

This is an Accepted Manuscript of a book chapter published by Routledge in
Teacher Professional Vision : Empirical Perspectives

available online: <https://doi.org/10.4324/9781003370604>

It is deposited under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

AUTHORS	Ilona Södervik, Henna Vilppu, Neea Heinonen, Mari Murtonen
TITLE	The interaction between professional vision and conceptual change in higher education teaching – self-reports, videos, and eye tracking as study methods
YEAR	2024
VERSION	Author's accepted manuscript
CITATION	Södervik, I., Vilppu, H., Heinonen, N., Murtonen, M. 2024. The interaction between professional vision and conceptual change in higher education teaching – self-reports, videos, and eye tracking as study methods. In Stahnke, R., & Gegenfurtner, A. (2024). Teacher professional vision: empirical perspectives: Vol. II. Routledge. https://doi.org/10.4324/9781003370604
LICENSE	CC BY-NC-ND

THE INTERACTION BETWEEN PROFESSIONAL VISION AND CONCEPTUAL CHANGE IN HIGHER EDUCATION TEACHING – SELF-REPORTS, VIDEOS, AND EYE TRACKING AS STUDY METHODS

Ilona Södervik

University of Helsinki, Finland

Henna Vilppu

University of Turku, Finland

Neea Heinonen

University of Helsinki, Finland

Mari Murtonen

University of Turku, Finland

Introduction

Professional vision as a key component of higher education teachers' pedagogical expertise

Currently, teacher expertise is seen as a multidimensional whole, consisting of various aspects of knowledge and skills that interact with each other and develop through formal training and practical experience (e.g., Blömeke et al., 2015, see also Blömeke, Chapter 5 in Volume 1). This holistic view of teaching considers both the teacher's disposition (e.g., knowledge, motivation, social, and cognitive skills) and performance (e.g., situation-specific skills, teaching practices), which together contribute to student learning. Previously, research on teaching has focused on unproductive dichotomies between competence and performance (e.g., Blömeke et al., 2015) or between the content of teaching and pedagogy (Shulman, 1987), whereas more recent accounts highlight the process nature and multidimensionality of teacher competence.

According to the classical work of Shulman (1987), teacher professional knowledge is understood to consist of three central elements. First is content knowledge (CK) of their own discipline and subject area. Second, general pedagogical knowledge (PK) refers to broad principles and strategies of classroom management and organization regardless of the subject matter. Third, the combination of these two, namely pedagogical content knowledge (PCK), is the understanding of instructional strategies and of students' (mis)conceptions, as well as of what makes learning a certain topic easy or difficult. While all these elements of teacher professional knowledge seem to contribute to student achievement (Evens et al., 2018), the PCK element is thought to be the most important knowledge category, as it distinguishes the understanding of a content specialist from the understanding of a teacher (Shulman, 1987). In addition to different knowledge bases, expert teacher knowledge is characterized by elaborated and coherent knowledge structures formed through experiences in teaching (Lachner et al., 2016). Putnam (1987) coined the term "curriculum scripts" to refer to this kind of knowledge organization, where initially isolated knowledge bases (CK, PK, PCK) gradually become integrated and organized into curriculum scripts (Lachner et al., 2016). Curriculum scripts enable the rapid recognition of meaningful patterns in the classroom and also help teachers make informed teaching decisions (for scripts relevant for teachers, see also Wolff et al., 2021).

In Finland, university teachers are highly educated experts and often also researchers in their own subject area, and thus they can be considered content specialists with a solid base of CK. However, they might lack PK, at least at the beginning of their teaching career. While at the lower levels of education, it is usually self-evident that teachers are pedagogically educated, at universities the matter is not so straightforward. Although university pedagogical training is increasingly offered and encouraged, in many countries such as Finland, such training remains voluntary (Murtonen & Vilppu, 2020). Further, due to a lack of resources and a limited number of study places in university pedagogical training, not everyone who is interested can automatically be selected (Vilppu et al., 2019). Unreadiness for teaching may lead to the uncritical adoption of a former teacher's style, which can be problematic (Knight, 2002). To build a strong teacher identity, the deliberate development of ideas, conceptions, and practices is needed (Vermunt et al., 2017), where formal pedagogical training offers support. In these circumstances, the development of teachers' pedagogical expertise depends highly on their own initiative and interest.

Situation-specific skills and processes are likely to mediate between teacher disposition and performance (Blömeke et al., 2015; Lachner et al., 2016). Professional vision (Goodwin, 1994) can be considered a situation-specific skill, referring to teachers' ability to rapidly notice information in the classroom and engage in knowledge-based reasoning about this information (e.g., van Es & Sherin, 2008; Seidel & Stürmer, 2014; see also Sherin et al., Chapter 3 of Volume 1). Professional vision seems to be interrelated with PCK and the beliefs teachers hold about teaching (Meschede et al., 2017). Teacher professional vision has been studied extensively with primary and secondary school teachers, but there is a paucity of professional vision research on university teachers, with only a few exceptions (e.g., Heinonen et al., 2022; Heinonen et al., 2023; Murtonen et al., 2022; Södervik et al., 2022). Furthermore, much previous research on professional vision has concentrated on the differences between novice and expert teachers (e.g., Stahnke & Blömeke, 2021; Wolff et al., 2016), but the variance in pedagogical backgrounds makes university staff a unique group of teachers in contrast to their colleagues at lower educational levels, and it highlights the need for professional vision research at the university level.

Teachers' conceptions on teaching and learning and the need for conceptual change

Teachers' conceptions of teaching and learning have implications for the way teachers observe, interpret, and act in teaching-learning situations, where several events and things compete for the teacher's attention at the same time (Borko & Putnam, 1996; Pajares, 1992). Based on their existing ideas about teaching and learning, teachers constantly choose, both consciously and unconsciously, how to direct their limited capacity of attention and effort, namely what to be sensitive to and what can be ignored.

Previous research has typically approached the question of teachers' conceptions of teaching from the perspectives of teaching as transmission of knowledge and teaching as facilitating learning (Pajares, 1992; Staub & Stern, 2002). Repeated activation of these underlying ideas in real classroom situations start to form patterns and scripts that lay the foundation for teachers' approaches to teaching. Approaches to teaching are the practices and strategies that are implemented in the classroom, and they have a strong effect on teacher performance (Postareff & Lindblom-Ylänne, 2008). Two frequently distinguished approaches are the content-focused approach and the learning-focused approach. Teachers with a more content-focused approach to teaching typically focus on transmitting correct knowledge to their students, who are assumed to passively focus on receiving that knowledge. They consider the role of the teacher to be more a provider of "accurate knowledge" rather than a facilitator of students' active learning. This type of approach is more typical for novices, for pre-service teachers, and for teachers of the so-called "hard sciences" compared to more experienced teachers or teachers of the so-called "soft sciences" in higher education (Biglan, 1973; Lindblom-Ylänne et al., 2006; Lueddeke, 2003). Teachers with a more learning-focused approach, on the other hand, have more constructivist conceptions of teaching and learning. They consider the role of a teacher to be more a facilitator of learning, and students' active role in processing knowledge to be a prerequisite for high-level learning.

Learners' existing conceptions may act as an obstacle to learning if the new knowledge contradicts one's existing ideas (Vosniadou, 2013). Teachers' less sophisticated prior conceptions on teaching and learning can also be very tenacious and hard to change (Heinonen et al., 2022). Conceptual change research has particularly focused on the learning of science disciplines, but recently more and more learning researchers have applied the theoretical frameworks of conceptual change in other contexts, such as in history (Leinhardt & Ravi, 2008), economics (Lundholm & Davies, 2013), and teacher education (Södervik et al., 2022; Vosniadou et al., 2020). These studies in a teacher education context have indicated that the conceptual change type of learning plays, or should play, a role in teacher education, where student teachers' beliefs and ideas of teaching and learning may conflict with current pedagogical theories. These unsophisticated conceptions in turn affect teachers' performance, including their professional vision in the classroom and their overall vision of students' learning.

Methodological solutions: video interpretations, eye movements, and interviews in investigating teachers' professional vision

The methods of studying higher education teachers' pedagogical skills and actions have been rather limited (Wolff et al., 2016). Teachers' pedagogical expertise and its effect on students' learning have been studied mainly with self-report questionnaires and interviews. These methods have been criticized (Paulhus & Vazire, 2007) because they do not necessarily depict actual teaching skills, but instead represent teachers' beliefs about their own aims and actions.

The use of a video-based approach in research in teacher education has become a popular tool to measure teachers' abilities to analyse teaching-learning situations (e.g., König et al., 2014; Gaudin & Chaliés, 2015; Seidel et al., 2011,

see also Junker & Holodynski, Chapter 8 of Volume 1). In assessing professional vision, digital classroom videos are usually used as prompts to model the complexity of teaching-learning situations combined with different response formats, such as open questions (van Es & Sherin, 2008) and rating items to measure situated teacher competence (Gold & Holodynski, 2015). In comparison with paper-and-pencil tests, for example, video-based approaches are considered to be more authentic and therefore useful for measuring situated knowledge and teacher cognitions, and for teachers to gain professional vision (Gold & Holodynski, 2015).

Eye tracking has been a popular method in the educational context of studying reading processes (e.g., Rayner, 1998) and mathematics learning (e.g., Andrá et al., 2015), but research on teacher education (Jarodzka et al., 2017) is also increasing. The use of eye tracking has proved to be a useful method of investigating teacher learning and professional vision (e.g., Pouta et al., 2020; Wyss et al., 2020). It measures cognitive processes in complex classroom interactions and therefore adds significant value to the research of visual perception (Jarodzka et al., 2021). To investigate how teachers interpret visually perceived information, eye-tracking recordings should be enriched with qualitative data from different kinds of verbal protocols, such as interviews or think-aloud protocols, in order to transform the visual input into conceptual understanding (Clarke & Tyler, 2015). A stimulated retrospective recall (SRR) interview is a useful complementary method, where eye movement data are played back for the participant as a memory cue, allowing participants to report what they had been thinking during a past activity (see, e.g., van Gog et al., 2009).

Research has shown that expert teachers have better abilities to identify and interpret significant teaching-learning events in video interpretation tasks, whereas novice teachers tend only to describe what they have seen on the observed video (Wolff et al., 2015). The ability to focus on important phenomena and produce a correct or expected interpretation can be explained by the top-down and bottom-up processes of the control of visual attention (e.g., Theeuwes et al., 2000). When watching a video, first the actions capture watchers' attention (bottom-up), after which the expert watchers use their attentive processes to shift their attention elsewhere (top-down) to focus on things they consider important. Noticing can thus be controlled and influenced by top-down and bottom-up processes (Catherwood et al., 2014). In general, more experienced teachers seem to engage in the top-down processing of visual attention by means of a knowledge-driven perception of events (Kopp & Mandl, 2005; Nassaji, 2007). In contrast, teachers with less experience and knowledge seem to engage in bottom-up processes in which certain stimuli from the environment tend to evoke the cognitive processes of the perceiver (Kopp & Mandl, 2005; Wolff et al., 2021).

In a teaching context, several studies relate to investigating teachers' eye movements while watching and interpreting videotaped classroom situations, and the results demonstrate expertise effects at the eye movement level. Analysis of previous eye-tracking studies have shown that novices' viewing is usually more fragmented, and they have difficulties in focusing on relevant events; whereas more experienced teachers' viewing focuses more on relevant information, and they manage to process the visual information more quickly (van den Bogert et al., 2014). Compared to more experienced teachers, student teachers, for example, have shown greater variance in fixation duration and in the frequency of their eye movements (Wolff et al., 2016).

Aims

The purpose of this chapter is to contribute to discussions about the role of professional vision in relation to conceptual learning and conceptual change in understanding the development of teacher expertise in higher education. For that purpose, we synthesize data from five studies conducted in the Finnish higher education context. Additionally, we compare the professional vision and conceptions of teachers with and without previous pedagogical training, teachers from different disciplines, and teachers with different degrees of teaching experience.

The research questions are as follows:

- 1 What kind of conceptions and potential misconceptions do higher education teachers have concerning teaching and learning, and how are these related to professional vision?
 - 1.1 Are there differences in these aspects between current and future faculty, between the pedagogically trained and the pedagogically untrained, or between teachers from the soft versus the hard sciences?
- 2 How do teachers' (mis)conceptions and professional vision develop as a result of pedagogical training?
 - 2.1 Are there differences in these aspects between current and future faculty, between the pedagogically trained and the pedagogically untrained, or between teachers from the soft versus the hard sciences?

Overview of methods and reviewed articles

The data for this chapter consist of a summary and synthesis of five empirical studies conducted by two Finnish joint research groups (Table 16.1). All the studies were conducted in the authentic context of university pedagogical courses, and most of them include a pre-test– post-test design. Methodologically, all the studies utilized video clips or longer videos as a stimulus, combined with either written interpretations or eye tracking with complementary methods. Comparisons were made with teachers of various backgrounds, such as those from different disciplines and with different teaching experience. The disciplines were divided into the soft and the hard sciences (e.g., Biglan, 1973). In our studies, *current faculty* refers to those teachers who have teaching tasks at the university, whereas *future faculty* refers to those prospective teachers, such as doctoral students, who do not yet have teaching tasks at the university but may have them in the future.

In all the studies, the video clips were scripted, and they included pedagogically relevant incidents. Each shorter clip included one incident (Murtonen et al., 2022; Södervik et al., 2022; Vilppu et al., 2019), whereas the longer classroom video contained several pedagogically relevant incidents that the participants marked by clicking their mouse (Heinonen et al., 2022; Heinonen et al. 2023). In the studies of Vilppu et al. (2019) and Södervik et al. (2022), the videos were filmed from the students' perspective, with only the teacher showing; whereas the other studies used an outside observer's perspective of the classroom situation, depicting the teacher, students, and slides (see Figure 16.1). The eye trackers used in the studies were Tobii Pro Spectrum (Heinonen et al., 2023) and Tobii TX300 (Murtonen et al., 2022) (Tobii Technology, Inc., Falls Church, Virginia). Additionally, in all studies, different questionnaires about teachers' conceptions of teaching and learning were included (see Heinonen et al., 2022; Heinonen et al., 2023; Murtonen et al., 2022; Södervik et al., 2022; Trigwell & Prosser, 2004).



FIGURE 16.1 Screen captures of the videos. On the left, the perspective of a student, and on the right, the perspective of an outside observer.

TABLE 16.1 The description of the aims and methodologies in the synthesized articles

Article	Aims and variables	Sample (N)	Design	Methods
Vilppu et al. (2019).	Development of teaching conceptions during a short online training. Comparisons between disciplines, current and future faculty, participants with or without previous pedagogical education, and teaching experience groups.	66	Pre-test–post-test	• Video clips (2 × 41–60 secs) from a student perspective • Written interpretations
Södervik et al. (2022).	Development of PV* and (mis)conceptions of teaching and learning during a short online training. Comparisons between disciplines and current and future faculty.	53	Pre-test–post-test	• Questionnaires • Video clips (3 × 41–59 secs) from a student perspective • Written interpretations
Heinonen et al. (2022).	Development of PV* and (mis)conceptions during an on-site training. Comparisons between current and future faculty teachers.	70	Pre-test–post-test	• Questionnaire • Video (11 mins 41 secs) from an observer perspective • Written interpretations
Murtonen et al. (2022).	Relations between visual attention, conceptions of teaching, and pedagogical training. Comparisons between participants with or without previous pedagogical education and teaching experience groups.	49	Cross-sectional	• Video clips (2 × 1 min 30 secs) from an observer perspective • Eye tracking and retrospective think-aloud interview
Heinonen et al. (2023).	Development of PV* and (mis)conceptions of teaching and learning during an on-site course. Comparisons between participants with less-sophisticated and more-sophisticated conceptions.	32	Pre-test–post-test	• Questionnaire • Video (11 mins 41 secs) from an observer perspective • Eye tracking & SRR interview

* PV = professional vision.

Results

Overview of the findings on higher education teachers' professional vision and related conceptions

University teachers' professional vision seems to be statistically significantly related to their conceptions of learning (Heinonen et al., 2023; Murtonen et al., 2022; Södervik et al., 2022). Teachers who had constructivist beliefs about learning and a less content-focused teaching approach were more successful in noticing and interpreting pedagogically relevant incidents compared to teachers who had more transmissive beliefs about teaching and learning. Teachers with more sophisticated conceptions also had fewer misconceptions and were reported to use more student-engaging teaching methods in their teaching (Södervik et al., 2022). Some of our findings from the video-based eye-tracking measures also indicate that teachers with more misconceptions and transmissive conceptions of teaching and learning tended to focus on the teacher's actions in the classroom

situation (Heinonen et al., 2023; Murtonen et al., 2022). Additionally, teachers with fewer misconceptions and with more constructive conceptions of teaching and learning tended to focus on students' actions regarding such classroom events, where several actions competed for the teacher's attention at the same time and selective attention was required (Heinonen et al., 2023).

The study by Murtonen et al. (2022) showed that when watching a video clip of a lecture, pedagogically trained teachers paid more visual attention to the students and less to the teacher, especially in an excerpt where students were bored. Noticing that the students were not active was connected to learning-facilitating conceptions. The previous result is in line with the study by Heinonen et al. (2022), which shows that professional vision skills of future faculty teachers were lower compared to current faculty. However, in our other studies, such differences in professional vision were not found between teachers with different amounts of teaching experience (Södervik et al., 2022). Future faculty teachers had more misconceptions related to teaching and learning compared to current faculty in one study (Heinonen et al., 2022), but not in another (Södervik et al., 2022). Thus, there is no clear indication of the effect of teaching experience on professional vision (see also Murtonen et al., 2022). However, it is important to notice that there is a difference whether we talk about future faculty or current faculty with varying lengths of teaching experience in years.

Comparisons between disciplines showed that teachers of the hard sciences (natural sciences and medicine) seem to have more transmissive beliefs of teaching compared to teachers of the soft sciences (law, economics, humanities, educational sciences, and social sciences) (Södervik et al., 2022). In general, our studies show that university teachers' conceptions about teaching and learning vary, and certain misconceptions do exist (Heinonen et al., 2022; Heinonen et al., 2023; Södervik et al., 2022).

Overview on findings related to the effectiveness of pedagogical training

Our studies have shown that even short online pedagogical training has the potential to direct university teachers' (mis)conceptions about teaching towards a more favourable direction (Södervik et al., 2022; Vilppu et al., 2019). Additionally, teachers' professional vision improves remarkably as a result of pedagogical training (Heinonen et al., 2022; Heinonen et al., 2023; Södervik et al., 2022). More specifically, particularly beginners seem to benefit from this education, since the professional vision scores of the future faculty improved more than those of the current faculty (Södervik et al., 2022). Further, teachers with no previous pedagogical education as well as teachers with up to two years of teaching experience changed their conceptions of teaching from knowledge transmission to learning facilitation (Vilppu et al., 2019). Similarly, teachers of hard sciences, who generally had lower scores before the course intervention, benefitted from the training more than teachers of soft sciences (Södervik et al., 2022; Vilppu et al., 2019).

Pedagogical training seems to decrease the number of misconceptions among teachers (Heinonen et al., 2023; Södervik et al., 2022). Contrary to the study of Vilppu et al. (2019) and Södervik et al. (2022), in the study of Heinonen and colleagues, current faculty teachers seemed to benefit more from pedagogical training than future faculty teachers, whose misconception scores showed no significant improvement during the course (Heinonen et al., 2022).

Discussion

The purpose of this chapter was to explore the theoretical underpinnings of studying higher education teachers' pedagogical expertise on the level of eye movements and professional vision. We also reflected on the possibility of investigating conceptual change in relation to the level of professional vision. First, we analysed the unique environment and preconditions of university teaching, university teachers' pedagogical expertise, and their possibilities for pedagogical development, as well as their conceptual understanding of the teaching-learning phenomenon. We then reviewed our empirical studies concerning the topic.

University teachers' pedagogical expertise – that is, their ability to facilitate learning in the best possible ways – is still an understudied research area. Teachers can intervene only in things which they detect and which are appropriately interpreted in teaching-learning situations. This notion highlights the role of professional vision as a central element in teacher expertise. However, professional vision has been mainly studied only in primary and secondary teacher education (e.g., Van den Bogert et al., 2014; Wolff et al., 2016). Furthermore, ways of studying professional vision as part of teacher expertise have taken methodological leaps forward during the last decade. The studies synthesized in this chapter show that combining online and offline measures provides interesting data regarding teachers' professional vision and pedagogical expertise that would be inaccessible without a process-

level research methodology and a mixed-methods approach. University teachers' conceptions about teaching and learning seem to be related to their professional vision. This suggests that teachers who have a more sophisticated understanding of teaching and learning are more successful in noticing and interpreting classroom situations compared to teachers with a weaker pedagogical understanding. Interestingly, this is also evident from eye movement data, where teachers with more misconceptions and transmissive conceptions of teaching and learning tended to focus mainly on the teacher's actions in the classroom situation. On the other hand, teachers with fewer misconceptions and with more constructive conceptions of teaching and learning tended to focus more on the students' actions in such video incidents where several activities competed for the participant's attention. Hence, our studies indicate that there is evidence of expertise in teachers' visual behaviour in terms of more sophisticated conceptions concerning teaching and learning. However, presumably other factors, such as emotions, also influence teachers' observations and interpretations, suggesting that the topic needs further research.

Our results also show that misconceptions seem to be relatively common both among prospective teachers and current faculty (see also Vosniadou et al., 2020). Discipline seemed to play an even larger role than experience when comparing teachers' conceptions, which aligns with previous studies that reported that teachers in the social sciences and humanities tend to be more learning-focused, whereas teachers in the natural sciences are typically more content-focused in their teaching (Lindblom-Ylänne et al., 2006; Lueddeke, 2003). On the other hand, a short pedagogical training was most efficient for the hard science participants, i.e., they were the most eager to learn or the most prone to receive education. Our results indicate that conceptual change research results and theoretical principles can be applied to university pedagogics.

While the self-report measures that education researchers have traditionally used often map the teachers' beliefs about how they function in teaching-learning situations, eye-tracking measures take a step forward and are able to capture the actual processes taking place while observing authentic-like situations. Combined with complementary methods of concurrent or retrospective reporting, the number of researchers' inferences can be reduced (van Gog et al., 2009). Although the use of classroom video assignments is not uncommon in teacher education, there are some limitations in the use of video-based teaching-learning situations when examining professional vision. The videos used in our studies were short compared to real-life teaching situations, and thus they show only a fraction of the numerous and complex events that usually occur in a classroom. In future, using mobile eye trackers in authentic classroom situations would be fruitful (see, e.g., Keller et al., 2022; Pouta et al., 2020). While our studies do not achieve the same level of authenticity as mobile eye-tracking studies, the strength of our studies lies in the fact that they are conducted in authentic university pedagogy courses, and many of them also include a pre-test– post-test design. Thus, our studies include larger and more diverse samples, which enable comparisons between participants with different backgrounds.

Conclusion

The lesson to be learned based on the results presented in this synthesis is that higher education teachers' prior conceptions of teaching and learning, which are not always in accord with current learning research, colour teachers' professional vision, namely their noticing and interpreting of classroom situations. Hence, promoting conceptual change is critical in advancing teachers' pedagogical expertise and the quality of teaching in higher education institutions.

References

- Andrá, C., Lindström, P., Arzarello, F., Holmqvist, K., Robutti, O., & Sabena, C. (2015). Reading mathematics representations: An eye-tracking study. *International Journal of Science and Mathematics Education*, 13(2), 237–259. <https://doi.org/10.1007/s10763-013-9484-y>
- Biglan, A. (1973). Relationships between subject matter characteristics and the structure and output of university departments. *Journal of Applied Psychology*, 57, 204–213. <https://doi.org/10.1037/h0034699>
- Blömeke, S., Gustafsson, J., & Shavelson, R. (2015). Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie*, 223, 3–13. <https://doi.org/10.1027/2151-2604/a000194>
- Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. Berliner, & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). Macmillan.
- Catherwood, D., Edgar, G. K., Nikolla, D., Alford, C., Brookes, D., Baker, S., & White, S. (2014). Mapping brain activity during loss of situation awareness: An EEG investigation of a basis for top-down influence on perception. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 56(8), 1428–1452. <https://doi.org/10.1177/0018720814537070>

- Clarke, A., & Tyler, L. K. (2015). Understanding what we see: How we derive meaning from vision. *Trends in Cognitive Sciences*, 19(11), 677–687. <https://doi.org/10.1016/j.tics.2015.08.008>
- Evens, M., Elen, J., Larmuseau, C., & Depaepe, F. (2018). Promoting the development of teacher professional knowledge: Integrating content and pedagogy in teacher education. *Teaching and Teacher Education*, 75, 244–258. <https://doi.org/10.1016/j.tate.2018.07.001>
- Gaudin, C., & Chaliés, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, 16, 41–67. <https://doi.org/10.1016/j.edurev.2015.06.001>
- Gold, B., & Holodynski, M. (2015). Development and construct validation of a situational judgment test of strategic knowledge of classroom management in elementary schools. *Educational Assessment*, 20(3), 226–248. <https://doi.org/10.1080/10627197.2015.1062087>
- Goodwin, C. (1994). Professional vision. *American Anthropologist*, 96(3), 606–633. <https://doi.org/10.1525/aa.1994.96.3.02a00100>
- Heinonen, N., Katajavuori, N., Murtonen, M., & Södervik, I. (2022). Short pedagogical training in supporting university teachers' professional vision: A comparison of prospective and current faculty teachers. *Instructional Science*, 51(2), 201–229. <https://doi.org/10.1007/s11251-022-09603-7>
- Heinonen, N., Katajavuori, N., & Södervik, I. (2023). Professional vision of life science university teachers: Relations to conceptions of teaching and learning: Findings from an eye-tracking study. *Frontiers in Education*, 8, Article 1232273. <https://doi.org/10.3389/feduc.2023.1232273>
- Jarodzka, H., Gruber, H., & Holmqvist, K. (2017). Eye tracking in educational science: Theoretical frameworks and research agendas. *Journal of Eye Movement Research*, 10(1), 3. <https://doi.org/10.16910/jemr.10.1.3>
- Jarodzka, H., Skuballa, I., & Gruber, H. (2021). Eye-tracking in educational practice: Investigating visual perception underlying teaching and learning in the classroom. *Educational Psychology Review*, 33, 1–10. <https://doi.org/10.1007/s10648-020-09565-7>
- Keller, L., Cortina, K. S., Müller, K., & Miller, K. F. (2022). Noticing and weighing alternatives in the reflection of regular classroom teaching: Evidence of expertise using mobile eye-tracking. *Instructional Science*, 50, 251–272. <https://doi.org/10.1007/s11251-021-09570-5>
- Knight, P. (2002). *Being a teacher in higher education*. The Society for Research into Higher Education & Open University Press.
- König, J., Blömeke, S., Klein, P., Suhl, U., Busse, A., & Kaiser, G. (2014). Is teachers' general pedagogical knowledge a premise for noticing and interpreting classroom situations? A video-based assessment approach. *Teaching and Teacher Education*, 38, 76–88. <https://doi.org/10.1016/j.tate.2013.11.004>
- Kopp, B., & Mandl, H. (2005). Universitätsbibliothek der Ludwig-Maximilians-Universität München. *Wissensschemata* [Knowledge schemata] (No.177). <https://doi.org/10.5282/ubm/epub.744>
- Lachner, A., Jarodzka, H., & Nückles, M. (2016). What makes an expert teacher? Investigating teachers' professional vision and discourse abilities. *Instructional Science*, 44(3), 197–203. <https://doi.org/10.1007/s11251-016-9376-y>
- Leinhardt, G. & Ravi, A (2008). Changing historical conceptions of history. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (2nd ed., pp. 253–268). Routledge.
- Lindblom-Ylänne, S., Trigwell, K., Nevgi, A., & Ashwin, P. (2006). How approaches to teaching are affected by discipline and teaching context. *Studies in Higher Education*, 31, 285–298. <https://doi.org/10.1080/03075070600680539>
- Lueddeke, G. R. (2003). Professionalising teaching practice in higher education: A study of disciplinary variation and 'teaching-scholarship'. *Studies in Higher Education*, 28, 213–228. <https://doi.org/10.1080/0307507032000058082>
- Lundholm, C., & Davies, P. (2013). Conceptual change in the social sciences. In S. Vosniadou (Ed.) *International handbook of research on conceptual change* (pp. 288–304). Routledge.
- Meschede, N., Fiebranz, A., Möller, K., & Steffensky, M. (2017). Teachers' professional vision, pedagogical content knowledge and beliefs: On its relation and differences between pre-service and in-service teachers. *Teaching and Teacher Education*, 66, 158–170. <https://doi.org/10.1016/j.tate.2017.04.010>

- Murtonen, M., Anto, E., Laakkonen, E., & Vilppu, H. (2022). University teachers' focus on students: Examining the relationships between visual attention, conceptions of teaching and pedagogical training. *Frontline Learning Research*, 10(2), 64–85. <https://doi.org/10.14786/flr.v10i2.1031>
- Murtonen, M., & Vilppu, H. (2020). Change in university pedagogical culture – The impact of increased pedagogical training on first teaching experiences. *International Journal of Learning, Teaching and Educational Research*, 19(3), 367–383. <https://doi.org/10.26803/ijlter.19.3.20>
- Nassaji, H. (2007). Schema theory and knowledge-based processes in second language reading comprehension: A need for alternative perspectives. *Language Learning*, 57, 79–113. <https://doi.org/10.1111/j.1467-9922.2007.00413.x>
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307–332. <https://doi.org/10.3102/00346543062003307>
- Paulhus, D. L., & Vazire, S. (2007). The self-report method. In R. W. Robins, R. C. Fraley, & R. F. Krueger (Eds.), *Handbook of research methods in personality psychology* (pp. 224–239). Guilford Press.
- Postareff, L., & Lindblom-Ylänne, S. (2008). Variation in teachers' descriptions of teaching: Broadening the understanding of teaching in higher education. *Learning and Instruction*, 18, 109–120. <https://doi.org/10.1016/j.learninstruc.2007.01.008>
- Pouta, M., Lehtinen, E., & Palonen, T. (2020). Student teachers' and experienced teachers' professional vision of students' understanding of the rational number concept. *Educational Psychological Review*, 33, 109–128. <https://doi.org/10.1007/s10648-020-09536-y>
- Putnam, R. T. (1987). Structuring and adjusting content for students: A study of live and simulated tutoring of addition. *American Educational Research Journal*, 24(1), 13–48. <https://doi.org/10.3102/00028312024001013>
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124(3), 372. <https://doi.org/10.1037/0033-2909.124.3.372>
- Seidel, T., & Stürmer, K. (2014). Modeling and measuring the structure of professional vision in preservice teachers. *American Educational Research Journal*, 51(4), 739–771. <https://doi.org/10.3102/0002831214531321>
- Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., & Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others? *Teaching and Teacher Education*, 27, 259–267. <https://doi.org/10.1016/j.tate.2010.08.009>
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57, 1–22. <https://doi.org/10.17763/haer.57.1.j463w79r56455411>
- Södervik, I., Vilppu, H., Boshuizen, H. P. A., & Murtonen, M. (2022). Development of university teachers' professional vision of students' prior knowledge during a short pedagogical training. *International Journal of Teaching and Learning in Higher Education*, 34 (1), 7–24.
- Stahnke, R., & Blömeke, S. (2021). Novice and expert teachers' situation-specific skills regarding classroom management: What do they perceive, interpret and suggest? *Teaching and Teacher Education* 98, 103243. <https://doi.org/10.1016/j.tate.2020.103243>
- Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology*, 94(2), 344–355. <https://doi.org/10.1037/0022-0663.94.2.344>
- Theeuwes, J., Atchley, P., & Kramer, A. F. (2000). On the time course of top-down and bottom-up control of visual attention. In S. Monsell & J. Driver (Eds.), *Control of Cognitive Processes: Attention and Performance XVIII* (pp. 105–124). MIT Press.
- Trigwell, K., & Prosser, M. (2004). Development and use of the approaches to teaching inventory. *Educational Psychology Review*, 16, 409–424. <https://doi.org/10.1007/s10648-004-0007-9>
- van den Bogert, N., van Bruggen, J., Kostons, D., & Jochems, W. (2014). First steps into understanding teachers' visual perception of classroom events. *Teaching and Teacher Education*, 37, 208–216. <https://doi.org/10.1016/j.tate.2013.09.001>
- van Es, E. A., & Sherin, M. G. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education*, 24, 244–276. <https://doi.org/10.1016/j.tate.2006.11.005>

- van Gog, T., Kester, L., Nievelstein, F., Giesbers, B., & Paas, F. (2009). Uncovering cognitive processes: Different techniques that can contribute to cognitive load research and instruction. *Computers in Human Behavior*, 25, 325–331. <https://doi.org/10.1016/j.chb.2008.12.021>
- Vermunt, J. D., Vrikk, M., Warwick, P., & Mercer, N. (2017). Connecting teacher identity formation to patterns in teacher learning. In D. J. Clandinin & J. Husu (Eds.), *The Sage handbook of research on teacher education* (pp. 143–159). SAGE Publications.
- Vilppu, H., Södervik, I., Postareff, L., & Murtonen, M. (2019). The effect of short online pedagogical training on university teachers' interpretations of teaching-learning situations. *Instructional Science*, 47, 679–709. <https://doi.org/10.1007/s11251-019-09496-z>
- Vosniadou, S. (2013). Conceptual change in learning and instruction: The framework approach. In S. Vosniadou (Ed.), *International Handbook of Research on Conceptual Change* (pp. 9–30). Routledge.
- Vosniadou, S., Lawson, M. J., Wyra, M., Van Deur, P., Jeffries, D., & Darmawan, I. G. N. (2020). Pre-service teachers' beliefs about learning and teaching and about the self-regulation of learning: A conceptual change perspective. *International Journal of Educational Research*, 99, 101495. <https://doi.org/10.1016/j.ijer.2019.101495>
- Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. A. (2021). Classroom management scripts: A theoretical model contrasting expert and novice teachers' knowledge and awareness of classroom events. *Educational Psychology Review*, 33(1), 131–148. <https://doi.org/10.1007/s10648-020-09542-z>
- Wolff, C. E., Jarodzka, H., van den Bogert, N., & Boshuizen, H. P. A. (2016). Teacher vision: Expert and novice teachers' perception of problematic classroom management scenes. *Instructional Science*, 44(3), 243–265. <https://doi.org/10.1007/s11251-016-9367-z>
- Wolff, C. E., van den Bogert, N., Jarodzka, H., & Boshuizen, H. P. A. (2015). Keeping an eye on learning: differences between expert and novice teachers' representations of classroom management events. *Journal of Teacher Education*, 66(1), 68–85. <https://doi.org/10.1177/0022487114549810>
- Wyss, C., Rosenberger, K., & Bühner, W. (2020). Student teachers' and teacher educators' professional vision: Findings from an eye tracking study. *Educational Psychological Review*, 33, 91–107. <https://doi.org/10.1007/s10648-020-09535-z>