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Video analysis professional vision training and multimedia instructional design: Investigating preservice teachers' noticing and reasoning about small-group tutoring and support from signaling, self-explanations, and situational interest

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Dedication

In loving memory, I dedicate this work to my Dad, Richard Farrell.

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Published Studies of Dissertation

The full scope of this publication-based dissertation includes the present work, together with two studies presented within peer-reviewed articles published in international journals. Due to author rights, the present work refers to these articles, but does not include them within this publication. However, both articles are freely available online from the two respective journals via open access.

Paper 1: Descriptive Study

Farrell, M., Martin, M., Renkl, A., Rieß, W., Könings, K. D., van Merriënboer, J. J. G., & Seidel, T. (2022). An epistemic network approach to teacher students' professional vision in tutoring video analysis. *Frontiers in Education* 7:805422. https://doi.org/10.3389/feduc.2022.805422

Paper 2: Experimental Study

Farrell, M., Martin, Böheim, R., M., Renkl, A., Rieß, W., Könings, K. D., van Merriënboer, J. J. G., & Seidel, T. (2024). Signaling cues and focused prompts for professional vision support: The interplay of instructional design and situational interest in preservice teachers' video analysis. *Instructional Science.* https://doi.org/10.1007/s11251-024-09662-y

Abstract

A teacher's skills in noticing and reasoning about learning-relevant moments in the classroom, also called professional vision, can lead to better decisions for student learning. Thus, early development of these skills should begin in teacher education. Following a practice-based approach, preservice teachers can be supported in tasks approximating teaching practice, for example, the video analysis of classroom scenarios focused on a core teaching practice. Such a training offers opportunities to notice and reason about a practical instructional context, building the bridge between knowledge of theoretical principles and practice in action. Previous research suggests that novices often have difficulty noticing events beyond general pedagogy and struggle to use knowledge-based evidence to reason about these events. Thus, for early video analysis interventions, a setting with reduced-complexity, such as the core practice of small-group tutoring, could offer further support. Accordingly, this dissertation presents two studies investigating a video analysis training intervention for the development of preservice teachers' professional vision skills in small-group tutoring instruction.

The preliminary Descriptive Study examines novice preservice teachers' professional vision performance elicited from the video analysis intervention and validates its training potential. This study further clarifies training performance parameters and highlights needs for further support through a low- and high-quality performance comparison using epistemic network analysis. Results indicate that, as expected, the majority of preservice teachers noticed general pedagogy rather than content-specific events. However, some preservice teachers demonstrated better-than-expected skills. Still, preservice teachers' baseline professional vision performance demonstrated that many could benefit from further support.

The Cognitive Theory of Multimedia Learning suggests that information from complex multimedia materials like video, with a transient information flow, can be difficult for novices to process due to their limits in prior knowledge and experience. Accordingly, research on multimedia instruction suggests design techniques for support. For videos, signaling cues highlight essential information and can aid learners in information selection. Further, self-explanation prompts focused on target learning content can help learners organize and integrate information by directing their own explanations of essential information. Moreover, since situational interest is typically elicited through external triggers in the learning content or design, this motivational component may offer further processing support in a multimedia learning situation or have an impact on other supportive techniques.

To this end, the second study of this dissertation, the Experimental Study, builds on Descriptive Study findings and investigates the provision of two multimedia instructional design techniques for further professional vision support via randomized experimental comparison: signaling cues and focused self-explanation prompts. Moreover, it explores the impact of preservice teachers' situational interest in the video analysis and its potential moderating role in design technique effectiveness. Results indicate that the training led to significant improvements in preservice teachers' noticing and reasoning about relevant tutoring instruction, regardless of condition. Yet contrary to expectations, signaling cues and focused self-explanation prompts did not offer additional support overall. Surprisingly, however, a situational interest moderation indicated that signaling cues *were* effective for a subgroup of preservice teachers with lower-than-average situational interest.

Implications of the research of this dissertation include the development of an effective professional vision training for novice preservice teachers, which can be flexibly implemented into teacher educational courses and extended for deeper learning. Further, this model offers an economical methodology to develop and investigate similarly designed trainings on other core teaching practices. This research also highlights the need for further novice support in areas like content-specific noticing. It is also noteworthy that the integration of multimedia design techniques in this context did not support learners as expected, leading to questions for further inquiry. Finally, it suggests that the impact of preservice teachers' situational interest in video analysis training is a promising area for future exploration.

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Introduction

A teachers' *professional vision*[1] involves the processes of in-the-moment noticing and reasoning about practice-relevant teaching and learning classroom events (Goodwin, 1994; Seidel & Stürmer, 2014; Sherin & van Es, 2009). Based on professional and experiential knowledge and skills, teachers apply these cognitive-psychological processes toward socio-cultural- and expertise-oriented teaching practices, which guide the shaping and decision-making of further actions supporting individual students' needs (Jacobs et al., 2010; König et al., 2022; Seidel et al., in press; van Es & Sherin, 2021). This integral component of teaching has become a daily automatized practice for many experienced teachers (Berliner, 2001). However, for novice preservice teachers with limited theoretical knowledge and experience, how might they begin to develop a professional vision?

At the end of teacher education, student teaching and school internships provide practical opportunities for training, yet truly authentic experiences can be overwhelming and difficult for preservice teachers to navigate without previous practice-oriented rehearsal (Grossman et al., 2009; Syring et al, 2015). Instead, they need authentically-framed practice opportunities to develop real-world proficiency (Darling-Hammond & Bransford, 2007). Moreover, preservice teachers often struggle with knowledge application in real-time teaching situations (Kersting et al., 2012; Korthagen & Kessels, 1999). When noticing, they tend to only focus on salient aspects, and demonstrate difficulties attending to content-specific pedagogy or seeing individual learners with diverse needs (Jacobs et al., 2010; Johannes & Seidel, 2012; van Es, 2011). When reasoning, preservice teachers often generate intuitive and superficial interpretations rather than making sense of events according to the specific educational theory and research evidence that applies (Kersting, 2008; Lortie, 1975; Sherin & van Es, 2002).

This evidence suggests that professional vision training in teacher education is needed even sooner, for example, with practice-based methods already starting in the first years of teacher education. This approach aims to equip preservice teachers, not only with the knowledge necessary

[1] Within the educational research literature, the terms *teacher professional vision* and *teacher noticing* represent highly-overlapping, often interchangeable constructs (König et al., 2022), thus both conceptualizations are relevant to this research. For consistency throughout this dissertation, the term professional vision is used to represent this phenomenon.

to be successful in the profession, but also the practical skills involved in a teachers' daily routine (Cohen & Ball, 1999). This is optimized with a focus on *core teaching practices*, or common practices that are important for student learning and have the potential for initial mastery in teacher training (Ball & Forzani, 2009; Kloser, 2014; McDonald et al., 2013; Windschitl et al., 2011).

Toward this aim, the Framework for Teaching Practice in Professional Education (Grossman et al., 2009; Grossman, 2018) offers a structure for implementing practice-based opportunities. With the incorporation of decompositions- and representations-of-practice, preservice teachers can apply theoretical and conceptual knowledge of core practices toward increasingly authentic approximations-of-practice tasks. Thus, early promotion of preservice teacher professional vision might be realized through training programs and activities designed to notice and reason about teaching and learning events situated within core teaching practices (Grossman, 2018; Seidel et al., 2022). In this training agenda, preservice teachers can learn about and rehearse individual core practices in a process that gradually builds in authenticity and complexity (Grossman et al., 2009). Thus, novices are supported in forming lasting connections between theory and practice and avoid fragmented and uncoordinated competence and performance preparation (Cochran-Smith & Zeichner, 2009; van Merriënboer & Kirschner, 2018).

Within this training agenda, video analysis is one approximation-of-practice task on the lower end of the authenticity spectrum, which could be a helpful starting point for preservice teachers to begin professional vision development. This activity approximates the professional vision components of in-the-moment noticing and reasoning by offering learners the chance to direct their attention toward target core practice learning components while observing a video representation of that practice in action and to reflect on their noticed events and make sense of them by connecting to relevant pedagogical conceptual knowledge (Blomberg et al., 2013; Kersting, 2008; Santagata & Angelici, 2010; Stürmer & Seidel, 2017b; van Es et al., 2017). Research demonstrates that video analysis interventions have potential for the development and improvement of (preservice) teachers' professional vision, for example, with a stronger focus on content- and situation-specific pedagogy, individual student understanding, and connections with evidence-based knowledge (Jacobs et al., 2010; König et al., 2022; Santagata & Angelici, 2010; Stürmer & Seidel, 2017a; van Es, 2011).

With the knowledge of preservice teachers' general professional vision limitations and promising methods for promotion, further chances for success may come from the consideration of design adaptations for novice learners (Paas et al., 2003). Choosing a core practice instructional context of reduced complexity, such as small-group tutoring instruction, allows for a more intimate setting to focus on. This context might help preservice teachers more easily notice and reason about a range of student-centered practices from this effective teaching method (Cochran-Smith et al, 2015; Cohen et al., 1982; Doyle, 2012; Graesser et al., 2011; Lehman et al., 2012), which can also transfer to a more complex classroom setting (van Merriënboer & Kirschner, 2018). Moreover, additional complexity reduction might be achieved with a scripted video format. Evidence-based scripted videos, developed from authentic practice examples, can maintain sufficient authenticity, while also offering several ways of simplifying the video material for novices' benefit, for example, by condensing content and making intended areas of focus more salient (Gartmeier, 2014; Piwowar et al., 2018; Seidel et al., 2022).

While the practice-based teacher education structure together with a focused content and format of reduced complexity seem to be a promising approach for fostering novice preservice teachers' initial professional vision, a video analysis intervention comprising these aspects has yet to be empirically investigated. Research evidence is needed to determine whether early support for professional vision development may be realized with this offering. These findings could present a baseline performance elicited from the training to understand novice preservice teachers' current strengths and further needs for support in professional vision for this specific core practice context. This information could justify the need for the intervention as well as highlight areas of focus for additional help to overcome these challenges. A successful intervention could offer preservice teachers an early induction into the teaching community with the development of initial professional vision of a core teaching practice. Additionally, it could serve as an initial practice-based intervention design model for researchers and teacher educators to develop further professional vision trainings with a focus on other core teaching practices. One potential challenge arising from this design is the use of video as a learning material medium.

Video representations-of-practice as learning material in video analysis tasks can be motivating to learners, promote noticing and reasoning skill improvements, and facilitate learning (Gaudin & Chaliès, 2015). For success with a video analysis intervention, The Cognitive Theory of Multimedia Learning (CTML; Mayer, 2014a) suggests that learning with multimedia (e.g., video) takes place with the active selection, organization, and integration of task-essential information. However, the transient nature of video as a dynamic medium can also introduce challenges for novice information processing (Derry et al., 2014; Hegarty, 2014; Lowe & Schnotz, 2014). Learners may expend unnecessary effort searching for essential information, select salient but irrelevant information, or have difficulties keeping all the important material in mind due to the continual information flow (Derry et al., 2014; Mayer & Fiorella, 2014; Mayer & Moreno, 2003). Since processing capacity is limited, it is important to consider how learning materials and design contribute to guidance toward essential information and the reduction of the distractions from extraneous content (Mayer & Moreno, 2010). Consequently, a video analysis intervention may not be effective for fostering professional vision if the challenges of video information processing hold preservice teachers back.

To address the challenges from video information processing, research in the field of multimedia learning suggests instructional design techniques that may offer support in this regard. The signaling principle recommends highlighting essential information in the material with cues to make it more salient to the learners and help them to ignore irrelevant content (van Gog, 2014). Moreover, the self-explanation principle recommends that learners explain content to themselves to clarify their (principle-based) understanding and reveal knowledge gaps (Renkl & Eitel, 2019; Wylie & Chi, 2014). The use of these techniques may support novices' video information processing. Within a video analysis intervention, implementing these techniques into the training design may offer further support for preservice teachers' professional vision development. Signaling cues may be especially useful for noticing relevant events during video viewing, while focused self-explanation prompts could be particularly helpful in connecting specific noticed events to preservice teachers' conceptual knowledge of the core practice within their reasoning about noticed events.

While research on cues and focused prompts offers evidence of support in learning with video, much of this evidence is provided from highly controlled lab studies rather than field studies investigating these techniques in more real-world contexts (Ayres, 2015; Mayer & Fiorella, 2014; Mayer & Pilegard, 2014). Especially for the complex field of teacher education, evidence supporting the external validity of these design techniques is needed to determine their utility for interventions in this domain. Alternatively, evidence demonstrating a lack of support could inform further inquiry into potential boundary conditions for these techniques for this context (Ayres, 2015). Accordingly, evidence on whether cues and focused prompts can offer preservice teachers further support in professional vision development, when integrated into a video analysis training, could inform the design of similar video-based trainings for novices in teacher education.

Beyond aspects of a training's design and materials, learners' individual states and characteristics can also have an impact on learning success (Blömeke, Hoth et al., 2015). The Cognitive-Affective Theory of Learning with Multimedia (CATLM; Moreno, 2005; Moreno & Mayer, 2010) suggests that learners' motivation, emotion, and metacognition influence the amount of processing capacity made available for a given task. Moreover, when design techniques for support are already integrated into the multimedia learning environment, these learner-specific features may influence the effectiveness of their support (Ayres, 2015; Azevedo, 2014). Situational interest is a motivational state that is particularly relevant for multimedia learning, since it is typically elicited by external features of the learning task, content, or environment (Hidi & Renninger, 2006; Krapp, 2002; Mitchell, 1993; Renninger & Hidi, 2002). Therefore, preservice teachers' situational interest during video analysis training may play a role in their engagement, performance, or need for additional support via design techniques (e.g., Endres et al., 2020; Knogler et al., 2015; Magner et al., 2014).

Recently, the field of multimedia learning has called for more research investigating both cognitive *and* motivational aspects of instructional design, since there is still limited research evidence on the impact of motivational influences (Ayres, 2015; Mayer, 2014b; Moreno & Mayer, 2010; Plass & Kaplan, 2016). To this end, investigation into motivational mechanisms (e.g., preservice teachers' situational interest) in a video analysis training, may differentiate whether an instructional design technique for support will be helpful, necessary, or possibly even harmful for learning (CATLM; Moreno, 2005; Moreno & Mayer, 2010).

Situational interest has been implicated in offering multimedia learning support with emotional design (Endres et al., 2020), content-relevant decorative illustrations (Magner et al., 2014), and interesting text additions (Muller et al., 2008). However, its impact in the context of teacher education video analysis has not yet been investigated. Thus, it is unclear whether and in what way preservice teachers' situational interest in a video analysis training might impact their professional vision development or interact with design techniques for cognitive support. Exploring situational interest could clarify its role as a potential influence in video analysis and gain initial understanding about the mechanistic impact this motivational variable may have on the effectiveness of signaling cues and focused self-explanation prompts. This exploration may illuminate possible boundary conditions in play and lead to better recommendations for training designs in the context of video analysis professional vision training.

In the investigations of the present dissertation, a video analysis intervention was designed to address the need for novice preservice teacher professional vision training. This training was designed according to principles of practice-based teacher education and design support for novice learning, for the promotion of their noticing and reasoning skills in the core teaching practice of small-group tutoring instruction. In some versions of the video analysis training, the multimedia design techniques of signaling cues and focused self-explanation prompts as potential learning supports were also implemented. Preservice teachers' professional vision performance and cognitive-motivational processes were assessed.

The investigations of the present dissertation focus on the outcomes from the video analysis training intervention with two research studies. The first, referred to as the *Descriptive Study*, concentrates on the initial professional vision performance of preservice teachers. Beyond initial performance, this dissertation also focuses on the potential support offered from multimedia instructional design techniques implemented into the training. In the second study, referred to as the *Experimental Study*, preservice teachers' professional vision performance from different versions of the video analysis training, some of which integrate cues and focused prompts, are investigated with an experimental design (see The Present Dissertation Research and Methods sections).

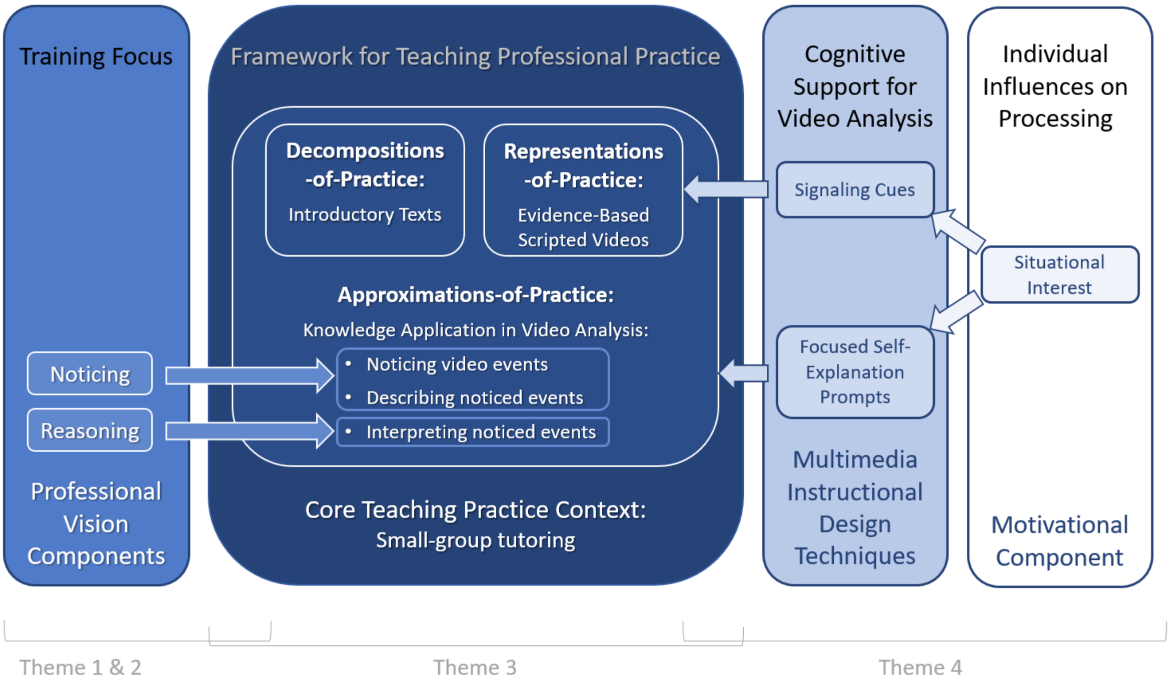
Four overall objectives and investigations are central to these studies: (1) to understand the baseline performance of preservice teachers' professional vision elicited by the video analysis training intervention; (2) to clarify preservice teachers' needs for further improvement to their professional vision; (3) to examine the support offered from signaling cues and focused self-explanation prompts; and (4) to explore preservice teachers' situational interest in the training and its impact on the instructional design techniques for support. The outcomes of these objectives establish a foundation for future study and professional vision training development for the video analysis intervention of the present studies, as well as similar professional vision training designs targeting novice preservice teachers.

This research is presented within this dissertation in the following structure: (1) an overview of the theoretical background relevant to these studies; (2) a synopsis of the research context, study aims, and the potential value to research and practice; (3) methods and materials used in this research; (4) brief summaries of each study, and finally (5) a comprehensive and integrated discussion which includes the findings, limitations, implications, and broader perspectives of this research, closing with key conclusions. As additional appendices, the coding schemes developed and used for the qualitative content analysis of each study are attached.

1.0 Theoretical Background

This section presents the theoretical background of the dissertation studies structured along four major themes. While each section elaborates on important aspects of the respective theme and their connection to the present research, it is important to clarify that these pertinent aspects of the research are not isolated components, but rather interconnected elements that comprise a unified foundation for the research of this dissertation (see Figure 1).

Figure 1. ***Integrated Model Summarizing Key Theoretical Constructs and Themes of the Present Dissertation.***



Theme 1 focuses on teacher professional vision. This section offers an overview of this concept. As the central dependent variable of focus in the present research, this section describes the relevance of teacher professional vision to teaching and learning, including its theoretical foundations, elemental components, and varied operationalization in research.

Theme 2 centers around professional vision training in teacher education. In this section, the need for training professional vision in teacher education is substantiated with a summary of research findings on novices' typical performance and needs for further development. For this training, this section further highlights a structure for novices’ development of professional core practice competencies, organized with a practice-based framework (Grossman, 2018).

Theme 3 concentrates on video analysis for novice professional vision training as a practice-based instructional intervention. Here, the instructional method of video analysis is presented as an approximation-of-practice for the facilitation of core practice professional vision skill development. In this context, this section further justifies and specifies how a video analysis intervention might be designed for novices through a focus on the core practice of small-group tutoring as a simplified instructional context.

Theme 4 emphasizes further support for novice learning in video analysis training. This section explains the Cognitive Theory of Multimedia Learning (CTML; Mayer, 2001) to clarify video-based learning and to outline potential challenges for novices. To this end, signaling cues and focused self-explanation prompts are described as two instructional design techniques for novice support. Next, it is further suggested, according to the Cognitive and Affective Theory for Learning with Multimedia (CATLM; Moreno, 2005), that further exploration is needed on the potential impact of motivational components, such as individuals’ situational interest, on performance and training design.

At the end of the Theoretical Background, a final section specifies the research of the present dissertation, with the description of the two research studies of focus in terms of their aims and research objectives, as well as their respective areas of focus within the larger research project context from which these studies are imbedded. This section concludes with the clarification of the added value potential this research could have for research and practice.

1.1 Teacher Professional Vision Research: Theory, Components, and Measurements

1.1.1 Theoretical Perspectives of Teacher Professional Vision

Professional vision is defined as systematic "ways of seeing and understanding events that are answerable to the distinctive interests of a particular [professional] social group" (Goodwin,1994, p.606). Members of a given profession discursively construct and challenge these practice-relevant events, or "objects of knowledge", which signify and distinguish the "theories, artifacts, and bodies of expertise" of the profession, which are commonly shared among practitioners (Goodwin,1994, p.606). Thus, this concept embodies multiple perspectives associated with expertise-oriented, socio-cultural, and cognitive-psychological practices of a professional group. The concept of professional vision can be a valuable knowledge base for studying a particular professional group to better understand the shared practices, knowledge, skills, and expertise that characterize them (Goodwin,1994). Moreover, to support novice and emerging professionals, this collective knowledge and expertise could be leveraged for the design of training programs and activities for building professional vision competencies, to establish a solid foundation for their upcoming professional lives (Vygotsky, 1978).

The teaching profession represents one such community in which advances in research and training of professional vision foster understanding and development among (soon-to-be) practitioners. The perspectives of professional socio-cultural learning, professional cognitive-psychological processing, and professional expertise, come together in this multifaceted concept. The socio-cultural perspective involves "seeing and understanding" the practices and events occurring within a teacher's daily routine, which are most relevant for teaching and learning in the classroom, according to a collective understanding of the practice (Goodwin, 1994, p.606; Seidel & Stürmer, 2014; Sherin, 2001). This development therefore involves the cognitive-psychological processes of noticing and reasoning about what is taking place in a teaching and learning situation from a professional point of view (König et al., 2022; Seidel et al., 2011; Seidel & Stürmer, 2014; van Es & Sherin, 2002). Moreover, research demonstrates that expert teachers quickly and accurately recognize patterns that are meaningful for learning, in order to take spontaneous, adaptable action (Berliner, 2001; 2004; Hogan et al., 2003). Thus, a teachers' ability to flexibly see and understand aspects relevant to the profession within their own classroom and subject-matter context demonstrates a certain level of expertise in the field.

For teachers in training, the development of these skills, practices, and competencies, is an induction into the teaching community. Early classroom teaching experiences within student teaching and practical internships can offer opportunities for professional vision promotion (e.g., Long et al., 2013). However, methodologies of practice-based teacher education have the potential to initiate preservice teachers' professional vision even sooner (McDonald et al., 2013; see next section). This approach focuses on core teaching practices: daily, routine practices, supported by research to promote student learning, and socio-culturally accepted by the teaching community as integral for early mastery (Grossman, 2018; see next section). Thus, early promotion of preservice teacher professional vision might be realized through training programs and activities designed to "see and understand" the "objects of knowledge" situated within core teaching practices (Goodwin, 1994, p.606; Grossman, 2018).

The research of the present dissertation focuses on the development of novice preservice teachers' professional vision following a practice-based teacher education approach. In this context, the theoretical perspective of professional vision embodies the socio-cultural and expertise-oriented perspectives through the focus on a core teaching practice (i.e. small-group tutoring strategies). Moreover, it encompasses the cognitive-psychological practices of noticing and reasoning about important events associated with this practice through a video analysis training intervention.

1.1.2 Professional Vision Components

The theoretical perspectives of teacher professional vision offer a structure for research as well as training design. Sometimes this concept is viewed holistically (e.g., Goodwin, 1994; Mason, 2011), however, more often it is considered a multi-dimensional phenomenon and discussed with respect to its cognitive-psychological process components (Santagata et al., 2021). While absolute consensus on component composition and terminology is still lacking in the field (König et al., 2022), the two major components typically associated with professional vision involve *noticing* (alternative terms: perceiving or attending) and *reasoning* (alternative terms: interpreting or making connections) about teaching and learning practice (König et al., 2022; Seidel & Stürmer, 2014; Stahnke et al., 2016; van Es & Sherin, 2002).

Noticing is a cognitive-psychological filtering process which allocates attention and directs perception to what is relevant through both top-down (individual) and bottom-up (stimulus) influences, interacting with long-term memory (Evans et al., 2011). Individuals select goal-oriented information and ignore goal-unrelated information (e.g., goal: event relevance to teaching and learning), which may be affected by features of the information stimulus (e.g., salience and/or complexity of event; Evans et al., 2011). This component is also often associated with naming or categorizing the noticed event (Star & Strickland, 2008).

Reasoning is a cognitive-psychological sense-making process, which interprets the noticed event according to the teachers' professional and contextual knowledge, goals, and beliefs (Brown et al., 1989; Schoenfeld, 1998; van Es & Sherin, 2008), typically making connections to abstract principles or knowledge about teaching and learning (Kersting, 2008; König et al., 2022; Seidel & Stürmer, 2014). [2] If this process necessitates some pedagogical action towards this noticed event to subsequently shape what is to take place, some frameworks also include a third process of decision making or shaping as the culmination of these noticing and reasoning processes (Jacobs et al., 2010; Scheiner, 2021; Sherin et al., 2011; van Es & Sherin, 2021). In the present research, the professional vision components of focus involve preservice teachers' noticing and reasoning. [3]

Since the myriad of practices that a teacher performs are nested in the situational context of the classroom, their professional vision is in active interplay with what is taking place (Scheiner, 2021). The "objects of knowledge" that could be noticed, reasoned about, and further acted upon could be focused on any event relevant to the profession (Goodwin, 1994, p.606). Depending on the situation or instructional goal, they may be focused on domain-general events, such as classroom management (e.g., Weber et al, 2018; Wolff et al., 2016) or equity and diversity (e.g., Lefstein & Snell, 2011; van Es et al., 2022), or they could focus on subject-specific events, such as the content and quality of students' thinking when solving a math problem (e.g., Santagata et al., 2007; Blömeke et al., 2014). Noticed events in one's professional vision are also perspectival (Goodwin, 1994), and may focus on perspectives from different actors involved (e.g., teacher-focused, student-focused, or focused on teacher-student interaction; van Es & Sherin, 2008).

For the study and training of this wide-ranging phenomenon, teacher professional vision is typically concentrated on a particular focus of teaching practice (Sherin et al., 2011; Kang & van Es, 2019). For the present dissertation research, preservice teachers' professional vision training is focused on noticing and reasoning within the context of small-group tutoring. The "objects of knowledge" (Goodwin, 1994) within this core teaching practice target instructional strategies, which

[2] There is some debate in the field about how the structure of some components are further delineated. For example, Seidel & Stürmer's (2014) model further breaks down the reasoning component into the *description*, *explanation*, and *prediction* about the noticed event. In contrast, van Es and Sherin (2002) envision professional vision as a cumulative developmental process starting with *noticing* events, then further *evaluation* of noticed events (i.e., positive or negative valuation without any knowledge-based explanation), and finally with further development, teachers exchange their evaluations with knowledge-based *interpretation* of the noticed event (van Es, 2011).

[3] For (early) preservice teacher training, the third professional vision component of decision making is sometimes omitted, since this skill typically involves considerable cognitive effort of complex processing from multiple sources and perspectives (Leinhardt & Greeno, 1986; McDonald et al., 2013), and novices have found this component to be particularly difficult in contrast to more experienced groups (Jacobs et al., 2010). Thus, this component is not trained or investigated in the present research, due to the target population of novice preservice teachers.

are more or less facilitative for learning in this setting, thus taking the perspective of the teacher and teacher-student interactions (see Methods section).

1.1.3 Professional Vision Measurement in Educational Research

Professional vision components also offer a structure for skill measurement in the study of teacher professional vision. Due to its multi-dimensionality, latent properties, and variety of expression in situation-specific instructional contexts, there is quite a range of measurement methods in the field (König et al., 2022; Santagata et al., 2021). Data elicited can be qualitative, quantitative, or mixed, so the operationalization of professional vision components can take many forms.

For the component of *noticing*, qualitative data may come from written or verbal retrospective self-reflections or interviews (e.g., Sherin et al., 2008), or video annotation (e.g., Rich & Hanafin, 2009). For this data, inductive, deductive, or iterative qualitative analysis and data coding is required to extract the meaningful indicators of professional vision components. Their respective coding schemes are often specified to the target content to be observed (Chan et al., 2020). Mixed methodologies often quantify qualitative measures into a given score to be used for further quantitative analysis (e.g., Fisher et al., 2018; Santagata et al., 2007). Quantitative data may come from multiple-choice tests (e.g., König et al., 2014; Stürmer & Seidel 2017; Star & Strickland, 2008), or, more recently, visual behavioral indicators from eye-tracking methodologies (Jarodzka et al., 2021; Nückles, 2021; Seidel et al., 2021).

For the component of *reasoning*, due to its latent nature and situation specificity, this component is most often elicited qualitatively (e.g., think-aloud, interviews, written reports, test open responses, discussion groups; König et al., 2021; Santagata et al., 2021). Some studies have also developed and validated quantitative knowledge tests, which measure reasoning according to the target learning context of the training (e.g., König et al., 2014; Stürmer & Seidel 2017). In the present research, the components of preservice teachers' professional vision are elicited via written descriptions (i.e., noticing) and interpretations (i.e., reasoning) of noticed events.

For analysis, operationalizations of noticing and reasoning offer the most meaning when they obtain information about *what* and *how* these professional vision components are demonstrated: the *content* represents *what* is noticed and reasoned about, while the *quality* represents *how* the content is noticed and reasoned about (Berliner, 2001; van Es, 2011). The content within event observations and sense-making reveals the "objects of knowledge" present within the observers' professional vision (Goodwin, 1994, p.606). The quality of one's noticing and reasoning skills typically indicates their proximity to expertise based on particular attributes (Berliner, 2001).

For the *noticing* component, what is noticed and what is ignored provides information about the observers' ability to attend to what is relevant within instructional events. Quality attributes of noticing skill often involve the level of specificity and elaborated detail, which provide deeper understanding of the event in context (Santagata & Angelici, 2010; Seidel & Stürmer, 2014). For the *reasoning* component, the type of reasoning about noticed events offers information about the (preservice) teacher's skills in making sense of the event from a professional knowledge perspective (Santagata & Angelici, 2010; Seidel & Stürmer, 2014). Attributes of reasoning quality typically focus on an analytical and logical basis of argumentation which relevantly connects to the noticed event, as well as the use of knowledge-based evidence (i.e., from teaching and learning theory or learning materials) for the justification of arguments made (Kersting, 2008; Santagata et al., 2007; van Es & Sherin, 2002). These *what* and *how* indicators for noticing and reasoning, respectively, often vary depending on the study context and learning goals, as well as the type of data and measurement methods employed (König et al., 2022; Santagata et al., 2021; van Es, 2011).

In the present research, preservice teachers' professional vision components are preliminarily measured with qualitative analysis of content (what) and quality (how) indicators for noticing and reasoning, respectively. The content and quality coding schemes developed for this measurement are based on the above-mentioned characterizations of the professional vision component indicators, as well as distinct event content, specified to the study context (see Methods Section for details).

While each content and quality indicator provide a piece of the professional vision puzzle, understanding their interactivity within (preservice) teachers' noticing and reasoning can present a representation of the complex nature of their professional vision proficiency. This interactivity could be further connected to the socio-cultural practices of teachers (Goodwin, 1994) with Epistemic Frame Theory (Shaffer, 2012, 2017). Accordingly, the epistemic frame demonstrates the cultural structure of a community, uncovered from the study of discourse between community members. This epistemic frame demonstrates "a pattern of associations among knowledge, skills, habits of mind, and other cognitive elements that characterizes communities of practice" (Shaffer et al., 2016, p.11). Epistemic Network Analysis (ENA) operationalizes a community's epistemic frame. This unified mixed methodology analyzes coded discourse data to uncover co-occurrence patterns, relationship intensity, and structure through weighted node-linked networks (Bowman et al., 2021; Shaffer et al., 2016). These networks go beyond indicator frequency counts (e.g., Bauer et al., 2019; Csanadi et al., 2018) to maintain a more nuanced *thick description* (Geertz, 1973) of outcomes (Shaffer, 2018).

The study of professional vision can also benefit from other mixed-methods approaches. When it is meaningful to an investigation to understand group differences, or relationships with other variables, quantifying qualitative outcomes can provide a means for further statistical analysis (Hochwald et al., 2023; Sandelowski et al., 2009). While there are some trade-offs in terms of what and how to quantify, and compromises to outcome complexity, this mixed methodology allows for hypothesis testing to answer questions which may not be answerable with qualitative analysis alone (Sandelowski et al., 2009).

In the present research, two different mixed-methods approaches are performed in the two research studies. In the Descriptive Study, content and quality indicators of noticing and reasoning, respectively, are measured with qualitative content analysis coding, then further analyzed with descriptive statistics and ENA. With its compatibility with professional vision, ENA allows for an in-depth and nuanced approach, facilitating visibility and exploration of the complex, multi-faceted relationship structures, helping to uncover salient connections between PV skill components, and potentially identifying subgroups that share similar co-occurrence patterns (Shaffer, 2018). In the Experimental Study, with qualitative content analysis, content and quality indicators are combined for noticing and reasoning, respectively, then outcomes are converted to professional vision scores for further analysis with quantitative inferential statistics. This mixed method approach offers the chance to understand preservice teachers' professional vision from a more holistic perspective and elucidate the impact from elements of the training design and individuals' motivational differences.

The next section justifies the need for professional vision training in teacher education and outlines ways in which this training might be designed. Firstly, the need for professional vision training is substantiated with the description of typical novice professional vision skills, according to previous research. Next, it elaborates on the concept of core teaching practices in practice-based teacher education as an appropriate frame for preservice teachers' professional vision training. To follow, the Framework for Teaching Practice in Professional Education (Grossman et al., 2009) is described as a fitting structure for the design of training interventions for novice learners of a professional practice. Finally, the training structure of the present research is clarified in connection with the Framework outlined in this section.

1.2 Professional Vision Training in Teacher Education

1.2.1 Typical Novice Professional Vision Skills

Research comparing the professional vision skills of novices and experts demonstrates the need for professional vision training in teacher education. This research also offers an understanding of novice-expert characteristic performance differences in noticing, reasoning, and (sometimes) decision-making for specific instructional contexts. These findings are the key to understanding of the current state of preservice teachers' skills, clarifying the goals toward expertise development, and the specific needs novices possess, which form the basis for initiating targeted professional vision training interventions, yet this area of research is still quite limited (König, et al., 2022).

From the few studies deliberately comparing novice and expert professional vision performance (e.g., Jacobs et al., 2010; Seidel et al., 2021; Wolff et al., 2016), experts are generally better than novices, across different subjects and for various target instructional contexts and outcomes (König et al., 2022; e.g., classroom management strategies: Gold & Holodynski, 2017; discourse: Lachner et al., 2016; student understanding in math: Dreher & Kuntze, 2015; judgment accuracy: Seidel et al., 2012; Seidel et al., 2020). Experts notice and make sense of more events, with greater variety, at deeper levels of detail and differentiation, and with more use of conceptual knowledge (Jacobs et al., 2010, van Es, 2011). This pattern recognition is typically ingrained as a daily automatic process for shaping teaching moments and making decisions that support individual students' needs (Berliner, 2001; Scheiner, 2021; van Es & Sherin, 2021). In part, these automatized skills come from the wealth of professional and experiential knowledge within their elaborated and complex mental models of practice, which are utilized in visual and cognitive processing together with long-term working memory (Gegenfurtner et al., 2022; Seidel et al., in press).

Preservice teachers, however, do not yet have these knowledge stores to rely on for quick decision making, nor have they developed automatized skills in intentional and continual in-the-moment knowledge-based noticing and reasoning (Berliner, 2001). Therefore, in terms of their noticing skills, they often rely on prominent cues to drive their attention, typically focusing on salient aspects of the classroom, general rather than content-specific pedagogy, and treating students as a group rather than individual learners with diverse needs (Jacobs et al., 2010). Moreover, in professional vision training activities, their descriptions of events are typically superficial and lack important contextual details to differentiate the specifics of the event (Jacobs et al., 2010; van Es, 2011).

Regarding novices' reasoning of noticed events, they often generate intuitive interpretations based on their own observational experiences developed when they were students themselves. However, this informal "apprenticeship of observation" (Lortie, 1975, p. 67) is acquired without understanding of the theoretical intentions behind observed teaching actions, leading many preservice teachers to enter teacher training with preconceived ideas about instruction based on (faulty) intuition rather than professional knowledge (John, 1996). Therefore, in professional vision training activities, novices' reasoning argumentation is typically vague and often makes judgmental evaluations or oversimplifications about student comprehension, which are deficient in knowledge-based evidence to justify their interpretations (Jacobs et al., 2010 ; Seidel et al., 2011; Seidel et al., 2017; Sherin & van Es, 2002; van Es, 2011). These typical shortcomings in novice professional vision performance suggest that their mental models of instruction are limited. Thus, professional vision training in teacher education is needed to help preservice teachers with noticing and reasoning skill development, as well as further elaboration of their mental models of teaching practices which integrate theoretical knowledge (Smith & Karpicke, 2014; van Es et al., 2017).

1.2.2 Training Professional Vision in Teacher Education: Focusing on Core Teaching Practices

Practice-based teacher education considers that the application of theoretical knowledge and understanding through the enactment of professional practices is fundamental to preservice teacher learning (Korthagen, 2018). These practices encompass a multiplicity of activities, strategies, and behaviors to perform in the classroom that direct competencies toward the goal of student learning across diverse contexts and circumstances (Darling-Hammond, 2006; Verloop et al., 2001). Evidence points to increased effectiveness and retention for teachers trained in practice-based programs (Darling-Hammond, 2000), which help to bridge the knowledge-practice gap by making practice accessible to novices (Broekkamp & van Hout-Wolters, 2007; Grossman et al., 2009).

This teacher education approach advocates for a common language, understanding, and application of foundational practices for the teaching profession via *core teaching practices* (Grossman et al., 2009; Matsumoto-Royo & Ramirez-Montoya, 2021; McDonald et al., 2013). These foundational practices (also sometimes termed *high-leverage practices*) are distinguishable central elements of teaching associated with student learning, which can be domain-general or -specific, and represent a range of (sometimes overlapping) practices involved in teachers' daily routine. Though there is not one particular set of agreed-upon practices, Grossman and colleagues (2009) outline six essential characteristics, such as suitability and flexibility of application for novices using diverse methodologies in varied domains, and potential for novice initial mastery (e.g., core practice of offering instructional explanations; core practice of facilitating classroom discussion; Grossman, 2018).

Since teacher professional vision can range from a wide and diverse set of teaching and learning practices, research in professional vision training has begun to differentiate into more specified teaching and learning contexts (Chan et al., 2020; Santagata et al., 2021). Thus, training not only encompasses the development of skill components (i.e., noticing and reasoning), but also situates these skills onto a particular teaching practice focus, which is relevant to the professional community (Goodwin, 1994; Kang & van Es, 2019; Sherin et al., 2011). Thus, for teacher education, a focus on core teaching practices could be a means for integrating practice-based education standards into professional vision training and offer a common-language structure, specified to the teacher education context.

The development of professional vision for a core teaching practice would therefore integrate instructional context and professional vision skill training. Preservice teachers would need to learn about the collective ways in which the core practice of focus is understood according to the greater community of teaching professionals (Goodwin, 1994). Furthermore, they would need to apply this knowledge toward seeing and understanding events that represent this common vision. While professional vision is an element of teacher expertise which develops over years of experience (Berliner, 2001), practice-based teacher education offers preservice teachers the opportunity to already begin to improve their professional vision with deliberate application methods within the context of individual core practices.

1.2.3 A Framework for Professional Vision Training of Core Teaching Practices

Practice-based teacher education calls for integration opportunities for knowledge and skill application in the enactment and rehearsal of everyday teaching practices (Ball & Forzani, 2009; Korthagen, 2018). However, preservice teachers developing professional vision often have limited experience in applying theoretical knowledge to practice. Thus, truly authentic enactment of professional vision in action can be initially overwhelming for novices (Grossman et al., 2009; Syring et al, 2015). Instead, they need authentically framed practice opportunities to develop real-world proficiency (Darling-Hammond & Bransford, 2007).

The training of core practice professional vision can be integrated into teacher education according to the Framework for Teaching Practice in Professional Education (Grossman et al., 2009; Grossman, 2018). This Framework provides a practice-based structure for the development of teacher training programs involving the incorporation of decompositions-, representations-, and approximations-of-practice, wherein preservice teachers can learn about and rehearse individual core practices in a process that gradually builds in authenticity and complexity (Grossman et al., 2009). Thus, novices are supported in forming lasting connections between theory and practice.

Within this Framework (Grossman et al, 2009), *decompositions-of-practice* represent learning materials that break down core practices into their principle components (e.g., explanatory texts or diagrams, step-by-step guides, planning templates). *Representations-of-practice* are artifacts that allow preservice teachers the chance to see practice-in-action (e.g., written cases, lesson plans, teaching transcripts, video cases, student work examples). Finally, a*pproximations-of-practice* comprise rehearsal tasks that allow preservice teachers to experiment with a variety of teacher moves, procedures, and techniques associated with the target core practice.

Approximation-of-practice tasks approach the rehearsal of practice activities along a continuum of authenticity (Grossman et al., 2009). On the low-authenticity end of the spectrum, practice tasks have reduced complexity, focusing on only a few elements of the target practice with a limited participatory scope, and involve tasks with many chances for rehearsal. On the high-authenticity end, tasks represent the target practice holistically and approach realistic contexts and timeframes with expectations of complete practice enactment with support. Example tasks along this continuum could begin with analysis of simplified written example cases, moving on to video-based analysis, then real-time role-plays or simulations of practice components, followed by creating or implementing specific elements of practice (e.g., lesson plan), and finally performing the complete target practice with feedback from instructors and peers (Grossman et al., 2009; Hoffman et al., 2015; Kaufman & Ireland, 2016; Matsumoto-Royo et al., 2021). Practiced-based experiences like these, help to prevent preservice teachers from having fragmented and uncoordinated competence and performance preparation (Cochran-Smith & Zeichner, 2009; van Merriënboer & Kirschner, 2018).

In the present research, preservice teachers' needs for professional vision training are addressed with the design and investigation of a training intervention. The training is intended for practice-based teacher education and is structured according to the Framework for Teaching Practice in Professional Education (Grossman et al., 2009; Grossman, 2018). Accordingly, the training integrates decompositions- and representations-of-practice into an approximation of professional vision practice (see next section). The approximation-of-practice chosen for this intervention targets the primary cognitive processes involved in in-the-moment professional vision - noticing and reasoning - via video analysis tasks (see next section). The instructional context for the training is focused on the core teaching practice of small-group tutoring (see next section). On the continuum of authenticity, this video analysis approximation-of-practice training fits on the lower end of the spectrum, between the analysis of core practice written cases and enacting role plays or simulations.

The next section further expands on the use of video analysis as a method for training professional vision in teacher education. It elaborates on video analysis as an approximation of professional vision practice, and further explains how a such a training intervention might be designed to facilitate video-based learning, giving examples from research on the improvement of professional vision skills. Next, further design elements are reviewed, which might offer support for novice preservice teachers' professional vision development via video analysis: a focus on the core practice of small-group tutoring as a simplified instructional context, and the use of evidence-based scripted videos for further reduction of complexity.

1.3 Designing Video Analysis Training to Support Novice Learners

1.3.1 Video Analysis as an Approximation of Professional Vision Practice

Due to the visual nature of professional vision, approximations of practice which integrate video-based learning material provide realistic and practical representations-of-practice which are often motivational and effective learning tools for analysis and reflection (Gaudin & Chaliès, 2015; Moreno & Ortegano-Layne, 2008; Moreno & Valdez, 2007; Stürmer et al., 2016). Videos can model certain teaching strategies or contrast more or less effective techniques, leveraging the benefits of situated authenticity (Borko et al., 2014; Sherin et al., 2009). Moreover, they can depict teacher-student interactions and demonstrate student learning processes in a wide spectrum of learning contexts. However, videos by themselves are not necessarily effective for learning (Seidel & Stürmer, 2014). Instead, video representations should be used for a particular purpose and imbedded into training methods that align with specific learning goals (Blomberg et al., 2013; Brophy, 2004; Le Fevre, 2003). Therefore, the use of video for professional vision training in teacher education should focus on a core practice instructional context and be designed around a central approximation-of-practice task, such as video analysis.

For preservice teachers, video analysis approximates the professional vision components of in-the-moment noticing and reasoning during instruction by offering learners the chance to direct their attention toward target core practice learning components while observing a video representation of practice and to reflect on their noticed events to make sense of them (Kersting, 2008; Santagata & Angelici, 2010). The application of conceptual and theoretical knowledge would also be necessary when beginning to train their skills in these professional vision cognitive-psychological processes (Santagata et al., 2007; Stürmer & Seidel, 2017b; van Es & Sherin, 2002). Practicing these processes via video analysis tasks can help them connect teaching actions to relevant pedagogical knowledge and begin to build cognitive schemas of the target core practice that integrate theoretical and practical knowledge (van Es et al., 2017). The more this type of training is implemented, the easier it may be to retrieve these schemas (Smith & Karpicke, 2014), and begin to automate the link from conceptual knowledge to in-the-moment noticing and reasoning (Korthagen & Kessels, 1999; van Merriënboer et al., 1992).

Video analysis interventions have demonstrated potential for the development and improvement of (preservice) teachers' professional vision, including improvements in the two main components of noticing and reasoning. For example, improvements are demonstrated with a stronger focus on content- and situation-specific pedagogy, individual student understanding, and use of elaborative evidence based on video-specific associations and integrated understanding of teaching and learning principles (Jacobs et al., 2010; König et al., 2022; Santagata & Angelici, 2010; van Es, 2011). Beyond these skills, some interventions have also made an impact on the actions and objectives resulting from these cognitive processes, such as the component of decision-making, as well as improvements in suggestions for alternative teaching strategies, self-reflection on noticing, or performance of an instructional practice (König et al., 2022).

Video analysis interventions could be designed in several ways. One promising structure for video analysis tasks supporting novice learners is offered with the practice-based Framework of Teaching Practice in Professional Education (Grossman et al., 2009). Decompositions-of-practice (e.g., diagram, outline, short text) could summarize important elements and events of the core practice to be noticed, providing specific aims for the analysis as well as foundational knowledge to be applied toward noticing and reasoning. Video example scenarios for analysis could offer a range of core teaching practice representations in action for noticing practice during observation. Finally, video analysis reflections of preservice teachers' noticing and reasoning (approximation-of-practice) could be elicited in some way so that these internal cognitive processes could be externalized (e.g., written reflection; facilitator asking discussion questions) for further processing and support. Continued deliberate practice of these skills (Ericsson et al., 1993) within various instructional contexts of increasing complexity and authenticity can help preservice teachers deepen their knowledge-based schema for noticing and reasoning about relevant teaching and learning moments within core practice instructional contexts.

The training investigated in the present research is designed according to the Framework for Teaching Practice in Professional Education (Grossman et al., 2009). It integrates both decompositions- and representations-of-practice as learning materials to be applied within video analysis approximation-of-practice tasks. As suggested by research (e.g., Kang & van Es, 2019), the training for the present studies focuses on a set of specific practices within the small-group tutoring context. These strategies are outlined within decompositions-of-practice in the form of introductory texts and depicted in representation-of practice video examples. Working deeply with the text and video materials, preservice teachers approximate the component skills of professional vision through observation and written reflection in the video analysis (see Methods section).

1.3.2 Small-Group Tutoring: Core Practice with Reduced Complexity for Novice Learning

With the knowledge of preservice teachers' general professional vision limitations, evidence on ways they can improve, and promising methods for video analysis practice, further chances for success may come from the consideration of design adaptations for novice learners (Paas et al., 2003). The 4C-ID method (van Merriënboer & Kirschner, 2018) suggests that complex skills should be trained holistically, but begin with a reduced complexity that gradually increases in difficulty with subsequent training trails. For the design of a professional vision intervention targeting novice preservice teachers, choosing a core practice instructional context of reduced complexity may increase the success of the intervention. The core practice of small-group instruction or small-group tutoring is an effective teaching method (Chi et al., 2001; TeachingWorks, 2023), which comprises a set of teaching strategies that can also be transferable to whole-class instruction (Graesser et al., 2011). Yet due to the group size, this context maintains a reduced complexity for noticing and making sense of key teaching and learning moments and allows for student-centered focus (Cohen et al., 1982). Thus, a professional vision training focused on the instructional context of small-group tutoring has the potential to support novices' complex skill development.

The core practice of small-group tutoring instruction can demonstrate the student-centered behaviors and methods that teachers should take advantage of within this intimate context (Lehman et al., 2012). Moreover, like classroom teaching, small-group tutoring is situated within the target subject matter and content to be instructed. Thus, small-group instructional strategies may cover a wide range of (core) teaching practices, grounded in both general pedological psychological knowledge (PPK; Voss et al., 2011) and subject-specific pedagogical content knowledge (PCK; Shulman, 1987). For example, a PPK-associated strategy could be reacting to students' inaccurate utterances with directed questions or feedback (VanLehn et al., 2003); and a PCK-associated strategy could be eliciting subject-specific misconceptions typical to the grade level and content (e.g., circulatory system misconception that blood flows back and forth from heart to body; Chi et al., 2001). With a multitude of practices to depict within this instructional context, research on the design of video-based training in teacher education suggests focusing on only a few specific learning objectives at a time (Kang & van Es, 2019; see also emphasis manipulation; van Merriënboer & Kirschner, 2018). Further, focusing on a content topic which is well-documented in the literature can ensure that the strategies of focus are reliable to the community of practicing teachers in a given subject-matter (e.g., circulatory system in 8th grade biology; Chi et al., 2001).

Beyond designing novice support with an emphasis on a specific set of target tutoring strategies, further complexity reduction can be done with the video format. The development of evidence-based scripted videos from authentic practice can still maintain sufficient authenticity, while offering several ways the video material can be simplified for novices' benefit (Gartmeier, 2014; Piwowar et al., 2018; Seidel et al., 2023). For example, through careful planning and editing, the content of focus can be condensed, streamlined, and made more salient, theoretical principles in action can be illustrated to emphasize particular behavior or characteristics, the scene can be set in a specified way to align with learning goals, differentiated events can be prominently contrasted, and events that may be rarely seen in authentic video can be demonstrated (Piwowar et al., 2018).

In the present research, the professional vision training under investigation targets skill development at a depth, pace, and complexity that is adapted for novice learners. The training is situated within a tutoring instructional context in 8^{th} grade biology, focused on the circulatory system, since this topic and the PCK strategies involved are well-documented in the literature (e.g., Chi et al., 2001). The introductory texts outline particularly relevant teaching and learning aspects of small-group tutoring instruction that are then applied to video scenarios of this context, which depict a variety of key practice elements to observe. After video viewing, preservice teachers' document what they noticed and how they reason about it with their response to a short answer prompt (see Method section).

While a training intervention using video scenes can offer many benefits for teacher training, the video format itself can introduce challenges for learners with limited prior knowledge (Derry et al., 2014; Mayer, 2001; Weidenmann, 1997). This suggests that additional considerations for learning support might be needed. The next section outlines ways this support can be achieved. First, the Cognitive Theory of Multimedia Learning (CTML; Mayer, 2001) is offered as an approach to understand the cognitive processing challenges that novices might face, and to suggest evidence-based design techniques for processing support. Next, two techniques are described and highlighted for their potential in supporting novice preservice teachers in video-based training: signaling cues and focused self-explanation prompts. To follow, the Cognitive-Affective Theory of Learning with Multimedia (CATLM; Moreno, 2005) is presented as an add-on to the CTML, which also considers the role of learners' affective-motivational processes in multimedia learning. In the context of video analysis, the motivational component of situational interest is justified as having a potential influence on preservice teachers' learning, and thus capable of moderating design technique support. Throughout this section, the design of the video analysis training for the present research is described in reference to the novice support measures highlighted in this section.

1.4 Further Novice Support for Professional Vision Video Analysis Training

1.4.1 The Cognitive Theory of Multimedia Learning and Challenges with Video

A promising area for novice support in the context of video-based training comes from the field of multimedia instructional design. The Cognitive Theory of Multimedia Learning (CTML; Mayer, 2014a) posits that multimedia information processing from different representational formats and presentation modalities (Weidenmann, 1997) occurs separately across two different channels, one for auditory processing and one for visual information. Moreover, it assumes that multimedia information processing of the dual channels occurs within working memory, which has a limited capacity. Finally, relevant knowledge from long-term memory is retrieved into working memory to facilitate the selection, organization, and integration of knowledge into processed knowledge schemas. This theory also assumes that due to limitations in novice learners' long-term memory stores, multimedia learning environments have the potential to overwhelm their working memory processing capacity more easily (Bannert, 2002). Thus, multimedia instructional designers should consider techniques that can offer processing support of essential task-relevant information, techniques that reduce extraneous or unnecessary information, and techniques that support generative processing capacity of relevant material (Kirschner, 2002; Mayer, 2014c; Sweller, 2005).

For learning with video, novice information processing could be challenged due to the transient nature of information flow and the interactivity among informational elements (Chandler, 2004; Singh, et al., 2017; Wong et al., 2019). Processing capacity could be overwhelmed if novices spend too much effort searching for relevant information or waste valuable cognitive resources processing information that is irrelevant to the task (i.e., incidental processing: Mayer & Moreno, 2003). Additionally, novices sometimes have difficulty differentiating between essential and extraneous information, and end up attending to what is most salient, even if it is not relevant (Superfine & Bragelman, 2018; Derry et al., 2014; Lowe, 2003). Moreover, novices may miss important information that arises if they are still concentrated on processing information that previously came to their attention (i.e., representational holding: Mayer & Moreno, 2003). These issues may inhibit novice performance of both noticing relevant events and further reasoning about them.

However, research in multimedia learning suggests several instructional design techniques, which may mitigate these challenges and support processing. Several techniques have demonstrated evidence that are specifically helpful for video learning. For example, the *pre-training principle* proposes that learning with multimedia can be more effective if learners are already familiar with the basics of the target learning concepts (Mayer et al, 2002; Mayer & Pilegard, 2005). Another technique involves *segmenting,* or breaking instructional material down into meaningful chunks that the learner can work through at their own pace (Mayer & Pilegard, 2014; Spanjers et al., 2010). Moreover, *emphasis shift training* can help to strengthen attentional processes within complex tasks through training iterations, wherein each trial changes attentional focus toward a different subset of components within the whole task (Burkolter et al., 2010; Gopher et al., 1989; Gopher, 2007). Beyond these techniques, two instructional design principles, which show particular promise for video analysis professional vision training, follow the principles of *signaling* (van Gog, 2014), and *self-explanation* (Wylie & Chi, 2014). [4]

1.4.2 Instructional Design Techniques to Support Video Challenges: Signaling Cues and Self-Explanation Prompts

The use of s*ignaling cues* is one technique to help mitigate video-based processing issues and support attention toward relevant events during video viewing. Cues can be integrated into instructional design to highlight relevant information in some way (e.g., arrows, bold text, zooming in), helping learners focus on the necessary information and ignore superfluous content (Alpizar et al., 2020; Schneider, Beege et al., 2018). In the information processing steps outlined in the CTML (Mayer, 2014a), cues seem to be especially helpful for information selection. Processing capacity is used more economically when learners can more easily attend to the necessary information (and ignore extraneous information), rather than wasting cognitive effort searching the material (Mayer & Moreno, 2003; Mayer & Fiorella, 2014; Ozcelik et al., 2010).

The use of text-based cues, for example, which present content-related keywords, may also support information organization and integration processes. Keyword cues could highlight some aspect of content that connects to corresponding prior knowledge, thus reducing the required effort for cognitive mapping and the necessity to hold so much information in working memory (Moreno, 2007; Moreno & Abercrombie, 2010; Richter et al., 2016). For noticing and reasoning about relevant teaching and learning events in video examples, keyword cues could link teaching theory and practice by directing learners' attention to the principle-based event taking place, giving them a specific noticing aim, and offering a label which could help them call-up associated knowledge for making sense of it.

Self-explanation is another multimedia principle that could offer support. Self-explanations are generative activities in which a learner explains a concept or principle to themselves (Bisra et al.,

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[4] Other design techniques for video learning according to the CTML (i.e., pre-training, segmenting, and emphasis shift training) were experimentally investigated within other project studies outside the focus of this dissertation.

2018; Renkl & Eitel, 2019; Wylie & Chi, 2014). This process helps learners clarify their understanding of a particular concept or principle and reveal knowledge gaps or uncertainties to be resolved with further learning (Chi, 2000). Thus, self-explanation prompts seem most closely connected to the CTML processes of organizing and integrating (Mayer, 2014a). Self-explanations can be integrated into multimedia instructional design with self-explanation prompts, which can take various forms across a spectrum of structure and activity involvement (Chi, 1996). At the high-structured end, prompt format facilitates more passive learning activities (e.g., choosing explanation from drop-down menu; Wylie & Chi, 2014). On the low-structured end of the spectrum, prompts may facilitate constructive writing-to-learn activities, which direct learners to create something new in a concept explanation (e.g., open-ended prompt: no specific structure; focused prompt: flexible structure targeting a particular element; Wylie & Chi, 2014).

While both open and focused constructive-style prompts could offer noticing and reasoning support, meta-analytic evidence is mixed regarding which technique might be best for a video analysis context (Bisra et al., 2018). However, considering that novice preservice teachers likely have limited prior knowledge and experience to draw from, they may benefit more from *focused prompts* which provide additional information that could help to scaffold their self-explanations according to the target learning goals and offset prior knowledge limits (van der Meij & de Jong, 2011). Further, prompt focus may make it easier for learners to narrow in on the content that is most relevant to the task and ignore less relevant information, especially when the complexity is high due to the amount of information and interactivity from video material (Wang & Adesope, 2017).

In the present research, while pre-training was not experimentally investigated, this principle is still relevant for the training design, since all participants in both studies were pretrained on the tutoring events to be noticed via the introductory texts. This pre-training was explicitly implemented to offer preservice teachers' task-relevant pre-knowledge for application (Mayer et al., 2002). Beyond this principle, the Experimental Study integrates the instructional design techniques of signaling cues and focused self-explanation prompts for a randomized selection of preservice teachers participating in the video analysis training intervention (see Methods section). According to the CTML (Mayer, 2014a), these techniques are hypothesized to assist novices in video-based information processing.

Signaling cues and focused self-explanation prompts offer promise to support novice preservice teachers in their professional vision development with video analysis. Yet these external design mechanisms are not necessarily one-size-fits-all, and may function differently, depending on the individual's own characteristics (Blömeke & Kaiser, 2017). Prior knowledge, for example, has already been implicated as a boundary condition for several multimedia techniques (Mayer, 2014c; 1997), meaning that techniques' support capacity is sometimes limited when prior knowledge is high (see also expertise reversal effect: Kalyuga et al., 2003; Paas et al., 2004). Beyond the impact of learners' cognitive predispositions, their motivational characteristics are also likely to impact performance (Moreno & Mayer, 2010). Exploring individuals' motivational impact on the effectiveness of cues and focused self-explanation prompts may illuminate other possible boundary conditions in play.

1.4.3 Exploring New Boundary Conditions with Situational Interest

Given that learner characteristics also have an impact on performance, The Cognitive and Affective Theory of Learning with Multimedia (Moreno & Mayer, 2010) builds on the CTML model (Mayer, 2014a) by adding the components of motivation, emotion, and metacognition as potential mechanisms of positive or negative influence during information processing of multimedia learning materials. With the call for further investigation into motivational mechanisms that support generative processing in multimedia learning (Mayer, 2014b; Moreno & Mayer, 2010), understanding the interplay between techniques for support and learners' motivation may tell us more about the boundary conditions for these techniques from a new perspective.

One motivational component with a high likelihood of influence in multimedia learning is *situational interest*, since it is typically activated from external aspects of the learning situation, such as identification with a topic or character or the introduction of novel, strange, or unexpected information, (Hidi & Renninger, 2006; Rotgans & Schmidt, 2014). Situational interest is a cognitive-affective state which facilitates in-the-moment engagement and boosts cognitive functioning and emotional connection through value valence and affect toward an object of interest (Harackiewicz & Hulleman, 2010; Hidi & Renninger, 2006; Krapp, 2002; Mitchell, 1993). When triggered, situational interest can direct learners' attention and help sustain their performance efforts (Hidi & Renninger, 2006).

It is reasonable to assume that the learning materials and design of a video analysis training in teacher education could trigger preservice teachers' situational interest, for example, in viewing new examples of practice, or in their identification with teachers in the scenarios. If the video-based training were to increase preservice teachers' situational interest, this generative processing boost could also support their professional vision performance. Moreover, it has the potential to interact with other support techniques, moderating their effect. For cues and focused self-explanation prompts, since there is still very limited research evidence on the impact of motivational influences (exceptions: Richey & Nokes-Malach, 2015; Schneider, Beege et al., 2017), it is unclear whether and in what way the interplay would impact preservice teachers' professional vision development. Thus, the exploration on the influence of preservice teachers' situational interest as a potential boundary condition for multimedia design techniques may lead to better recommendations for training designs.

In both studies of the dissertation, preservice teachers' situational interest in the video analysis task was measured. Considering the appropriateness of situational interest for the video analysis context (Hidi & Renninger, 2006), this focus on motivational mechanisms in multimedia learning (Mayer, 2014b) follows the call for more research in this area. Further, according to the CATLM (Moreno, 2005), the Experimental Study focuses on the potential moderating impact of preservice teachers' situational interest on the effectiveness of the cues and prompts, respectively, to explore the potential of the variable in contributing to boundary conditions for design technique effectiveness.

The next section presents an overview of the present dissertation studies, connecting the theoretical components from the presented theoretical background to the context of the present research. This section begins with a summary of the larger research project in which this dissertation has contributed, and situates the study aims of the present research within this context. Next, the two studies of the present dissertation are introduced, which outline the studies' aims and objectives, and respective areas of focus. Finally, the added value potential of this research to the research and practitioner communities is suggested.

2.0 The Present Dissertation Research

2.1 Research Project Context and Dissertation Aims and Objectives

In line with the Theoretical Background, the Teacher Education Video Improvement (TEVI) research project aimed to develop and investigate a video analysis training intervention designed for novice preservice teachers' promotion of professional vision skills in the core teaching practice of small-group tutoring instruction. Within this training, preservice teachers' professional vision performance and cognitive-motivational processes were assessed. The project aspired to get a better understanding of preservice teachers' strengths and shortcomings in professional vision from this video analysis training targeting novices. Further, from the perspective of research on learning with multimedia, the project aimed to investigate further improvements to professional vision by leveraging the support of instructional design techniques. Across four studies, this project contributed evidence toward these aims by investigating the training itself, as well as experimentally examining various multimedia instructional design techniques for learning support, including pre-training, segmentation, signaling, self-explanation, and emphasis-shift. As a member of this research team, I participated in the planning, execution, and reporting of this project's empirical research. The research presented in this dissertation comes from the TEVI research project.

This dissertation work represents my particular contribution to the TEVI project, investigating and reporting on two studies. The aim of this dissertation is to investigate how a video analysis training intervention focused on small-group tutoring instruction can support preservice teachers' development of professional vision. This research describes preservice teachers' baseline professional vision performance regarding the content and quality of their noticing and reasoning of tutoring strategies relevant to student learning (*Descriptive Study*). Moreover, it examines how the instructional design techniques of signaling cues and focused self-explanation prompts contributes to preservice teachers' video analysis performance, and explores the potential moderating role of individuals' situational interest (*Experimental Study*). The two studies pursuing these aims build upon one another and are brought together in this dissertation to offer complementary perspectives on the training of preservice teacher professional vision via video analysis. Four overall objectives and investigations are central to these studies:

(1) To better understand the baseline performance of preservice teachers' professional vision elicited by the video analysis training intervention and determine its effectiveness by investigating the overall range of preservice teachers' professional vision performance and the overall improvements made to their professional vision skills in small-group tutoring instruction (*Descriptive Study*);

(2) To clarify preservice teachers' needs for further improvement to their professional vision by investigating performance limitations and skill differences among low- and high-quality video analysis responses (*Descriptive Study*);

(3) To examine the support offered from two instructional design techniques for multimedia learning: signaling cues (highlighting relevant events in the videos) and focused self-explanation prompts (for describing and interpreting target noticed content), by investigating whether each technique facilitated additional improvements to preservice teachers' professional vision performance in the training (*Experimental Study*); and

(4) To explore preservice teachers' situational interest in the training and its impact on the instructional design techniques for support by investigating whether this motivational characteristic moderated the effectiveness of cues or focused prompts for preservice teachers' professional vision performance in the video analysis (*Experimental Study*).

2.2 The Present Research Added Value Potential to Research and Practice

The studies of the present dissertation offer potential for added value to the research and practice communities in the following ways:

- Offering a thorough account of the performance from this video analysis intervention and highlighting outcomes elicited from the training, could uncover the promise of this instructional context to early preservice teachers' professional vision skill development.
- Confirming that professional vision performance from the training is associated with typical novice performance could establish a feasible link to previous professional vision research and validate the video analysis intervention as an appropriate method for professional vision development.
- Presenting a description of a multifaceted range of baseline performances elicited from the training could offer a criterion measure for success and identify common pitfalls for novice training in this context so that tailored supports could be implemented for further training designs.
- Experimentally examining the impact of the video analysis training to supplement descriptive findings could offer evidence of effectiveness in improving professional vision skills in describing and interpreting noticed events. Moreover, it offers an opportunity to replicate and validate previous findings of training effectiveness, achieved within another experimental study of the TEVI project (Martin, 2022).

- Investigating the support provided by the instructional design techniques could offer new evidence on the impact of signaling cues and focused self-explanation prompts in the context of preservice teacher professional vision training with video analysis.
- Exploring preservice teachers’ situational interest in the training could clarify its role as a potential influence in video analysis and gain initial understanding about the impact this motivational variable may have on the effectiveness of the design techniques for support.

This potential for added value establishes a foundation for future study and professional vision training development for the video analysis intervention of the present studies, as well as similar professional vision training designs targeting novice preservice teachers.

In the next section, the research for the present dissertation is specified in terms its methodological aspects, highlighting shared elements of the Descriptive and Experimental Studies as well as explaining particular differentiations. The first section describes the sample of participants for each study. Next, similarities and differences in the training designs and procedures for both studies are described. To follow, a summary of the learning materials (e.g., introductory texts, videos) is given along with a brief explanation of the experimental conditions for the Experimental Study. Finally, the measures and analyses used in both studies are outlined. This section only offers a short overview introducing the methodological features of the present research. Further specific methodological details can be found in the original study articles.

3.0 Methods

In this section, the methodological aspects of both studies are summarized and differentiated. These aspects include study participants, training design and procedure, learning materials, and measures and analyses.

3.1 Participants

This subsection offers a brief summary of the participants for both studies. The video analysis training intervention was designed to target novice preservice teachers. In this context, novice preservice teachers are defined as students within the beginning to middle of their teacher education program, who have limited active teaching experiences. Participant selection was focused on biology preservice teachers, since the videos within the training depicted instruction on the circulatory system, thus similarities in sample-wide content-specific prior knowledge could be assured. Different participants were recruited for each study. The preservice teachers participated in the studies within one of their 90-min. biology teacher education seminars in order to increase the ecological validity of the training.

The Descriptive Study sample comprised 42 biology teacher students from two southern German universities and the Experimental Study sample comprised 130 participants from four German universities across two states. The majority of both samples were female (78.6% and 73.8%, respectively), which is typical for teacher training programs in Germany, and the age range was similar for both studies (Descriptive Study: M_{age} = 23.26 years, *SD* = 3.99; Experimental Study: M_{age} = 23.26, *SD* = 2.39). In the Descriptive Study, the majority of preservice teachers were bachelor's students, whereas the majority of participants in the Experimental Study were in the first semester of their master's program (semester 7).

Although the sample from the Experimental Study was slightly more experienced than the sample from the Descriptive Study, both samples demonstrated comparable features and represented a population of novice preservice teachers which the professional vision training intervention aimed to target (see Table 1). In both studies, the majority of their coursework experience was in biology content, they had little experience teaching their own classes, and had between one and two years of tutoring experience. Moreover, in the Experimental Study, more than half of participants had no experiences during any of their coursework using video for learning[5].

[5] This measure was added in the Experimental Study, so there is no data on this variable from the Descriptive Study.

Table 1. Comparison of Study Participants' Study-Relevant Experience

	Semesters ARC / M(SD)	Biology Courses ARC / M(SD)	Biology PCK Courses ARC / M(SD)	General PPK Courses ARC / M(SD)	Hours Teaching ARC / M(SD)	Weeks Intern. ARC / M(SD)	Months Tutoring ARC / M(SD)
DS	2-3	≥ 5	1-4	3-8	6-20	5-8	12-24
ES	8.67 (16.14)	14.59 (9.92)	3.63 (2.43)	10.05 (10.92)	10.82 (28.01)	9.51 (27.57)	13.38 (23.22)

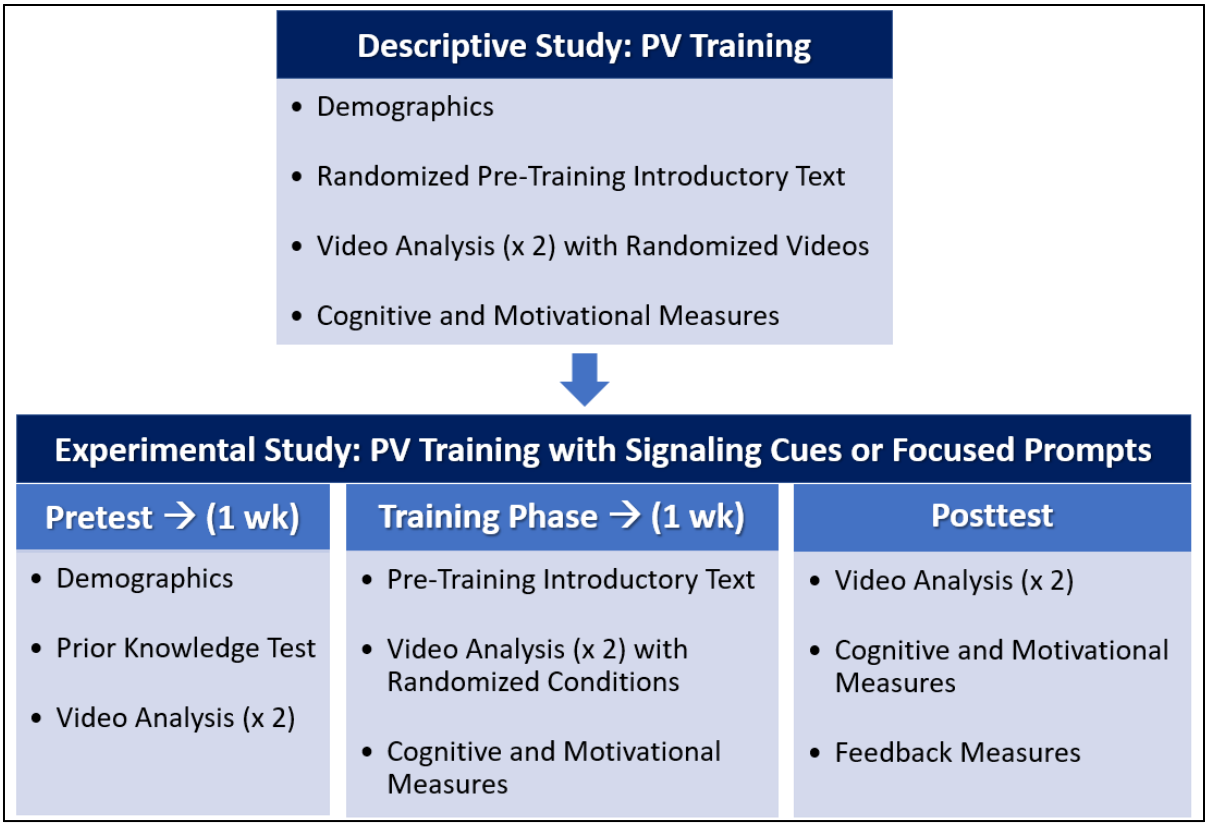
Note. DS = Descriptive Study. ES = Experimental Study. ARC = Average Range Category. Intern. = Internship. In the Descriptive Study, participants' experience was measured as a categorical variable with a choice of ranges. In the Experimental Study experience was measured as an interval variable with a fill in the blank response. Thus, the above reported ranges for the Descriptive Study coursework experience represent the ARC of the mean response and the values for the Experimental Study report the *M*(*SD*).

3.2 Training Design and Procedures

This subsection offers a brief summary of study procedures, highlighting similarities and differences between the two studies. Further details of the procedures can be found in the Methods sections of the respective study articles (DS: Paper 1; ES: Paper 2). Moreover, more information about the materials mentioned in this subsection can be found in the *Learning Materials* subsection to follow.

The design of the Descriptive Study focused on the professional vision training intervention. It was a one-group pre-experimental investigation. Participants were randomly assigned to pre-training texts as well as different video representations to ensure an even distribution of learning materials throughout the sample. The Experimental Study was designed to build on the professional vision training intervention of the Descriptive Study. A pretest and posttest phase were added one week before and after the training intervention, respectively. Moreover, the experimental conditions for this study were employed in the training phase. Figure 2 provides an overview of the procedures within each study's design.

Figure 2. Overview of Study Designs and Procedures



Note. This figure depicts the design and procedures for the Descriptive and Experimental Studies.

Both studies were administered with online survey software (DS: at university within a teacher education seminar; ES: at home during seminar hours due to covid-19 restrictions). After obtaining informed consent, the demographics questionnaire elicited information about participants' background and study-relevant experiences. The Descriptive Study procedures were quite similar to the Training Phase of the Experimental Study. Participants were randomly assigned to a pre-training theoretical introductory text. In both studies, they were asked to apply the knowledge from their text toward the observation and analysis of two videos. The video analysis procedures in each study differed to some extent.

In the Descriptive Study, a noticing tool was implemented, which recorded a time stamp at the moment participants noticed a tutoring strategy by pressing the space bar. After viewing the video without pause or playback, three of the marked noticed events were randomly selected for participants to review and then analyze. They were asked to describe in writing the tutoring event they noticed and interpret why it was relevant for teaching and learning in a tutoring situation.

In the Experimental Study, the randomized experimental conditions were implemented for the video analysis. Participants watched two videos according to their randomized assignment to the cues condition, which either presented keyword cues during relevant tutoring events in the video or not. For their analysis, they were randomly assigned to a self-explanation prompt condition (open or focused), wherein they were to describe and interpret the tutoring strategies they noticed from the video, either in an open response box or with an interactive diagram of tutoring strategies with pop-up response boxes.

For both studies, after the analysis of each video, participants rated their perceived cognitive load and situational interest in the video analysis. Afterwards, they rated their utility value perception of the overall training intervention. At the end of the Descriptive Study, participants could offer their feedback via open response, then were given a debriefing and compensated for their participation.

For the Experimental Study, the professional vision training was expanded to include a pretest and posttest. The *pretest* assessed participants' PPK and circulatory-system PCK prior knowledge. Then, to test the professional vision skills of participants prior to the training, the pretest included a video analysis task, wherein preservice teachers analyzed two videos depicting scenes from a tutoring lesson (different from the training phase videos). They were asked to pay attention to the tutor and any important events they noticed which were relevant to teaching and learning in a tutoring instructional context. Afterwards, they were to write about specific events they noticed (at least 3) by describing each event and interpreting its relevance. In the *posttest*, participants performed a video analysis task parallel to the pretest, completed the same cognitive and motivational measures from the training phase, then offered their voluntary feedback about their experience with the study overall. At the end, preservice teachers were debriefed and compensated for their participation.

3.3 Learning Materials and Experimental Conditions

Learning materials within both studies comprised the theoretical introductory texts and the videos for analysis. For the Experimental Study, the multimedia design techniques of signaling cues and focused self-explanation prompts were implemented in the training phase video analysis as experimental conditions.

3.3.1 Video Materials

The videos used for both studies were developed by the research team according to evidence-based guidelines (e.g., Piwowar et al., 2018). Each video was scripted and performed by actors. Scripts were based on authentic tasks and dialogues from a pilot video study. Each video depicted a scene from an 8th grade biology lesson on the circulatory system with one tutor and four students. Students demonstrated varied misconceptions about the circulatory system. Each video also presented a mixture of tutoring actions, both student-centered and instructive styles, and from both PPK and PCK perspectives. Two scripts focused on the beginning of a lesson (i.e., elicitation phase videos) of a lesson and two scripts focused on the middle of a lesson (i.e., learning phase videos). Each script was recorded twice, using different actors for each version.

For the Descriptive Study, all eight videos were used for the video analysis task, with random assignment to one of four elicitation phase videos, then one of four learning phase videos. The presentation of videos was randomized so that the sample-wide elicitation of professional vision skills would not be tied to one single video or set of actors, to ensure a more accurate representation of their professional vision skills at the sample level. Further, it allowed us to assess participants' perception of authenticity for each video. All videos were rated with six items (e.g., "The video was realistic") on a 4-point scale (1 = do not agree; 4 = fully agree; Piwowar et al., 2018). Overall, they found them to be sufficiently authentic (M = 3.00, SD = 0.46; Martin et al., 2023).

For the Experimental Study, the pretest video analysis used one elicitation phase video and one learning phase video. For the posttest, the parallel versions of these videos (with different actors) were used. The presentation of video versions was also counterbalanced to maintain comparability of the two tests, while also buffering against practice effects. For the training phase, participants were shown one elicitation phase video and one learning phase video. These videos were from the other two scripts, depicting different scenarios to the pretest and posttest videos. Appendix A provides an overview of each video from the project.

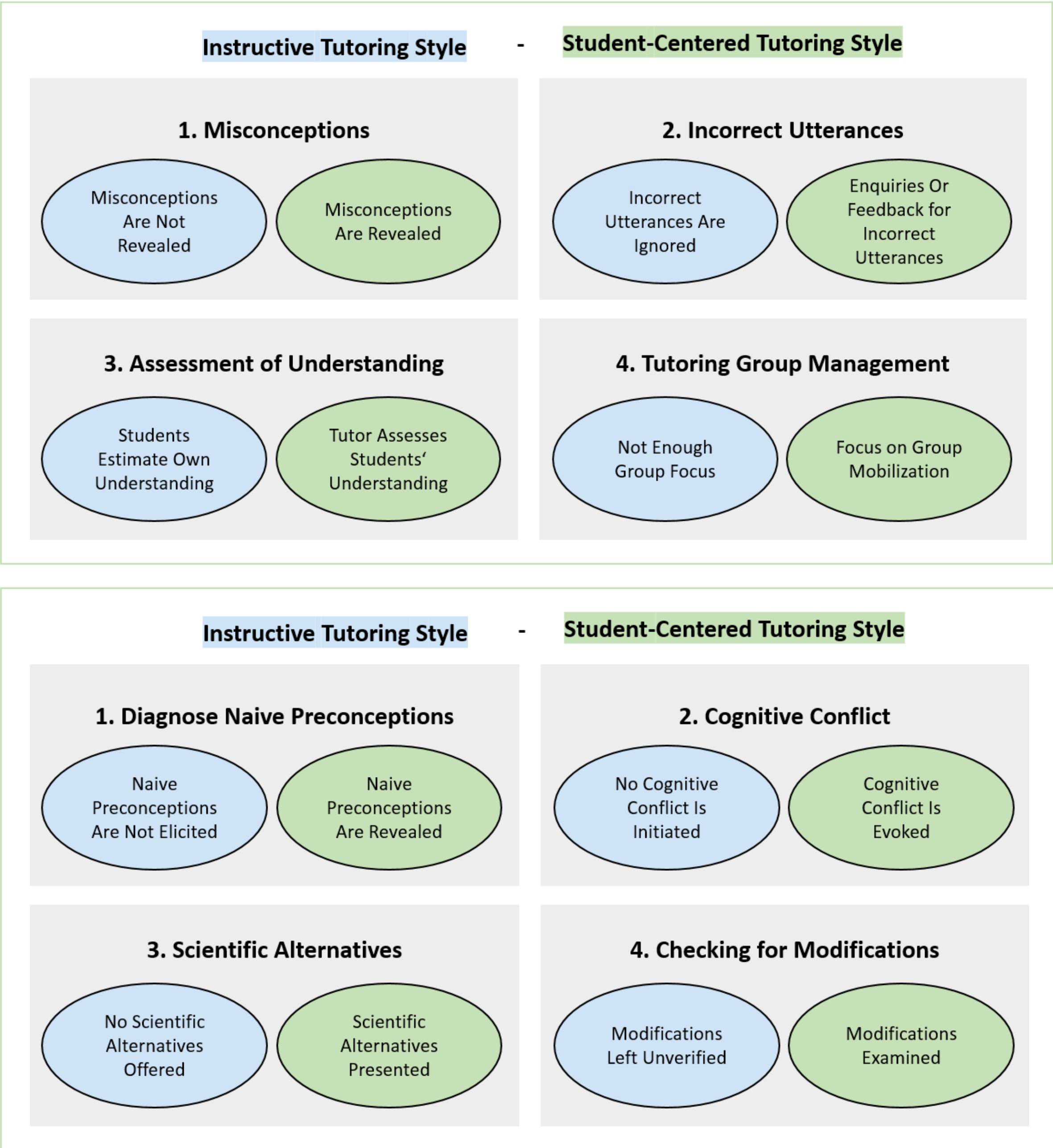
3.3.2 Theoretical Introductory Texts for Pre-training

The Descriptive Study and the training phase of the Experimental Study presented participants with a theoretical introductory text as a pre-training element (Mayer & Pilegard, 2005), which presented a decomposition-of-practice as learning material (Grossman, 2018). The texts offered support as a focused, knowledge-based resource to be applied subsequently within the video analysis task. To ensure a balanced distribution of sample-wide knowledge application and to mitigate differences in prior knowledge, the different versions of the text were randomly assigned (DS: 1 of 3 versions, PPK, PCK, or PV; ES: 1 of 2 versions, PPK or PCK)[6].

[6] The Experimental Study only used the PPK and PCK text versions, since these content-specific texts were found to be more facilitative for professional vision (Martin, et al., 2023).

The PPK and PCK texts were content-focused on tutoring strategies, presenting four strategies according to a student-centered tutoring style juxtaposed with four strategies following an instructive style, less optimal for the tutoring context (see Figure 3). The PPK text focused on strategies associated with general psychological and pedagogical knowledge, while the PCK text focused on content-specific strategies for instruction on the circulatory system. In contrast, the PV text was a content-general text which contrasted professional observational practices with common pitfalls of novice observers to instruct participants on successful strategies that could be implemented in the subsequent video analysis (for further details on the texts and text comparisons, see Martin et al., 2023).

Figure 3. Overview Diagrams for PPK and PCK Introductory Texts



Note. This figure depicts the diagrams used in the PPK text (top) and PCK text (bottom) which provide an overview of the tutoring strategies outlined in the respective texts. For the Experimental Study, participants in the cues and focused prompts conditions received the technique according to their respective text group.

3.3.3 Experimental Study Conditions

For the Experimental Study, the training phase video analysis incorporated the experimental conditions. First, during video viewing, participants were randomly assigned to either a signaling cues group or a group with no cues. In the cues group, videos integrated keyword signaling cues, which connected back to the tutoring strategies outlined in the pre-training text (see Figure 3). When a strategy began to take place, the video would pause for one second and show the keyword in the middle of the screen. Then the video would resume, and the keyword cue would remain in the top right corner for the duration of the strategy. The no cues group watched videos without cues.

After watching each video, participants were randomly assigned to analyze the video with either a focused or open self-explanation prompt. The focused prompt presented participants with the overview figure of the tutoring strategies from the participants respective introductory text (see Figure 3). This figure was interactive, and participants were instructed to click on the specific strategies that they noticed to analyze them (at least three). After clicking on a specific strategy, a pop-up window appeared instructing them to describe and interpret this particular strategy. For participants in the open self-explanation prompt group, the open prompt asked participants to describe and interpret as many noticed events as they could (at least three) in an open response box.

3.4 Measures and Analyses

For both studies, preservice teachers' professional vision performance was determined with (scaled) qualitative content analysis (Mayring, 2015) for the components of noticing and reasoning, operationalized as participants' descriptions and interpretations of noticed events, respectively. To this end, I developed coding schemes to extract professional vision indicators of content and quality (i.e., what and how structure: Berliner, 2001; van Es, 2011). The following section explains these coding schemes and describes the similarities and differences in professional vision analysis for each study. Next, further analyses performed in each study are summarized.

3.4.1 Professional Vision Qualitative Content Analysis

The data used to measure participants' professional vision came from their responses to the video analysis, wherein each video required three analysis responses (DS: analysis of two videos; ES: analysis of two videos at pretest and two videos at posttest). Each written response answered the open response prompt: *(1) describe the noticed tutor-specific action and (2) interpret why this event was relevant to the teaching-learning process for a tutoring situation*. For both studies, each response was analyzed with qualitative content analysis to obtain final professional vision description and interpretation scores, respectively. The specific analyses for each study shared many similarities, but also differed in some approaches. For both studies, professional vision was differentiated into a description and an interpretation score, since these skills represent the major theoretical components of professional vision (i.e., noticing and reasoning). Moreover, within each component, both the content (what is expressed) and the quality (how it is expressed) were assessed. In the

Descriptive Study, these aspects were coded separately. In the Experimental study, they were coded as a composite measure of both content and quality.

To evaluate the quality of preservice teachers' responses in both studies, I developed a scaled qualitative analysis coding scheme. This coding scheme was iteratively developed. First, important indicators of quality levels for descriptions and interpretations of noticed events were deductively extracted from a range of seminal and highly cited literature in the field of professional vision (e.g., Jacobs et al., 2010; Kersting, 2008; Santagata et al., 2007; Seidel & Stürmer, 2014; Sherin et al., 2008; Sherin & van Es, 2002, 2009; Star & Strickland, 2008; van Es, 2011; Weger, 2019). Based on these indicators, a scaled qualitative coding measure was developed, then inductively tested and refined with a subsample of the data. The finalized scaled qualitative coding scheme defined four levels of quality (0 = Unclear, 1 = Vague, 2 = Standard, 3 = Differentiated) for describing and interpreting a noticed event, respectively (see Table 2 and Appendices B and C).

Table 2. Scaled Qualitative Content Analysis Categories for Professional Vision Quality Scoring

Professional Vision: Description Quality Scoring
Four levels of focus and sophistication for describing a noticed tutoring event:
Unclear (0 pts): No mention of event; or describes event in overly general terms limiting any explicit or implicit connection to a tutor move from the text
Vague (1 pt): Vaguely describes an event with some implicit or explicit connection to a tutor move from the text; uses little-to-no detail as evidence from the video to pinpoint a specific event
Standard (2 pts): Explicit and concrete description of an event with a clear connection to a tutor move from the text; uses little-to-no generalizations and some specific details as evidence from the video to pinpoint a specific event
Differentiated (3 pts): Explicit and concrete description of an event with a clear connection to a tutor move from the text; uses elaborative and specific details as evidence from the video to clearly and explicitly pinpoint a specific event
Professional Vision: Interpretation Quality Scoring
Four levels of argumentation sophistication for interpreting a noticed tutoring event:
Unclear (0 pts): No interpretation of event; or interprets with only unjustified judgment and/or assumption (i.e., uninformed interpretation); or only includes problematic interpretations with no logical connection to event or text, or only contradictory or factually incorrect connections
Vague (1 pt): Interprets with at least one analytical point*, somewhat connected to the described event/text; uses minimal evidence from the video or text to support claims; typically, a mixture of uninformed and knowledge-based interpretations
Standard (2 pts): Interprets with at least one articulated analytical point, clearly and logically connected to the described event; uses substantially unambiguous evidence to support claims; interpretations are typically knowledge-based, with little-to-no use of uninformed interpretations
Differentiated (3 pts): Interprets with more than one analytical point, clearly and logically connected to one described event; multiple uses of substantially unambiguous evidence to support claims; interpretations are knowledge based, with no use of uninformed interpretations

Note. *An analytical point refers to using evidence (from video and/or text) to make sense of an event by offering at least one of the following: explanation based on the text or teaching and learning principles; prediction of cognitive/motivational student consequences; alternative strategy suggestion for a more student-centered approach; suggestion of teacher's response/decision-making for next steps; other thoughtful analysis of the event. This table is also presented in the Appendix B of the Experimental Study (Farrell et al., 2024).

For each study, I also developed content analysis coding schemes, which focused on the content within preservice teachers' video analysis responses, and aligned with the research aims of the Descriptive and Experimental Studies, respectively. The Descriptive Study took an in-depth approach to capture novice preservice teachers' professional vision performance, to better understand their strengths and shortcomings from a multifaceted perspective, and to differentiate professional vision proficiency for the rather homogenous group. Therefore, the content analysis focused on a broad scope of professional vision content indicators (see full coding scheme in Appendix B and full text of study for details), which are common across various professional vision training contexts (description indicators: actors and topics; interpretation indicators: reasoning methods).

In contrast, the Experimental Study aimed to capture preservice teachers' professional vision performance, specified to the context of the video analysis training. Therefore, the content coding scheme for this study focused on the specific noticed tutoring strategies which corresponded to the introductory texts (see Figure 3), and another coding category, "vague", was added to capture unfocused noticed events somewhat related to the tutoring context (see Appendix C). This content coding scheme was integrated with the scaled qualitative coding scheme so that professional vision scores could be determined at the level of noticed event, then averaged across all responses per participant per test, to determine a professional vision (PV) score for descriptions and interpretations, respectively. Moreover, a Total PV score was determined as the sum of both mean component scores.

For both studies, I developed coding manuals for each coding scheme, and one coder and myself trained with and refined the manuals by coding a random 10% selection of the data, discussing our findings, and clarifying discrepancies. For the coding procedure, all responses were blinded to conditions and independently coded by the trained coder and myself (DS: 240 responses; ES: 1169 responses). To prevent coding drift, responses were coded in a set of ten participants at a time. After each set, coder findings were compared, and any discrepancies were discussed to determine consensus. Inter-rater reliability scores were analyzed for each study, indicating substantial or better values (DS: content indicators ranged from K = 0.66 to K = 0.91 and quality indicators for description and interpretation were ICC = .88 and ICC = .90, respectively; ES: description ICC = .90, interpretation ICC = .89).

3.4.2 Further Statistical Analyses

In the Descriptive Study, Epistemic Network Analysis (ENA) was used as a further exploratory analysis. This analysis tool creates network models that display connections between various components (e.g., elements of knowledge) of a multifaceted (cognitive) system (Shaffer et al., 2016). From coded data representing these network elements (i.e., professional vision indicators), ENA recognizes associations, calculates the intensity of the relationships and the elemental structure of the links between these features, and graphically displays them in a network figure (Bowman et al., 2021; Shaffer and Ruis, 2017). In the analysis, two Describing Networks were created, one comprising low-quality descriptions and one comprising high-quality descriptions. Next, low- and high-quality Interpreting Networks were created. The networks demonstrated each group's interconnectivity patterns of the professional vision describing and interpreting indicators, respectively.

For the Experimental Study, a repeated-measures MANOVA was performed to analyze the change in preservice teachers' professional vision performance from pretest to posttest, as well as the transferred effectiveness of the experimental conditions. The within-subject factor included the pretest and posttest description and interpretation professional vision scores, and the between-subject factors included the signaling cues condition and the prompts condition.

Further in the Experimental Study, a moderator analysis was performed with a multiple regression approach (Baron & Kenny, 1986) with the PROCESS macro for SPSS (Hayes, 2017). Two moderation models were tested. The instructional design experimental conditions represented the antecedent variables in each of the models (1: signaling cues; 2: self-explanation prompts). The moderating variable was represented by participants' situational interest from the training phase. Preservice teachers' situational interest was measured with six items on a four-point Likert scale (1 = Not at all, to 4 = Very much), for example, "The video task sparked my curiosity." (Knogler et al., 2015). Participants' total posttest professional vision score was the dependent variable in both models, and their pretest total professional vision score was added as a covariate control variable. Significant moderation effects were further probed with the Johnson-Neyman method (Finsaas & Goldstein, 2021) to reveal the region of significant moderation for the sampled participants.

4.0 Summaries of Dissertation Research Studies

4.1 Descriptive Study Summary (Paper 1)

Teacher professional vision, involving in-the-moment noticing and reasoning about learning-relevant classroom events, can guide teachers toward knowledge-based and student-focused actions (van Es & Sherin, 2021). However, research demonstrates novices' need for further training in practice-based teacher education (e.g., Jacobs et al., 2010; Seidel, et al., 2021). For preservice teachers' initial development, The Framework for Teaching Practice in Professional Education (Grossman, 2018) offers a novice learning structure for approximating and practicing professional vision skills: video analysis focused on a core teaching practice (Grossman et al., 2009; McDonald et al., 2013). Moreover, a focus on the core practice of small-group tutoring, a reduced-complexity context, could offer a promising instructional context for preservice teachers' noticing and reasoning of events, transferable to a larger classroom setting (Chi, 2001; Graesser et al., 2011; Paas et al., 2003). Since the effectiveness of this design and context for novice professional vision development has yet to be examined, a video analysis training intervention was developed for investigation.

The present research examines preservice teachers' professional vision skills elicited from this training intervention with an in-depth approach on their video analysis responses based on theoretically grounded indicators of professional vision content and quality for describing and interpreting noticed tutoring events, respectively, with the following research questions:

RQ1 Do preservice teachers demonstrate typical novice professional vision performance regarding their skills in describing noticed events (i.e., the content they describe and the quality of information they provide) and skills in interpreting noticed events (i.e., the type of interpretations offered and the quality of their analytical arguments)?

RQ2 What are the differences in the indicator relationship structures among preservice teachers' descriptions and interpretations of noticed events, respectively, at different levels of quality?

It was assumed that preservice teachers' professional vision performance on the video analysis training would follow typical novice patterns, yet with the reduced-complexity instructional focus of small-group tutoring, this context was estimated to offer support for better-than-typical performance. Finally, in the exploration contrasting preservice teachers' response patterns, it was anticipated that for a rather homogenous population, their professional vision skill strengths and shortcomings could be further differentiated.

In examining and describing preservice teachers' baseline professional vision performance, this study aimed to confirm the particular utility of this targeted video analysis training for use in teacher education, especially for novice learners. Moreover, the exploratory contrast between low-and high-quality professional vision skill aimed to further delineate preservice teachers' patterns in describing and interpreting noticed events from the video analysis and better understand the range of skills elicited from the training and their further training needs.

In this study, 42 biology preservice teachers participated in the video analysis professional vision training. The content and quality of their descriptions and interpretations were evaluated to understand the range of professional vision Describing Skills and Interpreting Skills that were elicited from the intervention. Preservice teachers' video analysis responses were further explored with Epistemic Network Analysis (ENA), to contrast low- and high-quality epistemic networks.

Findings indicated that the preservice teachers' performance in describing and interpreting noticed events from the video analysis mostly paralleled the typical novice professional vision performance from previous research in the field. More specifically, the majority of preservice teachers were able to notice the tutor and their general pedagogical strategies (PPK). They also made more knowledge-based interpretations of these noticed events than expected. However, in general, participants had more difficulty with noticing content-specific instructional strategies (PCK) or focus on individual students. Moreover, their descriptions often lacked important details and their interpretations remained superficial, sometimes lacking knowledge-based justifications.

The exploratory contrast of low- and high-quality descriptions and interpretations with ENA, revealed further differentiated professional vision performance. For the Description Networks, low quality responses were associated with limited indicator inter-connectivity, demonstrating the majority of connections only between the tutor, PPK, and students as a group. In contrast, the high-quality network revealed multiple connections across all descriptive indicators. For the Interpretation Networks, low quality responses connected uninformed and knowledge-based interpretations, while high-quality networks showed most connections only among knowledge-based interpretations.

Thus, while preservice teachers' professional vision skills elicited from the video analysis training seemed to parallel typical novice professional vision performance, the emphasis on small group tutoring may have given some a head start toward more sophisticated skills than expected. Thus, the appropriateness of the training intervention was confirmed. Moreover, ENA helped to reveal salient relationships and made notable differences visible to gain a better understanding of the multi-faceted nature of preservice teachers' professional vision. While some preservice teachers demonstrated advanced skills, overall, it seems that further support is still needed for noticing content-specific instructional strategies, focusing on individual students, and noticing and reasoning with more specificity and professional knowledge justification.

Full text: https://doi.org/10.3389/feduc.2022.805422

4.2 Experimental Study Summary (Paper 2)

To offer further evidence-based substantiation on the effectiveness of the video analysis intervention, this study builds on the findings from the Descriptive Study by adding a pretest and posttest. Moreover, since we found that preservice teachers might need further support, instructional design techniques were implemented in some versions of the training, according to suggestions for video-based information processing support from research in multimedia learning and instruction design (Mayer, 2014c). In this study, versions of the training with signaling cues and focused self-explanation prompts were randomly assigned to preservice teachers, for experimental investigation. Furthermore, this study addresses the call for more attention to motivational aspects of multimedia learning (Moreno & Mayer 2010) with an exploration of situational interest and its potential mechanistic impact within the training. To this end, the following research questions were investigated:

RQ1.1 To what extent do preservice teachers' professional vision skills (i.e., descriptions and interpretations of noticed tutoring events) improve after a video analysis training session?

RQ1.2 To what extent does a video analysis training session using the supportive instructional design techniques of (a) signaling cues, or (b) focused self-explanation prompts enhance preservice teachers' professional vision skills (i.e., descriptions and interpretations of noticed events)?

RQ2 For preservice teachers who receive signaling cues (a), or focused prompts (b) during a video analysis training, does their situational interest in the training moderate the magnitude of their professional vision performance? (Exploratory)

Due to the structure and instructional focus of the video analysis training tailored to novice preservice teachers, it was expected that the intervention would support them in improving their professional vision skills. Moreover, according to multimedia learning theory (Mayer, 2014a), it was also assumed that preservice teachers who trained with cues and focused self-explanation prompts would be further supported in contrast to control conditions (i.e., no cues; open self-explanation prompts), and thus demonstrate superior professional vision skills. Finally, the situational interest moderation exploration would offer some clarity about its potential influence within the training.

The study aimed to validate findings from the Descriptive Study and another project study (Martin et al., 2022) on the effectiveness of the video analysis professional vision training intervention for preservice teachers. Further, this study sought to determine whether instructional design techniques for video learning support (i.e., cues; focused prompts) could facilitate further performance improvements, to determine the utility of these techniques for this training context. Finally, the exploration of participants' situational interest as a potential moderating influence on the design techniques should add new insights on possible differential effects for high versus low situationally interested participants, informing the field about potential implications for motivational boundary conditions in this study context.

Participants comprised 130 preservice biology teachers who completed the video analysis pretest, training phase, and posttest of the intervention study. Participants' pretest and posttest professional vision performance was analyzed with (scaled) qualitative content analysis and converted to participant-level description and interpretation scores. A repeated-measures MANOVA analyzed participants' professional vision improvements from pretest to posttest as well as the effectiveness of the instructional technique experimental conditions (cues, focused prompts) in offering further professional vision support. Finally, a multiple regression moderation analysis was performed to explore the role of preservice teachers' situational interest in moderating the impact of cues and focused prompts on professional vision performance.

Results indicated that regardless of condition, preservice teachers' professional vision skills significantly improved from pretest to posttest (medium - large effect: partial $\eta^2 = .11$, $p = .001$). After the training, participants described more noticed tutoring events with greater video-specific details (medium - large effect: partial $\eta^2 = .08$, $p = .001$) and they used more knowledge-based arguments with more sophistication in their interpretations (medium - large effect: partial $\eta^2 = .08$, $p = .001$). In terms of the instructional design techniques for support, neither signaling cues nor focused self-explanation prompts contributed to additional improvements in preservice teachers' professional vision performance (no significant differences between cues conditions or prompts conditions: $p = .79$, $p = .35$, respectively). However, the moderation analysis found situational interest to significantly moderate the effect of signaling cues on preservice teachers' professional vision performance ($p = .012$); but not prompts ($p = .388$). Thus, cues *were* effective, but only for a subgroup of participants with lower-than-average situational interest (26.2% of participants). For these preservice teachers, training with cues supported their professional vision performance more than training without cues.

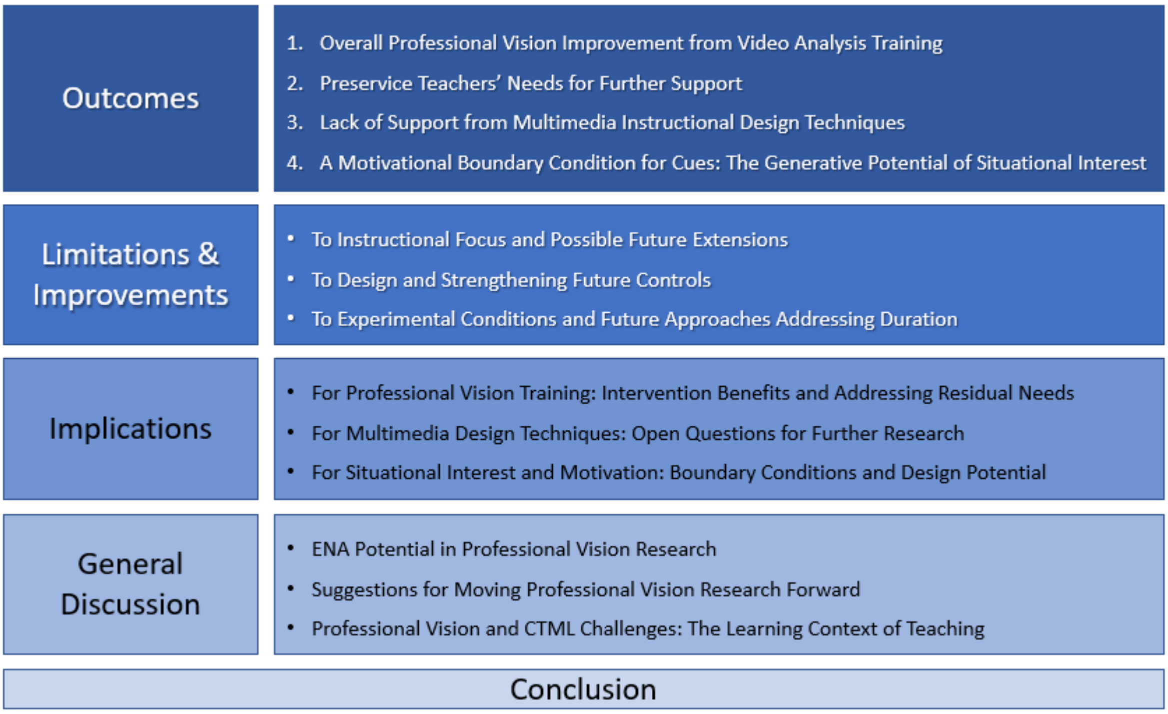
Thus, this study validated the effectiveness of the video analysis training intervention for preservice teachers' professional vision skill development in small group tutoring. While neither open nor focused self-explanation prompts lead to further improvements, signaling keyword cues were effective for preservice teachers who had lower levels of situational interest in the training. It seems that situational interest is an important factor to consider in the design of professional vision interventions and a potential motivational boundary condition for cues.

Full text: https://doi.org/10.1007/s11251-024-09662-y

5.0 Discussion

In this discussion, the overall outcomes based on the Descriptive and Experimental Studies' findings are outlined and explained in terms of four overarching themes. Next, the limitations to these studies are presented. To follow, the implications for practice and research as well as future study directions are elaborated. Finally, the added value of this research is highlighted in connection to the broader perspective and a short conclusion summarizes the key points of the present research and the discussion thereof (see Figure 4).

Figure 4. Overview of Dissertation Discussion



5.1 Overall Outcomes

The present dissertation encompasses a Descriptive Study and an Experimental Study of a video analysis training designed for novice preservice teachers' development of professional vision skills. The training focused on the core instructional practice of small-group tutoring, a context with reduced complexity, but transferable to a classroom setting (Graesser et al., 2011). Further, it was designed according to the Framework for Teaching Practice in Professional Education (Grossman, et al., 2009), which incorporated a decomposition-of-practice in the form of a pre-training theoretical text; representations-of-practice as short, scripted tutoring scenario videos; and a video observation and analysis task involving noticing and reasoning about relevant teaching and learning events as an approximation-of-practice for in-the-moment professional vision.

Overall, findings from these two studies offer four central outcomes. First, results offered evidence that the one-time video analysis intervention could help preservice teachers improve their professional vision skills in describing and interpreting noticed events (i.e., components of noticing and reasoning, respectively). Secondly, findings also indicated that further improvements in preservice teachers' professional vision performance could still be made. Third, signaling cues and focused self-explanation prompts, as instructional design techniques for support, did not lead to further improvements in performance, as initially expected. Fourth, when considering preservice teachers' situational interest in the video analysis training, signaling cues could nevertheless support preservice teachers with lower-than-average situational interest, implicating a potential motivational boundary condition for signaling in this context. To follow, each of these central outcomes will be further discussed.

5.1.1 Central Outcome 1: Overall Professional Vision Improvement from Video Analysis Training

Preservice teachers were able to improve their professional vision skills with the video analysis training intervention. At a fine-grained level of analysis, the Descriptive Study gave a range of preservice teachers' professional vision performances elicited. This baseline indicated that their skills in describing and interpreting noticed events were similar to the typical novice performance found in previous research (e.g., focused on instructor and general pedagogy; Chan et al., 2021; Jacobs et al., 2010; Santagata et al., 2007; van Es, 2011). However, results also gave some indication that more advanced skills could be elicited, such as unprompted focus on individual students and a more general use of knowledge-based explanations and predictions than expected. For a subgroup of preservice teachers with more advanced skills, it seemed that the video analysis could elicit high-quality descriptions and interpretations of noticed events. These participants noticed a wider scope of event indicators, used more context-specific details to describe them, and mostly made knowledge-based interpretations of these events using theoretical and/or learning material evidence. It seems that (preservice) teachers' ability to notice more complexity was linked to their use of knowledge-based reasoning (Zummo et al., 2022).

Yet the video analysis training was not only successful for this subgroup. In the Experimental Study, overall, preservice teachers significantly improved in describing and interpreting noticed events in a transfer video analysis task one week after training, independent of training condition. They noticed more relevant events, offered increased sophistication and detail in their descriptions of these events, and demonstrated higher-quality argumentation in their interpretations of the events they noticed. Moreover, this finding replicated similar results from another project study, where professional vision was measured directly after training (Martin et al., 2022), thus validating the training's effectiveness and offering further evidence to the sustained duration of effects.

There are some indications as to how the training contributed to improvements in preservice teachers' professional vision development. Firstly, the decompositions-of-practice (i.e., pre-training texts) likely offered support by providing some prior knowledge through the introduction of concepts and specific instructional strategies that preservice teachers would later work with when subsequently analyzing the videos (Mayer & Pilegard, 2005). From another project study, we found that the content-specific pre-training texts (i.e., PPK and PCK) facilitated more content-specific noticing and increased use of knowledge within interpretations in contrast to the content-general text (Martin et al., 2023). For the present dissertation, two-thirds of participants received a content-specific text in the Description Study, and these texts were exclusively used for the Experimental Study, so they may have made a similar impact.

Secondly, the representations-of-practice (i.e., videos for analysis) may have offered support to novice preservice teachers in several ways. The focus on the core practice of small-group tutoring instruction offered a context of reduced complexity (e.g., fewer people), which still included many classroom-applicable events. Moreover, videos were scripted into a concentrated format and designed according to evidence-based guidelines with close alignment to instructional focus of the text and task objectives (Blomberg et al., 2013; Piwowar et al., 2018). The lowered complexity and targeted focus could have helped reduce the risk of processing overload during the task and facilitate essential processing (Bannert, 2002; Grossman, 2018; Paas et al., 2004).

Finally, the application of decompositions and representations of practice toward the video analysis task itself, offers a practice-based approach in approximating professional vision practice (Grossman, 2018). Preservice teachers had to engage with the target learning material, by applying theoretical knowledge to their attentional processes when watching the videos, and towards their responses to the instructional prompt, asking them to reflect on what core teaching events they noticed and why they mattered to the tutoring context. Thus, theoretical knowledge application was implemented in information selection, organization, and integration processes to help preservice teachers further elaborate their knowledge-based mental models of teaching practices (Mayer, 2014a; Seidel & Stürmer, 2014; Smith & Karpicke, 2014; van Es et al., 2017).

The pre-training texts and representational supports were intentionally integrated into the practice approximation training to tailor the task to the needs of novices and support their initial professional vision skill development. However, it is difficult to elucidate direct causal evidence for any of these individual mechanisms, which might have contributed to the success of the training intervention, since they were not experimentally investigated with control conditions (e.g., group with no pretraining texts; group with no instructional focus; group with authentic practice situation). Therefore, though unlikely, the possibility cannot be ruled out that preservice teachers could have equally benefited from the training without decompositions-, representations- or approximations-of-practice. Moreover, it cannot be ruled out that other training features not pertaining to the instructional context or pre-training, may have contributed to its effectiveness (e.g., novelty effect of video, since over half of preservice teachers had never experienced working with video before; Tulving & Kroll, 1995). To disentangle the role that these training mechanisms might play in the overall effectiveness of the intervention, future research may benefit by experimentally investigating these specific features to assemble more robust evidence on their individual and collective impacts for video analysis training in teacher education.

5.1.2 Central Outcome 2: Preservice Teachers' Needs for Further Support

While the studies of this dissertation offered convincing evidence that preservice teachers could make improvements to their professional vision, areas of need for further improvement were also determined. In the Descriptive Study, the baseline performance demonstrated that although preservice teachers were mostly successful at noticing general pedagogical events (associated with PPK), many still had difficulty identifying content-specific ones (associated with PCK) or focusing on individual students. Moreover, in both studies, they also generally struggled to make clear connections to evidence from the video or theoretical text to specifically describe events or justify their interpretations. In the Experimental Study, although overall professional vision improvements were made after the training, preservice teachers' professional vision scores remained at the low end of the spectrum.

Preservice teachers may have had more difficulty with PCK-related events due to limits in their prior knowledge. For both studies, the participants had less coursework experience in biology teaching and didactics, wherein preservice teachers build PCK competencies, such as understanding and recognizing common content-specific misconceptions (Kloser, 2014). Thus, in contrast to general pedagogical events (PPK), preservice teachers may have had less processing support from their prior knowledge in long term memory to be able to recognize and interpret events related to PCK that were unfamiliar to them (Blomberg et al., 2011; Mayer, 2014c; Mevorach & Strauss, 2012; Stürmer et al., 2015), thus increasing their potential to overload their processing capacities and subsequent performance (Paas et al., 2004).

Small-group tutoring instruction offers more opportunity to take a student-centered approach (Chi et al., 2001; Graesser et al., 2011), yet an individual student focus was lacking in many preservice teachers' descriptions of noticed events. In the Descriptive Study, higher quality descriptions of noticed events balanced focus between all professional vision indicators, including individual students, but this trend was not prevalent across the whole sample. Preservice teachers' lack of individual student focus may have been due to the training focus on tutoring strategies, rather than events associated with student learning, as is the case in many professional vision trainings (e.g., van Es & Sherin, 2009). Perhaps if the training focus was rather aimed toward students or teacher-student interactions, preservice teachers would have shown further development in this area. This task adaptation would be easy to implement for extensions to this training.

Preservice teachers' low professional vision scores overall, reflected similar patterns in novice-expert comparison studies (e.g., Jacobs et al., 2010), and mirrored results from other project studies (Martin et al., 2022; Martin et al., 2023). This emphasizes the need for professional vision training in teacher education. Professional vision skills are developed over time, through many practice opportunities from diverse teaching and learning situations (Santagata & Taylor, 2018), so it was not expected that this one-time intervention would help preservice teachers to make drastic improvements to their skills. Rather, these findings demonstrate that even with a short intervention, improvements (albeit small) *can* be made, which offers the potential for further improvements if this training were extended.

5.1.3 Central Outcome 3: Lack of Support from Multimedia Instructional Design Techniques

For the Experimental Study, it was anticipated that the multimedia instructional design techniques for video-learning support would help preservice teachers make further advances in their professional vision skills, by helping them focus on essential information, ignore extraneous material, and promote generative organizational and integrative processing of task-relevant information (Mayer, 2014a). However, neither signaling cues nor focused self-explanation prompts in the training contributed to additional overall improvements in participants' professional vision performance one week after training.

For signaling cues specifically, it was expected that they would offer professional vision support, particularly for information selection processing according to the CTML (Mayer, 2014a), since this technique should direct attention toward relevant information, making it more salient to the learner (van Gog, 2014). However, in general, this hypothesis was not supported. There are a few explanations as to why the cueing effect was not found in the context of the training. Moreno and colleagues (2007) used cues in a similar video training, but with a list of keywords to the side of the video, which became highlighted when the corresponding strategy was depicted. They also did not find an effect for cueing and attributed this to a split-attention effect (Sweller et al., 2011). To avoid this, the keyword cues in the present training were integrated into the video (i.e., spatial contiguity; Schroeder & Cenkci, 2018), but still cues were not effective overall. This suggests that something other than split-attention could have been at play, for example, cue format. Perhaps using a graphical cue format, like spotlighting, or arrows, rather than a text-based labelling format could have led to improved outcomes. In their meta-analysis on signaling cues, Schneider, Beege and colleagues (2018) found that textual cues led to better retention, while graphical cues led to better transfer. Thus, graphical cues might have been more effective for preservice teachers' posttest transfer task performance.

For self-explanations, it was expected that the selection of specific strategies from the focused prompt interactive diagram would support preservice teachers in their focused attention toward noticing and reasoning about task-relevant events. It was anticipated that focused prompts would specifically support the CTML processing components of organization and integration, due to the generative nature of self-explanations in clarifying understanding and linking information (Mayer, 2014a; Wylie & Chi, 2014). However, this hypothesis was not supported. This may be due to the focus on teaching strategies as the learning domain within the video examples. Self-explanation prompts are typically best suited for well-defined domains (e.g., physics), wherein recognizing principles and categories and determining general heuristics can be reliably done through the study of example cases (Rittle-Johnson & Loehr, 2016; Williams et al., 2013). Yet due to the situated nature of teaching, many conditional circumstances or exceptions to general principles may make it difficult to recognize theoretical strategies and understand their relevance to the specific situation, even if they were understood from a theoretical point of view (McDonald et al., 2013; Williams et al., 2013).

Considering similarities with signaling cues and the focused prompts, both relied on keywords that linked back to the tutoring strategies outlined in the introductory text. It was assumed that each keyword would trigger preservice teachers' memory of knowledge about the respective strategy, facilitating recognition of the strategy depicted in the video (for cues) and elaboration and explanation based on theoretical knowledge (for prompts). However, given novice preservice teachers' limited knowledge and experience, perhaps the keywords were not effective in both experimental conditions because participants' mental models of unfamiliar strategies were not established or elaborated enough to be easily recalled, recognized, and interpreted, especially considering the variability in how teaching strategies can be depicted in practice (Manrique & Abchi, 2015; Mevorach & Strauss, 2012; Sweller et al., 2019). Thus, they would have to expend further effort trying to remember theoretical characteristics they read from the text.

When looking at both techniques from the perspective of the broader project, in another project study, we found similar results indicating a lack of transfer effects for the multimedia techniques of focus (i.e., segmenting and self-explanation prompts), but found that they *did* offer short-term support *during* the training for noticing (Martin et al., 2022). Thus, a similar trend could have also occurred in the present Experimental Study with cues and focused prompts.

5.1.4 Central Outcome 4: A Motivational Boundary Condition for Cues: The Generative Potential of Situational Interest

In the Experimental Study, the multimedia instructional design techniques did not facilitate additional improvements to preservice teachers' professional vision performance overall. However, in the moderation analysis, differential effects were found between cue conditions, indicating that cues *were* effective, but only for a subsection of participants with lower-than-average situational interest (more than one fourth). This finding offers evidence that a participants' situational interest may be a boundary condition for the cueing effect in the context of video analysis.

Preservice teachers' professional vision performance was found to be positively associated with their situational interest, indicating that interest could have positively influenced participants' generative processing capacity (Mayer, 2014b; Stürmer et al., 2015), since situational interest is typically induced by elements of the external learning environment, associated with directing attention, increasing cognitive functioning and task engagement (Hidi & Renninger, 2006; Moreno & Mayer, 2010). Yet, for preservice teachers who's interested was not triggered, this potential may have been lost. According to the findings, for this subgroup it seemed that for those who trained with cues, the cueing effect may have compensated for the generative processing boost typically associated with situational interest. As intended, the cues likely directed their attention to help them notice and reason about the target instructional strategies, while those without cues and interest likely put in little effort (Bétrancourt, 2005).

The same moderation effect was not found for the self-explanation prompt conditions. Since both open and focused self-explanations are associated with generative processing (Fiorella & Mayer, 2015; Wylie & Chi, 2014), perhaps both conditions were already situationally interesting techniques, which helped learners discover gaps in their thinking (Chi et al., 2001) and motivated them to fill these gaps (e.g., knowledge-deprivation hypothesis; Rotgans & Schmidt, 2014). Thus, the impact of situational interest may have been similar for both conditions, so differential effects were not detected.

5.2 Overall Limitations and Suggestions for Improvement in Further Research

While the outcomes of these studies present promising evidence on the effectiveness of the video analysis intervention, a critical evaluation of the research should also present limitations that warrant explanation and highlight potential for interpretive caution. In the following, I will emphasize three overall limitations of this research. After each limitation, I will provide suggestions for further research to address each issue.

5.2.1 Limits to Instructional Focus and Possible Future Extensions

First, the instructional focus of the intervention may have limited the scope of preservice teachers' professional vision that could be elicited. The video analysis training focused on the instructional context of small-group tutoring. This core teaching practice with reduced complexity was chosen to tailor the training to the needs of novices (Grossman, 2018; van Merriënboer & Kirschner, 2018), while still providing representations of many instructional strategies which were transferable to the whole classroom (Graesser et al., 2011). However, in terms of previous research on professional vision training, instructional contexts are typically presented with video recordings of authentic scenes (rather than scripted) depicting whole-classroom lessons (e.g., Jacobs et al., 2010; Star & Strickland, 2008). Further, the focus of professional vision is typically on noticing student learning of subject-matter content, rather than focusing on the teaching strategies observed (e.g., Sherin & van Es, 2008). The choice to limit the instructional context, may have inadvertently limited the scope of the professional vision skills that could be elicited from the training in relation to the typical professional vision construct.

Several recent systematic reviews on professional vision demonstrate a growing range of diverse instructional contexts as the focus of the professional vision training (e.g., Chan et al, 2020; König et al, 2022; Santagata et al, 2021). This demonstrates the expansion in the field toward an understanding of professional vision skills for a variety of core teaching practices and beyond. While it is clear that training preservice teachers to notice and reason about student learning is an important core practice for teachers to develop, it is also argued that for novice learners, the initial skill of recognizing teaching strategies in action which connect to their theoretical understanding of these practices, is a first step toward developing holistic knowledge-based mental models of teaching (Hegarty, 2014; Hogan et al., 2003; Korthagen, 2004; Mevorach & Strauss, 2012). Future research could investigate an extended version of this intervention, which shifts focus onto other perspectives (e.g., student learning; see also emphasis shift training: Burkolter et al., 2010). Furthermore, to adapt to the changing needs of preservice teachers developing professional vision, training extensions could systematically increase complexity into the target elements to be noticed, or transition from scripted to authentic video representations of similar instructional contexts (Grossman, 2018; van Merriënboer & Kirschner, 2018).

5.2.2 Limits to Design and Strengthening Future Controls

Second, at the training level, the Experimental Study had a one group pre-post design, which did not include a control comparison group without a training phase. This design was chosen due to ethical concerns that a group of preservice teachers would not be able to experience a potentially valuable learning opportunity. However, this less robust design limits the possible causal claims that can be made for the intervention. While preservice teachers significantly improved their professional vision skills from before the training to after the training, comparisons of these change scores to participants without training could not be made to solidify evidence that the improvements were specifically due to the training intervention.

To strengthen the design-related shortcomings, several controls to potential validity threats were made (Campbell & Stanley, 1963; Shadish et al., 2002). For example, to control for testing effects, pretest and posttest videos depicted the same content with different actors, and between tests, training phase videos depicted different scenes. Beyond the support based on the replication of previous findings (e.g., Martin et al. 2022), these controls offer some security that the training was validly effective. It is suggested that future research implement a more robust experimental design (e.g., two-group pre-post randomized control) to obtain stronger confidence in the evidence of intervention effectiveness (Shadish et al., 2002). To address the ethical implications of concern, a waiting-list control group could be implemented. This group could initially receive a control training phase involving observation of the videos twice, with no design techniques or written analysis, then after posttest data collection, receiving the full analysis training (Cook & Campbell, 1979).

5.2.3 Limits to Experimental Conditions and Future Approaches Addressing Duration

Finally, differential effects between instructional design technique conditions may have been difficult to detect due to the duration of support of these techniques. In the Experimental Study, it was unclear whether the techniques were effective in the short term. In the field of multimedia learning with dynamic visualizations (e.g., instructional videos, animation), much of the previous research evidence on technique effectiveness comes from very short interventions using limited material and content (Mayer & Pilegard, 2014; e.g., Lin & Atkinson, 2011). However, in contrast to lab studies, learning interventions in the field (e.g., within teacher education seminars) typically span at least the length of one lesson, if not longer (e.g., semester course), in order to have a lasting impact on learning (Darling-Hammond et al., 2005). It is possible that when supportive design techniques are used, their duration of support in video-based learning may be short-lived. Thus, for the present studies, the design technique experimental conditions (i.e., cues; focused prompts) may have offered support *during* the training, but this support may not have transferred to the posttest (as observed in another project study; Martin et al., 2022).

To detect differential effects more effectively between instructional design conditions, as well as the duration of effectiveness of these support techniques, it is suggested that future research explicitly investigate the effects of each technique *during* training as well as a transfer posttest. Further, a third experimental group could be compared in which participants initially receive a design technique with systematic fading out (Lajoie, 2005; Puntambekar & Hübscher, 2005). This strategy may be more effective at easing participants into the posttest without instructional design support and may determine whether fading helps techniques maintain effectiveness. Finally, for the application of these techniques into more real-world contexts, further investigation into the boundary conditions associated with intervention duration is suggested.

5.3 Implications for Practice, Research, and Future Study

The findings from the Descriptive and Experimental studies of this dissertation present several implications for both research and practice. Research in the fields of teacher education, teacher noticing and professional vision, as well as multimedia learning and instructional design with video may find applicable contributions from this research. Moreover, several implications for teacher educators, instructional designers, as well as preservice and in-service practitioners could be of particular utility. This section will present the most relevant implications for practitioners, researchers, and future study according to three overarching themes: (1) professional vision training, (2) multimedia design techniques, and (3) situational interest and motivation in video analysis.

5.3.1 Implications for Professional Vision Training

For professional vision training, the present research demonstrates implications for research and practice related to the benefits from interventions designed similarly to the present research intervention, and potential ways to address the residual needs of preservice teachers in their professional vision development through further interventions and research thereof.

5.3.1.1 Benefits of feasible, flexible interventions for research and practice

Professional vision skills need continuous practice to make lasting improvements (van Es, 2011), and are slowly developed over time through growing expertise and socio-cultural professionalization, along with associated knowledge and beliefs (Berliner, 2001; 2004; Goodwin, 1994; Schoenfeld, 2011). In teacher education, these skills often improve within semester-long training courses (e.g., van Es et al., 2017). Nevertheless, the video analysis intervention of the present research demonstrated that preservice teachers' professional vision skills in describing and interpreting noticed tutoring strategies can improve, even after a short-term intervention, and effects endure at least one week after training.

For teacher education, the feasibility and flexibly of this type of training demonstrates its potential for simple integration into a variety of teacher education courses. With the breadth of content that most teacher education programs should cover (Cochran-Smith, 2004), it may not be practical to implement a semester-long video-based professional vision training course, even if this duration would be ideal for skill development. The present research demonstrates that a training design, based on the Framework for Teaching Practice in Professional Education (Grossman et al, 2009), shows promise for the development of similar professional vision interventions, perhaps focused on different core teaching practices, or specialized to PCK within specific subject matter.

Decompositions-of-practice via pre-training text, representations-of-practice through short video scenarios, and professional vision approximations-of-practice as video observations and analyses, offer a flexible frame for teacher educators to implement professional vision training across many relevant teacher competencies.

Further, when there is time for extended practice, these short-term trainings have the potential to be broadened in multiple ways. Video analysis tasks could change the target focus for each video viewing to develop skills in shifting emphasis (Burkolter et al., 2010; Gopher et al., 1989), to practice alternation between the many perspectives that teachers need to consider, as in the Lesson Analysis Framework (Santagata et al., 2007). Moreover, collaborative and discursive elements could be integrated into a lesson after individual practice, so that preservice teachers could reflect on their ideas, share them with their peers, and build on their understanding with further guided discussion, similar to a video club (e.g., van Es & Sherin, 2009). Considering the simplified instructional context of small group tutoring in the present research, used to target novice preservice teachers, it may also be worthwhile to design trainings at different levels of representational complexity (Fischer, Bauer, et al., 2022; van Merriënboer & Kirschner, 2018) to meet the changing needs of preservice teachers as they make further developments to their professional vision skills.

The prospects from the present training are also relevant to research in teacher education and professional vision. It is not suggested that a one-time training intervention replace longer duration trainings, however, from a research point of view, shorter, yet effective interventions may be more feasible to investigate, considering the necessary time and resources, especially for the analysis of qualitative data. Moreover, research efforts to establish causal effectiveness from long-term interventions can often be limited by generalizability issues due to institution or course specificity (Cochran-Smith & Villegas, 2015), or have methodological limitations stemming from complex longitudinal research designs (e.g., Blömeke, Gustafsson et al., 2015). Therefore, the study of short-term interventions, as exemplified in the present research, may make it easier to implement more rigorous controls while also maintaining ecological validity (Dunlosky et al., 2009). This may allow researchers to establish more robust evidence on what works, at least initially, that could then be further investigated on a longitudinal scale in follow-up studies.

5.3.1.2 Further addressing preservice teachers' residual needs

The range of baseline professional vision skills outlined in the Descriptive Study offers insights into the areas where further support and practice for improvement were needed. The implications for teacher education practice suggest that further preservice teacher training interventions are needed to address these salient needs for more advanced professional vision skill development. These implications could also be relevant for researchers interested in developing and studying the effectiveness and impact of these further specified trainings. Their implementation and investigation could extend evidence on additional support measures for novice preservice teachers' development of professional vision.

First, preservice teachers had difficulty noticing biology-specific pedagogy (PCK). Their lower levels of didactic biology coursework, in contrast to biology content and general pedagogy (PPK) suggest that their prior knowledge may have contributed to this outcome (Barnhart & van Es, 2015; Stürmer et al., 2015). Thus, along with further PCK specific knowledge building, more integrated practice opportunities and explicit trainings are needed, which focus particular attention on noticing and reasoning about subject specific teaching knowledge. For example, preservice teachers could focus their video analysis on students' content specific thinking by reviewing video examples and transcripts in depth using research-oriented guidelines, then collaboratively reflecting on important events with their peers (e.g., Barth-Cohen et al., 2018).

Next, in terms of broader professional vision skills, the results from both the Descriptive and Experimental Studies demonstrated that novice preservice teachers still need support in improving the quality of their descriptions and interpretations of relevant noticed events. As novices, it is likely that preservice teachers need additional support to connect and establish a deeper understanding between theoretical knowledge of practice and interpretations of practice in action (Sherin et al., 2011). Following the example from the Learning to Learn from Teaching course (van Es et al., 2017), this kind of training could emphasize evidence artifacts to increase accuracy, elaboration, and integration through iterative application in video-based analysis practice.

Through the low- versus high-quality response comparison with ENA, we could more clearly determine that not all preservice teachers shared these needs, however, and that some exhibited more sophisticated professional vision performance than expected. For more advanced preservice teachers, further trainings could be designed with more complex levels of practice representation and approximation (Fischer, Bauer, et al., 2022; Grossman, 2018). For example, video analysis could skip ahead to more authentic approximations, such as working with more diverse and complex sets of authentic video representations with the aim and deliberate practice of noticing, reasoning, *and also decision making* for a range of holistic core practice competencies (e.g., van Gog et al., 2005). Moreover, advanced preservice teachers might also move forward on the authenticity continuum (Grossman et al, 2009) toward (component) enactment of approximations closer to practice via role plays or simulations (e.g., Sommerhoff et al., 2023; Gartmeier et al., 2015).

Finally, this ENA comparison also made the differences in content from low- and high-quality responses salient, pinpointing more specific areas for improvement for preservice teachers having difficulty with response quality. Lower quality descriptions often lacked awareness of event elements beyond the tutor and his/her general pedagogy while high-quality descriptions demonstrated awareness of all relevant components (e.g., additional connections to individual students, PCK, and tutor-student interaction). Training focusing on shifting emphasis (Burkolter et al., 2010; Gopher, 2007) in multiple iterations of video analysis could address this need (e.g., Santagata et al., 2007).

Moreover, lower quality interpretations contained a mixture of knowledge-based arguments (i.e., explanations, predictions) together with uninformed interpretations in the form of *unjustified assumptions* and *judgmental evaluations*. Their *assumptions* were typically in line with common illusions of learning (e.g., the illusions of knowledge mastery and transfer, wherein the teacher assumes the student completely understands an explanation about the content to be able to accurately transfer this knowledge; Graesser et al., 2009). These illusions often lead to faulty interpretations of noticed events. Further training in this regard could specifically address these illusions and offer strategies to overcome them (e.g., Cole & Knowles, 1993). Their *judgmental evaluations* characteristically attributed a positive or negative value toward a noticed teaching event without offering any evidence-based reasoning to support the claim. To address this component, interventions could implement sensitivity training to temper judgmental evaluations and offer practice strategies to remain neutral, yet sensitive to teachable moments (e.g., Mason, 2002).

5.3.2 Implications for Multimedia Design Techniques

For multimedia design techniques, the present research demonstrated that their hypothesized benefits for support were not realized. This leads to implications for further research to investigate open questions focused on the potential of other types of cues and prompts that may be more effective, as well as the possible moderating impact of two variables relevant to both multimedia learning and professional vision: preservice teachers' prior knowledge and experience.

5.3.2.1. Open questions for further research: What types of cues and prompts might be more effective?

The Cognitive Theory of Multimedia Learning (Mayer, 2014a) assumes that novice learners need processing support through features of the instructional design, since they cannot count on processing support from their long-term memory due to their limited prior knowledge and experience. The present research demonstrated that contrary to the hypotheses, overall, novice preservice teachers were not further supported with signaling cues or focused prompts in their professional vision performance on video analysis transfer tasks. These findings demonstrate implications for future research to investigate plausible reasons why these techniques did not support preservice teachers as expected. One area of inquiry is the duration of technique support (see Limitations Section). Furthermore, research could explore multiple variations of cues and self-explanation prompts to determine whether technique features might contribute to (in)effectiveness.

The unexpected findings from cues in the present research may have resulted from the choice of text-based keyword cues. Further research could shed light on this uncertainty through the investigation of various cue formats. For example, a no cues control group could be compared to three experimental groups: videos with keyword cues; videos with a graphical cue format, such as spotlighting areas of the video to focus on, or highlighting a specific moment worthy of attention with arrows; and videos with a combination of keywords and graphical cues. Results could offer information about the most supportive cueing types for this training context, if any, for both retention and transfer (Schneider, Beege, et al., 2018).

For self-explanations, since the Experimental Study only contrasted two types of constructive prompts (open versus focused), it may be worth investigating a wider variation of self-explanation prompt formats in contrast with a control group without self-explanations. For example, three experimental groups: one with a low-structured constructive prompt (e.g., open response with little guidance), one with a high-structured passive prompt (e.g., choice of explanation from drop-down menu), and one with a semi-structured prompt between these extremes (e.g., a fill-in-the-blank scaffolded prompt); could be compared with a no self-explanation control group, to clarify whether self-explanations do, in fact, offer support, and if so, which format would be the most effective (Chi & Wylie, 2014, Wylie & Chi, 2014).

5.3.2.2 Open questions for further research: What impact might inter-individual differences in knowledge and experience have?

Individual differences among learners may also influence whether design techniques are effective supports or not. Further investigation into relevant moderation between the learner and the intervention will offer an improved understanding of the use of multimedia design in the context of video analysis in teacher education. From the perspectives of CTML and professional vison, prior knowledge is implicated as an influential factor in performance (Mayer, 2014c; Stürmer et al., 2013). Moreover, in the cognitive processes involved in video analysis training, retrieval of information from long-term memory stores not only involves knowledge learned from coursework, but also knowledge acquired from prior experiences (Tulving, 1999). Thus, preservice teachers' prior knowledge and experience might be considered relevant variables for further exploratory investigation into their potential as boundary conditions for multimedia technique effectiveness.

Prior knowledge has already been associated with boundary conditions for several multimedia instructional design techniques (e.g., pre-training), indicating that the effectiveness of some techniques is limited to low prior knowledge learners (Mayer, 2014c). Future research may benefit from considering how the cues and focused prompts may contribute or distract from learning, especially for learners with very low or high levels of relevant prior knowledge (Moreno, 2005). Moreover, professional vision training and development within the educational context requires various types of knowledge application, in combination with coordinated situation-specific skills of practice (Blömeke, Gustafsson et al., 2015). This knowledge could be considered according to many sub-categories: declarative content knowledge (CK); conceptual, procedural, situational, and strategic knowledge about pedagogy in terms of both general (PPK) and content-specific (PCK) knowledge; as well as the quality of this knowledge (e.g., surface versus deep; isolated versus structured; de Jong & Ferfuson-Hessler, 1996; Shulman, 1987). Future research could address this open question with exploratory investigations into the mechanistic influence from different types and qualities of prior knowledge (e.g., CK, PPK, PCK, task-specific knowledge) on cues and focused prompts, by measuring participants prior knowledge in more differentiated ways and analyzing the influence both during the training and in the transfer task.

Experiential knowledge that is relevant to the training context could also contribute to variance in technique effectiveness. In the context of the present research project, a preliminary exploration of the role of training-relevant experience (e.g., tutoring experience, teaching experience, video analysis experience) revealed that experience in the instructional context of focus (i.e., tutoring) had the most influence on professional vision performance *during* the training, and moderated the effect of signaling cues (Molina, 2023). That is, preservice teachers with low levels of tutoring experience benefited more with the cues than without them. Though preliminary, this indicates that experience specific to the instructional context of the intervention likely has an impact on whether or not preservice teachers need or receive support from instructional design techniques. Future research could follow-up on these preliminary findings to better understand this relationship.

Thus, it is important for researchers and practitioners to consider how learners' prior knowledge and experience may interact with multimedia instructional design techniques, and find ways to adapt the video analysis intervention design with the consideration of the target learners' capabilities (Kalyuga et al., 2000; Lowe & Schnotz, 2014). This research could reveal ways in which video analysis professional vision training in teacher education could be further adapted to the needs of individual learners (e.g., Bauer et al., 2023), for example, through preliminary screening of prerequisites indicating whether and what types of techniques would be most appropriate and effective to support their performance and development.

5.3.3 Implications for Situational Interest and Motivation in Video Analysis

For aspects of preservice teachers' motivation in general, and their situational interest specifically, the present research offers implications to researchers and practitioners regarding the consideration of motivational boundary conditions for multimedia instructional design research, as well as the potential for video analysis training to explicitly plan situational interest into intervention designs and the investigation thereof.

5.3.3.1 Motivational boundary conditions for instructional design techniques

Multimedia researchers have made a call for increased integration and investigation of motivational features into instructional design (Mayer, 2014b; Moreno & Mayer, 2010; Plass & Kaplan, 2016). To this end, investigation into the motivational mechanisms at play within a learners' engagement and cognitive processing availability for a task, may differentiate whether an instructional design technique for support will be helpful, necessary, or possibly even harmful for learning (CATLM; Moreno, 2005; Moreno & Mayer, 2010). Situational interest is particularly relevant motivational variable for investigations in multimedia learning, due to its situational elicitation from external features of a learning environment (Hidi & Renninger, 2006; Krapp, 2002). While there was already some evidence on the impact of situational interest on professional vision (Stürmer et al., 2015) and within multimedia learning (e.g., emotional design, Endres et al., 2020), the evidence base for cues and focused prompts was limited. Thus, the present research investigated its moderating impact. The implications of these findings offer preliminary evidence to address this gap.

The Experimental Study found differential effects of cues on professional vision performance based on preservice teachers' perception of situational interest in the task. An implication for instructional design following these results suggests that when learners' interest is lacking, cues and potentially other techniques associated with attention and information selection (e.g., spatial contiguity; Mayer & Fiorella, 2014), may compensate for the generative processing power typically associated with situational interest. Replication studies are still needed for more substantial evidence that this boundary condition is reliable. However, it may be apt to implement cues and similar techniques for learning support when boring tasks are inevitable. For teacher educators, these findings demonstrate that video analysis trainings are not one-size-fits-all. Design techniques for support may optimize learning for some, but other factors, such as the individual's interest in the task, may influence a techniques' potential benefits. Moreover, these findings imply that considering preservice teachers' motivation in a task may be just as important as their cognitive capacities.

Considering that boundary conditions regarding preservice teachers' situational interest were detected for cues, the power of in-the-moment motivation during multimedia learning seems to be an area of future research ripe with opportunity. Along with situational interest, the qualitative feedback responses from participants also mentioned that the training was fun, they thought working with videos was enjoyable, and they considered the content and skills they were training to be useful for their upcoming teaching career. These examples indicate that motivational variables such as intrinsic motivation (Ryan & Deci, 2000), epistemic enjoyment (Pekrun et al, 2017), and utility value (Harackiewicz & Hulleman, 2010) may also contribute to video analysis performance, and deserve further attention in future research.

5.3.3.2 Utilize generative learning potential with planned situational interest in future designs

Since results indicated a strong positive relationship between situational interest and professional vision performance, both researchers and practitioners may also benefit from explicitly considering situational interest in the planning and design of video analysis training (e.g., Bikner-Ahsbahs, 2014). Intentional implementation of situationally interesting components may offer generative processing benefits that surpass the support of cognitive techniques such as cues and focused prompts, as long as the seductive details effect can be avoided (Sundararajan & Adesope, 2020). New video analysis training could be designed to include, for example, puzzles, unexpected information, or attention to knowledge gaps, which have been implicated in triggering situational interest in educational activities (Hidi & Renninger, 2006; Rotgans & Schmidt, 2014).

Further experimental research in this area could help to determine design elements, learning materials, and activities that are effective in triggering interest and potentially facilitating processing boosts for novice learners' professional vision development (Hidi & Renninger, 2006; Krapp, 2002). For the present research context, this might involve measuring situational interest beyond the video analysis task by adapting items toward specific training materials (e.g., introductory text, individual videos), or activities (e.g., noticing, reasoning) to determine the most interesting elements. Since situational interest is associated with directing attention and active task engagement (Hidi & Renninger, 2006), further behavior-related measures could be taken during the video analysis training (e.g., eye-tracking; Deng & Gao, 2023) to more accurately triangulate important moments of situational interest for participants.

Additionally, in further research, situational interest could be considered an outcome rather than a process variable in experimental comparisons of video observation with or without cues and video analyses with open or focused prompts. Or perhaps implementing design techniques which already have evidence on their impact on situational interest (e.g., emotional design, Endres et al., 2020; decorative illustrations, Magner et al., 2014; interesting text additions, Muller et al., 2008) could be employed in the current study context to determine whether their effects could be replicated. Moreover, investigating the mechanistic role these variables play in both the learning processes and outcomes may lead to further boundary condition discoveries.

5.4 General Discussion: Broader Theoretical and Methodological Considerations

The final section of this dissertation offers three broader theoretical and methodological points of general discussion and consideration, arising from the present research: (1) the potential of ENA for professional vision research, (2) design suggestions for moving professional vision research forward, and (3) challenges for multimedia instructional design in the real-world learning context of teaching.

5.4.1 ENA Potential in Professional Vision Research

The implementation of Epistemic Network Analysis in the present research was a valuable methodological tool for visualizing the complexity and multifaceted nature of preservice teachers' professional vision of small-group tutoring instruction. To date (February, 2022), this study was the first to use ENA in the context of professional vision research (see Sushil & Clarke, June, 2022, for a close second and more recently, van Driel et al., 2023), and its added value for professional vision researchers offers promising possibilities for further use in this field.

In the Descriptive Study, ENA offered a much more nuanced understanding of preservice teachers' video analysis responses in contrast to traditional coding and counting approaches (Csanadi et al., 2018). The aim of understanding a community of practice through discourse among community members is a shared theoretical feature of both professional vision and ENA's epistemic frame theory (Goodwin, 1994; Shaffer, 2012, 2017). This offered a quite complimentary foundation and shared objective to obtain a thick description (Geertz, 1973) of research outcomes. Networks displaying a multi-dimensional perspective on preservice teachers' response co-occurrence patterns provided insights into their individual and collective knowledge structures at work when noticing and reasoning about small-group tutoring events, offering an operationalization of their epistemic frame for this context (Shaffer, 2012). Moreover, network contrasts modeled differences in the sophistication of participants' professional epistemic frames of this core teaching practice (Shaffer et al., 2016). They displayed notable differences in PV skill indicator configurations, emphasized salient interconnectivity patterns, and highlighted disparities between network groups, along with determining significant quantitative differences in network relationship structures.

Future research on similar interventions for professional vision training may also benefit from ENA in several ways. In line with the present research, getting a better understanding of the interconnected relationship structures among various facets of PV skill for the target training context could help researchers discern professional vision strengths and areas of need for the given population under investigation. Moreover, network group contrasts could also be valuable for experimental designs, to visualize and statistically compare network structures between experimental groups as well as pre/post developmental changes after an intervention.

Additionally, the situated nature of teaching and thus the diversity of focus for professional vision training and research (e.g., instructional strategies; student content-specific thinking; equitable practices; Santagata et al., 2021) makes it is difficult to establish common indicators of professional vision skill which are generalizable beyond each study-specific context. To address this limitation in the field (Konig et al., 2022), professional vision researchers focused on similar professional vision contexts (e.g., student thinking in math) could come together to identify important codes to extract from discourse that could be shared across studies and further analyzed with ENA. This would allow network comparisons of the same codes across different studies and samples to build evidence for theory development and perhaps uncover commonly occurring, previously hidden subgroups. Finally, ENA is particularly suited for group interaction, so its use in group discourse analysis (e.g., during video clubs; van Es & Sherin, 2009) could also be an interesting area for ENA application.

5.4.2 Suggestions for Moving Professional Vision Research Forward

As exemplified in the present dissertation, foci for teacher professional vision research and training are expanding (König et al., 2022). This offers potential for moving the field forward in several ways: more specialization into other core practices; further expert comparison studies; increased use of robust research designs; and expansion into meta-analytic research.

First, with a focus on preservice teacher professional vision development, the present research focused on the core teaching practice of small-group tutoring instruction. This effective training could be used as a prototype to adapt new trainings and investigations toward various core practices (e.g., providing feedback; eliciting; assessing student thinking; TeachingWorks, 2023; Davis & Boerst, 2014). In line with the Core Practice Consortium, this research agenda could build evidence on effective methodologies, resources, and tools which aid preservice teachers in core practice application and skill development (Core Practice Consortium, 2023). Moreover, from the perspective of professional vision, research on various core practice contexts would help to differentiate skills and further needs for each practice, so that targeted support could be offered.

Second, since professional vision is theorized to progress developmentally towards noticing and reasoning expertise (Berliner, 2001; Jacobs et al., 2010; van Es, 2011), the present research only offers a glimpse into the novice baseline of this spectrum for the given context. These results might be given further clarity and meaning with the addition of comparative research from sequential levels of teaching expertise (e.g., new in-service teachers, expert teachers). For example, Jacobs and colleagues (2010) study illuminates salient differences in professional vision performance for participants at different stages of teaching. Thus, for the present research, expert comparisons might contribute meaningful evidence about how (preservice) teachers' professional vision of small-group tutoring instruction evolves and relates to teacher expertise (Berliner, 2001).

Third, learning from the limitations of the present research designs, recommendations for more robust designs and thorough reporting might help the field to strengthen the evidence-base. Following-up the present research with studies using classic randomized control experimental designs (e.g., self-explanation prompt vs given explanation), would offer confidence to the evidence of (in)effectiveness to pinpoint how elements of the present training supported professional vision performance. The field could benefit from an increase in robust experimental designs investigating the effectiveness of professional vision interventions and the particular elements that may contribute to success (König et al., 2022; Santagata et al., 2021). These results could then more confidently clarify which elements are most important for learning support.

Finally, when professional vision training studies use strong research designs, include clear documentation of methodological and design mechanisms, and report preservice teachers' inter-individual differences relating to their professional vision performance (e.g., knowledge, experience, beliefs, motivation), they make meta-analytic research feasible. This research could establish larger-scale evidence about professional vision intervention effectiveness and moderating mechanisms. Currently, there are not yet any meta-analytic studies investigating teacher noticing or professional vision, perhaps due to the limit in high-quality studies reporting effect size measurements (König et al., 2022). Santagata and colleagues' (2021) systematic review on video-based math noticing interventions offers a useful model for the consideration of relevant moderators. However, this review only offers a descriptive account, and does not go further to tie these components to significant changes in effect sizes through meta-analytic synthesis. Future research in this direction has the potential for furthering the evidence base and moving theory forward.

5.4.3 Professional Vision and CTML Challenges: The Learning Context of Teaching

From the field of cognitive science, much of the foundational evidence on the success of multimedia instructional design techniques has been established through highly controlled laboratory experimental studies (Ayres, 2015; Mayer & Fiorella, 2014). More recently, much needed extensions to this research within real-world learning environments and field settings are bringing new insights to the field, especially with new-found situation-specific boundary conditions, which demonstrate particular circumstances wherein a technique may not remain effective (Ayres, 2015; Renkl, 2014; e.g., self-explanations in second language grammar instruction; Wylie et al., 2009).

The present research findings lead to many open questions and future research suggestions regarding the use of multimedia design techniques in the context of video analysis professional vision training for teacher education (see limitations and implications sections). One further challenge to consider for this real-world application of multimedia learning research is the boundary condition potential associated with the learning domain of teaching. This learning domain encompasses a broad and complex range of theoretical and practical components and competencies, which address multiple knowledge domains (e.g., PPK, PCK). Additionally, consideration is necessary from various perspectives (e.g., teacher, content, individual students), and further influenced by the situation-specific contextual features (e.g., school environment, community culture; Darling-Hammond, 2000).

This intrinsic complexity leads to a lot of variability in the knowledge and skills (preservice) teachers need to differentiate events from one another, determine whether they are relevant, and to categorize and make interpretations about these events with theoretical evidence (Darling-Hammond & Bransford, 2007; Sherin & van Es, 2009; Stürmer et al., 2016). Two characteristics of teaching events which demonstrate particular variability are *duration grainsize of an event* (micro versus macro) and *sequence (in)dependence of an event*. Even with a simplified instructional context like small-group tutoring, this variability is still exhibited. In terms of *duration grain-size*, teaching and learning events to be noticed may be short and specific (e.g., "Do you understand?"; Chi et al., 2001) or may encompass a macro-level duration over a span of minutes (e.g., a back-and-forth exchange between the tutor and a student to elicit misconception specifics; Graesser et al., 2011). In terms of *event sequence (in)dependence*, events in teaching and learning scenarios are not often independent of each other, but rather represent successive, cumulative actions that often follow a consequential progression which can shape further teacher actions (e.g., a tutor follows up on a student's previous misconception to see if modifications have been made; van Es & Sherin, 2021).

For a professional vision video-based training, these event elements may have an impact on the theorized cognitive supports that multimedia instructional design techniques should provide, and instructional design principles may not adequately address this variability. Further research on the application of various multimedia techniques for video analysis professional vision training support, looking specifically at these event characteristics, would be an important area for future study to contribute to the debate regarding their generalizability or boundary for this real-world context.

These three broader points of general discussion emerging from the present research offer some areas for further consideration for theory, methodology, and future study. Finally, turning back to the specifics of the present dissertation research, the next section offers a concluding overview to summarize important points of value and opportunity offered from these studies.

5.5 Conclusion

Within the scope of practice-based teacher education of core teaching practices and the associated research supporting this agenda, the Descriptive and Experimental Studies of the present dissertation investigate a video analysis training designed for novice preservice teachers to improve their professional vision skills about important teaching events relevant to the core practice of small-group tutoring instruction. The findings from these studies offer several points of value as well as opportunities for future inquiry and application to the research and practice communities.

First, the short-term professional vision training was found to be appropriate and effective for novice preservice teachers in developing their skills in describing and interpreting relevant noticed tutoring events. Its design also demonstrated potential for flexible use and further extensions in teacher education courses, as well as facilitating an economical research methodology to develop and investigate similar trainings for other core teaching practices. Moreover, elements of the instructional framework for this approximation-of-practice (i.e., representations-of practice: simplified instructional context; decompositions-of practice: introductory texts; Grossman, 2018) seemed to offer a head start for skill development. Further research is recommended to build robust experimental evidence for training success mechanisms.

Secondly, while the training was effective in improving preservice teachers' professional vision skills, improvements were small, and there were particular areas where further support was needed (e.g., content-specific noticing; description and interpretation quality). The Descriptive Study offered a baseline for novice skills elicited from the training, and the contrast of low- versus high-quality video analysis responses with Epistemic Network Analysis clarified salient pattern differences, areas of strength (e.g., noticing general teaching strategies associated with PPK), and areas where further support is needed. This multi-faceted baseline at multiple levels of granularity could inform both researchers' and teacher educators' expectations and planning for targeted training extensions or further needs-based interventions for continued professional vision development.

Third, in the context of teacher education, investigating video-based learning from the viewpoint of the Cognitive Theory of Multimedia Learning (Mayer, 2014a) offered a new perspective for examining the learning potential for teacher education video improvement (TEVI), aiming to uncover evidence relevant to both fields of study. The Experimental Study demonstrated that the use of multimedia instructional design techniques for video learning support (i.e., cues; focused self-explanation prompts) did not offer any additional improvements in the video analysis transfer task, contrary to expectations. This opens the door to many areas of further inquiry (e.g., the duration of support in real-world contexts) and illustrates the need for more research into moderating mechanisms to clarify boundary conditions (e.g., individual learner differences in knowledge and experience) in the video analysis training context. This research agenda could inform practice on ways to optimize and adapt more individualized multimedia learning support for professional vision skill development.

Finally, the findings from this research highlight the impact of situational interest as a motivational variable worth further exploration in video analysis training. Preservice teachers' situational interest not only demonstrated a strong positive relationship to their professional vision performance, but also was found to moderate the cueing effect. A subgroup of low-interested preservice teachers benefited from the keyword cues, but this cueing effect disappeared for participants with average or higher situational interest. For this training context, results suggest situational interest has meaningful generative processing potential, and should also be considered as a potential boundary condition for multimedia learning technique effectiveness. Considering the CATLM (Moreno, 2005) and the call for more research on motivational impacts in multimedia instructional design, this research offers a meaningful contribution. Further, the specific planning and integration of situational interest into instructional designs is a suggested area for future inquiry for this training context.

The present dissertation demonstrated that the video analysis professional vision training was an effective intervention for novice preservice teachers' noticing and reasoning about the core practice of small-group tutoring instruction, regardless of the multimedia instructional design techniques which were implemented. For similar real-world multimedia learning contexts, it is unclear whether these techniques might be supportive, and more research is needed. Nevertheless, considering the present training as a prototype learning framework for structuring future trainings for other core practice contexts may be beneficial for preservice teachers' professional vision development. The more improvements that preservice teachers can make in being able to effectively use theoretical knowledge to notice and reason about relevant core practices, the stronger the bridge can be built between theory and practice (Sherin et al., 2011). This bridge provides them with a foundational professional vision to support knowledge-based teaching toward quality student learning in their future classrooms.

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Appendix A Overview of TEVI Project Videos

TEVI
Teacher Education Video Improvement

TEVI Video Descriptions

Videos in Descriptive Study (DS): One introductory phase video and one learning phase video were randomly assigned to participants for analysis.

Videos in Experimental Study (ES): The drawing task introductory phase videos and the diagram comparison learning phase videos were used for the pretest and posttest analysis (two different versions with different actors, counterbalanced; these versions were slightly shortened from DS versions). The brainstorming introductory phase video and the exchange student role-play learning phase video were used for analysis in the training phase of the intervention.

Introductory Phase Video: Drawing Task (DS: ~8 min; ES: ~4 min)

Storyline Overview	**Description**
1. Introduction to the topic	Tutor mentions the circulatory system theme and has students name places on the body where you can feel blood flowing
2. Activation question: Why does blood flow in the body?	Tutor asks students the activation question and collects answers
3. Task for students	Tutor gives students a blank body figure outline worksheet in which they should draw their own conception of how they think the circulatory system works in the human body
4. Partner work: comparison of the drawings	Students should compare their drawings with their neighbor in a partner exchange
5. Group work: Exchange	On the blackboard, each pair presents their results to the other pair in a group exchange
6. Summary of the results	Tutor summarizes what students have presented
7. Introduction of the research questions to work on	Tutor writes two research questions on the board that they will work on

Learning Phase Video: Diagram Comparison (DS:~7 min; ES:~4 min)

Storyline Overview	Description
1. Results of the sketches	The results of the sketches of the individual students are displayed
2. Comparison task	Tutor distributes a diagram of the blood circulation system to the students. They should compare their own sketches with the diagram
3. Discussion with tutor about results	Students discuss their findings from the task; the results are then summarized and clarified by tutor
4. Ask for the colors of the model	Tutor asks about the meaning of the different colors of the model and students answer; subsequent explanation from tutor
5. Correction of the sketches	Tutor gives students the task of correcting their sketches according to the diagram

Introductory Phase Video: Brainstorming (~8 min)

Storyline Overview	Description
1. Presentation of the topic and introduction	Tutor names the topic “blood”; Tutor asks students which terms come to their minds
2. Activation question	Tutor asks students which of these terms might be relevant to a biologist
3. Introduction of the blood circulation system	Tutor introduces the blood circulation system and elicits and discusses students’ prior knowledge on the topic; One student says that there are two cycles
4. Clarification of uncertainties	Tutor turns to this student and tries to correct the misconception
5. Schematic structure of the blood circulation system	Tutor sticks a diagram of the structure of the blood circulation on the board and guides this student through a dialogue to show how the blood flows

Learning Phase Video: Exchange Student Role-Play (~ 6 min.)

Storyline Overview	Description
1. Formulation of the problem	Tutor gives students a scenario in which the students must role-play that the tutor is an exchange student who has not learned about the circulatory system yet, and they must explain all that they know about this topic to teach him/her
2. Explanation by students	Students explain the blood circulation system
3. Subsequent discussion with tutor	Tutor changes role back to tutor and asks follow-up questions for students to discuss as a group
4. Dialogue about blood circulation system	Tutor asks a question to one student with misconception and conducts a dialogue with him/her; Tutor explains how the circulatory system works and how to visualize it

Appendix B Descriptive Study Coding Scheme

TEVI

Teacher Education Video Improvement

TEVI Study 1 Coding Scheme

Manual for Coding In-Depth Indicators of Professional Vision Skills in Describing and Interpreting Noticed Events from a Video Analysis Intervention

Introduction

This coding manual is to be used for content analysis and scaled qualitative analysis of open responses from a video analysis task.

The contents of this manual include initial coder training protocols and materials to ensure all coders begin the coding process with adequate knowledge of the study and the data they will be working with. This provides a common knowledge-base to support the reliability of coding from different coders.

This manual explains the coding rules for analysis. Firstly, some general coding rules are outlined. Next, the super categories are introduced and within each super category, content and quality categories and subcategories are outlined and specific rules per (sub)category, including inclusion/exclusion criteria are provided to help coders rate each response accordingly.

Additional resources for some coding subcategories are provided at the end.

Coding Aims

The overall aim for the coding that this manual supports, is for the analysis of free response texts, written by preservice science teachers in Germany in their analysis of particular events within video examples of practice (tutoring/small group scenarios).

The analysis aims at understanding the aspects of content and quality (*what* and *how*) of participant responses in order to evaluate the level of professional vision skills (in terms of these indicators) in noticing/describing and interpreting tutor-specific methods of instruction. To achieve this goal, each indicator is separately coded for each response, and a new data set is generated for descriptive statistical analyses of the findings.

Coder Training

Training Materials:

Coders should begin their training by reading through all training materials as well as viewing the 8 videos used in the study. This training ensures all coders have a general knowledge of the study contents and context specific to the data that they will work with. After training, coders should have a good knowledge of the contents of the following:

- Introductory Texts about tutoring (3 variations)
- Video material (8 different videos from 4 different scripts)
- Video analysis task performed by participants

Before moving on to the coding process and procedure overview, begin coder training of study materials.

Coding Practice:

After reviewing the training materials and coding process, coders will train their reliability with a practice task. The details of this task are outlined in the training guide

1. Coders should read through the coding process and procedures
2. Next, review the coding rules that correspond to the coding stage to be trained.
3. Coders then open the coder training Excel sheet and try out the coding for the first participant (first 6 responses).
4. With the trainer, the coder should compare their answers to the Master Codes and discuss any questions/problems/uncertainties.
5. Next, coders continue on to code the next three participants (18 responses), and follow the same procedure as before (step 4)
6. After questions are resolved through discussion with the trainer, the coder continues with the next 6 participants (36 responses).
7. At this halfway mark, together with the trainer, coders should measure their agreement with the Master Codes.
8. If 80% agreement is attained, coders can move on to "official" coding, if not, they should complete the practice coding for the final 5 participants.

At the end of the practice task, if 80% agreement has still not been achieved, coders should discuss any questions/uncertainties with the trainer, delete their initial practice coding, and try again until 80% agreement is reached with at least 50% of the practice set.

Research and Analysis Topic:

Professional Vision skills in the analysis of video examples of biology tutoring scenarios. In this context, Professional Vision skills are divided into aspects of (1) **attention allocation**, in the form of *noticing* and *describing* tutoring actions, or “moves” that are relevant to teaching and learning; and (2) **interpretation** of those events through knowledge-based *explanation* and/or *prediction* of student outcomes (when sophisticated), or uninformed interpretations, such as *judgmental evaluation*, when lacking evidence-based justifications (less sophisticated skills).

The **descriptions of tutor actions** are further broken down into subcategories of content indicators (actor: *tutor, group of students, individual student*; topic: *PPK move, PCK move, teacher-student interaction*) and quality indicators (*quality of information, word count*). The **interpretations of tutor actions** were further broken down into subcategories of content indicators (*explain, predict, judgmental evaluation*) and quality indicators (*quality of analytical argumentation, word count*).

Category and subcategory definitions are provided at the beginning of each section along with citations of theoretically foundational sources. A reference list of all cited sources is included at the end of this manual.

Questions Guiding Analysis:

What do biology teacher students notice in the video examples with regard to tutoring actions/moves that are relevant to the teaching and learning process, and how well do they describe these events?

What kinds of interpretations do they make about the events they notice, and how well can they justify their claims?

Data Structure and Units of Analysis

Participant Response = Participants' comments are divided into two parts, BEHAVIOR and RELEVANCE (Original German first, then English translation below)

- BEHAVIOR: Answer to the question "What did you notice about the behavior of the tutor?"
- RELEVANCE: Answer to the question "Why is this behavior relevant to the teaching / learning process for tutoring?"

Describe:

- For coding all subcategories within the "**Describe**" super category, the unit of analysis is the "**BEHAVIOR**" section of the comment.
- Here, it is assumed that this response provides the description of the tutor behavior that was noticed within the video clip, and thus contains the necessary information to be coded within the "Describe" super category. Other *new* "descriptions" within the "Interpret" category are coded within the "Other" subcategory. These responses are then coded according to the "Describe" subcategories in the interpretation coding session.

Interpret:

- For coding all subcategories within the "**Interpret**" super category, the unit of analysis is the entire response for both the "**BEHAVIOR" and "RELEVANCE**"
- The justification for combining these responses in the analysis of the "Interpret" super category stems from the literature from Professional Vision, where it is assumed that attention allocation (Noticing and Describing) and the interpretation of what has been noticed (Explaining and Predicting), are an integrated process that is generated from the organization of the teacher's knowledge base (Sherin, 2017). In building an argument for the justification of a tutor action or the prediction of a student outcome, the event that is described usually provides the basis for these arguments.

Coding Process and Procedures

Coding Sheet Orientation

- An Excel workbook is supplied for coding. Within the coding workbook, the open answers and codes are already sorted and prepared. Nothing should be changed in the structure of the workbook so that each completed sheet can then be converted into a template for calculating inter-rater reliability. Along with the open responses from each participant, additional information about the response is provided, as well as columns associated with each coding subcategory. An example is provided below.
- Not all coding categories are encoded at once, but rather grouped into stages. The stages of coding are organized within each sheet of the Excel worksheet (see example below).
- Columns within the stage/sheet represents (sub)category indicators to be coded for the response.
- Each row contains one response that is to be coded for ALL codes in that stage.
- *The **introductory text group affiliation** is explicitly hidden and locked from the descriptors to ensure a blinded evaluation.

The **stages** of the coding are organized as follows:

Sheet 1: Super-Category: *Describe* → Category: *Description Content (what)*→ Subcategories: *Actor* (Codes: *Tutor, Group of Student, Individual Student*) and *Topic* (Codes: *PPK, PCK, T-S Interaction*)

Sheet 2: Super-Category: *Describe* → Category: *Description Quality (how)* → Scaled Qualitative Analysis: *Scoring Quality of Information*

Sheet 3: Super-Category: *Interpret* → Category: *Interpretation Content (what)* → Subcategories: *Knowledge-Based* (Codes*: Explain, Predict*) and *Uninformed* (Codes: *Judgmental Evaluation, Other)*

Sheet 4: Super-Category: *Interpret* → Category: *Interpretation Quality (how)* → Scaled Qualitative Analysis: *Scoring Quality of Analytical Argumentation*

Coding Examples:

			DESCRIBE: VERHALTEN ONLY					
			WHAT					
R_ID	ID	Participant Response (Deutsch = original)	Tutor_Ver	SuS Grp_Ver	Indiv_Ver	Tut_PPK	Tut_PCK	TSInter_Ver
R2_1	2	E1.1_31.46_02: VERHALTEN: Sie macht dadurch eine kleine Hinführung zum Thema und ruft Vorwissen ab; RELEVANZ: Vorwissen abrufen um darauf später eingehen zu können und von dort aus weiteres Wissen zu vermitteln BEHAVIOR: She thereby gives a short introduction to the topic and calls up/elicits previous knowledge; RELEVANCE: Calling up previous knowledge in order to be able to deal with it later and to impart/convey further knowledge from there	1	0	0	1	0	0

Stage 1 Describe-What | Stage 2 Describe-How | Stage 3 Interpret-What | Stage 4 Interpret-How | Stage 5 Describe-What Relevanz | S ...

			DESCRIBE: VERHALTEN ONLY
			HOW
R_ID	ID	Participant Response (Deutsch = original)	InfoQual_Ver
R2_1	2	E1.1_31.46_02: VERHALTEN: Sie macht dadurch eine kleine Hinführung zum Thema und ruft Vorwissen ab; RELEVANZ: Vorwissen abrufen um darauf später eingehen zu können und von dort aus weiteres Wissen zu vermitteln BEHAVIOR: She thereby gives a short introduction to the topic and calls up/elicits previous knowledge; RELEVANCE: Calling up previous knowledge in order to be able to deal with it later and to	1

Stage 1 Describe-What | Stage 2 Describe-How | Stage 3 Interpret-What | Stage 4 Interpret-How | Stage 5 Des

			INTERPRET: VERHLATEN + RELEVANZ			
			WHAT			
R_ID	ID	Participant Response (Deutsch = original)	Expl_V&R	Pred_V&R	Judgmental Eval_R	Other
R2_1	2	E1.1_31.46_02: VERHALTEN: Sie macht dadurch eine kleine Hinführung zum Thema und ruft Vorwissen ab; RELEVANZ: Vorwissen abrufen um darauf später eingehen zu können und von dort aus weiteres Wissen zu vermitteln BEHAVIOR: She thereby gives a short introduction to the topic and calls up/elicits previous knowledge; RELEVANCE: Calling up previous knowledge in order to be able to deal with it later and to impart/convey further knowledge from there	1	0	0	0
		E1.2_11.26_02:				

Stage 1 Describe-What | Stage 2 Describe-How | Stage 3 Interpret-What | Stage 4 Interpret-How | Stage 5 Desc

			INTERPRET: VERHALTEN + RELEVANZ
			HOW
R_ID	ID	Participant Response (Deutsch = original)	Anlyt_V&R
R2_1	2	E1.1_31.46_02: VERHALTEN: Sie macht dadurch eine kleine Hinführung zum Thema und ruft Vorwissen ab; RELEVANZ: Vorwissen abrufen um darauf später eingehen zu können und von dort aus weiteres Wissen zu vermitteln BEHAVIOR: She thereby gives a short introduction to the topic and calls up/elicits previous knowledge; RELEVANCE: Calling up previous knowledge in order to be able to deal with it later and to impart/convey further knowledge from there	1

Stage 1 Describe-What | Stage 2 Describe-How | Stage 3 Interpret-What | Stage 4 Interpret-How | Stage 5 D

Coding Session

- Before beginning a coding session, the coder should review the coding rules from the coding manual for the codes within the stage that he/she will code.
- Coding should start with the first response of the first participant on the coding sheet and follow sequentially.
- Each response should be coded for ALL codes within the stage before moving on to the next response.
- Between breaks, coding sessions should be done in blocks of at least 6 responses (i.e., all responses for one participant), so that coding remains consistent for each participant.
- Each coding session should attempt to code 10 participants (60 responses) per session between longer breaks.
- Once a stage is completed, coders should take a break before moving on to a new stage. Coders should NOT move on to a new stage until ALL responses in the current stage have been coded.

Coding Guidelines

- Columns represent individual coding indicators/subcategories. A short summary of the coding rules is provided in a comment for each title on the coding sheet. These summaries provide a reminder, but the rules within the coding manual should always take priority.
- Content category codes are marked with “0” = not present, or “1” = present, according to the coding rules provided for each code. ALL category columns must be filled in accordingly. For missing data, categories should be coded with “-99”
- Unless otherwise specified in the coding rules, multiple content categories can be coded for an individual response
- Quality category codes are marked with “0” = Unclear, “1” = Vague; “2” = Standard; or “3” = Differentiated. These quality categories are mutually exclusive: only one code per response.
- Always code the comments at face value. For incomprehensible answers or those with very limited information, do not speculate or make interpretive guesses about what the participant “might” be trying to say. Do not look into the video to gather information about the event in question. Coders should use the contextual evidence provided within the comment to make their best judgement according to the coding rules.
- For those categories that apply to the introductory texts, keywords may be used to help decide on a category in uncertainties, (e.g., "ignore" corresponds to “incorrect utterance” or “not mobilizing the group”; "uncover" relates to “eliciting misconceptions/naïve preconceptions”). **However,** these keywords are neither necessary nor sufficient for assignment into a category, but rather indicators. The coder should take the complete context of the response into consideration before coding.
- As a rule, comments should be **coded at the response level**. However, **one exception** where the **participant level** should be considered is when individual comments from the same participant AND the same video contain (very close to) the exact same content. In this case, code the best response according to the coding rules, then code “0” for the repeated content from the corresponding category.
- If at any time the coder has any questions/concerns/insecurities about a particular coding decision, this should be noted down within the “Notes” section and prefaced with the particular category that the comment pertains to (e.g. Tutor: It’s unclear to me whether “he” in this comment refers to the tutor or the student).

Overview of Coding Categories, Subcategories, and Indicator Codes

Describe

- Describe: Content Analysis Categories (*what*)
  - Actor Subcategory
    - Tutor
    - Group of Students
    - Individual Student
  - Topic Subcategory
    - PPK move
    - PCK move
    - Teacher-Student Interaction
  - Other
- Describe: Qualitative Analysis (*how*)
  - Scaled Categories for Quality of Information

Interpret

- Interpret: Content Analysis Categories (*what*)
  - Knowledge-Based Interpretations Subcategory
    - Explanation
    - Prediction
  - Uninformed Interpretations Subcategory
    - Judgmental Evaluation
    - Unjustified Assumption (added post-hoc)
    - Other
- Interpret: Qualitative Analysis (*how*)
  - Scaled Categories for Quality of Analytical Argumentation

Definitions for Noticing/Describing Super-Category

Noticing is defined as the teaching and learning component of the video clip scenario that the participant attended to while watching.

Describing is defined as relating the information about what was happening in the clip (content/what) in neutral and well-differentiated terms, when demonstrating skill sophistication (quality/how).

In the context of the present study, Noticing is operationalized as the noticed content mentioned within participants' descriptions.

Selection of Literature-Based Sources on Noticing/Describing:

- "The **situations and events teachers direct their attention to while observing a classroom sequence** serve as a first indicator for the activation of teacher knowledge. […] Noticing describes **whether teachers pay attention to events that are of importance for teaching and learning** in classrooms" (Seidel & Stürmer, 2014, p. 4)
- "**attending to noteworthy events**" (van Es, 2011, p. 135)
- The aspect of "**highlighting**": "**makes specific phenomena in a complex perceptual field salient by marking them** in some fashion" (Goodwin, 1994, p. 606)
- "**Call-out**": "**noteworthy teaching episodes or features of teaching**" (Frederiksen, et al., 1992, p. 231)
- "Describe refers to **statements that recounted the events that occurred** in the clip" (van Es & Sherin, 2008, p. 250)
- A description with **optimal professional vision** skills "refers to the ability to **clearly differentiate the relevant aspects of a noticed teaching and learning component**" (Seidel & Stürmer, 2014, p. 7)
- **Answer to** the question "**What happened?**" **without** reference to "Why?" and / or "With what effect/consequence/implication?" (Weger, 2019, p. 5)

Actor Subcategory

- "The first dimension concerned **which Actor** in the clip the teachers commented on (**student, teacher, or other**)." (van Es & Sherin, 2008, p.250)
- "Growth indicators that can help professional developers identify and celebrate shifts in teachers' professional noticing of children's mathematical thinking. […] A shift from **considering children only as a group** to **considering individual children**, both in terms of their understandings and what follow-up problems will extend though understandings" (Jacobs, et al., 2010, p. 196)

Topic Subcategory

- "**pedagog**y refers to [general] **techniques and strategies for teaching** the subject matter" (van Es & Sherin, 2008, p.250)
- "**climate** refers to the **social environment** of the classroom" (van Es & Sherin 2008, p. 250)
- "**Student behavior / class management** is defined as the **ways the teacher deals with disruptions, pace of lesson, procedural processes, teacher's physical presence**" (Star & Strickland, 2007 p. 113)
- **Subject-matter "thinking**: **exploring the [students'] thinking process[es**]," and "Pedagogy: **explanation, interaction, and adaptation to students' needs, abilities, and interests**" (Frederiksen et al., 1998, p.291-293)

Describe Content Category (*what*): Actor Subcategory

Indicator Codes: Tutor, Group of Students, Individual Student

<u>Guidelines:</u>

The actor subcategory codes are not mutually exclusive. If a single description mentions the tutor, a single student, and/or a group of students, all mentioned actors should be coded for that response.

Sources: (Jacobs, et al., 2010; van Es & Sherin, 2008)

<table>
<tr><th>Description Actor Indicator Code: Tutor</th></tr>
<tr><td>This code answers the question:
Does the description mention the tutor/ tutor action?</td></tr>
<tr><td><u>Code “Yes” (1) when:</u>
the description mentions “tutor”, “teacher”, “instructor” or any similar noun
the subject of the description refers to “he” or “she” without further reference to another subject (assumed because of the prompt).
the subject verb is conjugated in the third person singular form (assumed to be the tutor because of the prompt).
the description refers to “all” [“Alle”]. One can assume this represents both the tutor and the group of students.
If “one-to-one” is mentioned, we assume one is the tutor</td></tr>
<tr><td><u>Code “No” (0) when:</u>
the description does <u>not</u> meet any of the above “Yes” criteria <u>AND</u> the description has no indication of a person as the subject (e.g. written in passive form, use of infinitives without pronouns, etc.)
the object within the description is indicated by a personal pronoun or verb conjugated in the third person, but there is ambiguity as to whom this is referring and the subject verb/action is not exclusive to a tutor move</td></tr>
<tr><td><u>Exception(s) to the above rules:</u>
When the description contains (1) an unambiguous subject-object relationship, (2) the subject is missing, AND (3) the subject verb and object are unambiguously specific to a typical tutoring action, one can assume the missing subject is the tutor because of the prompt.
If there is a “phantom” subject imposing a task on to all students, we can assume the missing subject is the tutor</td></tr>
</table>

Description Actor Indicator Code: *Group of Students*
This code answers the question: • Does the description mention a group of students?
<u>Code "**Yes**" (1) when:</u> • the description **mentions more than one student**, using words such as "the students", etc. • **the object** of the description uses **third person plural** pronouns • **object verbs** are conjugated in the **third person plural** form • the description refers to "all" ["**Alle**"]. One can assume this represents both the tutor and the group of students. • the description contains **compound plural nouns** or plural possessive nouns that **explicitly indicate more than one student**
<u>Code "**No**" (0) when:</u> • the description **does <u>not</u> meet any of the above "Yes" criteria** • the description **does not indicate more than one student**, i.e., tutor only, single student only, tutor and single student only • the description **mentions a plural object that may be from a group** of students, **but does not explicitly mention the students,** it is **unclear** whether this plural object is multiple objects from one student or individual objects from the group
<u>**Exception(s)** to the above rules:</u> • When the description uses (1) "Ss" [**"SuS"]** to refer to a student/group, **AND** (2) a **singular article or "one**" ["eine(r)"] **AND** (3) **third personal singular verb** conjugation (instead of plural form), one can assume this is a typographical error and the description is **referring to a single student** • When the description uses "student" ["**schüler**"] and it is **grammatically ambiguous** whether this is **singular or plural**, use the context from the description to make the best judgement, where more specific descriptions are likely a single student and more general descriptions are likely the group. Object nouns may also help, e.g. "conception" ["Vorstellung"] vs "conceptions" ["Vorstellungen"]

Description Actor Indicator Code: *Individual Student*
This code answers the question: • Does the description mention an individual student?
<u>Code "**Yes**" (1) when:</u> • the **description mentions an individual student** with words such as "the student", etc., or mentions a particular student's name • **the object** of the description (to whom the tutor is acting) **refers to an individual**, and **it can be explicitly/unambiguously inferred from the context** that these pronouns are **not referring to the tutor** or a group of students • **the object verb** is conjugated in the **third person singular form**, and it is **explicitly/unambiguously** referring to an individual other than the tutor • If "one-to-one" is mentioned, we assume one is an individual student
<u>Code "**No**" (0) when:</u> • the description **does <u>not</u> meet any of the above criteria for "yes"** • the description **does not indicate a single student**, i.e., tutor only, group of students only, tutor and group of students only
<u>**Exception(s)** to the above rules:</u> • When the description uses (1) "Ss" [**"SuS"]** to refer to a student/group, **AND** (2) a **singular article or "one**" ["eine(r)"] **AND** (3) **third personal singular verb** conjugation (instead of plural form), one can assume this is a typographical error and the description is **referring to a single student** • When the description uses "student" ["**schüler**"] and it is **grammatically ambiguous** whether this is **singular or plural**, use the context from the description to make the best judgement, where more specific descriptions are likely a single student and more general descriptions are likely the group. Object nouns may also help, e.g. "conception" ["Vorstellung"] vs "conceptions" ["Vorstellungen"]

Describe Content Category (*what*): Topic Subcategory

Indicator Codes: PPK, PCK, Teacher-Student Dialogic Interaction

Guidelines

The topic subcategory codes are not mutually exclusive. If a single description mentions **multiple topics, all corresponding topic categories should be coded** for that response. However, **for PPK/PCK, each individual tutor move described should only meet the criteria for one or the other**.

The key differentiation between PPK and PCK moves is that **PCK moves** must have **explicit mention of biology-specific** terms, vocabulary, conceptions, etc. relating to the topic of the blood circulatory system, AND/OR **explicit use of the specific PCK vocabulary within the PCK introductory texts.**

PPK moves are not biology specific AND/OR correspond to the **PPK tutor moves outlined within the PPK introductory text**.

Sources: (Frederiksen, et al., 1998; Schulman, 1987; Seidel & Stürmer, 2014; Sherin et al., 2008; Star & Strickland, 2007; Stürmer et al., 2013; van Es & Sherin, 2008)

Introductory Text Sources: (Cade et al., 2008; Chi, 1996; Chi et al., 2001; Chi et al., 2004; Cohen et al., 1982; Graesser & Person, 1994; Graesser et al., 2009; Graesser et al., 2011; Großschedl et al., 2015; Herppich et al., 2013; Kaufman & Holmes, 1996; Kleickmann et al., 2013; Kloser, 2014; Köning et al., 2014; Lehman et al., 2012; Lu et al., 2007; Park & Chen, 2012; Scharfenberg & Bogner, 2019; Schmelzing et al., 2013; Seidel & Stürmer, 2014; VanLehn et al., 2003; Voss et al., 2011)

Description Topic Indicator Code: *PPK*
This code answers the question: • Does the description mention any tutor behavior/event related to general or psychological pedagogy (PPK)?
Code "**Yes**" (1) when: • it refers to **any of the student-centered and/or non-student centered PPK tutor moves outlined in the introductory text** (see PPK introductory text for details on each move): o Understanding problems and misconceptions are not revealed o Understanding problems and misconceptions are revealed o Incorrect student utterances are ignored/overlooked o Targeted questions or feedback on incorrect student answers/utterances o Students assess their own understanding (e.g., Tutor: "Do you understand?") o Tutor assess student(s) understanding o Management of the tutoring situation: too little mobilization of the whole group o Management of the tutoring situation: group mobilization • PPK introductory text **keyword indicators** include: misconception / misunderstanding / error; group mobilized; prior knowledge • Additionally, it could refer to the **positive or negative form of any of the behaviors** mentioned below:

General Pedagogy:

- When it **does not explicitly refer to science, but** refers to the use of pedagogical strategies such as "**coherent presentation**", "**explanation", "interaction"** and "**adaptation to students' needs, abilities, and interests"** ("Pedagogy": Frederiksen et al., 1998, p. 291-293)
- When it **does not explicitly refer to science, but** "refers to [**general**] **techniques and strategies for teaching the subject matter**" ("pedagogy": van Es & Sherin, 2008, p.250)
- When it **does not explicitly refer to science, but** refers to "**exploring the [students'] thinking process[es]**" (Frederiksen et al., 1998, p. 291-293)
- When it **does not explicitly refer to science, but** refers to "**goal clarity** and **orientation** (clarifying teaching and learning goals, structuring the lesson)" or "**Teacher support and guidance** […] Teacher questions, as well as their reactions to student responses in the form of feedback" (Seidel & Stürmer, 2014, p. 743)

Social Learning Climate/Motivation:

- it refers to **"participation and engagement in small group settings / individual settings"** (Frederiksen, et al., 1998, p. 291-293)
- it "refers to the **social environment of the classroom**" ("climate": van Es & Sherin 2008,p. 250)
- it refers to "**how the social environment that the teacher has created in his/her classroom, empowers learning**", i.e., "**rapport**", "**encouragement and support**", "**mutual respect**", "**sensitivity to diversity**" (Frederiksen, et al., 1998, p. 291-293)
- it refers to a "**motivational and affective background** in which learning takes place […] **teacher humor** as well as teachers **taking the needs of students seriously**" (Seidel & Stürmer, 2014, p. 743)
- it refers to topics related to **motivation, interest, enjoyment**, and/or similar topics

Classroom Management

- it "**includes the ways the teacher deals with disruptive events, pace changes, procedures for calling on students or handling homework, and the teacher's physical presence** (e.g., patterns of moving around the classroom, strategies for maintaining visibility, tone and volume of voice)" (Star & Strickland, 2008, p. 113)
- it refers to aspects of **how "the class runs smoothly and efficiently**", i.e., "**mechanics**", "**effective time management**", "**student understanding of classroom practices**", "**fostering appropriate behaviors**", and "**monitoring class activities**" (Frederiksen, et al., 1998, p. 291-293)
- it "refers to statements about the **mechanics of the classroom**" (van Es & Sherin, 2008, p.250)

Code "**No**" (0) when:

- the description **does not meet any of the above criteria for "yes"**
- the description has **no indication** of a tutor behavior or event related to **general pedagogy**
- tutor move(s) **rather meet(s) the criteria for PCK** because it/they is/are **subject-specific**

Exception(s) to the above rules:

- When more than one tutor move is described, it may be the case that one is a PCK move and the other is a PPK move. In this case, code for both

Description Topic Indicator Code: *PCK*

This code answers the question:

- Does the description mention any tutor behavior/event related to content-specific teacher/tutor pedagogy in biology?

Code "**Yes**" (1) when:

- it refers to **any of the student-centered and/or non-student centered PCK tutor moves outlined in the introductory text** (see PCK introductory text for details on each move):
  - Naïve preconceptions are not revealed
  - Naïve preconceptions are revealed
  - Naïve preconceptions: No cognitive conflict is stimulated
  - Naïve Preconceptions: Cognitive conflict is evoked*
  - No convincing alternatives are offered
  - Convincing alternatives are demonstrated
  - Naïve preconceptions: Modifications are not assessed
  - Naïve preconceptions: Potential modifications are examined

- Additionally, it could refer to the **positive or negative form** of **any of the moves** mentioned below:
- When **explicitly referring to science content** and it "includes **representation[s] of […science**] ([…]models, [diagrams]), examples used, and problems posed" (Star & Strickland, 2008, p.113)
- When **explicitly referring to science content** and "**exploring the [students'] thinking process[es]**" (Frederiksen et al., 1998, p. 291-293)
- When **explicitly referring to science content** with the use of pedagogical strategies such as "**explanation"** and "**adaptation to students' needs and abilities"** ("Pedagogy": Frederiksen et al., 1998, p. 291-293)
- When **explicitly referring to science content** and "refers to **techniques and strategies for teaching the subject matter**" ("pedagogy": van Es & Sherin, 2008, p. 250)

Code "**No**" (0) when:

- the description **does <u>not</u> meet any of the above criteria for "yes"**
- the description has **no indication** of a tutor behavior or event related to **biology-specific** pedagogy
- the tutor move(s) **rather meet(s) the criteria for general pedagogy (PPK)** because it/they is/are **not subject-specific**
- "topic/subject/theme" ["Thema"] is not explicit enough to count as "content-specific"
- "drawing" ["zeichnung"] is not explicitly content specific on its own, since PPK and PCK introductory texts both mention it
- "attention" ["aufmerksamkeit"], "busy" ["beschäftigt"], or "turning to" ["wendet zu"] are not specific enough for this subcategory

<u>Exception(s)</u> <u>to the above rules:</u>

- When more than one tutor move is described, it may be the case that one is a PCK move and the other is a PPK move. In this case, code for both
- Cognitive conflict can only be counted for the description when described as an offering from the tutor, not the presumed process going on within the student's mind without further descriptions of that process

Description Topic Indicator Code: *Teacher-Student Dialogic Interaction*

This code answers the question:

- Does the description mention an explicit discourse interaction between the tutor and student(s)?

Code “**Yes**” (1) when:

- The description refers to a **verbal interaction or exchange between the tutor and a/the student(s)**. Here, verbal interaction or exchange is **defined as** the description of **a tutor’s verbal action** and **the subsequent explicit or implicit verbal reaction of a/the student(s)** in response to the tutor, **or vice-versa** (student→ tutor), where this interaction must take place within the context of the **same topic or task**
- Verbal interactions are **limited to** descriptions of conversations, discussions, or other forms of **verbal discourse** between the tutor and student(s), i.e., “focus on how teacher and students communicated with each other or the process of idea articulation or discussion” (“Discourse”: Sherin et al, 2008)
- If the description does not have an explicit student response, **but** uses **terms indicating a collaborative process of communicating together**, such as “working together with him to achieve…” [“mit ihm zusammen…zu schaffen”]
- If the description mentions a tutor response to student(s) conception(s): only code for interaction when it **describes a response to a specific student’s verbalized conception** also mentioned

Code “**No**” (0) when:

- the description **does not meet any of the above criteria for “yes”**
- the description has **no indication of a verbal exchange** between tutor and student(s)
- the described verbal action is **only referenced as an action of one actor** toward another actor**, but does not include** the **explicit** description of the **receiver’s verbal response**
- a **sequential list** of what happed, where there is **no explicit connection** of tutor and student verbal actions **as an interaction** between the two, or verbal exchanges that extend beyond the same topic or task
- the **negative form of any of the positive moves mentioned above**, which would indicate a lack of interaction
- if the description mentions a tutor response to student(s) conception(s): code no interaction when it describes a response to **students’ conception(s) in general**
- When there is no clear dialogic exchange: (e.g.)
  - **asks about prior knowledge** then builds on it/uses this for questions
  - **Takes up previously expressed ideas** for explanation
  - **Uncommunicative non-verbal actions**, e.g. listening, eye contact, etc.
  - Simply using the word “**discussion**” **without any further description** of dialogic exchange (**however**, the use of „one-on-one“ to describe the „discussion“ provides enough context for a dialogic exchange, thus should be coded as yes (1).)

Exception(s) to the above rules:

- When the description mentions **a non-verbal interaction** wherein there is a **clear description of the tutor and student exchange of information** (e.g. tutor asks something, students nod in response)

Describe Quality Category (*how*)

Refers to: **how** the "Behavior" ("Verhalten") open response is described, i.e. quality of description

Indicator Codes: Quality of information (scaled categories); **Word count** ("Behavior" response only)

Guidelines:

- The quality of information subcategory codes **are mutually exclusive**. Each response can **only** be coded with **one code**. Codes range in a **scale from 0** (= not enough information/unclear) **to 3** (= more than enough information/differentiated).
- Since the **sample** for these studies represents **novices** (i.e., teacher students), there will **likely be few answers coded as 3**.

Sources: (Berliner, 2001; Jacobs et al, 2010; Santagata et al, 2007; Santagata & Angelici, 2010; Schäffer & Seidel, 2015; Schulman, 1996; Seidel & Stürmer, 2014; Sherin & van Es, 2009; van Es, 2011; van Es & Sherin, 2008; Weger, 2019)

<table>
<tr><th>Description Quality Scaled Indicator Categories: Quality of Information</th></tr>
<tr><td>This code answers the question:
To what extent does the description provide a well-differentiated account of the tutor action?</td></tr>
<tr><td><u>Code 0 (Unclear) when:</u>
The description refers to:
no or very limited information (too general or unspecific) for the reader to understand what the tutor is doing (i.e. no subject; overly generic or abstract verbs/adjectives)
unspecific to video or introductory texts, or only uses "buzzwords"
a sequential list of several unspecific events, not at all linked to one another
The description does not refer to the tutor or an action of the tutor.
Indicator: described action is irrelevant to teaching and learning</td></tr>
<tr><td><u>Code 1 (Vague) when:</u>
parts of the description that leave the reader with questions/needing more information to understand the complete picture
the description is difficult to pinpoint back to a specific event in the video
The description refers to:
tutor moves from the introductory text vaguely or implicitly described
sequential list of several events in mixture of general/abstract and specific/concrete, at least some of them loosely linked
Specific/concrete in this sense is defined as using evidence from the video (e.g., explicit action of an actor; example of something that was said, etc.) to provide an unambiguous account of something that happened</td></tr>
</table>

<u>Code **2** (Standard) when:</u> The description refers to: • **mostly explicit and concrete moves**/actions/behaviors, with **little-to-no overly generalized** descriptions • The description provides the reader with **a clear account of what was happening**, though not overly detailed, **without leaving the reader with important questions** to understand the described scenario • if **several events** are mentioned, they should have a **clear connection** to each other (e.g. within the same task) • **Indicator, but not hard rule**: **enough specific information to pinpoint** the event **to the video** • **Indicator, but not hard rule**: describes **moves** from the tutor that were **salient/obvious**, but does not catch subtle / non-salient moves (see code 3 for details)
<u>Code **3** (Differentiated) when:</u> The description refers to: • **all the requirements for code 2 <u>PLUS elaborative details</u>** defined as a link back to further evidence in the video, to teaching and learning theory/language, and/or content-specific terms/explanations to provide a finer-grained depiction of the scenario • **Indicator, but not hard rule**: use of **content-specific terms**. • **Indicator, but not hard rule**: use of **teaching and learning theory-specific terms**, especially those **from introductory texts**. • **Indicator, but not hard rule**: refers to **subtle, non-salient tutor moves/behavior**, where this is defined as atypical observations, uncommon to most responses, but also relevant to teaching and learning

A simplified table of this scaled qualitative coding scheme for description quality is also included in Methods section of this dissertation (p. 41)

Description Quality Indicator: *Word Count*
Document the number of words within the "Behavior" response ("Verhalten") in the word count column of the excel sheet.

Definitions and Literature for Interpreting Super-Category

Interpretation is defined as the participants' justification and/or analytical reasoning about the teaching and learning event noticed within the video scenario, wherein knowledge-based arguments demonstrate higher sophistication.

Selection of Literature-Based Sources on Interpreting:

- "**knowledge-based reasoning**, refers to the ways in which a teacher reasons about what is noticed based on his or her knowledge and understanding" (Sherin & van Es, 2009, p 22)
- "teachers […] became more 'productive'; that is, the teachers talked in a **more focused**, **in-depth**, and **analytical manner** about **specific issues** related to teaching and learning the selected mathematical problems." (Borko, et al., 2008, p.432)
- "The ability to **take a reasoned approach to events noticed** in the classroom provides insight into the quality of teachers' mental representations of knowledge and the application of those representations in the classroom context" (Stürmer & Seidel, 2014, p. 745)
- ”The third category described responses that showed **a very comprehensive, coherent, and integrated interpretation, connecting analytic points through cause–effect relationships** […] closely reflected findings from the expert–novice studies" (Kersting, 2008, p. 848-849)
- "When **interpreting** classroom situations, **reasoning about the functions of lesson elements** […] depends on **reasoning about the instructional intention and rationale** amidst the context of classroom teacher-student interaction. […] the interpretation of events goes beyond generating mental representations, since it strongly **depends on reframing and transforming knowledge**." (König et al., 2014, p. 78-79)
- „**Interpreting** refers to […] efforts to **reason about what is observed**, to understand the roots of an idea, and to explain what was meant by a particular statement, drawing, gesture, or expression" (van Es, 2011, p.138)
- "the extent to which the teacher's **reasoning** is **consistent with** both the details of the specific child's **strategies and** the **research** on children's mathematical development […] use of ”**productive (evidenced-based) interpretation”** (Mason, 2002)." (Jacobs et al., 2010, p.172-173)
- Answer to the question "**Why?"** and / or "**With what effect/consequence/implication?"**, with reference to the event described from the question "What happened?"(Weger, 2019)
- "**level of interpretation**, indicated the overall quality of analysis contained in the response: that is, **how analytic points were connected** and **how complete the analysis was**." (Kersting, 2008, p. 849)

Knowledge-Based Interpretations:

Explaining is defined as elaborating on the event through a justification of the tutor action by connecting it with theoretical or video-based evidence (based on conception of Seidel & Stürmer, 2014).

Predicting is defined as forecasting likely consequences the tutor actions could have for student outcomes, from a cognitive, emotional, and/or motivational perspective (based on conception of Seidel & Stürmer, 2014).

- ”**Explanation** refers to the ability to use what one knows to reason about a situation. This means **linking classroom events to professional knowledge**” (Seidel & Stürmer, 2014, p. 746)
- “participants’ ability to **observe critically**, **justify their opinions**, and **explain** the effects of the proposed alternatives.” (Santagata, et al., 2007, p. 135)
- “**Prediction** refers to the ability to predict the consequences of observed events in terms of student learning” (Seidel & Stürmer, 2014, p. 746)
- “**Accuracy in prediction** seems to be an important characteristic of experts” (Berliner, 2001, p. 478)

Uninformed Interpretations:

Judgmental Evaluation is defined as a positive or negative assessment, critique, or opinion about the described event ascribed by the participant, with little to no evidence as support for their claim (based on conception of Sherin & van Es, 2002, 2009; van Es, 2011)**.**

Unjustified Assumption is defined as unjustified and/or overgeneralized conjecture about the tutor’s or students’ current state of knowledge, or affective-motivational state, or mentions illusions of student learning that has taken place (based on conception of Graesser et al., 2009), with little to no evidence as support for their claim.

- “**evaluating** included **judgments about the quality** of the interactions in the video” (Sherin & van Es, 2009, p.24)
- “in evaluating, the group makes **uninformed judgements** about **what was good or bad** or should have been done differently” (van Es, 2011, p.138)
- “statements identifying aspects of classroom in **superficial or judgmental** way with **no connection to professional knowledge or theories**” (Schäfer & Seidel, 2015, p.45)
- “**negative judgement without evidence or rationale**, they included a negative judgement but not an explicit rationale or supporting evidence from the video” (“critical approach”: Santagata et al., 2007, p. 135)
- “conclusions were sometimes **overgeneralized, going beyond the evidence provided**.” (Jacobs et al., 2010, p.186)
- “**illusions that typical human tutors have** about cognition and communication. These illusions may get in the way of optimizing learning. […] **illusion of feedback accuracy** […] **illusion of student mastery** […] **illusion of knowledge transfer** […] These illusions undermine the tutor’s building an accurate and detailed model of the cognitive states of the student, or what is called the student model.” (Graesser et al., 2011, p. 418)

Interpret Content Category (*what*): Knowledge-Based Interpretations Subcategory

Indicator Codes: Explanation, Prediction

<u>Guidelines</u>

- The interpret "what" subcategory codes are **<u>not</u>** mutually exclusive. If a response refers to any of the codes, each should be coded for that response.
- A differentiating factor between knowledge-based interpretation and uninformed interpretation is **knowledge-based interpretations <u>MUST</u> use evidence** from the video, introductory texts, or teaching and learning theory/concepts to justify their claims, and **uninformed interpretations lack this evidence**
- Help with knowledge-based evidence terms for teaching and learning theory are provided in a list of suggestions at the end of this manual for reference (from Schmelzing, 2010, p.164)
- A major **difference between explain and predict** is the perspective of the interpretation. If the interpretation is **<u>explaining</u>** the **intention of the tutor**, it is most likely an explanation, while an **effect the tutor move has on the student(s)** is likely a **<u>prediction</u>**
- Pay attention to the location of the comment – RELEVANCE vs BEHAVIOR -when trying to determine **borderline cases**. Comments that could be perceived as both a description OR an interpretation AND are within the **RELEVANCE section** should be **assumed to be an interpretation** in most cases, and **vice versa for descriptions**.
- If there are clear and **descriptive details of a new event in the RELEVANCE** section, that is a new description beyond what is already described in the BEHAVIOR section, this should be coded as further **description** in a later coding step for the "**Other category**"

Sources: (Berliner, 2001; Borko et al., 2008; Borko et al., 2011; Jacobs et al, 2010; Kersting, 2008; Kersting et al 2010; Mason, 2002; Santagata, et al, 2007; Schäfer & Seidel, 2015; Schmelzing, 2010; Seidel & Stürmer, 2014; Sherin et al., 2008; van Es, 2011; van Es & Sherin, 2009; Weger, 2019)

Interpretation Knowledge-Based Indicator Code: *Explanation*
This code answers the question: • Does the response (BEHAVIOR+RELEVANCE) interpret a tutor action by explaining/justifying the tutor action based on its connection to principles of teaching and learning with the use of evidence (from theory/introductory text or video)?
<u>Code "**Yes**" (1) when:</u> • the response mentions at least one **explanation** of a tutor action, where this is **defined as** making a **link/connection** to principles of teaching and learning (T&L) (e.g. evidence from theory/introductory text or from other events in video) to **explain/justify the tutor action** • the response **connects the tutor action to a teaching and learning strategy** outlined in the introductory text, or other relevant T&L theories • the response **connects the tutor action to evidence from the video** that justifies this action or explains the tutor's intention

- there is a description of a **missing tutor move**, along with a **justification about why** the tutor did not perform this action based on video or T&L theory/introductory text evidence - I**ndicator**, but not hard rule: perspective of **student** in **passive** voice
<u>Code "**No**" (0) when:</u> - the response **does <u>not</u> meet any of the above criteria for "yes"** - there is **not enough information** to provide an answer that could possibly explain "why is the tutor action relevant?" - the response explains/justifies a tutor action based on information that could not be known from the video (i.e., **unjustified assumption** of tutor knowledge) - the response provides a critique (i.e., **judgmental evaluation**) of the tutor action, rather than explaining the reasoning for the tutor move - the response **does not indicate an explanation, but only a prediction** of tutor action consequences, OR **further description of events**

<u>**Exception(s)** to the above rules:</u>
- When the intention of the tutor move is also an outcome for student– here, explanation and prediction are inseparable, so code for both, especially if there is another prediction afterwards
- When the response has a focus on **cognitive conflict (CC)**, pay attention to the wording to understand the perspective:
    o If the interpretation states that the **tutor's objective** for the tutor move (e.g. asking student to compare drawing to diagram) is to **induce a CC** for the student, this is only an **explanation**.
    o If the comment is from the **student's perspective** and describes the student **experiencing a CC due to the tutor move** (without providing evidence that this is occurring) this is a **predicted cognitive outcome** because without evidence, one cannot know if the student is actually experiencing the CC.
    o **If evidence is provided** that student is **actually experiencing the CC**, this is a **description** of the student behavior.

Interpretation Knowledge-Based Indicator Code: *Prediction*

This code answers the question:

- Does the response (BEHAVIOR+RELEVANCE) interpret a described tutor action by making a prediction about the potential student outcome(s)/consequence(s) of the tutor move (from a cognitive, emotional, or motivational perspective), with use of evidence (from theory/introductory text or video)?

Code "**Yes**" (1) when:

- the response mentions **a cause-effect relationship** between the tutor move (cause) and a potential outcome/consequence for the student (effect), **with evidence** from theory/introductory text or from other events in video
- the response contains at least one prediction of tutor action, where this is **defined as** making a **guess/assumption** based on knowledge (e.g. from theory/introductory text or of evidence from the video) on the **effect/impact** (i.e. change) of the tutor action **on student thinking and learning** in terms of **cognitive, emotional, and/or motivational outcomes.** This does **NOT** include the **subsequent action of student** based on tutor instructions/action, (e.g. tutor asks question and student answers; tutor gives task, students work on task – this is description)
- there is a description of a **missing tutor move**, along with a **predicted (lack of) outcome** for the students concerning the lack of this action
- **Indicator**, but not hard rule: perspective of **student** in **active voice**
- **Indicator,** but not hard rule: use of "encourage/stimulate" ["anregen"]
- **Indicator**, but not hard rule: use of motivational behavioral moves, like hand raising

Code "**No**" (0) when:

- the response **does not meet any of the above criteria for "yes"**
- there is **not enough information** to provide an answer that could possibly explain "why is the tutor action relevant?"
- the response predicts a student consequence of a tutor action based on information that could not be known from the video (i.e., **unjustified assumption** of tutor knowledge)
- the response provides a critique (i.e., **judgmental evaluation**) of the tutor action, rather than predicting the consequence of the tutor move
- the response **does not indicate a prediction, but only an explanation** of tutor action or description of student action (as consequence)
- Indicator, but not hard rule: use of "attention" ["aufmerksamkeit"] or "include/involve" ["miteinbeziehen"] is not enough for motivational outcome

Exception(s) to the above rules:

- When the intention of the tutor move is also an outcome for student– here, explanation and prediction are inseparable, so code for both, especially if there is another prediction afterwards
- When the response has a focus on **cognitive conflict (CC)**, pay attention to the wording to understand the perspective:
    - If the interpretation states that the **tutor's objective** for the tutor move (e.g. asking student to compare drawing to diagram) is to **induce a CC** for the student, this is only an **explanation**.

    - If the comment is from the **student's perspective** and describes the student **experiencing a CC due to the tutor move** (without providing evidence that this is occurring) this is a **predicted cognitive outcome** because without evidence, one cannot know if the student is actually experiencing the CC.
- **If evidence is provided** that student is **actually experiencing the CC**, this is a **description** of the student behavior

Interpret Content Category (*what*): Uninformed Interpretations Subcategory

Indicator Codes: Judgmental Evaluation, Unjustified Assumption (extracted from "Other" post-hoc)

Guidelines:

- A differentiating factor between knowledge-based interpretation and uninformed interpretation is **knowledge-based interpretation MUST use evidence** from the video, introductory texts, or teaching and learning theory/concepts to justify their claims, and **uninformed interpretations lack this evidence**
- A major **difference between judgmental evaluation and unjustified assumption** is the presence of value. **Judgmental evaluations do not have a neutral tone** (defined as a comment lacking positive or negative evaluative language (Mason, 2002)), while **assumptions** are typically **neutral**, but make claims about **student success that are not warranted or could not be possible**.
- Pay attention to the location of the comment – RELEVANCE vs BEHAVIOR -when trying to determine **borderline cases**. Comments that could be perceived as both a description OR an interpretation AND are within the **RELEVANCE section** should be **assumed to be an interpretation** in most cases, and **vice versa for descriptions**.
- If there are clear and **descriptive details of a new event in the RELEVANCE** section, that is a new description beyond what is already described in the BEHAVIOR section, this should be coded as further **description** in a later coding step for the "**Other category**"

Sources: (Berliner, 2001; Graesser et al., 2011; Jacobs et al, 2010; Kersting, 2008; Mason, 2002; Santagata, et al, 2007; Schäfer & Seidel, 2015; Scriven, 1972; Turner, 2012; van Es, 2011; van Es & Sherin, 2009)

Interpretation Uninformed Indicator Code: *Judgmental Evaluation*
This code answers the question: • Does the response (BEHAVIOR+RELEVANCE) interpret the noticed event with any judgmental evaluations (i.e., response not written in a neutral tone) of the tutor or event?
Code "**Yes**" (1) when: • the response contains some type of critique with **evaluative language (positive or negative)**, such as "good", "bad" or similar adjectives, **WITHOUT any justification for evaluation based on evidence,** where **evidence** is **defined** as justification based on previous occurrence in video or teaching and learning theory/introductory text • the response uses positively/negatively charged adverbs (e.g., terribly, perfectly, etc.) • the response **explains what the tutor should have done,** e.g., "should have" ["hätte…sollen"], "should"["sollte"] **WITHOUT any justification** for the alternative based on evidence • Indicator, but **not hard rule**: the response uses quantifiers (e.g., too much/little); and/or qualifiers to modify magnitude, (e.g., somewhat, very, really, quite, rather) • Judgmental language should **clearly convey** a **positive/negative evaluative tone**.

Code "**No**" (0) when: • the response does not meet any of the above criteria for "yes" • the response provides an **account of what happened in neutral terms**, without any explicit or implicit (personal) judgement/evaluation (positive or negative) about what occurred – this is a **description** • the response predicts a student consequence of a tutor action based on information that could not be known from the video (i.e.,. **unjustified assumption** of tutor knowledge) • The response uses evidence from the video or teaching and learning theory/introductory text to explain a tutor action (i.e., **explanation)** • The response uses evidence from the video or teaching and learning theory/introductory text to predict a student consequence of a tutor action (i.e., **prediction**)
Exception to the above rules: • **If** the response includes a **positive/negative evaluation** OR explains what the tutor **should** do/should have done, AND provides **sound evidence** from T&L principles to justify this suggestion for an alternative teaching strategy, the rater can code for no (0)

Interpretation Uninformed Indicator Code: *Unjustified Assumption*
This code answers the question: • Does the response (BEHAVIOR+RELEVANCE) interpret the noticed event with any unjustified assumptions about the tutor, event, or student consequence?
Code "**Yes"** (1) when: • the response contains unjustified conjecture about the tutor's or students' current state of knowledge, or affective-motivational state, or mentions illusions of student learning (Graesser et al., 2009) without connecting to theoretical- or video-based evidence. • Help with coding unjustified assumptions is offered from the descriptions of the five illusions of tutors (Graesser et al., 2011, p. 417-418; and Graesser et al., 2009, for details): **Five Tutor Illusions regarding cognition and communication = unwarranted assumptions:** • **"Illusion of grounding"**: tutor assumes what is discussed is shared knowledge with students • **"Illusion of feedback accuracy"**: tutor assumes student feedback is accurate (e.g., saying yes to CGQ "Do you understand?") • **"Illusion of discourse alignment"**: tutor assumes students understand the purpose of a particular discourse element (e.g., offered hint) • **"Illusion of student mastery"**: tutor assumes students' mastery is much greater than reality • **"Illusion of knowledge transfer"**: tutor assumes student understands everything and thus the associated knowledge is transferred
Code "**No**" (0) when: • the response does not meet any of the above criteria for "yes" • the response provides a critique (i.e., **judgmental evaluation**) of the tutor action, rather than predicting the consequence of the tutor move • The response uses evidence from the video or teaching and learning theory/introductory text to explain a tutor action (i.e., **explanation)** • The response uses evidence from the video or teaching and learning theory/introductory text to predict a student consequence of a tutor action (i.e., **prediction**)

(Assumption category was uncovered inductively emerging from the data within "other" category and added post hoc.)

Interpret Quality Category (*how*)

Refers to: **how** the "Relevance" ("Relevanz") open response interprets what is described ("Verhalten"), i.e. quality of analytical argumentation

Indicator Codes: Quality of analytical argumentation (scaled categories); **Word count** (total for "Behavior"+ "Relevance" responses)

Guidelines:

- The quality of analytical argumentation subcategory codes **are mutually exclusive**. Each response can **only** be coded with **one code**. Codes range in a **scale from 0** (unclear) **to 3** (differentiated).
- Help with knowledge-based evidence terms for teaching and learning theory are provided in a list of suggestions at the end of this manual for reference (from Schmelzing, 2010, p.164)
- Since the **sample** for these studies represents **novices** (i.e., teacher students), there will **likely be few answers coded as 3**.

Sources: (Berliner, 2001; Borko et al., 2008; Graesser et al., 2011; Jacobs et al., 2010; Kersting, 2008; Kersting et al., 2010; König et al., 2014; Santagata et al., 2007; Schäffer & Seidel, 2015; Seidel & Stürmer, 2014; van Es, 2011; van Es & Sherin, 2009; Weger, 2019)

Interpretation Quality Scaled Indicator Categories: *Quality of Analytical Argumentation*
This code answers the question: • To what extent does the response (BEHAVIOR+RELEVANCE) provide logical and reasoned analytical argumentation of their interpretation of the noticed event?
Code **0** (Unclear) when: The response contains: • **Very little to no** explicit or implicit **logical connection** between described tutor action and interpretation • interpretation is **unreasonable, illogical, contradictory** • Argumentation is **based upon unfounded grounds** or a **false assumption** about teaching effects (i.e., unjustified assumption) • no tutor action described • **absolutely no connection** between what is described in the "BEHAVIOR" and what is interpreted in the "RELEVANCE" without interpretations/guesses by the coder about the possible connection • Potential **Exception** to the above rule: **group mobilization**. Be more liberal with group mobilization when they interpret that a tutor ignoring students leads to an **assumption** of a **lack of student outcome**. **Even without evidence** to justify argument, t**his claim is plausible/not unfounded**, thus should be **coded as 1**. If evidence in the form of students' behavioral cues are also included, this could be coded as a 2

Code **1** (Vague) when:

The response contains:

- **at least one analytical point*** that **somewhat connects** described tutor action and interpretation
- argumentation is **thematically ambiguous, generalized, partially comprehensible, rather unspecific or implicit** based on context, events rather indirectly related
- arguments indirectly/implicitly based on contents from introductory texts
- **indicator**: **not enough "evidence"** from video or introductory text to understand reasoning/connection within argumentation

Code **2** (Standard) when:

The response contains:

- **at least one analytical point that logically connects** described tutor action and interpretation
- **clearly linked argumentatively** with signal words (e.g., "because" ["da"-clause], verbs, symbols (-->)
- content reference is **substantially UNambiguous and explicit**
- Could make **attempts** to make **multiple connections**, **BUT only one** is clearly connected
- **indicator:** connection to deeper levels of understanding with some use of explicit teaching and learning theoretical concepts

Code **3** (Differentiated) when:

The response contains:

- **meets all criteria for code 2 PLUS** argumentation **connects multiple related points** to provide a deeper understanding of the bigger picture
- **more than one analytical point that logically connects** described tutor action and interpretation
- the response does **NOT** contain any **unjustified assumptions or judgmental evaluation**

*Analytical point = **Using evidence** (from video, introductory text, or teaching theory) to make sense of event by offering: **explanation** based on introductory text or teaching and learning principles; **predicting** cognitive/motivational student consequences; **alternative strategy** suggestions for a more student-centered approach; suggesting **teacher's response** / **decision-making** for next steps; other thoughtful analysis of the event.

A simplified table of this scaled qualitative coding scheme for interpretation quality is also included in Methods section of this dissertation (p. 41)

Interpretation Quality Indicator: *Word Count*

Document the number of words within the "Behavior + Relevance" response ("Verhalten + Relevanz") in the word count column of the excel sheet.

Resource: List of Didactic Knowledge Indicators to Evaluate PPK/PCK Codes

Support for evaluating the use of teaching and learning principles or didactic knowledge within PPK and PCK codes. List is guideline rather than complete account.

Didactic Knowledge Indicators	
• Build on previous knowledge • Working memory • Work phase • Reference to everyday life • Berlin model • Educational standards • Model based on educational theories • Cognitive Load Theory • Conceptual Growth • Conceptual Change • Didactic reconstruction • Didactic triangle • Elaboration • Result phase; Safeguarding the result • Experiment: verify & falsify • Experiment: hypotheses • Experiment: record keeping • Experiment: Observation and interpretation • Experiment: control of variables • Frontal teaching • Researching-developing teaching style • Professional correctness • Professional jargon • Professional goals • Hamburg model • Error culture / learning from mistakes • Action-oriented didactics • Individual support • Cooperative learning • Students‘ conceptions / preconceptions • Self-fulfilling prophecy	• Interest • Interest theory • Classroom management • Cognitive activation • Constructivism • Competencies /areas of competence • Conceptual change • curriculum • Teaching / learning objectives • Teacher-centered / -presentation • Learning styles • Diversity of methods • Models: model criticism & model reflection • Models: model-level and reality level • Motivation • Scientific path of knowledge • Open lessons • Operators • Positive error Culture • Problem; question • Students‘ activation • student Orientation • Independent work • Structural models /functional models • Transfer • Practice/ Practice phase • Dealing with heterogeneity • Teaching quality • Teaching phase • Use ideas as a learning opportunity • Science-introductory course • ...

* For this study, models and strategies specific to mathematics, should be replaced with corresponding models and strategies specific to Biology and the Circulatory System

Source: (Schmelzing, 2010, p.164)

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Appendix C Experimental Study Coding Scheme

TEVI

Teacher Education Video Improvement

TEVI Study 3 Coding Guide

Introduction

The coding of TEVI study 3 data for this particular investigation focuses on the responses from the pre-test and posttest only (N = 1169 responses). Responses are anonymized and prepared in an excel sheet for coding. They are blinded to condition and test sequence is randomized. For the 130 participants' responses, 13 coding sessions are planned. To avoid coding drift, all responses for 10 participants should be coded for each session (one week per session). After each session, coders meet to determine inter-coder reliability for this set of participants' responses and discuss any discrepancies to determine a consensus decision.

Units of Analysis:

Coders analyze at the response level

Response Level	Unit of analysis includes a participant's complete response about the noticed event (both describe & interpret) because some participants provide more description in interpret response to indicate category, sometimes they only further describe the event or another event
Response scores	- **Describing sum score** for all noticed/described events within the response - **Interpretation sum score** for all interpretations of events within the response
Participant Test Level	Participants provided 2-5 responses per video (combined: 4-10 responses), thus this unit of analysis includes all responses for both videos for a single testing session
Participant Test Score	- **Describing sum score** for all noticed/described events within all responses for both videos of the testing session - **Interpretation sum score** for all interpretations of the events all responses for both videos of the testing session

Coding Procedure

Step 1: Start at the response level. Decide the category/ies of the tutor move/s within the complete response (i.e., description and interpretation, in case there are descriptions in the wrong place): use tutoring category guidelines

- If more than one category is described in the response, score each separately
- Use guidelines for coding help in this sequence: (1) tutoring category guidelines, (2) deciding between noticing/ describing categories

Step 2: Determine Describing score for first described tutor move: use scaled describing quality analysis guidelines

Step 3: Determine Interpretation score for the interpretation of the first described tutor move: : use scaled interpreting quality analysis guidelines

Step 4: Repeat steps 2&3 for each subsequent event category captured within the response

Step 5: Move on to next response. Repeat steps 1-4.

Example Coding

Coder 1	Eliciting / diagnosing (prior) misconceptions / preconceptions		Reacting to incorrect student utterances		Evoking cognitive conflict		Providing scientific alternatives		(Actor) assessing understanding (from lesson)		Checking for modifications		Group Focus		Vague	Other
	TC	SC	TC	SC	TC	SC	TC	SC	TC	SC	TC	SC	TC	SC	SC	No Score: Y/N
Noticing / Describing 0-Unclear 1-Vague 2-Standard 3-Differentiated	0	**2**	0	0	0	0	0	0	0	0	0	0	0	**2**	**1**	N
Interpreting 0-Unclear 1-Vague 2-Standard 3-Differentiated	0	**1**	0	0	0	0	0	0	0	0	0	0	0	**2**	0	N

Red = PCK Introductory Text Yellow = PPK Introductory Text Orange = Both PPK and PCK text TC = Tutor-centered SC = Student-centered

Noticing Categories of Described Tutoring Events: General Rules:

- The Noticing/Describing event codes include 15 tutoring-specific moves, which correspond to the introductory texts (see below for details)
- In addition to the 15 tutoring moves, the "Other" category includes teaching moves **not** related to tutoring specifically that are coded as present or absent (see below for guidelines)
- When multiple moves are described, try to capture the description of all moves (even if this means scoring interpret 0), BUT make sure the description is a description and not a predicted outcome or what the tutor "should have done" within an interpretation
- Description within the interpretation section should also be coded. BUT, be careful whether this is additional detail / new description OR whether it is prediction/conjecture (pay attention to clues such as modal verbs "could"/"should"). EXCEPTION: only interpretation and no description → code 0 for both
- When there is a described move that could fit into more than one category, use the argument from the interpretation for clues to help you categorize (i.e. intention of the tutor). If still not clear, vague tutor move or "other" might be the best option.
- When no tutor move is mentioned, code 0/0 for all categories
- When a participant has multiple responses FROM THE SAME VIDEO AND SAME TEST (double check this), which describe (practically) the same event, only code and score for the best one
- Watch out for use of intro-text "buzzwords" without any real description. Keep to guidelines.

15 Small-Group Tutoring Categories:

Eliciting / Diagnosing misconceptions and naïve preconceptions (in prior knowledge): (both PPK and PCK)	• Teacher Centered (TC): Student misconceptions or preconceptions **not** elicited / revealed • Student Centered (SC): Student misconceptions or preconceptions are elicited / revealed
Reacting to incorrect student utterances (or confusion): (PPK)	• TC: Incorrect utterances are ignored/overlooked or mistakenly reinforced • SC: Targeted questions or feedback for incorrect utterance
Evoking cognitive conflict: (PCK)	• TC: No attempt at initiating a cognitive conflict • SC: Attempt to evoke a cognitive conflict
Providing scientific alternatives: (PCK)	• TC: No factual alternatives offered • SC: Presents factual scientific alternative(s)
(Actor) assessing understanding (from lesson): (PPK)	• TC: Students estimate own understanding • SC: Tutor assesses students' understanding
Checking for modifications: (PCK)	• TC: Potential modifications left unverified • SC: Potential modifications examined
Group focus: (PPK)	• TC: Mismanagement, lack of focus on the whole group • SC: Management of the whole group, focused on group mobilization
Vague tutoring move/event:	• SC only: Tutor-related move, not specified

Tutoring Category Coding Guidelines:

Decide to which category the noticed/described tutor event belongs, based on the event descriptions in this guide

Eliciting / Diagnosing misconceptions and naïve preconceptions (in prior knowledge)	
TC: Student misconceptions or preconceptions **not** elicited / revealed	**SC:** Student misconceptions or preconceptions are elicited / revealed
- tutor gives long, lecture style instruction/ general explanations - tutor might weave in fill-in-the-blank elicitation questions that do not disrupt the red thread of explanation, but not more - tutor does not search for individual student misconceptions typical of the content and cannot diagnose comprehension problems	- tutor lets students explain or draw their ideas - tutor asks reflection questions about the topic - tutor looks for typical content-specific misconceptions from student responses/drawings Circulatory system misconceptions include: eb and flow, one loop, or two separate loops - Keyword "Prior knowledge" not enough to choose eliciting misconceptions category, also needs to have elements of tutor doing something to elicit the knowledge, even if this is only initiating a task

Reacting to incorrect student utterances (or confusion)	
TC: Incorrect utterances are ignored/overlooked or mistakenly reinforced	**SC:** Targeted questions or feedback for incorrect utterance
- student misconception or incorrect utterance is ignored or overlooked, or given positive feedback (reinforced) - tutor does not want to disrupt the flow of explanation, so does not address the misconception /incorrect utterance - tutor does not want to confuse students in the moment - tutor does not want to dissuade the students from working it out themselves Exception: tutor points out incorrect utterance but explicitly says they will come back to this later in the lesson (this is SC)	- explicitly points out problem of understanding or misconception - provides targeted feedback regarding the incorrect aspect(s) of the response - asks specific/targeted questions to better understand the specific conceptions in which the student's utterance is based -- aim is to help the student pinpoint their erroneous thinking

Evoking cognitive conflict	
TC: No attempt at initiating a cognitive conflict	**SC:** Attempt to evoke cognitive conflict
- brief (typically ineffective) feedback response to naive preconception / misconception, e.g. implicit - "Really?"; explicit - "No, that's not correct", without explanation -individual students' naive preconception / misconception not specifically addressed or asked about - no attempt to point out/question inconsistencies in student misconception or contrast with targeted factual scientific alternative explanations - mention of students not understanding and highlights simplified response of tutor, not going further with misconception	- provides specific/targeted feedback pointing out inadequacies / inconsistencies / contradictions of students' expressed naive preconception/ misconception - asks discriminating questions about student's naive preconceptions / misconceptions to bring inconsistencies to light - challenges student with a change of perspective to think about in contrast to their conception - points out implications of student misconception so that the student can recognize it as illogical

Providing scientific alternatives	
TC: No factual alternatives offered	**SC:** Presents factual scientific alternative(s)
- does not offer any convincing /factual scientific alternatives to the students' naive preconceptions Exception: tutor is still in the process of diagnosing the student's naive preconception / misconception (digging deeper with targeted inquiry) before deciding on a refutation strategy (here choose SC reacting or assessing)	- "rejection strategy" for superficial misconceptions: plausibility of students' idea and contrast with factual explanation, discuss plausibility of contrast - "common ground" and "connecting strategy" for deep misconceptions: point out accurate aspect of student thinking, link this to scientific ideas step by step

(Actor) assessing understanding (from lesson)	
TC: Students estimate own understanding	**SC:** Tutor assesses students' understanding
- Tutor uses general comprehension gauging questions (CGQs), e.g. "Do you understand", "Is everything clear?" "Any questions?" - tutor expects students to recognize whether they understand correctly without targeted inquiry or feedback - tutor unable to diagnose individual student's comprehension problems	- tutor frames comprehension checking questions that allow students to express their understanding (e.g. Could you explain what is meant by...?") so the tutor can judge if problems/ misconceptions have occurred - tutor designs task (e.g. drawing task, role play) to provide opportunities for checking student understanding - tutor able to diagnose individual students' comprehension problems

Checking for modifications	
TC: Potential modifications left unverified	**SC:** Potential modifications examined
- tutor mistakenly assumes that students have acquired new knowledge / adapted their misconceptions based on the lecture/explanations - tutor does not explicitly check (via questions or task) if students have modified their thinking from their original misconceptions	- asks targeted or reflection questions with the purpose of examining whether student's thinking has changed - elicits student explanations through the task to examine whether student have modified their original misconceptions - determines if students are "bending" their conceptions, i.e. maintaining their misconception and additionally integrating new knowledge (still a contradiction)

Group Focus	
TC: Mismanagement, lack of focus on the whole group	**SC:** Management of the whole group, focused on group mobilization
- imbalance in student attention -intensely involved with only one student - deals with an individual's comprehension problems BUT ignores the rest of the group in the process	- balance in student attention - actively involving everyone - deals with individual comprehension problems AND includes the group in the process

Vague Tutor Move
SC only: Tutor-related move, not specified
- the move only generally mentions the tutor acting with student-centeredness and adapting teaching to individual student needs, but does not give any further information to categorize move more specifically OR -somewhat connected to more than one move, but not enough information to explicitly categorize it, (e.g., when, as a coder, you find yourself needing to make your own interpretations/justifications about what the participant "might" be saying in order to determine the category, even after looking to the interpretation for hints). Choose vague before making a guess. NOTE: be conservative with this code, try to categorize in tutor move if possible before choosing vague

<u>“Other” Category</u>

General guidelines:

- Moves within the “Other” category include descriptions of events/moves that are completely separate from introductory text / tutor-specific moves (TC and/or SC), BUT are relevant to teaching and learning (in a more general sense)
- Coding for “Other” is not scored (describing and interpreting), only documented as “present” (yes), or “not present” (no)
- The move needs to be clear enough (i.e., would be scored at least 1 for describe) to belong outside the tutor moves as a separate “other” move. Simply the use of buzzwords is not enough.
- If too general for “teaching and learning” give 0 score rather than put it into “other” category”
- Some examples of “other” events include mention of:
    - Establishing a positive/productive learning climate/environment
    - Students’ individual/independent self-discovery learning
    - Aspects of classroom management (e.g., time on task, behavioral management)
    - Activating students’ motivation / giving praise (general)
    - Building communication/presentation skills or other social competencies
    - Group collaborative learning
    - Offering general student support (not specific to individual)
    - Establishing clear lesson aims/goals

<u>Deciding Between Noticing Categories:</u>

Guidelines

- Use these hints conservatively, only when the guidelines above have still not directed you to the appropriate category
- These points should be used as general helpful guides, but not hard rules

Eliciting <-> Assessing	• *Eliciting* focuses on tutor’s initial attempt at understanding students’ misconceptions that they come to the lesson with (pre-conceptions) and should involve prior knowledge (e.g., beginning of first video lesson: drawing task/pair discussion; second video: none unless prior knowledge explicitly mentioned). • *Assessing* should involve lesson content with a focus on the tutor doing the assessing through questions/task (e.g., end of first video: group discussion/presentation of drawings; second video: diagram comparison) • Keyword: “mention / touch upon” [“auf etw. eingehen”] is too general for eliciting. To be categorized as *eliciting*, more explicit verbs pointing to this process or mention of prior knowledge is needed

Eliciting <-> Checking for Modifications	• Assume category based on video if there are enough clues (first video: *eliciting* vs second video: *modifications*) • *Vague* if not enough context to make decision
Reacting <-> Cognitive Conflict:	• *Cognitive conflict* focuses more on inconsistent thinking AND goes beyond pointing out the misconception to (together with the student) work towards students' new understanding; OR when specifics of the inconsistent/illogical thinking process between tutor and student are well described • *Reacting* does not go beyond pointing out misconceptions/errors in student thinking to make them aware they have them
Reacting <-> Offering Alternatives:	• *Reacting* focuses on the tutor offering feedback or questions in order to pinpoint/make students aware of their erroneous thinking; • *Alternatives* should be chosen when focus is on the tutor specifically using diagram/scientific alternative as a medium through which to direct/organize targeted explanations/questions (especially directed toward student questions/uncertainties)
Cognitive Conflict <-> Offering Alternatives:	• *Cognitive conflict* if alternatives are involved in the elicitation of cognitive conflict AND there are connecting points about the student's misconceptions • *Alternatives* can be the first step towards cognitive conflict, but not coded for cognitive conflict unless explicitly mentioned as tutor's intention. • Code for both if both moves are separately interpreted
Checking for modifications <-> Assessing / Alternatives:	• Look for hints in interpretation to categorize toward correct move • *Modifications* likely when focused on the end of the lesson, focused on content understanding • *Modifications* if intention of tutor is to understand whether students have changed their misconceptions • *Assessing* if intention of tutor is to generally assess understanding of an idea the first time. • *Alternatives* if intention of tutor is to offer diagram so that students start to think about differences between own and scientifically correct understanding
Group Focus <-> Vague tutor move:	• Look for hints in interpretation to categorize toward group focus • *Group focus* could be indicated with keywords like "collectively", "together", "join in", "think together" ["gemeinsam", "zusammen", "mitmachen", "mitdenken"]; OR when the tutor fields a student question/confusion to the group or another student instead of directly answering (use own judgment based on context) • *Group focus* when focused on individualized attention and explicitly mentions equal attention for all students
Group Focus <-> Other (collaborative learning) :	• *Group focus* when tutor explicitly mentioned/involved/facilitating the process • *Other* (e.g., collaborative learning) when no mention of tutor involved in the process, only students

Other General Moves:

Tutor asking questions:	• Consider if there are specific types of questions described that could help to categorize the move • Think about the aim of the questions: o for the tutor to understand→ *assessing* o for the students to become aware of their misconceptions → *reacting* o for the student to question their thinking → *cognitive conflict*

Sources for Tutor moves: (see reference list from Study 1 Coding Scheme for full list of references)

(Cade et al., 2008; Chi, 1996; Chi et al., 2001; Chi et al., 2004; Cohen et al., 1982; Graesser & Person, 1994; Graesser et al., 2009; Graesser et al., 2011; Großschedl et al., 2015; Herppich et al., 2013; Kaufman & Holmes, 1996; Kleickmann et al., 2013; Kloser, 2014; Köning et al., 2014; Lehman et al., 2012; Lu et al., 2007; Park & Chen, 2012; Scharfenberg & Bogner, 2019; Schmelzing et al., 2013; Seidel & Stürmer, 2014; VanLehn et al., 2003; Voss et al., 2011)

Scoring for Describing and Interpreting Quality

General guidelines: *Describing Score*

- Determine description score for each noticed category coded: use the scaled qualitative analysis guide
- Important indicators for describe scoring: (1) Connection to introductory text, (2) Evidence from video, (3) Level of detail/specificity linking to video
- Score 0 → no connection to introductory text, then look for a potential fit in "Other"

Helpful Tipps

- Should be very clearly belonging to a particular category to score as 2
- Using direct quotations from the video can help differentiate 1 vs 2 score for describing, but use own discretion depending on quotation relevance to associated description
- When much time is needed to figure out what is meant by general terms/descriptions in order to place it into correct category → typically level 1 (and into vague if coder has to make interpretations about what the description might be attempting to describe). EXCEPTION: when multiple categories are described and somewhat intermingled, this may also take time to separate each move, but does not necessarily mean each can only be scored 1.

General guidelines: *Interpreting Score*

- Determine interpretation score for each noticed category coded: use the scaled qualitative analysis guide
- Important indicators for interpret scoring: (1) Link to described event/tutor move for each described event, (2) Evidence from video and/or introductory text to justify argument, (3) One or multiple logical arguments
- Only score interpreting more than 0 if describing is more than 0

Helpful Tipps

- Think about the true connections to the intro-text/video and the described event within its tutor move category, double check the simplified/decomposed version of the argument (removing auxiliary details and/or repetition) to help make decisions

Scaled Qualitative Analysis Guidelines

Level of Sophistication	Noticing / Describing Event*
Unclear **(0 pts)**	No event mentioned, OR Event described in overly general/unspecific/unclear terms, to make any implicit or explicit connection to a tutor move from either introductory text OR Describes what generally happens within the whole video, no particular event mentioned
Vague **(1 pt)**	Vaguely describes an event - some implicit or explicit connection to at least one tutoring move from either introductory text - little to no detail/evidence from the video to pinpoint the description to a specific event.
Standard **(2 pts)**	Explicit and concrete description of an event - clear connection to at least one tutoring move from either introductory text - little-to-no generalizations - some specific details/evidence from the video to pinpoint the description to a specific event. • Border cases: use of direct quotes → likely 2 • Border cases: use of content-specific terms → likely 2
Differentiated **(3 pts)**	Clearly identifies an event - use of explicit connection to at least one tutoring move from either introductory text - depicts event with elaborative and specific details/evidence from the video to clearly and explicitly pinpoint the event to the video

*Noticed/Described events = 14 Tutoring moves from introductory text and SC Vague Tutoring Move

Sources: (see reference list from Study 1 Coding Scheme for full list of references)

Level of Sophistication	Interpreting Event
Unclear (0 pts)	No interpretation of event**, OR only includes judgement or assumption OR Only a problematic attempt at interpretation with no logical connection to event / introductory text OR Connection is factually contradictory/incorrect
Vague (1 pt)	Use of at least one analytical point†, - somewhat connected to the described event/ introductory text - minimal evidence from video or introductory text to support claims - mixture of uninformed (judgement and assumption) and knowledge-based (explanation and prediction…) interpretations
Standard (2 pts)	Use of at least one articulated analytical point, - clearly and logically linked with described event - using substantially unambiguous evidence to support claims (i.e., content references from video/ introductory text) - little-to-no use of uninformed interpretations: judgement or assumption
Differentiated (3 pts)	Use of more than one analytical point, regarding one described event - clearly and logically connected to described event - multiple uses of substantially unambiguous evidence to support claims (i.e., content references from video/ introductory text - no use of uninformed interpretations: judgement or assumption

** **Not** an analytical point = **No use of evidence** (from video or introductory text) to make sense of event by commenting with: **further description** of the event or description of a new event; **judgmental evaluation** of the tutor or tutor action with critique (positive or negative) or suggesting what the tutor should have done without justifying claims; **assumption** or unjustified conjecture about the tutors' or students' state of knowledge, or affective-motivational state; or mention of any illusions of student learning (Graesser et al, 2009)

† **Analytical point = Using evidence** (from video or introductory text) to make sense of event by offering: **explanation** based on introductory text or teaching and learning principles; **predicting** cognitive/motivational student consequences; **alternative strategy** suggestions for a more student-centered approach; suggesting **teacher's response** / **decision-making** for next steps; other thoughtful analysis of the event

A simplified table of these scaled qualitative coding schemes for description and interpretation quality is also included in Methods section of this dissertation (p. 41)

Sources: (see reference list from Study 1 Coding Scheme for full list of references)