2013; Kleickmann et al., 2016). Previous research has shown that university teachers' conceptions of teaching and learning vary, and less sophisticated and more sophisticated prior conceptions are found in different disciplines (Trigwell, 2002; Lueddeke, 2003; Lindblom-Ylanne et al., 2006). Teachers who conceive teaching as transmitting knowledge to students tend to employ content-focused approaches, whereas teachers who see teaching as facilitating students' learning tend to use learning-focused approaches (Parpala and Lindblom-Ylänne, 2007). Hence, less sophisticated conceptions might have an effect on teacher performance, and previous studies suggest that transmissive beliefs hinder a teacher's professional vision (Meschede et al., 2017). In contrast, university teachers' appropriate skills in professional vision seem to be related to more sophisticated conceptions of teaching and learning (Södervik et al., 2022).

In addition to the fact that university teachers' conceptions of teaching and learning vary widely, misconceptions are also apparent. For example, the presence of preferred learning styles, namely the idea that students learn best which they receive information in their preferred mode (e.g., visual, auditory, kinesthetic), is a common misconception among teachers (Dekker et al., 2012; Grospietsch and Mayer, 2018). As misconceptions related to teaching and learning are also found among university teachers (Heinonen et al., 2022), they often need to modify their existing conceptions to support the learning of their students, and this commonly requires development in conceptual understanding (Chi, 2013; Vosniadou, 2013; Vosniadou et al., 2020). In the process of such a change, pedagogical training is important (Vilppu et al., 2019; Heinonen et al., 2022; Södervik et al., 2022). However, teachers' misconceptions might often be very persistent and sometimes even hard to change (Heinonen et al., 2022). Therefore, we aim to investigate to what extent university teachers' (mis) conceptions and professional vision are affected by pedagogical training.

Based on previous research in secondary school contexts, eye-movement studies have revealed that expert teachers with more sophisticated conceptions of teaching and learning tend to look longer at students compared to novices, who focus more on teacher actions (McIntyre et al., 2017). Previous research also shows that more experienced teachers are able to focus more deeply on student learning than novice teachers, and they are able to use knowledge-based information rather than bottom-up visual observations (e.g., Levin et al., 2009). In the university context, pedagogically trained teachers seem to pay more attention to the students in the classroom than non-trained teachers (Murtonen et al., 2022). However, we still lack this type of research concerning university teachers, where eye movements reveal where university teachers are focusing in classrooms in situations where several simultaneous things compete for the teacher's attention. Additionally, little is known how teachers' (mis)conceptions affect their professional vision capabilities. Thus, our research focuses on university teachers' pedagogical expertise operationalized by both (mis)conceptions of teaching and learning and professional vision, and through the connection between them. Studying university teachers' professional vision and their conceptions of teaching and learning together is essential to gain a comprehensive understanding of their instructional practices and decision-making processes.

1.3. The aim of the study

Based on previous premises, the aim of this study is to investigate university teachers' professional vision and (mis)conceptions of teaching and learning using a classroom video assignment, a questionnaire, and an SRR interview. Furthermore, we focus in more detail on classroom incidents in which several things compete for the university teacher's visual attention, and study and test whether there are differences between teachers with less versus more sophisticated (mis)conceptions in their visual perception using eye-tracking. Additionally, we investigate how do university teachers' conceptual understanding and professional vison develop during a short pedagogical training.

2. Methods

2.1. Participants

The participants were university teachers who attended a basic university pedagogical training (5 ECTS) organized by the University of Helsinki. The university teachers who took part in the study consisted of a fairly homogeneous group. They were novices in terms of pedagogical knowledge, but they were all from the same field of research, representing eight different departments of life sciences. A total of 33 university teachers (27 female, 5 male) participated in the

TABLE 1 Study procedure.

Pre-test	Pedagogical training	Post-test
Background information ($n = 32$)	10-week university pedagogy course in Autumn 2021 (5 ECTS)	
Teacher conceptions questionnaire ($n = 32$)		Teacher conceptions questionnaire ($n = 29$)
Eye-tracking recordings + SRR interviews ($n = 31$)		Eye-tracking recordings + SRR interviews ($n = 9$)

pedagogical training held in autumn 2021. Of them, 32 participants participated in the study's pre-test; of these, 29 participated in the post-test. Unfortunately, for two participants, a stimulated retrospective recall (SRR) interview failed in the pre-test. A total of 9 participants participated in the study's eye-tracking post-test. Covid restrictions had an impact on the eye-tracking post-test.

The pedagogical training in which the data were collected was the first university pedagogy course at the University of Helsinki that provides a foundation for further pedagogical studies. To participate in the course, teaching duties at the university, or employment with the university, or study rights to pursue a doctoral degree, were a requirement.

Informed consent, and the anonymity of participants were ensured in the research process. The questionnaire and the first eye-tracking measures were part of the course assignments, but the participants could decide for themselves whether to give their consent for the answers presented in the study. Because the study involves intervening in the physical integrity of research participants (eye gaze locations), an ethical review for experiments was carried out by the University of Helsinki Ethical Review Board in the Humanities and Social and Behavioural Sciences. All experiments were performed on healthy adult test participants who gave their written informed consent.

2.2. Pedagogical training and study procedure

University teachers who participated in the study attended a short, university pedagogy course (5 ECTS) in which they familiarized themselves with basic educational theories and concepts concerning teaching and learning. This course is the first university pedagogy study at the University of Helsinki that provides a foundation for further pedagogical study. The course lasted 10 weeks and included three online meetings as well as extensive independent study. Each meeting lasted 3 h, including two 15-min breaks. The themes of the course meetings were: (1) introduction to university pedagogy, including conceptions and theories of learning, (2) factors affecting learning (e.g., metacognition, self-regulation, motivation) and prior knowledge and conceptual change, and (3) development of university teachers' expertise, and teaching and learning at the university. The contents of the course emphasized pedagogical theories and practical training, with a special emphasis on reflection as a tool to develop one's expertise development as a teacher. Meetings included traditional lecturing, but they were also used for active and collaborative learning activities, such as peer-group assignments and discussions. To complete the course, participants needed to attend all three course meetings and complete all the course requirements.

The study procedure is given in Table 1. Before beginning the pedagogical training, participants were sent the teacher conceptions online questionnaire, which included background information questions. After the first meeting, participants enrolled themselves in the eye-tracking laboratory, which was open for 3 weeks. A pre-test/post-test design was utilized, so the questionnaire was repeated in an identical form after the last meeting. Following the training, voluntary participants were invited to a post-test eye-tracking measurement. The eye-tracking post-test had to be postponed due to the COVID-19 situation in Finland. The pandemic also affected the number of participants in the post-test, and only nine participants eventually registered for the final measurement.

2.3. Measures

2.3.1. Teachers' (mis)conceptions questionnaire

All the participants filled in a questionnaire regarding their conceptions and potential misconceptions about teaching and learning. The questionnaire of 27 Likert items regarding conceptions of teaching and learning at university and seven true/false items measuring potential misconceptions, was used (Heinonen et al., 2022). The Likert items represented conceptions about (a) teaching as transmission of subject knowledge (TRAN), and in contrast, items about (b) beliefs that learning is a constructive activity (CON). All items were measured via Likert scale items, which ranged from 1 (completely disagree) to 5 (completely agree). Participants' misconceptions were examined using seven true/false items, and an opportunity to provide open-ended explanations for their answers was given (Table 2). The items concerning misconceptions were reconstructed on the basis of some previous studies (Stofflett, 1994; Grospietsch and Mayer, 2018; Vosniadou et al., 2020), to meet the purpose of this study.

2.3.2. Teachers' professional vision – classroom video annotation task and stimulated retrospective recall interviews

To study teachers' professional vision, we used a video-based task, as video-based approaches are considered to be more authentic and therefore quite a promising tool for measuring situated knowledge and teacher cognitions (Gold and Holodynski, 2015; Jarodzka et al., 2021), and to avoid problems related to self-report measures (Paulhus and Vazire, 2007; Vilppu et al., 2019). A tailor-made video represented a typical university teaching-learning situation (Heinonen et al., 2022), and it was filmed from the perspective of an outside observer (Figure 1). The video was depicting an activating university lecture, including group work and discussions. The video represents one of the

TABLE 2 True/false items measuring participants' potential misconceptions of teaching and learning.

True/false items	Scoring
(1) Individuals learn better when they receive information in their preferred learning styles (e.g., auditory, visual, kinesthetic).	False
(2) Information that is studied over longer periods is learned better than the same information studied over shorter periods.	True
(3) It always eases learning if students have preconceptions about the topic to be learned.	False
(4) Changes in students' misconceptions are mostly dependent on the teacher's ability to explain the content clearly enough.	False
(5) Deep learning means that one can repeat information adopted from the course material.	False
(6) Misconceptions are developed through students taught wrongly.	False
(7) Misconceptions are changed via proof or authority.	False

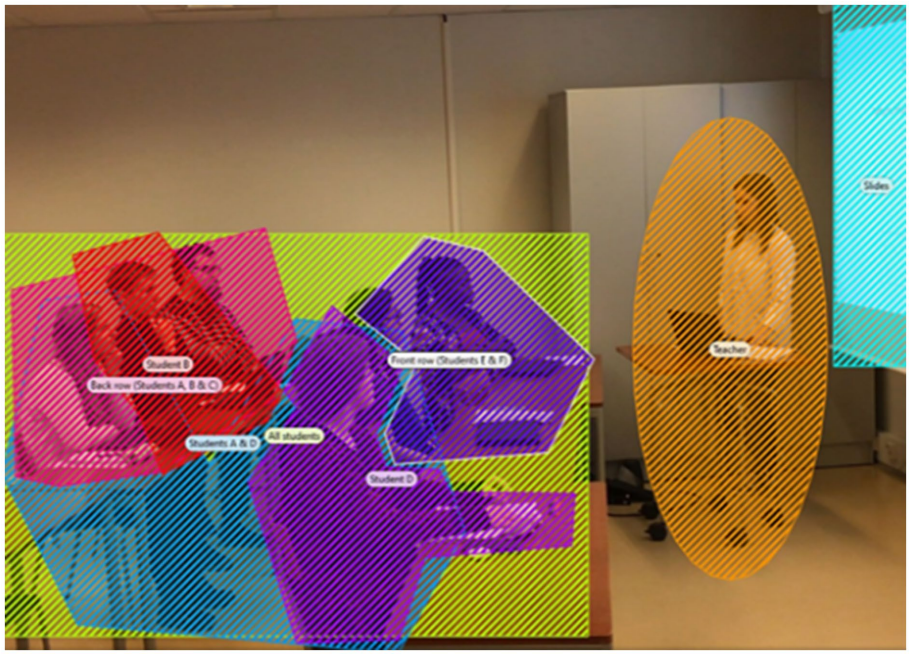

FIGURE 1
The classroom video used in the study with areas of interest (AOIs).

more typical teaching methods at the University of Helsinki. The customized video used actors as teacher and students. The video (12 min) aimed to represent as authentic a teaching-learning situation as possible, since the authenticity of video interpretations has been regarded as highly important in terms of participants' viewing experience and knowledge activation (Seidel et al., 2011). A total of 15 pre-defined pedagogically significant events, so-called incidents, were incorporated into the video. The incidents include different, pedagogically important episodes, which were designed to represent traditional learning-related theories and educational psychology phenomena, such as understanding constructivist teaching activities and being able to activate and consider students' prior knowledge in one's own teaching.

To study teachers' noticing, participants were instructed to press down the left mouse button each time they noticed something pedagogically significant and/or relevant in terms of teaching and learning. Mouse clicks were recorded in the video system and formed a time stamp. The participants' mouse clicks were not limited and they were allowed to press the mouse whenever they experienced something pedagogically significant in the video.

A stimulated retrospective recall (SRR) interview was conducted to gain a deeper understanding of the participants' interpretations of the incidents they had noticed. While rewatching the video, the researcher paused the video each time the participant had pressed down the mouse button in the first viewing. At every pause, participants were asked to recall what they were thinking during the first viewing and to think aloud what was pedagogically significant and/or relevant in terms of teaching and learning. On average, the SRR interviews lasted approximately 20–35 min. The SRR interviews (audio and visual data) were recorded using a video camera.

2.3.3. Eye-tracking In measuring teacher noticing

Five classroom incidents, where several things were occurring at the same time, were selected for the eye-tracking measurement (Table 3). In these particular incidents there was a simultaneous active role for both the teacher and the students, and the interaction of these parties played a role in these incidents. The viewer either consciously or unconsciously made a decision what to focus on (Van Es and Sherin, 2002). In the other 10 events, more homogenous observation

TABLE 3 Description of the pedagogically relevant incidents in the classroom video, where several simultaneous things competed for the teacher's visual attention.

Incident	Explanation of the incident
1	Student B (see Figure 1) raises a hand to ask a question, but the teacher ignores the student because the teacher is so concentrated on preparing lecture slides.
6	Peer group work starts, but one student (D) is left alone without a partner. However, the teacher does not notice this and does not intervene.
8	Student B raises a hand to ask a question, but the teacher ignores the student for a long time because the teacher is so concentrated on lecturing.
10	Two students (A and D) start discussing with each other while the teacher is lecturing. The teacher does not notice their discussion and other students are a bit disturbed before the teacher finally intervenes.
12	The teacher is lecturing using a very teacher-centered approach. All the students have become passive; some of them are even sleeping and some of them are focusing on their devices, such as laptops or phones. The teacher does not notice their passive behavior because the teacher is concentrating on lecturing.

behavior was expected, and the distribution of attention was presumably less due the nature of these events. In these events there was only one active party (e.g., the teacher explaining the intended learning outcomes for the lesson, or the teacher recapping the previous lesson, see Appendix). The selected five events, on the other hand, represented more complex interaction situations and required conscious or unconscious guiding of visual attention compared to the incidents mentioned above.

Participants' eye movements were recorded while watching the video to investigate where they focus their attention, in other words, what they noticed while watching the video. The use of eye-tracking has proved to be an important tool to investigate learning processes (Jarodzka et al., 2017) and a promising method for professional vision research (see, e.g., Wyss et al., 2020). Learning to make relevant observations from the classroom was one learning outcome of the pedagogical training that participants attended. Thus, a classroom video annotation task was a central part of the course content and was a mandatory task for all participants. Especially in the pre-test, the video annotation task was an important part of the course and the participants also received feedback on their own observation during the SRR interview.

A Tobii Pro Spectrum (Tobii Technology, Inc., Falls Church, VA) was used to record participants' eye movements while watching the video. Infrared cameras tracing the position of the pupils of the participants' eyes were integrated into the body of the same high-resolution 24″ computer monitor operating at 600 HZ, from which the classroom video was presented. The accuracy of the eye tracker was 0.6°. Eye-tracking data collection took place individually. The participants were briefed on the eye-tracking device and proper viewing distance and height relative to the eye-tracking device were ensured. No supporting chin rests were used, as the eye tracker allows the participants' to more their heads. When the eye tracker was adjusted, an initial five-point calibration was performed. After this, instructions regarding the video interpretation task were given. The instructions were kept very general; no hints about the upcoming incident or any other preparatory information about the video were offered. The eye movement recordings lasted approximately 15 min, including the calibration. The full experiment (eye-tracking and SRR interview) took approximately 45 min for each participant.

2.4. Data analysis

To investigate (mis)conceptions with respect to participants' professional vision, standard median splits were used to turn conception factors into dichotomous variables (that is, categorical variables with two groups). A median split was used to identify the extremes in the participants in relation to different variables. The differences between groups were tested using non-parametric Mann–Whitney *U* tests. Differences between participants were tested using the Wilcoxon signed-rank test. Additionally, correlations were calculated between the participants' (mis)conception and professional vision scores.

The quantitative data were analyzed using IBM SPSS Statistics 28. Principal component analyses (PCA) with Varimax rotation were conducted for the pre-test Likert-scale items concerning the participants' conceptions related to teaching and learning (KMO = 0.208, Bartlett $\chi^2[351] = 533.801$, $p < 0.001$). The PCA revealed two scale dimensions, which were exactly the same as used in the research by Heinonen et al. (2022). In the pre-test, two sum variables were used: (1) "teaching as transmission of subject knowledge (TRAN)," with an acceptable alpha ($\alpha = 0.778$) and "beliefs that learning is a constructive activity (CON)," with an acceptable alpha ($\alpha = 0.603$). In the post-test, the same sum variables were used: "teaching as transmission of subject knowledge (TRAN)," with an acceptable alpha ($\alpha = 0.653$) and "beliefs that learning is a constructive activity (CON)," with an acceptable alpha ($\alpha = 0.569$). Participants' misconceptions were scored using dichotomous scoring. Participants received a point for giving an incorrect answer to a true/false question and were given no points for answering the question correctly.

Participants' mouse clicks with their eye movements and videotaped interviews together constituted the foundation for conceptualizing university teachers' professional vision. Teacher noticing was analyzed based on timestamps from the mouse clicks, and noticing was scored using dichotomous scoring. First, the researcher counted how many pre-defined pedagogically significant events the participant had noticed during the correct time point. To be awarded one point for noticing, the mouse button should have been pressed during a pedagogically significant incident. If participants did not press the mouse button during the incident, they did not receive any points for noticing a certain incident. As the pedagogically significant incidents were based on certain time frames, it was not possible for the participant to gain noticing points by constantly clicking the mouse. Since the video included 15 pedagogically significant incidents, the participants could receive a total score of up to 15 points of noticing.

The interpreting skills of the participants were based on their videotaped SRR interviews. The SRR interview recordings were transcribed and analyzed qualitatively (Table 4). First, the transcripts were timestamped and the timing of the eye-tracking

TABLE 4 Examples of analysis units representing the domains and sub-levels of teachers' verbal interpretations.

Domains of interpreting	Points received	Example citation
Description		
Statements lacking an interpretation or providing a false interpretation or else the interpretation was not clear, for instance incorrect use of pedagogical terms and/or theories or misconceptions.	0	"Well, it wasn't related to the topic, that question, a quick answer, then an aside and then (from the teacher) the thought was interrupted, and you have to look at the screen where you were going." (P109, incident 9, pre-test)
Statements simply describing what is seen or understood to be occurring in the video, presenting only a limited and descriptive explanation of the teaching learning situation.	+1	"Well, all the students are starting to look quite upset at this point, each in their own way." (P84, incident 12, pre-test)
Explanation		
Statements representing some understanding of pedagogically significant actions by the teacher, such as facilitating or supporting students' learning.	+1	"This is clearly where students start to lose focus and motivation. So maybe now at this point we need a bit of something stimulating on the teacher's part, something about what kinds of thoughts this arouses or what do you think, because clearly now no one really listens anymore if the teacher only goes from one thing to another without involving the students anywhere in between." (P89, incident 12, pre-test)
Statements representing a clear understanding of pedagogical concepts and theories; using/linking them correctly with interpretations of the teaching-learning situation.	+1	"So now I somehow drew attention to this, that he still spends time on this, but then he says that he does not want to spend time on this. Would this be the teacher-based pedagogical method, that is, when the teacher defines what the topics are that will be discussed, and especially when, from the student's point of view, they are not necessarily terribly stimulating for the discussion or with the teaching material, because in a way, it related to this? I understand that this was a somewhat irrelevant question in a certain way, but maybe it could be handled somehow more sensibly, let us say this." (P95, incident 9, pre-test)
Prediction		
Speculation about an action that the teacher (or a student) in the video will soon take in terms of teaching and learning *or* speculation about actions that the participant her/himself would have taken in a similar situation.	+1	"So this is probably related to those students' dozing off, they do not clearly show that they are not interested, they are tired or they have already heard these things enough times or somehow too many times... They might want a break and since they have clearly shown here many times that they would like to participate and that they would like to be asked. So maybe they are somehow, maybe they are somehow not good at listening to a real lecture and they would be better in some kind of interactive activity, at least some of them... It could also be that there is somehow too much repetition in this lecture or there is somehow too monotonous rambling. You cannot know that now, and maybe it's their preliminary task... maybe they are like that because they have already become quite familiar with this matter. That's right, if the very same subject is lectured again, then the reaction may be the same, but you cannot know. Yeah." (P101, incident 12, post-test)

recordings with mouse clicks was synchronized. Next, the researcher went through the transcripts based on Heinonen et al.'s (2022) analysis framework. The aim of the SRR interviews was to gain access to the interpretation skills of the participants, while the scoring of the transcripts comprised three domains: description, explanation, and prediction, including sub-levels that were also considered Heinonen et al.'s (2022) analysis. The interview data were scored using continuous scoring ranging from zero to four points per incident.

In interpreting scores, statements simply describing what is seen in the video without any additional explanations scored one point (Table 4). If the participants' interpretation deepened from the pedagogical perspective by using explanation, the participants was rewarded from one to three points depending on the nature of the answer. Statements representing an understanding of pedagogically significant actions were rewarded one point, and statements representing a clear understanding of pedagogical concepts and theories were rewarded further point. In addition, speculation about an action that a teacher or the student would soon take was also rewarded one point. With a total of four points awarded for each pedagogically significant incident, participants could receive a total score of up to 60 points.

All excerpts from the interviews were translated from Finnish into English by the authors. The first author had the main responsibility for the analysis, but both the first author and an external, educated evaluator independently scored the SRR interview data to assess and score the quality of the participants' interpreting skills. Inter-rater reliability was determined using Cohen kappa coefficients, and there was an excellent degree of agreement between the scoring of two raters' (Cohen kappa 0.80) (Fleiss and L., 1981). After the scoring, any

TABLE 5 Participants' (mis)conception and professional vision scores in the beginning of pedagogical training.

	Max. score	*M*	Md	SD	Min	Max
TRAN ($n = 32$)	5	2.23	2.25	0.79	1	4
CON ($n = 32$)	5	4.30	4.33	0.39	3.50	5
Misconceptions ($n = 32$)	7	2.50	2.00	1.37	0	6
Noticing ($n = 31$)	15	10.55	11.00	2.20	6	14
Interpreting ($n = 30$)	60	13.30	13.00	4.60	1	23

TABLE 6 Participants' (mis)conceptions of teaching and learning with respect to their noticing of pedagogically significant incidents.

Incident no.	Results	
1	N/A	
6	N/A	
8	Teachers with fewer misconceptions focused on student B's behavior compared to teachers with more misconceptions ($Z = -2.143$, $p = 0.032$)	Teachers with more misconceptions focused on the teacher's actions compared to teachers with fewer misconceptions ($Z = -3.096$, $p = 0.002$)
10	Teachers with fewer transmissive conceptions focused on students A and D compared to teachers with more transmissive conceptions ($Z = -3.283$, $p < 0.001$)	Teachers with more transmissive conceptions focused on teacher's actions compared to teachers with fewer transmissive conceptions ($Z = -1.962$, $p = 0.050$)
12	Teachers with fewer misconceptions focused on all students' actions compared to teachers with more misconceptions ($Z = -2.223$, $p = 0.026$)	

disagreements and borderline cases were discussed during the analysis phase and resolved by expanding the coding manual and consensus discussion. In this way perfect overall reliability (Cohen kappa = 1.0) was achieved.

Incidents where selective attention was needed, were selected for a more detailed analysis. To obtain gaze data on the incidents, areas of interest (AOIs) were set in the Tobii ProLab software. A total of eight AOIs were divided, which in this study were: (1) back row (students A, B, and C), (2) student B, (3) student D, (4) student A and D, (5) front row (students E and F), (6) all students, (7) teacher, and (8) slides (Figure 1). The AOIs were defined according to who were active participants in various incidents. After defining the AOIs, the sum of visit durations (total visit duration; TVD) on each AOI was used to analyze the gaze of the participants. In order to find out the connection between the participants' (mis)conceptions and professional vision, statistical analyses were conducted. The eye movements of the groups divided by media split were compared to the divided AOIs by using the Mann–Whitney *U* test.

3. Results

3.1. University teachers' (mis)conceptions of teaching and learning with respect to their professional vision

University teachers' professional vision scores and (mis) conceptions of teaching and learning varied at the beginning of the course (Table 5). In the pre-test, the participants noticed an average of 9.78 incidents out of 15 from the video ($Md = 10.00$; $SD = 1.48$; $Min = 7$; $Max = 12$) and received on average 13.30 interpreting scores ($Md = 13.00$; $SD = 4.60$; $Min = 1$; $Max = 23$). Additionally, the participants ($n = 32$) had an average of 2.50 misconceptions related to teaching and learning ($Md = 2.00$; $SD = 1.37$; $Min = 0$; $Max = 6$).

When investigating the relationship between participants' (mis) conceptions of teaching and learning and professional vision scores in general, including all 15 incidents both in the pre-test and post-test, no significant correlation was identified.

After that, incidents that required selective attention allocation due to simultaneous classroom interactions were further investigated using eye movement data. The Mann–Whitney *U* tests revealed that with regard to three incidents, university teachers with more and less sophisticated conceptions of teaching and learning made different kinds of observations when several actions competed for the viewer's attention simultaneously (Table 6). In general, participants with more misconceptions and/or less sophisticated conceptions of teaching and learning tended to focus on the teacher's actions in the classroom video. On the other hand, participants with fewer misconceptions and with more sophisticated conceptions of teaching and learning tended to focus on the students' actions. This became evident in three out of five incidents where teachers' visual attention needed to be selectively allocated.

3.2. How do university teachers' (mis)conceptions and professional vision change as a result of pedagogical training?

The Wilcoxon signed-rank test revealed that participants changed in their (mis)conceptions about teaching and learning from less sophisticated conceptions to a more sophisticated direction (Table 7). Conceptions related to beliefs that teaching is the transmission of subject knowledge decreased among participants ($Z = -3.376$, $p = 0.009$). In contrast, beliefs that learning is a constructive activity improved among participants during the pedagogical training ($Z = -2.176$, $p < 0.001$).

The Wilcoxon signed-rank test revealed that the number of misconceptions decreased statistically significantly among participants in the post-test ($Z = -3.682$, $p < 0.001$), and that participants ($n = 29$) had an average of 1.28 misconceptions related to teaching and learning ($Md = 1.00$; $SD = 0.88$; $Min = 0$; $Max = 4$).

TABLE 7 Participants' (mis)conception and professional vision scores before and after pedagogical training.

	Max. score	Pre-test					Post-test				
		M	Md	SD	Min	Max	*M*	Md	SD	Min	Max
TRAN (pre-test: $n=32$; post-test: $n=29$)	5	2.23	2.25**	0.79	1	4	1.75	1.75**	0.54	1	3
CON (pre-test: $n=32$; post-test: $n=29$)	5	4.30	4.33***	0.39	3.50	5	4.64	4.67***	0.35	3.67	5
Misconceptions (pre-test: $n=32$; post-test: $n=29$)	7	2.50	2.00***	1.37	0	6	1.28	1.00***	0.88	0	4
Noticing (pre-test: $n=31$; post-test: $n=9$)	15	10.55	11.00*	2.20	6	14	11.67	12.00*	2.45	7	15
Interpreting (pre-test: $n=30$; post-test: $n=8$)	60	13.30	13.00	4.60	1	23	18.00	18.50	5.98	7	26

*$p<0.05$, **$p<0.01$, ***$p<0.001$.

In the post-test, the participants noticed an average of 11.67 incidents out of 15 from the video ($Md=12.00$; $SD=2.45$; $Min=7$; $Max=15$) and received on average 18.00 interpreting scores ($Md=18.50$; $SD=5.98$; $Min=7$; $Max=26$). The Wilcoxon signed-rank test showed statistically significant improvement in teachers' noticing ($Z=-2.209$, $p=0.027$), but not in their interpreting skills ($Z=-1.951$, $p=0.051$).

4. Discussion

The aim of this study was to investigate university teachers' (mis) conceptions of teaching and learning with respect to their professional vision in general and with regard to classroom episodes, where several simultaneous things compete for the teacher's attention. Additionally, the development of university teachers' conceptual understanding was a subject of interest. This study acknowledges the importance of understanding how university teachers' (mis)conceptions influence their noticing and interpretation skills of classroom events when several things compete for the teacher's attention at the same time.

4.1. The relation between university teachers' (mis)conceptions and professional vision

The findings of the present study indicate that in general there was no significant correlation between university teachers' professional vision scores and (mis)conceptions of teaching and learning. However, with regard to classroom incidents, where the teacher was required to attend to some interactions while filtering out other simultaneous classroom activities, differences were found between teachers with more and less sophisticated conceptions of teaching and learning. Thus, the results of our study provided more insight into the assumption that teachers' conceptions and professional vision are interrelated, as suggested in earlier studies (Borko and Putnam, 1996; Blömeke et al., 2015; Meschede et al., 2017; Södervik et al., 2022). University teachers with more misconceptions and less sophisticated conceptions of teaching and learning tended to focus on the teacher's actions in the classroom video. In contrast, university teachers with fewer misconceptions and with more sophisticated conceptions tended to focus on students' actions. These outcomes are in line with previous findings (Murtonen et al., 2022), indicating that pedagogically aware teachers pay more attention to their students than teachers with no pedagogical understanding. Thus, teachers directed their attention while watching the video based on their prior knowledge of teaching and learning.

Based on theories of human cognition, individuals have only limited attentional capacity, which restricts how many events they can focus on at any given time, while irrelevant information is discarded (Kahneman, 1973; Rensink, 2009). The choice of whether to focus on the teacher or the students is reflected by the teacher's conceptions of teaching and learning (Mason, 2002). Less sophisticated conceptions are associated with content-focused approaches, which may have led to a focus on the teacher's activities. On the other hand, teachers with more sophisticated conceptions are more learning-focused, which shows their focus on the students' activities.

The results suggest that more sophisticated conceptions are a significant predictor of teachers' more developed professional vision capability in such incidents where the viewer's attention is divided between salient stimuli and irrelevant information. In contrast, less sophisticated conceptions predict noticing irrelevant actions in such incidents. Therefore, teachers' misconceptions of teaching and learning might lead to misinterpretations in real-life classroom situations, and naïve conceptions might lead to ignoring relevant incidents (Meschede et al., 2017). By contrast, more sophisticated conceptions support a teacher's ability to notice and interpret pedagogically significant incidents properly, and in that way support student learning more effectively (Södervik et al., 2022).

4.2. University teachers' (mis)conceptions and professional vision development as a result of pedagogical training

Our study showed that even a short pedagogical training can have the potential to direct university teachers' conceptions of teaching and learning from a less sophisticated to a more sophisticated direction, while pedagogical training also decreased the number of misconceptions among university teachers. Additionally, university teachers' noticing skills improved remarkably as a result of pedagogical training. After the pedagogical training, participants noticed significantly more pedagogically significant incidents in a video than before the pedagogical training. These results are in line with some previous findings related to the effect of

a short pedagogical training (Vilppu et al., 2019; Heinonen et al., 2022; Södervik et al., 2022).

However, in our study the participants did not significantly improve in their interpreting skills during the pedagogical training. Since participants attended basic university pedagogical training and the participants were novices in terms of pedagogical knowledge, it is understandable that as a result of this short training, their noticing skills developed statistically significantly, but their interpreting skills did not. According to previous studies, more experienced teachers have better skills in verbalizing classroom events (Carter et al., 1988). Teachers with more experience are likely to have developed a broader repertoire of knowledge and strategies, enabling them to make more sophisticated interpretations (Stahnke et al., 2016; Wolff et al., 2016, 2017). Interpreting skills involve higher-level cognitive processes, such as making inferences, connecting information, and understanding context. These skills may presumably require practical teaching experience, which our participants were lacking, because previous studies have indicated that teaching experience is influential in the way that teachers process classroom information (van den Bogert et al., 2014; Wolff et al., 2016, 2017). More experienced teachers' interpretations are more elaborate, and they understand the connections between teacher and student activities in the classroom better than novices (Wolff et al., 2017; Stahnke and Blömeke, 2021). These processes require a deep understanding of the subject matter and the ability to integrate various sources of information. As a result, developing these skills may take more time compared to noticing skills, which often focus on more immediate and surface-level observations in general. However, in observing classroom situations where teachers attend to some interactions while filtering out others when multiple events are happening simultaneously, also involves a more complex collection of techniques that help teachers to notice pedagogical incidents (Mason, 2011). It is essential to recognize that assessing university teachers' professional vision development should consider both noticing and interpreting skills as separate dimensions. While noticing skills provide the foundation for professional vision, interpreting skills enable teachers to make sense of what they observe and make informed instructional decisions. Both aspects are vital for effective teaching and supporting the development of both skills is crucial in pedagogical expertise development.

There is an increasing interest in use of the eye-tracking measurement for instructional purposes, where teachers could receive feedback on their own observation skills (Tunga and Cagiltay, 2023). For example, eye movement modeling examples (EMME) are novel learning materials for these purposes, as modern eye-trackers can record individuals' eye-movements in a reusable format (Tunga and Cagiltay, 2023). Previous eye-tracking studies have shown that there are differences between experts and novices regarding eye-movement (Lowe, 1999; Jarodzka et al., 2010). The beauty and benefit of these EMME materials are that they enable producing of video-based learning material, where it is modeled not only, how the expert teacher interprets, but also, how they observe the classroom and students' working (van Gog et al., 2009). Utilizing of classroom videos as learning material is relatively common method in teacher education, but EMME is a novel approach and could work as teaching material to support the development of university teachers' pedagogical expertise.

Contrary to our results, some previous studies also suggest that longer periods of pedagogical training are needed for teachers to change their (mis)conceptions and point them in a more sophisticated direction (Gibbs and Coffey, 2004; Prebble et al., 2004; Postareff et al., 2007). Additionally, short pedagogical training in higher education does not always seem to be successful in changing participants' conceptions to make them more student-centered, instead the change can even point participants in a more teacher-centered direction (Ödalen et al., 2018). Thus, longer pedagogical training should be emphasized to ensure more permanent changes.

4.3. Limitations and future directions

There are some limitations to our study that need to be considered. First, due to the laborious procedure of the assessment, the sample of the study was rather small ($n = 32$), especially in the second measurement in the eye-tracking phase ($n = 9$), and therefore generalization of the findings is limited. Therefore, further research with a larger sample size is needed. In this study, the emphasis was especially on the pre-test measurement, but in the future studies it is important to have the same number of participants in both the pre-test and post-test measurement. Additionally, the study sample might have been somewhat biased, as all participants were voluntarily enrolled in the pedagogical training and therefore it can be assumed that they were motivated in terms of developing their pedagogical expertise. In future studies, it would be interesting to study professional vision and its related (mis)conceptions among university staff who have teaching duties but who do not want any further pedagogical training. Further, it would also be interesting to study university staff who have already completed more pedagogical training, and therefore might be thought to be experts in terms of pedagogical competence. Comparisons between real pedagogical experts and future faculty should be made.

Second, the participants in our study were all university teachers from the faculties of life sciences. Even though the discipline-specific perspective is one of the strengths of our research, it is still important to conduct research in the context of different disciplines in the future. To ensure disciplinary differences, it would be beneficial in further studies to compare teachers from the so-called 'soft' and 'hard' sciences. Third, in future studies it would be interesting to investigate further how teachers' professional vision is related to their actual classroom performance in real-life teaching-learning situations. In studying the development in authentic teaching-learning situations, it would be useful to use mobile eye-tracking (Pouta et al., 2020; Chaudhuri et al., 2022; Keller et al., 2022).

Fourth, the alpha value of the scale "beliefs that learning is a constructive activity (CON)," is unfortunately low and therefore the results related to this dimension and their generalizability must be treated with caution. However, the change in the scale of "teaching as transmission of subject knowledge (TRAN)," was more relevant to this study. In the following studies, it is important to perform more detailed statistical analyzes with the measure, such as confirmatory factor analysis (CFA).

Finally, short interventions provide insight into the change in teachers' (mis)conceptions in the short term. If one really wants to go deeply into teachers' conceptual changes, longer-term changes should be studied. Therefore, it would be interesting to conduct a longitudinal study in which teachers' (mis)conceptions and their possible changes would be monitored over a longer period of time. Additionally, it would be interesting to study how the changed (mis)conceptions are reflected in their real-life classroom performance.

Despite the limitations of this study, it introduced a new perspective on investigating the pedagogical expertise development of university teachers.

5. Conclusion

To conclude, in this study the general professional vision scores were not connected to the (mis)conceptions of teaching and learning, but in certain situations requiring the teacher's selective attention allocation, the observation differed between the teachers with less and more sophisticated conceptions of teaching and learning. This more detailed examination about teacher noticing utilizing eye-tracking methodology introduces a new insight into professional vision research. This study acknowledges the importance of understanding how university teachers' (mis) conceptions of teaching and learning influence their professional vision. Additionally, it showed that even a short pedagogical training can have an effect on university teachers' (mis)conceptions of teaching and learning and their professional vision.

Combining eye-tracking methodology with SRR interviews and a teacher conception questionnaire provided interesting data regarding professional vision and university teachers' expertise that would not be possible without a mixed-methods approach. Using eye-tracking methods to capture the actual cognitive processes of teachers led to new methodological leaps in investigating university teacher expertise and professional vision. Recognizing and understanding teachers' (mis)conceptions related to pedagogical theories and the need for conceptual understanding development is crucial in supporting university teachers' expertise development. This study highlights the fact that pedagogical training is needed to achieve expertise. This research also contributes by focusing on a very unique group of teachers, namely university teachers. Unlike other levels of education, university teachers are a special group, as most of them teach without any kind of pedagogical qualification or training.

Based on the research findings, we suggest that it is important to acknowledge that university teachers (mis)conceptions of teaching and learning may guide their professional vision in the classroom. In order to direct their noticing skills more consciously and efficiently and to be able to interpret the aspects that guide their noticing, university teachers require pedagogical knowledge and practical training of professional vision at the beginning of their teaching career. Thus, our study provides more insight into university teachers' pedagogical expertise development, and the results can be used to advance teacher education at a higher education level.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the University of Helsinki Ethical Review Board in the Humanities and Social and Behavioural Sciences. The patients/participants provided their written informed consent to participate in this study.

Author contributions

NH, NK, and IS: conceptualization, methodology, and writing – review and editing. NH and IS: formal analysis. NK and IS: supervision. NH: investigation, visualization, and writing – original draft. IS: funding acquisition and project administration. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

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Appendix

Incidents selected for the classroom video presenting pedagogically significant events in teaching-learning situations.

Incident	Time frame	Explanation of the incident
1	0:30–0:44	Student B (see Figure 1) raises a hand to ask a question, but the teacher ignores the student because the teacher is fully concentrated on preparing lecture slides. → several things compete for the viewer's visual attention
2	0:55–1:00	The structure of the beginning lecture is presented by the teacher.
3	1:01–1:33	The teacher summarizes what has been previously learned in the course.
4	1:37–1:58	The teacher reminds the students of the pre-assignment that the teacher has given to the students at the end of the previous lecture.
5	1:59–2:07	The teacher asks students to discuss the given pre-assignment with a partner in order to activate students.
6	2:08–2:50	Peer group work starts, but one student (D) is left alone without a partner. However, the teacher does not notice this and does not intervene. → several things compete for the viewer's visual attention
7	2:53–3:40	The teacher discusses the learning outcomes for the current lecture.
8	4:15–4:45	Student B raises a hand to ask a question, but the teacher ignores the student for a long time because the teacher is so concentrated on lecturing. → several things compete for the viewer's visual attention
9	4:46–5:27	The teacher answers the student's question.
10	6:13–6:40	Two students (A and D) start discussing with each other while the teacher is lecturing. The teacher does not notice their discussion and other students are a bit disturbed before the teacher finally intervenes. → several things compete for the viewer's visual attention
11	6:41–7:42	The teacher notices that students A and D are talking and goes to ask if something is unclear.
12	7:49–8:45	The teacher is lecturing using a very teacher-centered approach. All the students have become passive; some of them are even sleeping and some of them are focusing on their devices, such as laptops or phones. The teacher does not notice their passive behavior because the teacher is concentrating on lecturing. → several things compete for the viewer's visual attention
13	8:46–9:02	The teacher asks a bad/rhetorical question to try to activate students.
14	9:45–10:13	The teacher asks a question, which activates students' prior knowledge about the topic.
15	11:07–11:16	The teacher gives all the students an activating group assignment, but the instructions are vague.