Cultivating teacher expertise: The role of pedagogical training in shaping life science university teachers' professional vision and conceptions of teaching and learning

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Abstract: This study investigated how life science university teachers' professional vision, that is, their ability to notice and interpret pedagogically significant incidents in the classroom, was related to their (mis)conceptions of teaching and learning at the beginning of pedagogical training, and how these changed after the training. In addition, we examined whether distinct teacher profiles could be identified based on their conceptions of teaching and learning, and how these profiles differed in their professional vision before and after pedagogical training. A total of 127 life science university teachers from the University of Helsinki filled in a questionnaire and completed a video interpretation task. A pre-test / post-test design was used, and data were analysed quantitatively. This study shows that life science university teachers' professional vision and conceptual understanding were related. In the pre-test, participants with fewer misconceptions tended to notice more pedagogically significant incidents compared to participants with more misconceptions. Statistically significant improvements were found in participants' professional vision after pedagogical training. Additionally, participants' conceptions became more scientific. In the post-test, more sophisticated conceptions of teaching and learning were related to better skills in both noticing and interpreting a classroom video. These findings suggest that life science university teachers' professional vision may vary depending on their conceptual understanding that guides their noticing and interpreting of pedagogically relevant events in the classroom. Moreover, the cluster analysis revealed distinct teacher profiles based on their conceptions, which differed in their development of noticing skills from pre-test to post-test.

Keywords: professional vision, (mis)conceptions, pedagogical training, university teachers, life science education

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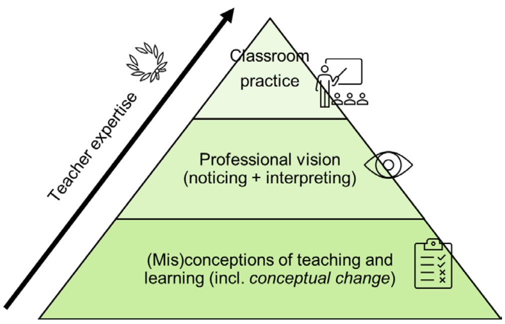

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1 Introduction

Life science university teachers play a pivotal role in shaping the next generation of scientists and researchers, and teachers' pedagogical expertise is crucial in supporting the high-level learning of their students on their way towards expertise (Burroughs et al., 2019). The quality of teachers' content knowledge, that is their expertise in their own discipline has been the most respected feature of university teachers and is considered a central precondition for teaching (Baumert et al., 2010; Friedrichsen et al., 2009). Today, however, the need to improve university teachers' pedagogical knowledge and education is acknowledged in supporting their students' learning (Murtonen & Vilppu, 2020). To thrive in their profession, university teachers' expertise requires a good pedagogical conceptual understanding as well as situation-specific skills in complex classroom situations (Kaiser et al., 2015).

For the promotion of university students' learning in life sciences, university teachers must be aware of critical classroom incidents which might foster or hinder student learning. In these situations, university teachers need professional vision (Goodwin, 1994), meaning a skill in noticing situations that are relevant for student learning and interpreting these situations to support student learning properly (Sherin et al., 2011). Teachers are likely to observe and interpret teaching-learning situations in ways that are shaped by their own beliefs related to teaching and learning (Blömeke et al., 2015; Meschede et al., 2017). However, university teachers without pedagogical training may hold preconceptions about teaching that can be inaccurate, partly unconscious, and resistant to change (Grossman et al., 2009). Thus, teachers might need to modify their prior knowledge if their conceptions of teaching and learning are out of date or even false. In this process, pedagogical training plays a crucial role to point teachers' conceptions in a more sophisticated direction (Vosniadou et al., 2020). However, the extent to which such (mis)conceptions actually shape professional vision in the university context remains underexplored.

This study investigates life science university teachers' pedagogical expertise, meaning their professional vision together with their pedagogical conceptual understanding, and how their professional vision and (mis)conceptions of teaching and learning develop during a short pedagogical training. In addition, we examined whether distinct teacher profiles could be identified based on their conceptions and how these profiles differed in their professional vision. Teacher expertise has been studied before at lower education levels, but studies concerning university teachers are scarce, despite a few recent studies (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Södervik et al., 2022; Vilppu et al., 2019). However, a discipline-specific perspective is still largely missing, even though subject traditions and epistemic cultures may shape how university teachers develop their professional expertise. A better understanding of how university teachers' conceptions of teaching and learning relate to their professional vision in a discipline-specific context would provide valuable insight for improving university pedagogy programmes and enhancing teaching and learning in higher education. As universities strive for excellence in teaching and learning, it becomes increasingly imperative to bridge the research gap in exploring and illuminating the intricacies of professional vision among university teachers.

1.1 University teachers' professional vision as a part of their pedagogical expertise

Human visual attention capacity is severely limited, and we are unable to focus our attention on all possible stimuli that are happening around us (Neisser, 1976). In dynamic teaching-learning environments, such as classrooms or lecture halls, university teachers are simultaneously exposed to several different stimuli and events, ranging from students' behaviours to instructional materials (Seidel et al., 2011). Teachers' observations and teachers' actions in the classroom in general have a significant impact on students' learning (Schneider & Preckel, 2017). In order for teachers to be able to support their students' learning as efficiently as possible, it is important for them to learn to detect and recognize events that are important in terms of learning and at the same time to filter out irrelevant information. This is what is known as *teacher professional vision* (van Es & Sherin, 2002; Sherin et al., 2008).

In the education context, professional vision refers to the ability of teachers to notice and interpret what is happening in the classroom (van Es & Sherin, 2002). Noticing refers to actions in which teachers pay attention to certain moments in the teaching-learning situation while filtering out others, whereas interpreting refers to the ways in which teachers interpret what was noticed based on their prior knowledge, experience, and pedagogical understanding (Seidel & Stürmer, 2014). These two dimensions of professional vision are interrelated and cyclical (Sherin & van Es, 2009). University teachers interpret things they notice and direct their attention based on their interpretations (Sherin et al., 2011). Although noticing and interpreting are strongly connected, previous research has indicated that these two dimensions of professional vision might develop at a different pace (Heinonen, Katajavuori, Murtonen, et al., 2023; König et al., 2014). Heinonen et al. (2023), for example, found that university teachers improved in their interpreting skills during short pedagogical training, but not in noticing. This suggests that while prospective teachers were able to keep up in terms of their interpreting abilities during the pedagogical training, their noticing skills lagged behind. Additionally, König et al. (2014) found that future mathematics teachers' knowledge was correlated with interpreting, but not with noticing.

1.2 Do university teachers' conceptions of teaching and learning shape their professional vision?

Teachers employ their conceptions of teaching and learning to understand a particular teaching and learning scenario (Blömeke et al., 2015). This understanding then empowers them to make adjusted, situational instructional decisions and teaching actions, and ultimately this has an impact on students' learning (Borko et al., 2008).

Two fundamental conceptions of teaching often distinguish educational approaches: the traditional model sees teaching as transmitting knowledge from the teacher to students, while the constructivist perspective envisions teaching as facilitating students' active learning through knowledge construction (Kember & Kwan, 2000; Kleickmann et al., 2016; Pajares, 1993; Staub & Stern, 2002). In addition to the fact that university teachers' conceptions of teaching and learning vary, misconceptions also occur (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023). By the concept of misconception, we mean a conception that differs from current scientific understanding. In the educational context, previous studies have shown that teachers, and student teachers in particular, may have conceptions that are not in unison with current scientific understanding about pedagogical theories (Vosniadou et al., 2020). For example, teachers might have beliefs that learning is something that happens quickly, or that teaching is an innate or fixed ability and that it cannot be taught (Vosniadou et al., 2020).

Based on their conceptions of teaching and learning, teachers constantly make conscious or unconscious choices regarding what to focus on and what can be disregarded in the classroom (Es & Sherin, 2002). Previous studies indicate that teachers' conceptions affect their professional vision and to the kind of pedagogical decisions and actions they make in the classroom (Barenthien et al., 2023; Eßling et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Mason, 2002; Meschede et al., 2017). For example, Eßling et al. (2023) found that pre-service teachers' inter-individual differences in transmissive and constructivist beliefs were associated with their professional vision, and transmissive beliefs hindered their professional vision development. Similar results were found in the study of Meschede et al. (2017), which indicated that transmissive beliefs hindered professional vision among in-service teachers and Master's students in teacher education. Barenthien et al. (2023) also found a positive relation between knowledge and professional vision among preservice teachers. Even though previous studies indicate that teachers' conceptions are related to how they observe and interpret classroom situations, the relationship between professional vision and conceptions of teaching and learning is still somewhat unclear and poorly understood among university teachers, especially in a discipline-specific context. Additionally, while transmissive beliefs are shown to hinder the development of professional vision (Meschede et al., 2017), it is unclear whether they affect noticing and interpreting differently.

1.3 Discipline-related nuances concerning the pedagogical expertise of life science university teachers

Previous studies in science education indicated that professional vision is a domain-specific construct (Blomberg et al., 2011; Es & Sherin, 2002; Palmeri et al., 2004). Previous discipline-specific perspectives in professional vision research have focused mostly on mathematics and physics, and on lower education levels or pre-service teachers, but there is hardly any research in life science and university teaching contexts (Sherin et al., 2011; Wöhlke & Höttecke, 2022). However, a recent study by Stahnke and Friesen (2023) found disciplinary differences in professional vision in terms of noticing and interpreting classroom events between biology and mathematics lower secondary school teachers. The professional vision of experienced biology and mathematics teachers differed in that both groups of teachers paid particular attention to teaching practices that were particularly relevant to their subject (Stahnke & Friesen, 2023). These results highlight the importance of considering discipline-specific nuances when examining professional vision among university teachers.

Each discipline has its own culture and therefore the discipline in which university teachers work strongly shapes their conceptions of teaching and learning and ways of thinking as well as their practical performance while teaching (McCune & Hounsell, 2005; Neumann et al., 2002). Life science fields are particularly characterized by the rapid obsolescence and exponential growth of knowledge, so teachers may be under pressure to fit as much content as possible into the teaching at the expense of activating students. For effective life science teaching, teachers need to pay attention to their discipline-specific features of instruction and implement them in their teaching-learning practice. According to previous studies, university teachers in the so-called hard sciences (physics, chemistry, mathematics, life sciences) tend to have more traditional and less-sophisticated conceptions and even misconceptions of teaching and learning compared to university teachers in the so-called soft sciences (law, economics, humanities, educational sciences, and social sciences) (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Kreber & Castleden, 2009; Lindblom-Ylänne et al., 2006; Lueddeke, 2003; Meyer, 2004; Södervik et al., 2022; Trigwell, 2002).

For the relationship between professional vision and conceptions of teaching and learning, this implies that life science university teachers may have a narrower or more content-focused professional vision, which can limit their ability to adopt more innovative or student-centred teaching methods. Heinonen, Katajavuori, & Södervik (2023), for example, found that life science university teachers with less sophisticated conceptions of teaching and learning tended to focus on teacher's behaviour in comparison to teachers with more-sophisticated conceptions, who tended to focus on students' actions in the classroom. Life science university teachers' professional vision could possibly be aligned with delivering as much information as possible, which might lead to an overemphasis on a teacher-centred approach. This could restrict their ability to perceive and implement more dynamic teaching strategies that foster deeper student learning.

A crucial ability of life science university teachers is that they can identify domain-specific problems in teaching-learning situations and make appropriate decisions that improve student learning. Understanding how university teachers develop and apply professional vision within the unique context of life sciences classrooms can provide invaluable insights for improving teaching practices, curriculum design, and student engagement. By delving into the discipline-specific nuances of professional vision within the life sciences, researchers can uncover the intricacies of effective teaching strategies, identify challenges unique to this field, and propose targeted interventions for professional development.

1.4 Enhancing university teachers' expertise development through pedagogical training

Even though university teachers are highly educated experts in their own subject area, most of them have only limited knowledge of pedagogical theories and educational sciences (Postareff & Nevgi, 2015) and this might cause problems in the classrooms. This is because in many countries pedagogical training for university teachers is optional (Murtonen & Vilppu, 2020). This sets them apart from elementary and secondary school teachers, who usually undergo extensive teacher training before starting their teacher careers. The absence of pedagogical education can result in a lack of understanding of educational theories and concepts, potentially leading to misconceptions (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Postareff & Nevgi, 2015). Since university teachers observe what happens in the classroom based on their views of teaching and learning, they may with limited knowledge of pedagogical theories struggle to recognize and interpret pedagogically significant events. Therefore, pedagogical training plays a crucial role in equipping teachers with both up-to-date educational knowledge and practical tools to effectively navigate classroom dynamics, which could require a conceptual change related to teaching and learning (Vosniadou et al., 2020).

For instance, professional vision can be shaped by exposure to pedagogical theory and practice (Barenthien et al., 2023). Without training, university teachers may struggle to recognize key moments in the classroom that could inform better teaching strategies and support student learning. Pedagogical training can challenge and refine these skills, promoting a shift from traditional to more learner-centred and constructivist approaches (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Vilppu et al., 2019; Vosniadou et al., 2020). Finally, the relationship between professional vision and conceptions of teaching is not self-evident; it requires explicit connections to be made. Pedagogical training might help teachers link what they observe in the classroom to their underlying educational beliefs, fostering more coherent and reflective teaching practices (Heinonen, Katajavuori, & Södervik, 2023). Thus, pedagogical training equips teachers with both the theoretical background and practical skills to see and interpret classroom dynamics more effectively. These skills challenge and refine their beliefs, and ultimately, improve their teaching practices to better align them with contemporary educational research. This transformation results in a more adaptive and student-centred approach to teaching. Therefore, more evidence is needed on whether short pedagogical training in universities can advance the development of university teachers' pedagogical expertise.

Furthermore, from different contexts and on younger learners' (Schneider & Hardy, 2013; Vančugovienė et al., 2024), it is likely that teachers also form a heterogeneous group of learners and experience varying benefits from education. Just as students with differing levels of background knowledge or abilities show diverse learning outcomes, teachers with different conceptual understandings may develop in distinct areas and at a different pace. This highlights the importance of utilizing so called person-oriented approaches in investigating teachers' professional vision and conceptions of tailored approaches in teacher education to meet diverse needs and effectively foster growth across all participants (Edelsbrunner et al., 2018).

1.5 Aim of the research

The primary objective of this study is to explore life science university teachers' professional vision before and after undergoing pedagogical training in relation to their (mis)conceptions about teaching and learning. Additionally, we are interested in exploring whether distinct profiles exist among university teachers and whether they benefit from pedagogical training in different ways. The professional vision dimensions – specifically noticing and interpreting – are investigated both together and separately. The study aims to address the following research questions:

1. What are the initial levels of life science university teachers' professional vision dimensions (noticing and interpreting) and their (mis)conceptions of teaching and learning, and how do these change during pedagogical training?
2. Which kind of conceptions of teaching and learning can be found among life science university teachers before and after pedagogical training, and how are they related to their professional vision dimensions? Do university teachers have misconceptions about teaching and learning and if so, how many?
3. Are there different profiles with regard to teacher conceptions on teaching and learning, and do these profiles differ in relation to their development of professional vision dimensions or in their score on these dimensions before and after pedagogical training?

2 Methods

2.1 Participants

A total of 127 (female n = 75; male n = 44; not wishing to define n = 8) life science university teachers from the University of Helsinki participated in this study. The data were collected during authentic basic university pedagogical training courses, which were organized between spring 2020 and autumn 2021. During this period, a total of four pedagogical courses were organized that were similar in terms of content and course implementation. A total of 148 participants participated in these pedagogical training courses, but a total of 19 participants did not participate in the study or dropped out of the course at a very early stage, so they were omitted from the data. In addition, one participant had already participated in the pilot phase of the study, and one was not from the life science departments, so they were also omitted. The number of participants in the post-test measurement varied due to the impact of the COVID-19 pandemic, which particularly affected implementations of the courses in autumn 2021. Additionally, some participants dropped out from the course for various, personal reasons, so they did not respond to the final questionnaire or participate in the video annotation task's post-test measurement. The university teachers who took part in the study consisted of a fairly homogenous group. They were complete novices regarding pedagogical training, and they were all from the same field of research, representing eight different departments of life sciences. Their teaching experience varied based on their academic career positions. However, the majority had little to no prior teaching experience. In the beginning of the data collection, the participants were briefed about the purpose of the study and the study's privacy statement. All the participants were asked to sign an informed consent form, and voluntary participation and anonymity were ensured throughout the research process. Participation did not contribute to passing the course.

2.2 Research procedure and pedagogical training

A pre-test was conducted in the first meeting of the pedagogical training. The participants answered a questionnaire concerning their (mis)conceptions of teaching and learning. After that, a video interpretation task was completed individually. The data collection procedure took up about 45 min of the course meeting. A pre-test / post-test design was utilized, so both the questionnaire and the video interpretation task were repeated in an identical form during the last course meeting.

The university teachers participated in an authentic, basic university pedagogy course (5 ECTS), where they were introduced to fundamental educational theories and concepts related to teaching and learning. This course is the inaugural university pedagogy programme at the University of Helsinki organized by the Centre for University Teaching and Learning, laying the groundwork for advanced pedagogical studies. At the University of Helsinki pedagogical training is voluntary but recommended.

The themes in the course included an introduction to university pedagogy, factors affecting learning and teaching at the university, and the development of university teachers' expertise, emphasizing reflection to develop teaching skills. During the course, participants were not trained in professional vision, and video incidents or similar case examples were not discussed in the course contents. The meetings featured traditional lectures as well as active and collaborative learning exercises, including peer-group tasks and discussions. To successfully complete the course, participants were required to attend all meetings and fulfil all course obligations. Although the courses primarily covered general pedagogical theories and concepts, they were specifically tailored for life science university teachers, incorporating topics and viewpoints from the perspective of these disciplines.

2.3 Measures

2.3.1 Video interpretation task measuring professional vision

The video interpretation task used a video of a teaching-learning situation as a stimulus to investigate participants' professional vision. A tailor-made video about a classroom situation was filmed from the perspective of an outside observer. The video (Heinonen, Katajavuori, Murtonen, et al., 2023) represented a typical life science lecture that dealt with biodiversity, aiming to represent as realistic a classroom situation as possible. The video (11 mins 41 secs) included a total of 15 pre-defined pedagogically significant events, so-called incidents, which represented typical interactions in a university classroom (see, Table 9, Appendix 1). The video annotation task was carried out by each participant at their own pace. They were instructed to pause the video whenever they noticed something significant related to teaching and/or learning and to record the time at which they paused the video. After noting the time, participants were required to explain why they stopped the video and briefly comment on the pedagogical strengths or weaknesses observed. Since a pre-test/post-test design was implemented, the same video annotation task was repeated at the start of the final course meeting with the same video.

Watching the video was combined with either written (paper-pencil task) or oral interpretations (interview), depending on the course implementation, but the content of the task was exactly the same. In the oral condition, the interviewer's role was restricted to presenting the task instructions and inviting participants to verbalize about the classroom video. The interviewer did not provide the additional probing questions, guidance, or feedback. This ensured that the oral interpretations remained directly comparable to the written responses and that the interviewer's influence on participants' answers was minimized. The video used in both data collection methods was the same for both the initial and final assessments. This consistency ensured that any observed differences in participants' responses could be attributed to instructional interventions rather than variations in the video content. Additionally, the instructions given to participants about the task were identical in both methods, ensuring that all participants approached the task with the same expectations and guidelines. This standardization was crucial for maintaining the reliability and validity of the study's findings.

2.3.2 Questionnaire measuring (mis)conceptions of teaching and learning

The questionnaire used in this study was designed by the first and the last author to assess participants' conceptions and potential misconceptions about teaching and learning (Appendix B, see also Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023). It included background questions which consisted of questions about the participants' gender, age, discipline, previous pedagogical studies, and teaching experience at the university. Some of the items regarding conceptions of teaching and learning were adapted from previous studies (e.g., Vosniadou et al., 2020), and the items addressing misconceptions were also based on earlier research (e.g., Grospietsch & Mayer, 2018; Vosniadou et al., 2020). The questionnaire included two parts (Table 1). Part 1 asked the university teachers about their conceptions of teaching and learning via five constructs: beliefs that teaching is an innate quality (5 items); the role of pedagogical theories is important in supporting learning and developing one's own teaching (5 items); teachers' perceptions of pedagogical expertise (5 items); teaching as transmission of subject knowledge (6 items); and beliefs that learning is a constructive activity (6 items). Participants rated all the items in Part 1 on a five-point Likert scale (1 = completely disagree, 2 = somewhat disagree, 3 = do not agree nor disagree, 4 = somewhat agree, 5 = completely agree). Part 2 included a total of seven true/false items with open-ended explanations examining participants' potential misconceptions concerning teaching and learning. These statements differed from those in Part 1 in that they were based on typical misconceptions found in previous studies, from which it was possible to formulate response options on a true/false axis. The added value of Part 2 lies in its ability to capture nuanced misunderstandings that may not be evident in the Likert-scale responses of Part 1, by providing participants with the opportunity to explain their reasoning. Although the qualitative explanations were not analysed in this study, the inclusion of these items helped ensure that the questionnaire addressed not only the strengths of participants conceptions but also areas where misconceptions might exist. This design contributed to a more comprehensive assessment of teachers' pedagogical conceptual understanding and their potential link to professional vision.

Table 1. Dimensions of the questionnaire concerning conceptions of teaching and learning

Dimension	Number of items	Item example
Beliefs that teaching is an innate quality	5	Item no. 1: Some people are naturally better teachers than others.
The role of pedagogical theories in supporting learning and developing one's own teaching	5	Item no. 13: I believe it is possible to develop teaching by knowing pedagogical theories.
Teachers' perceptions of pedagogical expertise	5	Item no. 4: The most important thing to support students' learning is that the teacher knows the subject matter thoroughly.
Teaching as transmission of subject knowledge	6	Item no. 26: Learning means that students adopt the information from the teacher in detail.
Beliefs that learning is a constructive activity	6	Item no. 7: Learning requires connecting aspects of what is to be learned into one's previous knowledge.
Misconceptions	7	Item no. 1: Individuals learn better when they receive information in their preferred learning styles (e.g., auditory, visual, kinesthetic).

3 Data analysis

3.1 Professional vision analysis

The professional vision task scoring was based on a defined scale made by Heinonen et al. (2023). Participants provided their responses in Finnish or English, and the first and the last author collaboratively developed the scoring criteria for these responses. The scoring of professional vision was based on two parts: noticing and interpreting, which were scored separately, but together formed the whole of professional vision (Table 2). Participants were first assessed on the number of pre-defined pedagogically significant events they noticed, with a maximum score of 15 points (see Table 9, Appendix A). The interpretation of these events was then qualitatively analysed, with scores ranging from zero to four points per incident. Description, explanation, and prediction were rewarded with one to four points each, resulting in a potential total score of 60 points per participant. Examples of participant responses representing low, medium, and high scores have been presented in our previous research (see, Heinonen, Katajavuori, & Södervik, 2023).

Table 2. Scoring scale for the professional vision analysis and its corresponding definitions

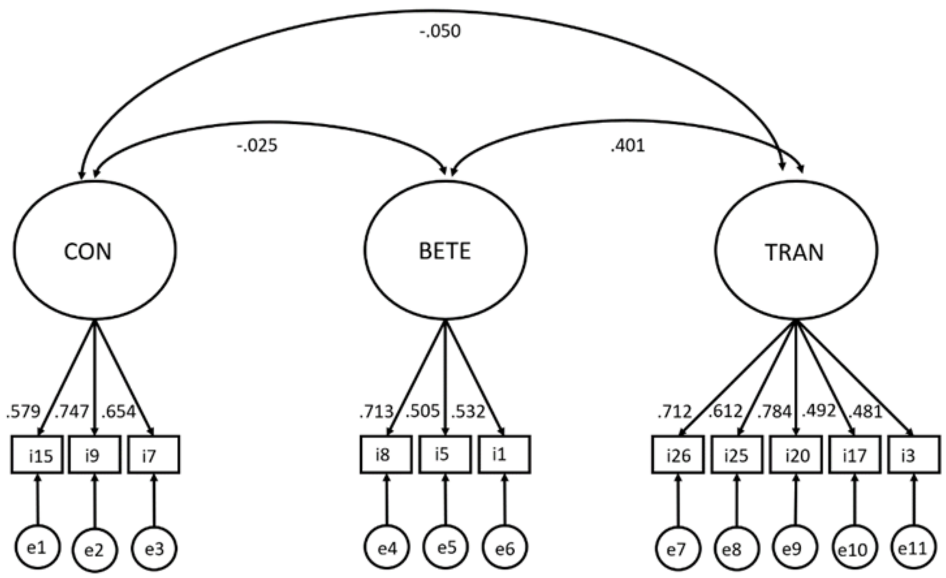
Noticing	Interpreting				
	Description		Explanation		Prediction
Pre-defined pedagogically significant incident mentioned in the correct period	Statements lacking an interpretation or providing a false interpretation or else the interpretation was not clear, for instance incorrect use of pedagogical terms and/or theories or misconceptions	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	Statements representing some understanding of pedagogically significant actions by the teacher, such as facilitating or supporting students' learning	Statements representing a clear understanding of pedagogical concepts and theories; using/linking them correctly with interpretations of the teaching-learning situation	Speculation about an action that the teacher (or student) in the video will soon take in terms of teaching and learning *or* speculation about actions that the participants themselves would have taken in a similar situation
0–1	0	+1	+1	+1	+1

To ensure inter-rater reliability, the initial cohort of professional vision data was rated by the first and the last author. Inter-rater reliability was evaluated for 20% of the initial cohort of the data, with separate assessments for noticing and interpreting. For the rest of the data, the first author led the analysis, but both the first author and an external evaluator independently scored the data to assess participants' interpreting skills. Using Cohen kappa coefficients to determine inter-rater reliability, an excellent agreement was found between the two raters (Cohen kappa = 0.80) (Fleiss, 1981). Following the scoring, any disagreements or borderline cases were again addressed through consensus discussions and adjustments to the coding manual, ultimately achieving perfect overall reliability (Cohen kappa = 1.0).

3.2 Confirmatory factor analysis (CFA) in investigating conceptions of teaching and learning

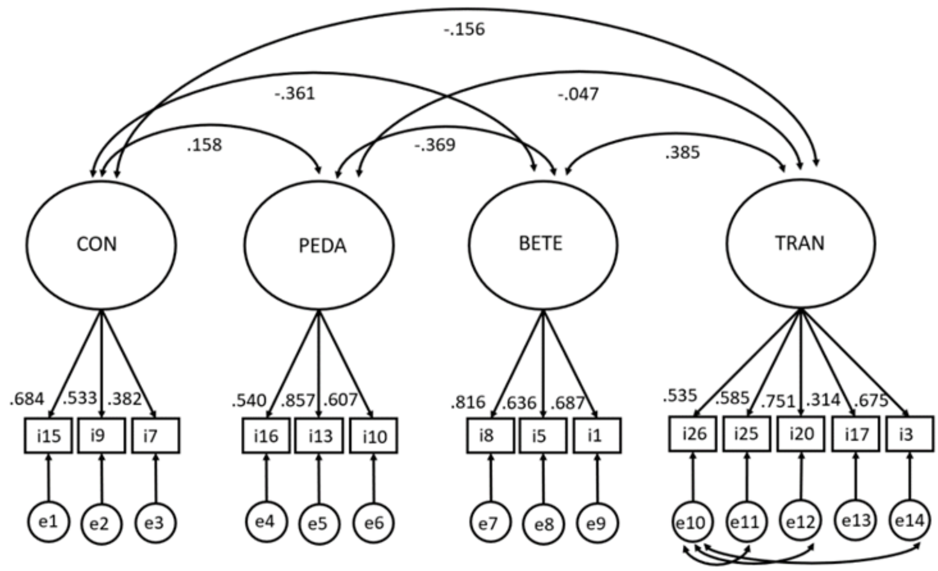
The factor structure and the construct validity of the conceptions of teaching and learning scales were examined using confirmatory factor analysis (CFA) with Mplus version 8.4 (Muthén & Muthén, 2017). We allowed all items for each scale to load on the corresponding factor only. All solutions were generated using the Maximum Likelihood (ML) estimation because the data were normally distributed. Two separate models of pre- and post-questionnaires were conducted. Based on previous research by Heinonen et al. (2023), we hypothesized five dimensions to emerge from the pre-questionnaire. However, a three-factor model was mostly supported by the pre-test data (Figure 1). Some of the original items had to be omitted due to the low internal consistency of the scales. Thus, 11 items remained for the final factor structure of the pre-test. The goodness-of-fit indicators indicated a good fit ($\chi2 = 79.57$, df = 62, p = 0.07, CFI = 0.936, TLI = 0.919, RMSEA = 0.533, SRMR = 0.071) (Browne & Cudeck, 1993; Hu & Bentler, 1999). Thus, three subscales emerged from the pre-questionnaire: CON (beliefs that learning is a constructive activity), with an acceptable alpha ($\alpha = 0.689$); BETE (beliefs that teaching is an innate quality), with an acceptable alpha ($\alpha = 0.593$); and TRAN (teaching as transmission of subject knowledge), with an acceptable alpha ($\alpha = 0.746$).

Figure 1. Three-factor model with standardized regression coefficients (pre-test). Note: CON = beliefs that learning is a constructive activity; BETE = beliefs that teaching is an innate quality; TRAN = teaching as transmission of subject knowledge, p < .05



In the post-test, a four-factor model was mostly supported by the data (Figure 2). In addition to the subscales of CON, BETE and TRAN, a subscale PEDA (the role of pedagogical theories is important in supporting learning and developing one's own teaching) was included in order to obtain a fitting model. In addition, the residuals between item26 and item3, item20, and item25 within factor TRAN were allowed to correlate. Out of a total of 27 items, 14 items remained for the final factor structure of the post-test. The goodness-of-fit indicators indicated a good fit ($\chi2 = 55.47$, $df = 41$, $p = 0.07$, $CFI = 0.941$, $TLI = 0.920$, $RMSEA = 0.420$, $SRMR = 0.069$) (Browne & Cudeck, 1993; Hu & Bentler, 1999). The Cronbach's alpha value of the additional factor, PEDA (the role of pedagogical theories is important in supporting learning and developing one's own teaching), was 0.683. When a good factor structure was obtained, sum variables could be created for further analyses. Participants' misconceptions of teaching and learning were scored using dichotomous scoring.

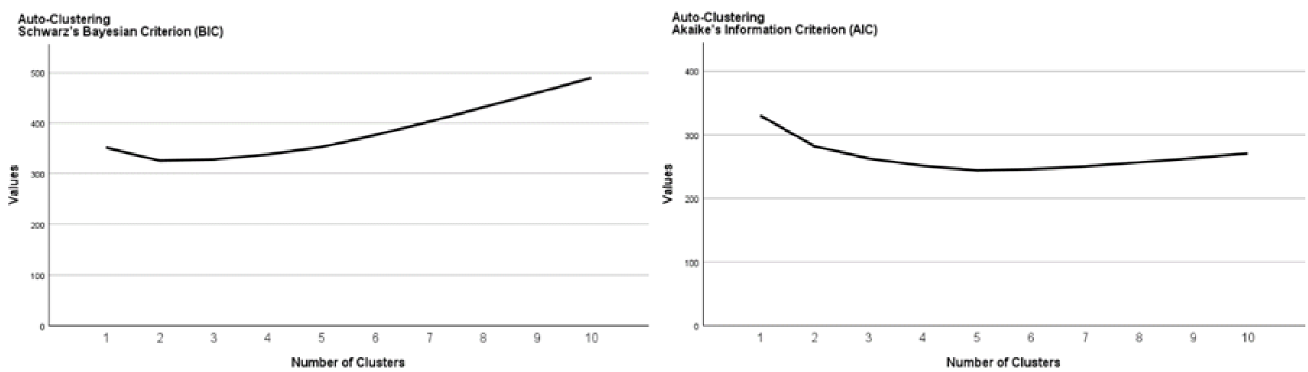
Figure 2. Four-factor model with standardized regression coefficients (post-test). Note: CON = beliefs that learning is a constructive activity; PEDA = the role of pedagogical theories is important in supporting learning and developing one's own teaching; BETE = beliefs that teaching is an innate quality; TRAN = teaching as transmission of subject knowledge, $p < .05$



3.3 Statistical comparisons

The quantitative data were further analysed statistically using IBM SPSS Statistics 29. The change in life science university teachers' professional vision and (mis)conceptions of teaching and learning during the pedagogical training were examined using a paired-samples t-test. Additionally, the correlations were calculated between professional vision and (mis)conception scores across all participants. To identify potential differences in how university teachers responded to the pedagogical training, a cluster analysis was conducted on the post-test scores about conceptions of teaching and learning. The factor structure of the questionnaire differed between pre- and post-test, and in the post-test a new dimension emerged, namely the role of pedagogical theories in supporting learning and developing one's own teaching (PEDA). This justified focusing the clustering on post-test data, as participants were better able to meaningfully respond to these more demanding items only after the training, when they had gained sufficient pedagogical knowledge to evaluate the importance of theoretical perspectives. This analysis aimed to uncover distinct teacher profiles, highlighting whether certain groups benefitted more from the training than other and whether some participants were more resistant to change. By examining these clusters, we could better understand individual differences in learning trajectories and the development of professional vision and conceptions of teaching and learning during pedagogical training. To identify profiles of university teachers with different conceptions of teaching and learning, a TwoStep cluster analysis method was chosen, since this clustering technique allows one to determine the (optimal) number of clusters based on statistical criteria (BIC and AIC values, see Figure 3). The model comparison using the Bayesian Information Criterion (BIC), and Akaike Information Criterion (AIC) suggested that the two-cluster model was preferred (for detailed values, see Table 10 in Appendix C). These values indicate a better fit for the two-cluster model compared to other models, as lower BIC and AIC values generally suggest a more parsimonious and better-fitting model. Finally, an independent samples t-test was conducted to test whether the misconceptions and professional vision variables, that is, noticing and reasoning skills, significantly differed across the found clusters. The change in professional vision scores and misconceptions between the pre- and post-tests within the clusters was examined using paired samples t-test.

Figure 3. Elbow plot information criteria values for Akaike's Information Criterion (AIC) and for Schwarz's Bayesian Criterion (BIC)



4 Results

4.1 Life science university teachers' professional vision and (mis)conceptions of teaching and learning before and after the pedagogical training

Before the pedagogical training, the participants noticed an average of 9.31 incidents out of 15 from the video (SD = 2.82; Min = 2.00; Max = 14.00) and received on average 12.79 out of 60 for interpreting scores (SD = 4.93; Min = 1.00; Max = 23.00) (Table 3). The participants' (mis)conceptions about teaching and learning also varied at the beginning of the pedagogical training. In the scores for the items concerning misconceptions, the participants averaged 2.94 misconceptions related to teaching and learning.

Table 3. Life science university teachers' professional vision and (mis)conception scores before and after the pedagogical training

	Max. score	Pre-test			Post-test		
		M (SD)	*Min*	*Max*	*M (SD)*	*Min*	*Max*
		n = 116			*n* = 88		
Noticing	15	9.31 (2.82)	2.00	14.00	9.58 (3.19)	2.00	15.00
Interpreting	60	12.79 (4.93)	1.00	23.00	17.41 (7.55)	4.00	40.00
		n = 126			*n* = 114		
CON	5	4.60 (0.47)	3.00	5.00	4.73 (0.39)	3.33	5.00
PEDA	5	-	-	-	4.42 (0.60)	2.00	5.00
BETE	5	2.80 (0.70)	1.00	5.00	2.42 (0.83)	1.00	4.67
TRAN	5	3.14 (0.76)	1.20	5.00	2.55 (0.70)	1.20	4.60
Misconceptions	7	2.94 (1.45)	0.00	6.00	1.79 (1.49)	0.00	6.00

Note: CON = beliefs that learning is a constructive activity; PEDA = the role of pedagogical theories is important in supporting learning and developing one's own teaching; BETE = beliefs that teaching is an innate quality; TRAN = teaching as transmission of subject knowledge

A paired sample t-test revealed a statistically significant improvement in participants' noticing ($p = .005$) and interpreting ($p < .001$) skills during the pedagogical training (Table 4). After the pedagogical training, the participants noticed an average of 9.85 incidents out of 15 from the video (SD = 3.19; Min = 2.00; Max = 15.00) and received on average 17.41 for interpreting scores (SD = 7.55; Min = 4.00; Max = 40.00). Four sum variables explained the conceptions of teaching and learning in the post-test, as a new variable, PEDA, emerged from the data compared to the pre-test. A paired sample t-test revealed that participants showed an increase in their conceptions of learning as a constructive activity ($p = .012$). In turn, their conceptions regarding teaching as transmission of subject knowledge ($p < .001$), teaching as an innate quality and misconceptions of teaching and learning (p < .001), and misconceptions concerning teaching and learning (p < .001), decreased statistically significantly during the pedagogical training (Table 4).

Table 4. Paired sample t-test results for pre- and post-test measures of professional vision and (mis)conceptions

	Mean (SD)		Paired samples *t*-test			
	Pre-test	Post-test	*t*	*df*	*d*	95 % CI
	n = 88					
Noticing	9.10 (2.59)	9.85 (3.19)	- 2.871**	87	2.45	- .519, - .091
Interpreting	13.02 (4.78)	17.41 (7.55)	- 6.348***	87	6.48	- .907, - .443
	n = 112					
CON	4.60 (0.47)	4.73 (0.40)	- 2.540*	112	.56	- .425, - .051
BETE	2.74 (0.68)	2.41 (0.82)	5.022***	112	.70	.277, .666
TRAN	3.13 (0.71)	2.54 (0.70)	9.172***	112	.69	.645, 1.078
Misconceptions	2.92 (1.47)	1.80 (1.49)	8.651***	112	1.38	.602, 1.030

* p < .05, ** p < .01, *** p < .001. Note: CON = beliefs that learning is a constructive activity; BETE = beliefs that teaching is an innate quality; TRAN = teaching as transmission of subject knowledge.

4.2 The relation between life science university teachers' professional vision and (mis)conceptions of teaching and learning

When investigating the relationship between the two dimensions of professional vision, namely noticing and interpreting, and (mis)conceptions of teaching and learning in the pre-test, participants who had better skills in noticing had fewer misconceptions related to teaching and learning (r = - .190, p = .043) (Table 5). In the post-test, however, participants who had better noticing and interpreting skills less often perceived teaching as an innate quality (r = .220, p = .040; r = - .261, p = .015). In addition, participants having better interpreting skills were more likely to consider that learning was a constructive process (r = .226, p = .035).

Table 5. Correlation table of pre-test and post-test variables

Pre-test		Interpreting	TRAN	BETE	CON	Misconceptions	
Professi-onal vision	Noticing	.727***	.011	- .118	.103	- .190*	
	Interpreting		- .381	- .069	.153	- .142	
	TRAN			.267**	- .031	.169	
	BETE				- .031	.108	
	CON					- .074	
Post-test		**Interpreting**	**TRAN**	**BETE**	**CON**	**PEDA**	**Misconceptions**
Professi-onal vision	Noticing	.736***	- .075	- .220*	.094	.152	- .084
	Interpreting		- .195	- .261*	.226*	.119	- .150
	TRAN			.244**	- .053	.010	.265**
	BETE				- .271**	- .276**	.247**
	CON					.168	- .057
	PEDA						- .075

*p < .05, **p < .01, ***p < .001. Note: CON = beliefs that learning is a constructive activity; PEDA = the role of pedagogical theories is important in supporting learning and developing one's own teaching; BETE = beliefs that teaching is an innate quality; TRAN = teaching as transmission of subject knowledge.

4.3 Life science university teachers' professional vision in different teacher profiles

In the cluster analysis, the two-cluster solution fitted the data best, based on statistical criteria, meaningful differences between the profiles, and the distribution of the university teachers in the profiles (cluster sizes). Table 6 provides the descriptive information of the profiles concerning the clustering variables (conceptions of teaching and learning in the post-test).

Table 6. Descriptive information of the two university teachers' profiles

	University teacher profiles (post-test)		
	Mean (SD)		
	Cluster 1: More sophisticated conceptual understanding (n = 61)	Cluster 2: Less sophisticated conceptual understanding (n = 53)	Total (n = 114)
CON	4.84 (.27)	4.61 (.47)	4.73 (.39)
PEDA	4.56 (.46)	4.26 (.70)	4.42 (.60)
BETE	1.80 (.51)	3.14 (.45)	2.42 (.83)
TRAN	2.32 (.59)	2.82 (.73)	2.55 (.70)

Note: CON = beliefs that learning is a constructive activity; PEDA = the role of pedagogical theories is important in supporting learning and developing one's own teaching; BETE = beliefs that teaching is an innate quality; TRAN = teaching as transmission of subject knowledge.

An independent samples t-test was used to test for differences in both pre-test and post-test professional vision scores between the two university teacher profiles (Table 7). In the pre-test, there was a significant difference in noticing between two clusters ($p = .016$). Participants with a more sophisticated conceptual understanding had better skills in noticing compared to participants with a less sophisticated conceptual understanding. In the post-test, there was a significant difference in interpreting ($p = .012$) and misconceptions ($p < .001$) between two clusters. Participants with a more sophisticated conceptual understanding had better skills in interpreting and less misconceptions compared to participants with a less sophisticated conceptual understanding.

Table 7. Independent samples t-test results of pre-test and post-test

	Teacher cluster	*Mean (SD)*	*Min*	*Max*	Independent samples *t*-test *t*	*df*	*d*	95 % CI
	Pre-test							
Noticing	1 (n = 56)	9.93 (2.43)	3.00	14.00	2.440*	104	2.55	.087, .860
	2 (n = 50)	8.72 (2.67)	3.00	14.00				
	Total (n = 114)	9.36 (2.60)	3.00	14.00				
Interpreting	1 (n = 56)	13.41 (4.85)	1.00	23.00	1.343	104	4.63	- .122, .644
	2 (n = 50)	12.20 (4.38)	3.00	23.00				
	Total (n = 114)	12.84 (4.65)	1.00	23.00				
Misconceptions	1 (n = 60)	2.68 (1.47)	0.00	6.00	-1.854	110	1.45	- .725, .024
	2 (n = 52)	3.19 (1.43)	1.00	6.00				
	Total (n = 114)	2.92 (1.47)	0.00	6.00				
	Post-test							
Noticing	1 (n = 37)	10.43 (3.23)	2.00	15.00	1.563	85	3.16	- .090, .766
	2 (n = 50)	9.36 (3.12)	2.00	15.00				
	Total (n = 114)	9.82 (3.19)	2.00	15.00				
Interpreting	1 (n = 37)	19.51 (8.03)	4.00	40.00	2.553*	85	4.63	- .122, .644
	2 (n = 50)	15.54 (6.48)	4.00	31.00				
	Total (n = 114)	17.23 (7.40)	4.00	40.00				
Misconceptions	1 (n = 61)	1.38 (1.23)	0.00	6.00	- 3.306***	112	1.43	- .996, - .243
	2 (n = 53)	2.26 (1.63)	0.00	5.00				
	Total (n = 114)	1.79 (1.49)	0.00	6.00				

*p < .05, **p < .01, ***p < .001. Note: Cluster 1 = a more sophisticated conceptual understanding; Cluster 2 = a less sophisticated conceptual understanding.

When examining the differences between pre- and post-tests within the clusters, there was no statistically significant development in noticing within cluster 2 (less sophisticated conceptual understanding) (p = .089), meaning that participants with a less sophisticated conceptual understanding did not develop their noticing skills further during the pedagogical training. However, all other variables showed statistically significant improvement in both clusters (Table 8).

Table 8. Paired sample t-test results for Clusters 1 and 2

		Mean (SD)		Paired samples *t*-test			
		Pre-test	Post-test	*t*	*df*	*d*	95 % CI
Noticing	Cluster 1 (n = 37)	9.49 (2.33)	10.43 (3.23)	- 2.546**	36	2.26	- .752, - .080
	Cluster 2 (n = 50)	8.72 (2.68)	9.36 (3.12)	- 1.735	49	2.61	- .525, .037
Interpreting	Cluster 1 (n = 37)	13.87 (4.98)	19.51 (8.03)	- 4.744***	36	7.24	- 1.145, - .407
	Cluster 2 (n = 50)	12.20 (4.38)	15.54 (6.48)	- 4.106***	49	5.75	- .878, - .278
Misconceptions	Cluster 1 (n = 60)	2.68 (1.47)	1.40 (1.22)	7.341***	59	1.35	.640, 1.250
	Cluster 2 (n = 52)	3.19 (1.43)	2.25 (1.64)	4.881***	51	1.39	.372, .976

*p < .05, **p < .01, ***p < .001. Note: Cluster 1 = a more sophisticated conceptual understanding; Cluster 2 = a less sophisticated conceptual understanding.

5 Discussion

The aim of this study was to investigate life science university teachers' professional vision in relation to their (mis)conceptions of teaching and learning, and how these change during a short pedagogical training. We were also interested in whether there are differences between teachers with a more sophisticated conceptual understanding and teachers with a less sophisticated conceptual understanding in their professional vision. In addition, we conducted a cluster analysis to examine whether distinct teacher profiles could be identified based on their conceptions, and to explore how these profiles developed in terms of their professional vision from pre-test to post-test. By combining the analysis of professional vision and (mis)conceptions, we were able to follow learning processes during the pedagogical training and to examine how teachers with different conceptual profiles benefitted in different ways. This study highlights the role of teachers' (mis)conceptions of teaching and learning as an important foundation for professional vision and its development.

Our findings showed that participants' professional vision improved as a result of pedagogical training. This aligns with previous results in university contexts, indicating that professional vision develops positively during short pedagogical trainings (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Vilppu et al., 2019). Our study adds to these results by extending them to life sciences, a discipline where strong content expertise and transmissive teaching traditions may shape how teachers notice and interpret classroom events. During the pedagogical training, both participants' noticing and interpreting skills generally developed statistically significantly, which means that the participants noticed more relevant incidents from the video and relied more on their pedagogical knowledge when interpreting these noticed incidents after the training. Especially with regard to the interpreting component of professional vision, this finding is noteworthy, as interpreting noticed events has previously been shown to be particularly challenging for pre-service or novice teachers (Stürmer et al., 2016). However, our earlier studies (Heinonen, Katajavuori, Murtonen, et al., 2023) have indicated that interpreting tends to improve during a short period of pedagogical training, while noticing has proven more resistant to change. In this study, the development of noticing appeared uneven, as teachers with a less sophisticated conceptual understanding did not show significant improvement. This suggests that in the life sciences, where disciplinary content can dominate classroom attention, novice teachers may require additional support to shift their focus from subject matter to pedagogically meaningful cues. Furthermore, the results suggest that life science university teachers not only begin their pedagogical training with varying levels of professional vision and differing conceptions of teaching and learning, but they also exhibit different developmental trajectories throughout the training. This aligns with the similar findings in research in other contexts on younger students' learning (Schneider & Hardy, 2013; Vančugovienė et al., 2024) and shows that teachers benefit from training in different ways. Just as students with varying levels of prior knowledge or skills may experience different learning outcomes, teachers with different levels of conceptual understandings are likely to develop at different rates and in different areas, indicating that pedagogical training could benefit from acknowledging variation among teachers and providing opportunities for extra support where necessary, for instance by offering targeted support for those who struggle to notice things.

Interestingly, the factor loadings regarding the conceptions of teaching and learning differed in the post-test from the pre-test solution and the scale named "the role of pedagogical theories is important in supporting learning and developing one's own teaching" was only separated into its own dimensions in the post-test. We assume that this dimension did not stand out in the pre-test because the participants may not have enough prior knowledge to answer these statements. However, after the pedagogical training, they better understood how important role pedagogical research plays in terms of teachers' expertise development. At the same time, participants demonstrated an increase in constructivist beliefs (CON), and a decrease in transmissive (TRAN) and essentialist (BETE) beliefs indicating a shift towards more student-centred and flexible views of teaching and learning. Given that transmissive and innate beliefs have been shown to hinder professional vision (Meschede et al., 2017), these changes are particularly significant in the life sciences, where traditional views of teaching are often strong. In particular, less sophisticated conceptions and misconceptions seemed to be related to professional vision among life science university teachers, as has also been indicated in previous research in other research contexts (Barenthien et al., 2023; Eßling et al., 2023;

Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Meschede et al., 2017). When university teachers hold traditional or rigid views about teaching and learning, or even hold misconceptions about educational phenomena, it can distort their professional vision and might negatively affect their students' learning if they do not notice or misinterpret crucial moments in the classroom. This might lead to biased judgements, hinder adaptability, and limit responses to various aspects of teaching-learning situations. Teachers with rigid or naïve conceptions may misinterpret classroom events, potentially affecting student learning, whereas teachers with flexible, accurate conceptions develop a more refined professional vision (Blömeke et al., 2015). On the other hand, teachers with accurate and flexible conceptions tend to develop a more refined professional vision. Hence, our results provide more empirical evidence for previous research, suggesting that conceptions act as a disposition for situation-specific skills, which professional vision also represents (Blömeke et al., 2015). These results are in line with previous studies concerning university teachers' expertise development, identifying a shift in thinking towards a more student-centric view after participating in a short pedagogical training (Heinonen, Katajavuori, Murtonen, et al., 2023; Heinonen, Katajavuori, & Södervik, 2023; Vilppu et al., 2019), although some studies show the exact opposite direction change (Ödalen et al., 2019). Similarly, pedagogical training has been found to refine professional vision and reshape teachers' conceptions by connecting practical experiences with theoretical frameworks (Blömeke et al., 2015; Sherin & van Es, 2009). Without such training, university teachers often hold transmissive or even naïve conceptions, which may hinder both noticing and interpreting (Meschede et al., 2017). Since our participants were novices regarding pedagogical training, their pre-test performance and misconceptions may partly reflect this limited exposure. Future research should therefore examine how teaching experience and prior pedagogical training interact with university teachers' professional vision and (mis)conceptions, as these factors may shape initial profiles and influence subsequent developmental trajectories.

The results of our study indicate notable differences between two profiles of university teachers, categorised based on their level of conceptual understanding, in both pre-test and post-test professional vision scores. Before the pedagogical training, there was a statistically significant difference in noticing between the two teacher profiles. Specifically, participants with a more sophisticated conceptual understanding exhibited better noticing skills compared to those with a less sophisticated understanding. The results of our study indicate notable differences between the two profiles of university teachers, categorized based on their post-test conceptions of teaching and learning. This suggests that even before pedagogical intervention, participants who had a stronger conceptual foundation were better at identifying relevant information in classroom contexts. In the post-test, significant differences were found in both interpreting and misconceptions between the two groups. Participants with a more sophisticated conceptual understanding not only had better interpreting skills but also had fewer misconceptions. This highlights that those with a stronger initial understanding were better equipped to analyse and make sense of professional scenarios after the training and were less prone to misunderstandings. This ability shapes the learning experience in a decisive way and can have an impact on both the classroom atmosphere and students' individual learning experience (Chaudhuri et al., 2022). A key finding was that participants with a less sophisticated conceptual understanding (Cluster 2) did not show statistically significant improvement in noticing during the pedagogical training. This indicates that their ability to identify key elements in professional settings did not significantly evolve despite the intervention. However, all other variables measured showed statistically significant development in both teacher profiles, indicating that other skills—aside from noticing within participants with a less sophisticated conceptual understanding—improved in both groups over the course of the training. This result is the opposite of previous findings, which have indicated that the development of interpreting skills is typically more challenging (König et al., 2014) and highlights the need for person-oriented research approaches that take into account different learning pathways. Uneven development highlights the importance of considering teacher profiles in pedagogical training: some teachers may require explicit support to practise noticing in classroom contexts, while others may advance more readily once their conceptions align with constructivist perspectives. Our findings also demonstrate that although the majority of previous studies assume parallel development, noticing and interpreting do not necessarily develop in parallel ways but may instead follow distinct developmental trajectories. This suggests that professional vision is not a uniform construct; rather, its components may require different forms of scaffolding and practice depending on teachers' prior conceptions and disciplinary backgrounds.

In summary, the results suggest that while pedagogical training can foster development in many areas, participants with a less sophisticated conceptual understanding may struggle to improve certain foundational skills, like noticing, without additional support. However, the overall positive development in other areas highlights the general effectiveness of the training. These findings highlight the importance of considering different teacher profiles in assessing pedagogical training outcomes. The cluster analysis conducted in this study successfully identified distinct groups of participants based on their conceptual understanding, illustrating that teachers do not develop uniformly. By examining these clusters, it becomes evident that individual differences play a critical role in how effectively teachers respond to and benefit from pedagogical training. By combining the analysis of professional vision and conceptions, this study contributes novel evidence that teachers' beliefs not only act as dispositions for situation-specific skills but also help to explain why teachers benefit differently from training.

5.1 Limitations and future directions

The study limitations must be acknowledged when interpreting the results. First, the number of the participants was relatively small for the statistical analyses. However, given that our sample size was small, it was necessary to conduct a confirmatory factor analysis

(CFA), as it enabled us to test the hypothesized factor structure of our measurement model without estimating the full complexity of a structural model. CFA focuses specifically on the relationships between observed variables and their underlying latent constructs, which makes it more suitable for smaller samples compared to full structural equation modeling (SEM). This approach allowed us to evaluate the validity and internal consistency of the proposed constructs in a statistically more robust way, despite the limited sample size. Therefore, while CFA was an appropriate choice given our sample size, future research with a larger sample could benefit from applying SEM to better explore the relationships between the constructs.

Second, short interventions also offer valuable insight into the short-term shifts in teachers' professional vision and conceptual understanding. However, to truly understand the depth of conceptual change in teachers, longer-term developments need to be explored. A longitudinal study would be particularly beneficial, tracking the evolution of teachers' professional vision and (mis)conceptions over an extended period. Furthermore, it would be insightful to examine how these changes are manifested in actual classroom practices in which mobile eye-tracking could be used, providing a more comprehensive view of the impact on their teaching performance in authentic teaching-learning situations. When attempting to generalize the results in relation to changes in participants' conceptions during the short pedagogical course, caution should also be exercised because the factor structure was different in the post-test compared to the pre-test. This may be because teachers' conceptions of the phenomenon actually changed, or it may also be because teachers' interpretations of the statements changed.

Third, this study does not consider other aspects of university teachers as learners, such as their motivation, time allocation, or self-regulation skills. These factors are known to influence learning outcomes, but they were not measured in our study. Future studies could examine how these learner characteristics interact with pedagogical training to further explain individual differences in professional vision and their pedagogical conceptual understanding.

Fourth, this study investigated the changes in the participants' professional vision and (mis)conceptions using within-subject design. Thus, one significant limitation of our research design is the absence of a control group, which presents challenges in interpreting the results. Without a control group, it becomes difficult to ascertain whether the observed changes can be directly attributed to the intervention or if they might be influenced by external factors, such as natural fluctuations over time or other confounding variables. This limitation impacts the internal validity of our study and raises concerns about the generalisability of the findings. In addition, our sample might be biased due to the voluntary nature of the participation in the pedagogical training. This might indicate participants' motivation to develop their pedagogical expertise in the first place. Future research should include a control group to provide a more robust basis for determining causality and to enhance the reliability of the results. On the other hand, the data was collected as part of an authentic pedagogy course, which made it difficult to establish a control group. The authenticity of the pedagogical setting is precisely the strength of this study.

Last, one potential limitation in our research was using the same video at two different measurement points, which can cause the testing effect. In the context of using the same video twice, the testing effect may arise because participants become familiar with the content and the test situation. This familiarity can lead to learning or memory effects, where participants remember specific details, narrative structures, or visual cues from the first viewing. As a result, their responses or behaviours during the second measurement may reflect this prior exposure rather than genuine changes due to intervention or experimental manipulation. Additionally, repeated exposure to the same stimulus could induce boredom or reduced engagement. Participants might pay less attention or have less emotional involvement the second time around, as the novelty and initial impact of the video have worn off. This reduced engagement can bias the results, as the second measurement might underestimate participants' true reactions under normal circumstances. Moreover, using the same video may prompt participants to anticipate questions or assessments, leading them to respond more strategically or in a socially desirable manner. This expectation may distort the validity of the measurement, as participants' responses might no longer reflect their natural, unprimed reactions. Thus, the testing effect from using the same video at two different measurement points can undermine the reliability and validity of the research findings.

5.2 Theoretical and practical implications

This study contributes to the theoretical framework of professional vision in education by demonstrating that university teachers' professional vision is closely tied to their conceptual understanding of teaching and learning. The findings support the notion that professional vision is not merely a set of observational and interpretational skills but is deeply intertwined with teachers' (mis)conceptions. This aligns with theories suggesting that teachers' cognitive frameworks significantly influence their pedagogical practices and perceptions. The results indicate that professional development programmes and pedagogical trainings should be designed to address and rectify university teachers' (mis)conceptions about teaching and learning. By focusing on improving conceptual understanding, such programmes can enhance university teachers' ability to notice and interpret pedagogically significant incidents in the classroom. This suggests that pedagogical training should be comprehensive, integrating both theoretical knowledge and practical application. Given that different teacher profile groups have developed in varied ways, it may be beneficial to better address this diversity in teaching practices through targeted pedagogical training for teachers. Providing this support for those facing greater challenges could enhance overall educational outcomes. Additionally, it is important to highlight that the dimensions of professional vision should be examined separately, as this represents a valuable theoretical contribution to our understanding of noticing and interpreting teaching-learning situations.

6 Conclusions

Our research contributes to a better understanding of how professional vision and (mis)conceptions of teaching and learning are related to each other and how they change when investigated before and after a pedagogical training. Professional vision research has previously focused mainly on lower education levels. This study provides further empirical evidence in a university context that teachers' conceptions affect their ability to notice and interpret pedagogically significant situations in classrooms, and this in turn affects student learning. This research also introduces new information, especially from a discipline-specific perspective in the domain of life sciences. By understanding how university teachers attend to and interpret classroom events based on their conceptions, effective instructional practices can be identified and provide evidence-based recommendations for improving teaching effectiveness. This research can inform the design of faculty development programmes and initiatives that support the alignment of professional vision and conceptions, ultimately leading to enhanced teaching and learning experiences for students in life sciences.

Research ethics

Author contributions

N.H.: conceptualization, investigation, methodology, data curation, formal analysis, visualization, writing—original draft, and writing—review and editing
N.K.: conceptualization, methodology, supervision, and writing—review and editing
E.K.: methodology, formal analysis, supervision, and writing—review and editing
M.M.: supervision, and writing—review and editing
I.S.: conceptualization, methodology, formal analysis, supervision, writing—review and editing, funding acquisition, and project administration

All authors have read and agreed to the published version of the manuscript.

Artificial intelligence

No artificial intelligence has been used in the research or writing the article.

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Institutional review board statement

Voluntary participation, informed consent, and anonymity of the participants were ensured in the research process. The study did not involve intervention in the physical integrity of the participants, deviation from informed consent, studying children under the age of 15 without parental consent, exposure to exceptionally strong stimuli, causing long-term mental harm beyond the risks of daily life, or risking participants' security (cf. Finnish Advisory Board on Research Integrity 2019). Consequently, this study did not require a Finnish ethics review.

Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

The data presented in this study are available on request from the corresponding author.

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Conflicts of interest

The authors declare no conflicts of interest.

Appendix A

Table 9. 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 raises a hand to ask a question, but the teacher does not notice the student because the teacher is fully concentrated on preparing lecture slides.
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.
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 does not respond to the student for a long time because the teacher is so concentrated on lecturing.
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 little disturbed before the teacher finally intervenes.
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-centred 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 behaviour because the teacher is concentrating on lecturing.
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.

Appendix B

The questionnaire used in the study.

Name: ____

Studying this course begins with filling in this short questionnaire. It helps you to orientate to the themes of the course. Please answer the following questions regarding your own ideas and/or experiences. Please read each question with care and choose the option (only one!) that describes your ideas best.

PART 1:
The following questions concern your experiences about teaching and learning. Please answer each item. Choose the alternative (1 – 5) that best describes your opinion. Do not spend too long time on each: your first reaction is probably the best one.
Please answer the questions on a scale of:
1 = Completely disagree
2 = Somewhat disagree
3 = Do not agree or disagree
4 = Somewhat agree
5 = Completely agree

1. Some people are naturally better teachers than others.
2. My students will learn better if I plan my teaching based on the results of a recent pedagogical research.
3. A skilled teacher can transmit exact knowledge for students effectively.
4. The most important thing to support students' learning is that the teacher knows the subject matter thoroughly.
5. Some people are good instructors, and you can't teach people how to teach.
6. I make use of pedagogical research in my own teaching.
7. Learning requires connecting aspects that are being learned into one's previous knowledge.
8. Some people just have a knack (=skill) for teaching and others don't.
9. When students activate their existing knowledge about a topic, they learn more.
10. I can get new perspectives for my teaching through pedagogical research.
11. Students' learning depends on what they already know about the topic.
12. I cannot teach a topic that is not in my research field because the most important thing in teaching is that I master every detail of the content.
13. I believe it is possible to develop teaching by knowing pedagogical theories.
14. Learning means that students adopt course material in detail.
15. Learning is better when students connect new information to what they already

know.
16. I consider it important that my teaching is based on pedagogical theories.
17. As a result of a successful teaching situation, the student is able to repeat the teachers' main message.
18. Some people are poor instructors, and it is almost impossible to affect that.
19. University teachers do not need to have a profound understanding related to learning theories as they are already experts in their own fields.
20. Teaching means that knowledge is transmitted from the instructor for the learner.
21. Teaching is a natural activity and university teachers don't need to be taught how to teach.
22. It is important that the teacher is aware of students' previous conceptions concerning the topic.
23. Being an expert in some discipline doesn't automatically mean that one is a good teacher.
24. If I know the subject well, I can also teach it.
25. If students are able to remember things that the teacher explained, they have learned it.
26. Learning means that students adopt the information from the teacher in detail.
27. Students existing knowledge about a topic influence how they understand new information being presented by the teacher.

PART 2:

The following questions concern your ideas about learning and teaching. Please answer each item. Choose the alternative (true or false) that best describes your opinion. Briefly explain your opinion in the line below.

1. Individuals learn better when they receive information in their preferred learning styles (e.g. auditory, visual, kinesthetic). true / false

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2. Information that is studied over longer periods is learned better than the same information studied over shorter periods. true / false

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3. It always eases learning if students' have preconceptions about the topic to be learned. true / false

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4. Changes in students' misconceptions is mostly dependent on the teacher's ability to explain the content clearly enough. true / false

5. Deep learning means that one can repeat information adopted from the course material. true / false

6. Misconceptions are developed through students being taught wrongly. true / false

7. Misconceptions are changed through proof or authority. true / false

Thank you for your answers.

Appendix C

Table 10. Information criteria values for different profile solutions

Number of Clusters	Akaike's Information Criterion (AIC)	Schwarz's Bayesin Criterion (BIC)
1	330.071	351.960
2	281.991	325.770
3	262.604	328.273
4	250.911	338.470
5	243.643	353.091
6	245.576	376.914
7	249.942	403.169
8	256.408	431.525
9	263.157	460.164
10	270.613	489.509

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