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Two Eyes See More Than One: An Online-Based Pedagogical Model for Enhancing Student Teachers' Professional Vision

Introduction

Professional vision, the ability to notice and make sense of classroom situations, is a key part of teaching expertise (e.g., Goodwin, 1993; Pouta et al., 2021). This skill helps teachers make well-informed decisions to support pupils' learning. To develop professional vision during teacher education, student teachers need opportunities to connect their theoretical knowledge with real classroom practices (Blomberg et al., 2011) and to discuss their observations and experiences with others (Ottesen, 2007). Usually, these opportunities are provided through teaching practicums in classrooms, but the COVID-19 pandemic and its resulting restrictions have made this impossible for many student teachers.

In response to this challenge, we developed an innovative, online-based pedagogical model with the purpose of providing an accessible yet authentic solution for student teachers to enhance their professional vision skills. This chapter delineates our model along with its underpinning theoretical principles. Furthermore, vignettes collected from a course in which the model was first implemented are provided to illustrate the development of student teachers' professional vision in pair discussions. Finally, we discuss the potential applications of our model in a post-pandemic world.

The Pivotal Role of Professional Vision in Teaching

Effective teaching demands the application of a multifaceted skill set to provide optimal guidance to pupils (Blömeke & Kaiser, 2017). In the classroom, teachers must identify and navigate numerous simultaneous learning processes, a task that becomes even more complex in increasingly prevalent inclusive classrooms. This optimal guidance relies heavily on professional vision (a concept originally introduced by Goodwin, 1993), defined as a teacher's capacity to notice, interpret, and make decisions concerning classroom events (van Es & Sherin, 2002). Given the numerous ongoing learning processes in the classroom, a teacher's professional vision process occurs rapidly and recurs throughout a lesson.

Goodwin (1993) approached professional vision from a sociological perspective, viewing it as a shared process among individual professionals. Goodwin defined professional vision as a process consisting of "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (p. 606). While the educational sciences have generally considered professional vision as an individual teacher's process, the concept of a shared professional vision is increasingly pertinent in contemporary schools where co-teaching is becoming commonplace. Collaborative work provides professionals with the opportunity to supplement and enhance each other's observations, potentially improving the quality of teaching and the functioning of the classroom (Meadows & Caniglia, 2018).

Professional vision has been found to be notably challenging for novice teachers (Stahnke et al., 2016; Star & Strickland, 2008; Stockero et al., 2017). Novices need training to base their perceptions on knowledge rather than primarily on visual cues, as their perceptions tend to be less focused (Wolff et al., 2016). Teaching scenarios present numerous cues, and through training, teachers can refine their skills to focus on relevant features (Hogan et al., 2003; Miller, 2011), thereby enhancing their visual processing efficiency (McIntyre et al., 2017). With practice, processing classroom situations becomes faster and more effortless (Berliner, 2004). Additionally, their reasoning becomes more comprehensive and integrated, overcoming the initial difficulty of establishing connections between teachers' and pupils' actions (Wolff et al., 2015).

A pivotal qualitative change in professional vision occurs when the focus transitions from the teacher's actions to the pupils' (Sherin & Han, 2004), a shift characteristic for expert teachers (McIntyre et al., 2019; McIntyre et al., 2017; Stürmer et al., 2017; Van den Bogert et al., 2014). Developing this skill necessitates deliberate practice to foster student teachers' selective attention—focusing on essential aspects of the teaching situation (Sherin & van Es, 2009; Fadde & Sullivan, 2013). Without proper training, student teachers tend to concentrate on superficial elements, such as the teacher's and pupils' characteristics, or make judgments about the effectiveness of the teaching, hence not focusing on elements related to the pupils' learning (Castro et al., 2005).

Professional vision is knowledge-based (Blomberg et al., 2011; Stürmer et al., 2013a; Wolff et al., 2016; Meschede et al., 2017), which underscores the importance of providing support for knowledge development. Teachers' professional knowledge is acknowledged as multifaceted (Kaiser et al., 2014; Tynjälä et al., 2016). Teaching requires several domains of knowledge, such as content knowledge (understanding of the subject-specific content, such as the concept of rational numbers), general pedagogical knowledge (aspects common to all teaching), and pedagogical content knowledge (a combination of understanding subject-specific content and the pedagogy specifically related to it) (Shulman, 1987).

Developing Professional Vision Skills through Professional Training Programs

Professional vision is a skill that can be honed through experience and deliberate practice (Bronkhorst et al., 2014; Ericsson, 2018; Gegenfurtner, 2020; Lehtinen et al., 2020). Guided video observation has been proven to be a promising tool for enhancing professional vision in several studies (e.g., Blomberg et al., 2013; Sherin & van Es, 2009; Stahnke et al., 2016; Stockero et al., 2017; Stürmer et al., 2013b; Weber et al., 2018). Videos are an efficient tool for bridging the gap between theory and practice and have been demonstrated to positively influence teachers' knowledge and observation skills (e.g., Carlson & Falk, 1990; Overbaugh, 1995). For novice teachers, videos offer the opportunity for observation without the pressure of managing an actual classroom, which is vital for professional development, as it allows resources to be dedicated to analyzing the situation at hand (Sherin, 2004). Moreover, there is encouraging evidence that even brief pedagogical interventions can contribute to the enhancement of professional vision (Vilppu et al., 2019).

While videos alone do not enhance professional skills (Kang & van Es, 2019; van Es, 2009), observational tasks can be specifically designed to do so. Blomberg et al. (2013) emphasized that the observational task, instructions, and materials should all align with the learning goals (Blomberg et al., 2013). The limitations of videos should also be acknowledged: watching even short clips of authentic classroom situations can be overwhelming, and the video clip should be chosen carefully (Blomberg et al., 2013). A major benefit of mobile eye-tracking technology is the possibility of guiding the viewer's attention to essential features. For example, eye movement modeling examples (EMME) have shown promising results in developing professional vision in various domains (Gegenfurtner et al., 2017; Tunga & Cagiltay, 2023).

Student teachers often struggle to integrate theory and practice, especially upon entering school after graduation. This "practice shock" (Stokking, 2003) can cause them to rely on their personal experiences from their own schooling rather than applying the research-based knowledge gained during their teacher education (Lampert & Ball, 1998). As a result, more effective strategies are needed to foster the integration of theory and practice (Lehtinen, 2023). Traditional teacher training periods and theoretical knowledge building within university courses are not always sufficient to develop student teachers' classroom management and pedagogical scripts, whereby relevant theoretical knowledge is encapsulated (Boshuizen & Schmidt, 2018). An expert's superior performance is attributable to a large number of well-developed scripts associated with well-encapsulated theoretical knowledge that can be activated when

an individual is working on very demanding, complex, or surprising cases (van de Wiel et al., 2000). Given that professional vision is a process heavily guided by knowledge (Blomberg et al., 2011), it is efficacious to incorporate support for knowledge building and restructuring within professional vision training.

The Present Study: A Pedagogical Model for the Promotion of Student Teachers' Professional Vision Skills

The course in question, designed to implement the pedagogical model, was hosted at a Finnish university for student teachers nearing the end of their five-year classroom teacher education, leading to a master's degree. The voluntary course provided an opportunity for student teachers to complete a teaching training period focused on a self-selected theme of professional development. The participating student teachers, being in the final stages of their studies, were considered to have adequate teaching experience and professional knowledge, enabling them to engage meaningfully with course exercises focusing on professional vision from both theoretical and practical standpoints. Up to this point, the student teachers also had had three teaching practicums in authentic classrooms, including approximately 620 hours of practicing, of which about 100 hours was the student teacher's responsible teaching in a classroom. In the Finnish teacher education system, it is common for all teaching practicums to include a student teacher's independent teaching supervised by the supervisor teacher in addition to observing classroom situations.

The course was conducted during the academic year 2020–2021, coinciding with the first outbreak of the COVID-19 pandemic, which made in-person training opportunities in primary schools challenging. In response, the course was developed to offer a flexible solution for professional development training amid the pandemic. As such, the course was delivered entirely online via Zoom (a communications platform connecting users through video technology) and Moodle (a learning platform for managing course content), and a schedule for completing the course exercises was designed to be flexible for the participants.

In terms of organization, all student teachers near the end of their studies were initially informed about the course, resulting in a total of 16 enrollments. The course began with an introductory Zoom session providing an overview of the course and its upcoming collaborative learning activities, with student teachers paired up for these activities. This was followed by a four-week intensive period during which all collaborative activities, namely literature discussions and video observations, were conducted in student teacher pairs. After each pair session, the student teachers also wrote personal learning journals in which they reflected further on their professional development based on the collaborative activities.

The university's ethics committee granted ethical approval for the research. All participating student teachers provided written consent to participate in the research as part of the course. Ethical approval and written consent for the use of video recordings as observation material had previously been obtained (see Pouta et al., 2021). To respect the participants' anonymity, pseudonyms were used, and any other identifying information was removed.

At its core, the pedagogical model is founded on the view that the development of a teacher's professional vision necessitates deliberate practice (Gegenfurtner, 2020; Lehtinen et al., 2020), encompassing both professional knowledge (Kaiser et al., 2014) and observations (van Es & Sherin, 2004). These elements work together to support student teachers in refining their selective attention (Sherin & van Es, 2009; Gaudin & Chaliès, 2013). Accordingly, the model comprises literature discussions and video observations of genuine teaching scenarios.

In line with the socio-constructive paradigm, the literature discussion and video observations offered a valuable opportunity for co-constructing knowledge. Opportunities for both individual and collective

reflection embedded within the activities were intended to foster reflective practice among the student teachers. Reflective practice, as outlined by Schön (1983), is widely considered a central learning process in professional development and teacher education (Segal, 2023).

Expanding Professional Vision Understanding through Literature Discussions

The primary goal of the literature discussions was to broaden student teachers' understanding of teachers' professional vision and professional knowledge related to the teaching of rational numbers. Approximately one week before each of the four literature discussions (each lasting 90 minutes), the student teachers were provided with two international research articles. They were expected to individually review these articles in preparation for an intensive discussion about the content with a partner during the session. Along with the articles, the student teachers were provided with guiding questions targeting the articles' key aspects to foster meaningful comprehension and dialogue. In addition, they were encouraged to expand the conversation beyond these to combine the content of the articles with their personal professional development and experiences, aiming to encourage the integration of theory and practice. A comprehensive index of all the articles used and the corresponding guiding questions can be found in Appendix A.

As an overview, the literature discussions began with two articles that conceptually focused on teachers' professional vision and its significance in teaching mathematics. Each subsequent session consisted of one article aimed at deepening the student teachers' understanding of professional vision and another focusing on the teaching and learning of rational numbers. This latter category addressed topics such as misconceptions, characteristics, and the common issue of natural number bias encountered in the study of the subject. The literature discussions were structured to build professional knowledge about the concept of rational numbers and progressively understand the importance of professional vision, thereby enriching the student teachers' understanding throughout the course.

Observations from the literature discussions revealed that the discussions among student–teacher pairs extended beyond simply understanding the theoretical notions related to professional vision and mathematics from the provided articles. This co-construction process was often enriched by their personal experiences as learners or educators. The following vignette illustrates this dynamic, wherein Jenna and Ella integrate knowledge from the articles with their own experiences, expanding step-by-step their understanding of the diverse challenges associated with teaching and learning fractions and decimals.

> Jenna: *[Compared to fractions], decimals might not be as difficult because their notation is closer to whole numbers.*
>
> Ella: *Right.*
>
> Jenna: *However, one common source of confusion can be determining the number of zeros. For instance, it can be difficult to tell which is larger between 0.3 and 0.03.*
>
> Ella: *Absolutely. As highlighted in our reading, it's crucial to understand the decimal unit. For example, decimal number 0.1 is essentially one part of 10, but this isn't always apparent just by looking at the numbers—it requires a good understanding.*
>
> Jenna: *Agreed.*
>
> Ella: *Interestingly, the article also mentioned how teachers can sometimes project their own difficulties onto their pupils, which is not always beneficial. Nevertheless, I remember, as a child, when at school or reading sports results, I found it difficult to understand why there were only two decimal places in a hundredth of a second. It didn't make sense to me since a hundred has three*

digits. Eventually, I just made a rule that there are two digits in hundredths, even though it still didn't make sense to me. Now, I understand better why "the younger me" found this difficult.

Jenna: *Yeah. Another interesting thing about decimals is the effect of placing a zero. For example, if you put a zero on the right side of the number three, it becomes larger, like 30. But in the case of a decimal, a zero on the right does not have the same effect. Thus, if you compare 0.3 and 0.30, that can be confusing.*

Ella: *Indeed. I remember while tutoring pupils on decimal representation of percentages, they easily grasped that 0.25 is 25%, but when it came to 0.5, they would invariably answer 5%. As we discussed in one of our earlier meetings, practical examples can significantly enhance comprehension. I posed a simple question to them about the value of 2.5 or 0.5 euros, and they promptly replied with 50 cents. This approach ultimately helped them understand the concept. But certainly, I agree that mastering these concepts can be really challenging.*

At best, the integration of new concepts and knowledge obtained from the literature, combined with the exchange of personal experiences during these discussions, could lead to enlightening insights into their own professional vision. One such moment is captured below, with Ella referring back to her experiences with the same tutoring group as above.

Ella: *Relating to the relationship between fractions and division, there was a task in which the pupils had to multiply some fraction, like 8/4 by two. However, they struggled, complaining that they didn't know how to multiply fractions. At that moment, I realized that they lacked an understanding of how you can simply reduce 8/4 to a straightforward whole number.*

Ella: *Hmm ... I actually utilized a form of professional vision when I noticed they didn't grasp this relationship ... Wow, this was a really cool insight that I've actually made such an observation! (laughs)*

Jenna: *Without even realizing it! (laughs)*

Observing Professional Vision in Practice

Acknowledging the importance of observations in cultivating professional vision, we incorporated weekly video observation sessions (90 minutes each) into the intensive period of the course (starting in week two). These sessions were scheduled on a different day following the literature discussion, allowing the student teachers ample time to reflect upon their discussions and compose their learning diaries. This order of activities was intended to empower student teachers to leverage their recently acquired knowledge about professional vision and the teaching and learning of rational numbers when observing videos from actual classrooms.

The video materials used in these observation sessions originated from a previous research project (Pouta et al., 2021). These consisted of recordings from three distinct fourth-grade mathematics lessons focusing on rational numbers. These videos were captured from the perspective of experienced teachers (9 to 21 years of teaching experience) using the Tobii Pro Glasses 2 mobile eye tracker (Tobii, 2016). Resembling ordinary eyeglasses, these devices record the wearer's view of the situation while also detailing eye movements. For student teachers, the opportunity to thoroughly analyze the eye-tracking data of experienced educators aimed to stimulate invaluable insights and provoke engaging discussions about professional vision. The provision of such in-depth exposure to professional practice was expected to support the integration and application of the concepts and strategies discussed in the literature discussions.

The three video observation sessions were carried out on Zoom, facilitated by either the first or second author. Each of these sessions maintained a consistent structure while showcasing different experienced teachers to show different ways to apply professional vision and support pupils' understanding of the rational number concept. Videos of different experienced teachers in each session also enabled the student teachers to make new observations for every distinct session. The video observation sessions included four phases: instructions, introduction video, observation tasks and concluding discussion.

Instructions and Introduction Video

To begin each session, student-teacher pairs were presented with a PowerPoint slide that provided a reminder of the session's structure and the context of the observed videos, which were filmed during a fourth-grade mathematics lesson on rational numbers (see Pouta et al., 2021).

Following this presentation, the student-teacher pair was shown a video from the beginning of the lesson, typically featuring the experienced teacher introducing and teaching the lesson's topic in front of the class. This video, between 7 to 12 minutes in length, was recorded using eye-tracking glasses from the teacher's perspective but was presented to the student teachers without the actual eye movement data to give them the possibility to make their own observations and interpretations first.

The aim of the introductory video was to introduce the classroom context and lesson topic, as prior research suggests that insufficient information about the contextual factors related to videotaped teaching situations can impede effective engagement and learning from these videos (Gaudin & Chaliès, 2015). The student–teacher pair was then given a few minutes to discuss their observations to ensure their initial understanding of the situation and prepare them for observing the upcoming videos.

The discussions provoked by the introductory video successfully engaged the student teachers, prompting them to focus on aspects of the teaching situation related to rational numbers, as exemplified in the dialogues between Anna and Olivia. These dialogues included observations of the teacher's actions and the structuring of the lesson content. However, the student teachers did more than merely describe the content; they were also capable of identifying the key features needed to prevent natural number bias. An example of this was their understanding of the distinctions between numerators and denominators when comparing fractions:

> Anna*: Well, at least it really emphasized the relationship between the numerator and denominator and how you can see how big the fraction is based on the numerator. They emphasized that you can compare based on the numerator when the denominators are the same. It came up that you can still compare them, even when the denominators are different, but that wasn't the topic of the lesson.*
>
> Olivia*: Yeah, definitely. It really highlighted where the numerator and denominator come from. And it seemed like they mentioned at the beginning that they'd gone through these things before, and it was clear that the pupils had a good understanding of these concepts.*

The introductory videos also encouraged the student teachers to pay attention to the pupils' thought processes. This is noteworthy, as it is generally more common for student teachers to focus on a teacher's actions when observing a teaching situation through a video (Sherin & Han, 2004):

> Olivia*: And it was funny when that one pupil already realized that when it's three-thirds, it's equal to a whole.*
>
> Anna*: Yeah, exactly. It didn't come across in the clip that the teacher mentioned it, even though all the parts were shaded. But she probably would have mentioned it later, as she said there.*

Furthermore, the student teachers successfully connected their observations with their theoretical understanding of the pedagogical strategies associated with teaching the concept of rational numbers, a topic they had previously discussed in the literature discussion. They demonstrated an ability to discern the representations of fractions, observe the teacher's actions during the lesson, and reflect on how these elements could impact the pupils' learning:

> Olivia*: That moment reminded me of what we talked about in the literature discussion yesterday, about teachable moments (meaning pivotal teaching moments), and the first type, the extended one.*
>
> Anna*: Yeah, same. And it made me think that we covered fractions pretty much according to that pie model.*
>
> Olivia*: Yeah, no other forms were mentioned.*
>
> Anna*: Exactly. When she asked how many parts of a circle, pizza, or pie, they're all essentially the same. There wasn't an example with a bar or something.*
>
> Olivia*: Yeah, true. Then it was nice when she asked why and didn't just settle for the answer, but also wanted the reasoning behind it.*
>
> Anna*: That was good, constantly asking why so that the pupils can verbalize it.*

Observation Tasks

The introductory video was succeeded by a carefully chosen clip from a later phase of the same lesson. This video segment, approximately seven minutes long, captured critical incidents involving the teacher providing individualized instruction on rational numbers during seatwork. Classrooms, being dynamic systems, often host rapidly changing and simultaneous occurrences (Greeno, 2006; Jacobson et al., 2016). Therefore, the literature on the use of videos in teacher professional development typically recommends multiple viewings of the same video segment to allow for more in-depth insights and comprehension of the situation; however, viewing the video more than three times might lead to an unnecessary saturation effect (Gaudin & Chaliès, 2015). Consequently, each selected clip was viewed three times in total, with the aim of gradually deepening the student teachers' observations.

The first viewing of the selected clip was uninterrupted, a*llowing the student teachers to gain an overall grasp of the scene* unfolding in the video. During the second viewing, the student–teacher pair was instructed to pay specific attention to any signs of *mathematical thinking they could discern from the pupils* in the video. When either of the student teachers noticed something in this regard, they prompted the facilitator to pause the video. This enabled the pair to engage in discussion about the situation, after which the video resumed again.

During the second viewing, the following pair (Alma and Nina) noticed and interpreted the teacher–pupil interaction from the perspective of fractions. They paid attention to both the teacher's guidance and the pupil's understanding based on concrete indicators. Their discourse revealed that they were attending to various sources of information, such as marks on the workbooks and the pupils' verbal expressions. However, the student teachers also acknowledged the complexity of the pupils' thought processes, as they identified several possible reasons for a pupil's single action:

> Alma*: It was interesting when the pupil said it when the teacher asked ...*
>
> Nina*: "What was ten?"*

Alma*: Yeah. They answered "two." I was like, did they accidentally say it wrong, or was there something difficult about saying or answering that question, even though they understood because they immediately put the correct fraction there, so they must have understood it. Or was it more like they just couldn't say it right away or answer those teachers' questions?*

Nina*: Yeah, I was thinking about that too. Maybe it was a bit difficult question also—"What was ten?" But somehow, the answer was so quick that they probably didn't think much when they said "two." But then it was just that they said "two" ...*

Alma*: Like, where did they ...*

Nina*: Yeah, I don't know if it came from there; that maybe because often we ask, "What is two?" Well, one-tenth. So, when it's often asked that way, it's thought of that way, that there are two-tenths, and if you say the numerator is two, the teacher could understand it as "what is two?" So, tenths.*

Alma*: So, the other way around.*

Nina*: So maybe they got confused there. But it might also indicate that they didn't fully understand the concept of what those tens and twos in that number were. Maybe that could have been further discussed.*

Alma*: Maybe the teacher could have asked a bit more.*

Nina*: Yeah, like if there were five in the twos, they could have started thinking about that.*

In the third and final viewing, the focus shifted to *the teacher's perceptions and actions regarding the pupils' mathematical thinking*. This viewing was distinct from the previous two, as it incorporated each teacher's actual eye movements captured through eye-tracking glasses. This innovative approach was anticipated to provide the student teachers with a richer and more accurate source of visual data to consider, guiding them to focus on the aspects that the teacher in the video attended to. This technique aims to bolster the development of student teachers' selective attention, aiding them in focusing on crucial elements of the teaching situation (Fadde & Sullivan, 2013).

During this viewing, Alma and Nina observed that the teacher used the pupil's facial expressions as a source of information. They also took note of the pupil's attention focus, even though the evidence for this was not substantial. They also attended to the teacher's guidance-related actions in conjunction with their eye movements, noting that the teacher anticipated the next task in the workbook before leaving the pupil's side. Hence, the video added to the understanding of the teacher's guidance and the pupil's understanding of fractions:

Alma*: I was thinking about how the teacher stayed with that one pupil for such a long time. I wonder if he knew that the pupil needed more help in the following tasks, too, because he didn't spend as much time or guide anyone else as much to make sure the pupil doesn't just get stuck coloring squares but can move forward.*

Nina*: Yeah, maybe he progressed at a slower pace than the others.*

Alma*: Yeah, you can color it like this so you can move forward. If you think about what the pupil understood, he tried to look at it. The pupil mainly looked at the book, but the teacher tried to look at the pupil's face, too, to see if there was any uncertainty. But he managed to move forward quite well on his own, and the teacher didn't have to help much except after the very first coloring task to see which one went up and which one went down.*

Nina*: I didn't really catch if it was just that the pupil wasn't very fast or if he had difficulty. I don't know if he could do it without help.*

Alma*: For example, in that one, it was like 23 hundredths, not in the coloring task, but in the next task, he calculated it without counting the squares. So he got the answer really quickly, while the other pupils might have counted each square and arrived at 20 or 23, whatever it was, but he immediately knew how much it was.*

Nina*: Right, the ones and tens.*

Alma*: Yeah, so he was really fast there again.*

Nina*: Maybe he needed that next to him.*

Alma*: Yeah, to move on.*

Nina*: But about the teacher's observation. When he was doing that task, she (the teacher) looked at the next task, so I don't know if she was thinking that she still needs to see if it's a whole compared to a fraction, how it sticks in his mind.*

Concluding Discussion

Each video session was wrapped up with a discussion involving the student-teacher pairs, generally lasting between 10 to 20 minutes. During these discussions, the student teachers were encouraged to reflect *on how their understanding of teaching and learning rational numbers was influenced by the video observations as a whole*. They were also urged to incorporate insights from the literature discussed during the literature discussions, thereby creating a bridge between theory and practice.

These concluding discussions seemed to create an important dialogical space for broader reflections and insights that extended beyond the specifics of the observed videos. For instance, the student teachers built up their understanding of effective teaching practices by comparing their notes on different teachers they had observed during the intensive study period:

Mia: *If we compare this to our first observation session, this teacher focused heavily on the task materials and only minimally made observations about the classroom and individual pupils.*

Laura: *Yes, I remember our discussion last week about the teacher constantly monitoring the classroom and tracking individual pupils' progress by looking at their task sheets and workbooks, as was evident from the video capturing eye movements in detail. However, during this specific lesson, the teacher only did this a few times in the classroom.*

In a similar vein, combining professional knowledge from the literature, detailed observations of different experienced teachers and personal reflections could lead to new insights into the student teachers' own desired practices as future teachers. This was the conclusion drawn by one student–teacher pair at the end of their last video session:

Olivia: *Now that we're more familiar with PTMs [pivotal teaching moments; referring to a concept introduced in literature discussion session 3; see Appendix A], it's easier to identify how a teacher should respond in such situations, such as extending the [pupils' thinking].*

Anna: *I think it will be easier for me to pay more attention to and identify such moments in my own teaching in the future.*

Olivia: *Yes. As we noticed in previous observation sessions, there are constantly situations where the teacher reacts in some way, but it's a different story whether these reactions are "pivotal." However, when such a situation arises, it really matters how the teacher reacts.*

Anna: *Absolutely.*

Olivia: *Essentially, you have to stay constantly alert to avoid accidentally overlooking something important or ignoring pupils' comments ... you really have to think and listen to what the pupils are saying!*

Discussion

The pedagogical model highlighted here arose from the need to offer student teachers authentic opportunities to develop their professional vision skills despite the restrictions the pandemic imposed on traditional practicum experiences. Drawing on the perspective that the development of a teacher's professional vision requires deliberate practice (Gegenfurtner, 2020; Lehtinen et al., 2020), involving both professional knowledge (Kaiser et al., 2014) and observations (van Es & Sherin, 2004), we designed an innovative, fully online-based course to empower student teachers to bridge theory into practice (Boshuizen et al., 2018).

Regarding the activities embedded in the model, the student teachers were able to focus on the relevant mathematical aspects already during the first introduction video, which can be considered a rather demanding task as it requires interpreting the characteristics of a completely unfamiliar situation. In doing so, the student teachers also referred to the content of the literature discussions. This implies a transfer effect from the literature discussions to the observations. Furthermore, in the observations, the student teachers were also able to focus on meaningful features of the teaching situation, such as individual pupils and a variety of sources of information (Sherin & van Es, 2009; Fadde & Sullivan, 2013). Finally, the eye-movement videos provided novel possibilities for more in-depth observations and for noticing additional sources of information about a pupil's learning, for example, a teacher looking at a pupil's face in addition to looking at the pupil's work book.

In addition to scrutinizing the video to offer insights about the functioning and usefulness of the model to support professional vision development (cf. the vignettes), we also gathered feedback from the participants for additional insights. One prominent theme was the motivational element of the literature discussions. Given that these sessions required a solid understanding of the materials, the participants felt driven to prepare thoroughly for these meetings.

Based on the feedback, collaborative discussions were crucial in enriching the student teachers' conceptual understanding during both the literature discussions and the video observations. These benefits mainly materialized in two ways. First, within a pair, if one student teacher exhibited greater proficiency in professional knowledge (for instance, in mathematics), they could scaffold their partner's understanding within their zone of proximal development (Vygotsky, 1978):

> *My learning was facilitated by my partner's interest and skills in mathematics. He was able to explain many concepts in such a way that I understood them during the literature discussion, even though they had seemed difficult when reading the articles alone.*

Second, the activities promoted the co-construction of knowledge, leading to new understandings and insights about literature and videos that would not have been possible if working individually, highlighting the benefits of collaboration. This process took shape through building upon each other's contributions to new knowledge and by introducing unique, and at times contrasting, perspectives to the discussion:

> *We considered different things and discussed observations from various perspectives. This enriched our understanding and the development of our observation skills. The discussion around the topic deepened my understanding as we collectively translated theory into practical examples. My partner's understanding of the articles supplemented my own, so I was able to fill any potential gaps during the literature discussions. The discussions also compelled me to organize my thoughts, which certainly enhanced my understanding.*

In general, the participants found the guiding questions, prepared for the literature discussions to inform their reading and discussion, helpful in scaffolding their learning process of complex topics. This was also beneficial as the literature used was in English, which was not their first language. Furthermore, the learning outcomes of the literature discussions were instrumental in enabling meaningful observations during the video observation sessions. They helped the student teachers become more attuned to noticing certain types of interactions and bridging the gap between theory and practice:

> *In my opinion, the observation discussions greatly supported my learning, as they allowed me to connect the knowledge learned from the articles to real life and an actual teaching situation. Given my limited teaching experience, I found these observations particularly important.*

Furthermore, we were particularly keen to understand how the student teachers perceived the influence of both the video material and the structure of the video sessions on their learning. The videos taken from the teacher's perspective proved enlightening, as they provided participants with a unique and intimate lens to understand the interplay between the pupil's thinking during task performance and the teacher's instructions. Interestingly, while all videos were deemed instrumental in deepening their understanding, the final video clip, with the teachers' eye movements, did not seem as significant as anticipated in eliciting substantial new insights:

> *I didn't find the eye movement video to be very important for my observation. It wasn't harmful, but I didn't make any new observations that I would have missed without it. In my opinion, individual guidance was the most beneficial for my observations, as it allowed me to observe the pupil's thoughts and the effects of the teacher's instructions on the pupil's thinking. The preparatory video showing the entire class was important to provide an idea of the actual progress of the lesson and the pupils' starting situation before doing the tasks and providing individual guidance.*

One reason for this was that at this point, the student teachers had already viewed the same clip (without eye movements) twice, which limited the opportunities for new, significant insights. However, some pairs were able to derive new insights from this video, as illustrated in the last vignette in Section 2.2.2. Furthermore, tracking and interpreting moment-to-moment changes in eye movements were perceived as challenging and cognitively demanding tasks (cf. Seidel et al., 2011). In conclusion, future studies could investigate whether introducing eye-movement data earlier in the video sessions yields different results, and whether more focused training on interpreting such data could assist student teachers in using it as a more fruitful resource in their professional vision development.

Summary of the Model

Finally, the overarching structure of the model and the interplay among its various components are encapsulated in Figure 4. Starting from the top, the text boxes represent the four-week intensive period of the course during which the model was first implemented. The rectangles located beneath these boxes indicate the learning activities conducted online by the student teachers in pairs throughout this period. The subsequent parenthetical text specifies the learning focus for each activity.

The bidirectional arrows between the rectangles symbolize the intent that the professional knowledge gained from the literature discussions would assist the student teachers in making meaningful observations and reasoning about different situations during the observation sessions. The vignettes, for instance, offer tangible empirical evidence supporting this intended interplay, as they demonstrate how the student teachers referred back to the literature discussions to make sense of their observations.

At the bottom, the individual reflections refer to student teachers' personal learning journals documenting the insights gained from the literature discussions and video observations. As indicated by the dashed arrows, the student teachers were expected to update their journals after each learning activity.

Lastly, the large arrow underpinning the entire figure represents the assumption that the model and its embedded learning activities could foster the development of student teachers' professional vision skills. While some improvement can be inferred based on the presented data excerpts and student teachers' feedback, this aspect necessitates more rigorous investigation in future studies.

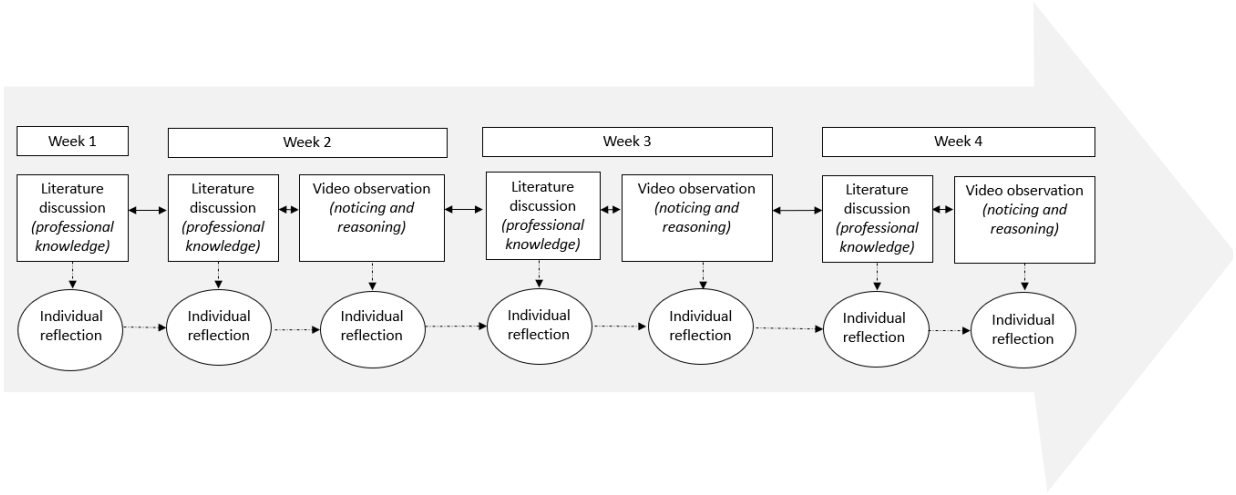

Figure 4. A summary of the pedagogical model.

Future Directions

Recent educational policy suggestions underscore the value of flexible online learning environments that foster personalized learning opportunities and strengthen the resilience of entire educational systems, not just during crises, but also in their aftermath (OECD, 2021). While our pedagogical model was initially developed in response to the challenges posed by the COVID-19 pandemic, we believe its potential extends to the enhancement of student teachers' professional vision in a post-pandemic world, where the demand for accessible online pedagogical training remains high. For instance, the model could be integrated into traditional teacher practicums to facilitate the development of student teachers' pedagogical scripts, encapsulating relevant theoretical knowledge (Boshuizen et al., 2018). A significant value of the model lies in its use of video observations to develop professional vision skills; although video-based observations have demonstrated their effectiveness in professional development, they are frequently underutilized in teacher education.

Although preliminary empirical evidence suggests the model's functionality, further rigorous research is necessary to explore its potential contribution to the development of professional vision. Concerning limitations, the model was only piloted with a small number of student teachers, and its implementation

might prove challenging with larger participant groups. To address this, future iterations could conduct literature discussions and video observations without the active involvement of a facilitator afforded by technological solutions, such as video conferencing tools. Importantly, this approach would also require clear, pedagogically driven guidelines for the student teachers, in addition to a comprehensive video library containing relevant clips for observation and discussion. As professional vision is a situated skill vital for integrating theory and practice, future research might examine the impact of introducing the model at earlier stages of teacher education (as participants in this study were nearing the end of their studies). Finally, given that professional vision is a subject-specific socialization process (Blomberg, 2011), offering similar training in domains other than mathematics could prove beneficial.

In conclusion, the pedagogical model enriches the pedagogies of practice by offering an innovative approach to practicum experiences through online training. This not only addresses the challenges brought about by the pandemic, but also holds promise for enhancing student teachers' professional vision in a post-pandemic world.

Acknowledgements

Tba

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Appendix A. Preparatory Reading and Guiding Questions for the Four Literature Discussion Sessions.

	Session 1	Session 2	Session 3	Session 4
Articles	Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169–202. Pouta, M., Lehtinen, E., & Palonen, T. (2021). Student teachers' and experienced teachers' professional vision of students' understanding of the rational number concept. *Educational Psychology Review*, *33*, 109–128.	Obersteiner, A., Van Hoof, J., Verschaffel, L. & Van Dooren, W. (2016). Who can escape the natural number bias in rational number tasks? A study involving students and experts. *British Journal of Psychology*, *107*, 537–555. Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169–202.	van Es, E., Cashen, M., Barnhart, T., & Auger, A. (2017). Learning to Notice Mathematics Instruction: Using Video to Develop Preservice Teachers' Vision of Ambitious Pedagogy. *Cognition and Instruction*, *35*:3, 165–187. Lortie-Forgues, H., Tian, J., &; Siegler, R. (2015). Why is learning fraction and decimal arithmetic so difficult? *Developmental Review*, *38*, 201–221.	Stockero, S., & Van Zoest, L. (2013). Characterizing pivotal teaching moments in beginning mathematics teachers' practice. *J Math Teacher Educ 16*:125–14. Rakes, C. (2010). Misconceptions in rational numbers, probability, algebra, and geometry. Electronic Theses and Dissertations. Paper 1176. (Note: pp. 19–44 from Chapter 2).
Guiding questions	1. What does the term "professional vision," or "noticing," imply for teachers, and how does it develop? Why is it a crucial part of a teacher's professional competence? (Refer to Jacobs et al., 2010 & Pouta et al., 2021.) 2. What are the potential challenges a teacher might encounter during the different stages of professional vision in teaching situations? (Refer to Jacobs et al., 2010 & Pouta et al., 2021.) 3. What type of guidance can successful professional vision lead to? From the standpoint of teaching fractions, what kind of features support learning? (Refer to Pouta et al., 2021; see also the appendix at the end of the article.)	1. Initially, provide brief definitions for the following terms: a) natural numbers and b) rational numbers. 2. What does the concept of "natural number bias" entail, and what types of incorrect inferences can it cause? Reflect on the strategies a teacher might employ to guide pupils away from such mistakes (Obersteiner et al., 2016). 3. Jacobs et al. (2010) outlined certain "growth indicators" linked to a teacher's professional vision (p. 196). Consider how these indicators might be demonstrated in the context of rational number instruction. (For instance, what are the key issues in a pupil's thought process when dealing with rational numbers?)	1. Lortie-Forgues et al. (2015) described seven inherent difficulties associated with the nature of fractions and decimal numbers. What are these challenges, and how does each one manifest in a pupil's learning? 2. Lortie-Forgues et al. (2015) also described two types of culture-bound challenges. Contemplate how these practices are manifested within the context of the Finnish school system. 3. In their article, Van Es et al. (2017) discuss a form of guidance they call "ambitious pedagogy." What type of guidance is referred to? 4. How could you implement such guidance in the context of rational numbers and assist pupils in avoiding and overcoming the challenges mentioned by Lortie-Forgues et al. (2015)?	1. What differences did Rakes (2010) point out between "misconceptions" and "reasoning errors"? 2. What misconceptions can pupils have in relation to rational numbers (Rakes, 2010)? 3. What do Stockero and Van Zoest (2013) mean by the term "pivotal teaching moment (PTM)"? How can a teacher's ability to utilize PTMs enhance a pupil's learning? Why might identifying PTMs be particularly challenging for beginning teachers? 4. Stockero and Van Zoest (2013) identified five types of PTMs in their data. What were these, and what potential effects were reported on a pupil's learning? Furthermore, in what ways did beginning teachers react to PTMs? 5. Consider what kinds of PTMs might occur in the context of rational numbers.