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Investigating the Development and Enhancement of Professional Vision Throughout Teacher Education

Kumulative Dissertation zur Erlangung des akademischen Grades Doktorin der Philosophie (Dr. phil.)

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März 2025

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Zusammenfassung

Das vorrangige Ziel der Lehramtsausbildung ist es, angehenden Lehrkräften die Kompetenzen zu vermitteln, welche für professionelles Unterrichten erforderlich sind. In diesem Kontext wird die professionelle Wahrnehmung als eine wichtige praxisorientierte Kompetenz anerkannt (Baumgartner et al., 2020; Blömeke et al., 2015; Kaiser et al., 2017; Krauss et al., 2020). Die professionelle Wahrnehmung umfasst die kognitiven Prozesse des Erkennens und Auswählens von relevanten Ereignissen (*noticing*), deren Interpretation (*reasoning*) (van Es & Sherin, 2002) und darauf aufbauend das Entwickeln von Handlungsalternativen (*generating alternatives of action*) (Dückers et al., 2022; Jacobs et al., 2010). Dabei weisen Expertenlehrkräfte folgende Merkmale auf, wenn sie Unterricht analysieren und beobachten (Berliner, 2001; Stahnke & Blömeke, 2021): die Anwendung von Konzepten der Unterrichtsqualität, die Fokussierung auf das Lernen und Engagement der Schüler*innen, das Ziehen von Schlussfolgerungen anstelle von Beschreibungen und das Einnehmen mehrerer Perspektiven. Insbesondere die Beobachtung und Analyse der Unterrichtsqualitätsdimensionen Klassenmanagement, instruktionale Unterstützung und emotionale Unterstützung (Pianta & Hamre, 2009; Praetorius et al., 2018) sind zentral. In Anbetracht der Bedeutung der professionellen Wahrnehmung stellt ihre Entwicklung und Förderung einen wesentlichen Bestandteil der Lehramtsausbildung dar.

Die Entwicklung professioneller Wahrnehmung wurde häufig unter Bezugnahme auf Modelle zur Entwicklung von Lehrkraftexpertise und -kompetenz untersucht. Modelle zur Entwicklung von Lehrkraftexpertise gehen von mehreren Expertisestufen sowie von Plateaus und Abnahmen in ihrer Entwicklung aus (Berliner, 1988). Erste Forschung hat einen linearen Anstieg während des Universitätsstudiums, aber eine Abnahme der professionellen Wahrnehmung von angehenden Lehrkräften beim Eintritt in die Unterrichtspraxis festgestellt (Barenthien et al., 2023; Bastian et al., 2022). Darüber hinaus haben Modelle zur Kompetenzentwicklung in der Lehramtsausbildung die zentrale Rolle von Lerngelegenheiten hervorgehoben (Kaiser & König, 2019). Allerdings fehlt es an Untersuchungen darüber, wie sich Lerngelegenheiten auf die Entwicklung der professionellen Wahrnehmung während der gesamten Lehramtsausbildung auswirken. Ein erstes Ziel dieser Dissertation besteht daher darin, die Entwicklung der professionellen Wahrnehmung mit dem Fokus auf das Klassenmanagement zu untersuchen und die Effekte von Lerngelegenheiten während der Lehramtsausbildung zu prüfen.

Vor dem Hintergrund von Modellen zu Lehrkraftexpertise- und Kompetenzentwicklung, untersuchte Artikel I die Entwicklung der professionellen

Wahrnehmung während der ersten Phase der Lehramtsausbildung an der Universität und der zweiten Phase im Referendariat. Bei den Teilnehmer*innen handelte es sich um 34 Lehramtsstudierende, die zu Beginn und am Ende ihres Bachelorstudiums untersucht wurden, und 102 Lehramtsstudierende, die zu Beginn und am Ende ihres Masterstudiums sowie nach dem Referendariat untersucht wurden. Die Mehrebenenmodelle zeigten keinen linearen Anstieg der professionellen Wahrnehmung im Bachelorstudium, was darauf hindeutet, dass ein gewisses Grundwissen für die Entwicklung erforderlich ist. Dennoch konnten Ergebnisse repliziert werden, welche eine Abnahme der professionellen Wahrnehmung beim Übergang von der Universität in die Unterrichtspraxis zeigten. Darüber hinaus konnte kein Einfluss der Lerngelegenheiten auf die professionelle Wahrnehmung, aber ein negativer Einfluss der Reflexion gezeigt werden. Diese Befunde bestätigen die postulierten Expertisestufen und verdeutlichen die Unterschiede zwischen den Merkmalen und Anforderungen der verschiedenen Phasen der Lehramtsausbildung. Der fehlende Effekt von theoretischen und praktischen Lerngelegenheiten auf die professionelle Wahrnehmung könnte darauf zurückzuführen sein, dass nicht nur die Quantität, sondern vor allem die Qualität der Lerngelegenheiten eine entscheidende Rolle bei der Kompetenzentwicklung spielt.

Die Lehramtsausbildung wird häufig wegen ihres Mangels an Praxisorientierung und -relevanz kritisiert. Ein mögliches Gegenmittel zu den Erkenntnissen in Artikel I könnten praxisorientierte Lerngelegenheiten sein (Renkl & Nückles, 2006). Das vorrangige Ziel dieser Dissertation ist daher zu untersuchen, wie Lerngelegenheiten gestaltet sein müssen, um die professionelle Wahrnehmung effektiv zu fördern. In der aktuellen Forschung wurde vor allem die Bedeutung des Einbezugs von Unterrichtsvideos (Gaudin & Chaliès, 2015) als Praxisdarstellungen (*representations of practice*) in der Lehramtsausbildung hervorgehoben (Grossman, 2021). Es wurde gezeigt, dass videobasierte Analysen von authentischen Unterrichtsvideos, welche in eine angemessene instruktionale Lernumgebung eingebettet sind (Blomberg et al., 2013; Santagata et al., 2021) als Annäherungen an die Praxis (*approximations of practice*) dienen (Grossman, 2021) und die professionelle Wahrnehmung wirksam fördern können (Santagata et al., 2021). Einige Rahmenkonzepte bieten allgemeine Leitlinien für den Einsatz videobasierter Analysen in der Lehramtsausbildung (z. B. Santagata & Angelici, 2010), berücksichtigen jedoch weder Unterschiede in der Expertise noch die Phasen der Lehramtsausbildung. Erste Vorschläge (Seidel, 2022; Seidel et al., 2024) besagen, dass in den frühen Phasen der Lehramtsausbildung angehende Lehrkräfte durch die Veranschaulichung und Analyse theoretischer Konzepte unterstützt werden können, das erlernte Wissen mit der Unterrichtspraxis zu verknüpfen. Wenn angehende Lehrkräfte von der Perspektive des passiven

Beobachters zum tatsächlichen Unterrichten im Klassenzimmer übergehen, gewinnen Prozesse der Reflexion und absichtsvolles Üben an Bedeutung.

Als theoretischer Rahmen für die Gestaltung der Lernumgebungen stützen sich die Artikel II, III und IV dieser Dissertation auf Theorien der pädagogischen Psychologie, wie die Theorie der kognitiven Belastung (Sweller, 1988, 1994) und die kognitive Theorie des multimedialen Lernens (Mayer, 2001). Die Grundannahme dieser Theorien ist, dass die Kapazität des Arbeitsgedächtnisses begrenzt ist und daher unnötige extrinsische Belastung reduziert werden muss, um kognitive Kapazitäten für das Lernen freizusetzen. Ausgehend von dieser Annahme wurden mehrere instruktionale Prinzipien identifiziert, die das Lernen effektiv fördern können (Mayer & Moreno, 2003; Paas et al., 2004). Dabei betreffen die zentralen Fragen in der pädagogischen Psychologie die Übertragbarkeit dieser Erkenntnisse, welche größtenteils in gut strukturierten Domänen gefunden wurden, auf schlecht strukturierte Domänen wie die Lehramtsausbildung und die Anpassung von instruktionaler Hilfestellung an die Expertiseniveaus der Lernenden (van Merriënboer, 1997). Die ersten Studien, welche die instruktionalen Prinzipien auf die Lehramtsausbildung übertragen haben, um die professionelle Wahrnehmung zu verbessern, zeigten uneinheitliche Ergebnisse (z. B. Gabel et al., 2024; Grub et al., 2022a; Martin et al., 2022; Tannert et al., 2023). Die meisten Studien konzentrierten sich entweder nur auf eine Unterrichtsqualitätsdimension (z. B. Klassenmanagement) oder reduzierten die Komplexität von Unterricht (z. B. durch komplexitätsreduzierte Situationen). Nur eine Studie untersuchte die Wirksamkeit der instruktionalen Prinzipien in unterschiedlichen Phasen der Lehramtsausbildung und konnte keine Effekte nachweisen. Daraus ergeben sich Forschungslücken, die in den Artikeln II, III und IV behandelt werden: Wie lassen sich instruktionale Prinzipien aus der pädagogischen Psychologie auf den schlecht strukturierten Bereich der Lehramtsausbildung übertragen? Wie können Lernumgebungen rund um videobasierte Analysen auf unterschiedliche Phasen der Lehramtsausbildung zugeschnitten werden? Wie können angehende Lehrkräfte dabei unterstützt werden, alle Unterrichtsqualitätsdimensionen gleichzeitig zu fokussieren?

In Artikel II wurde untersucht, ob die zusätzliche instruktionale Unterstützung durch ein vollständiges oder ein schrittweise reduziertes Beispiel die kognitiven Prozesse und Expertenmerkmale der professionellen Wahrnehmung angehender Lehrkräfte im Vergleich zu einer Kontrollgruppe verbessert. Teilnehmer*innen waren 410 angehende Lehrkräfte, die an videobasierten Online-Kursen im Selbststudium teilnahmen. Die Kovarianzanalyse der residualisierten Veränderungswerte zeigte einen nachteiligen Effekt der Beispiele auf die professionelle Wahrnehmung und auf die Anwendung von Klassenmanagementkonzepten. Die

Ergebnisse der Prozessdaten zu den schrittweisen reduzierten Beispielen deuteten darauf hin, dass die angehenden Lehrkräfte nicht in der Lage waren, sich die Beispiele effektiv selbst zu erklären. Die Ergebnisse unterstreichen die Herausforderung der Anwendung von instruktionalen Prinzipien in schlecht strukturierten Bereichen wie der Lehramtsausbildung und verdeutlichen die erhebliche intrinsische Belastung durch die in den Videos dargestellten komplexen Unterrichtssituationen, welche angehende Lehrkräfte bewältigen müssen.

In Artikel III wurde untersucht, ob die Analyse der Unterrichtsqualitätsdimensionen in isolierter oder integrierter Form die professionelle Wahrnehmung und die gleichzeitige Fokussierung der Unterrichtsqualitätsdimensionen im Vergleich zu einer Kontrollgruppe verbessert. Teilnehmer*innen waren 140 angehende Lehrkräfte in einem videobasierten Kurs oder in der Kontrollgruppe. Bayessche gemischte Modelle zeigten, dass sich die isolierte Gruppe in der professionellen Wahrnehmung von emotionaler Unterstützung und die integrierte Gruppe in der professionellen Wahrnehmung von Klassenmanagement und der gleichzeitigen Fokussierung verbesserte. Die Gruppen unterschieden sich jedoch lediglich in der professionellen Wahrnehmung von emotionaler Unterstützung und in der gleichzeitigen Fokussierung. Interesse und vorherige Lerngelegenheiten hatten keinen Einfluss. Diese Ergebnisse deuten darauf hin, dass sich angehende Lehrkräfte vorrangig auf pädagogische Aspekte konzentrieren und dabei auf ihr pädagogisches Wissen zurückgreifen, wenn sie nicht über ausreichende fachliche und fachdidaktische Kenntnisse verfügen. Außerdem war die integrierte Gruppe mit der Aufgabe sich gleichzeitig auf die drei Unterrichtsqualitätsdimensionen zu konzentrieren überfordert.

In Artikel IV wurde untersucht, ob die Präsentation der theoretischen Konzepte der Unterrichtsqualität vor oder nach der videobasierten Analyse die professionelle Wahrnehmung in Abhängigkeit der Phase der Lehramtsausbildung verbessert. Die Teilnehmer*innen waren 140 Lehramtsstudierende an der Universität und 42 Lehramtsanwärter*innen im Referendariat. Randomisierte lineare gemischte Modelle zeigten, dass sich die angehenden Lehrkräfte nur in einer Unterrichtsqualitätsdimension verbessern konnten. Die Ergebnisse deuten auch auf einen Expertise-Umkehr-Effekt für die professionelle Wahrnehmung von instruktionaler Unterstützung hin. Diese Ergebnisse unterstreichen, dass eine wirksame Verbesserung der professionellen Wahrnehmung von der unterschiedlichen Fokussierung auf die Unterrichtsqualitätsdimensionen und der Phase der Lehramtsausbildung abhängen kann.

Insgesamt zeigten die Befunde, dass angehende Lehrkräfte an der Universität von der intrinsischen Belastung, die durch die Komplexität der in den Videos dargestellten Klassenzimmer ausgelöst wurde, überfordert waren, und instruktionale Prinzipien konnten diese Überlastung nicht mindern. Darüber hinaus profitierten angehende Lehrkräfte je nach Expertisestufe und Phase der Lehramtsausbildung von unterschiedlichen instruktionalen Prinzipien und verbesserten sich in unterschiedlichen Fokussierungen der professionellen Wahrnehmung. Zusammenfassend betont diese Dissertation daher die Notwendigkeit, die unterschiedlichen Merkmale und Anforderungen der Phasen der Lehramtsausbildung bei der Entwicklung professioneller Wahrnehmung sowie bei der Gestaltung praxisorientierter Lerngelegenheiten zu berücksichtigen. Zudem zeigen die Befunde, dass die Übertragung instruktionaler Prinzipien auf schlecht strukturierte Domänen relativ schwierig ist und dass angehende Lehrkräfte Schwierigkeiten haben pädagogische und inhaltsbezogene Aspekte miteinander zu verbinden. Daher ist weitere Forschung erforderlich, um herauszufinden wie und unter welchen Bedingungen die instruktionalen Prinzipien auf schlecht strukturierte Domänen übertragen werden können und wie angehende Lehrkräfte während der Lehramtsausbildung unterstützt werden können professionelle Wahrnehmung zu entwickeln und Pädagogik mit Inhalt zu verknüpfen.

Abstract

The primary objective of teacher education is to equip future teachers with the competencies required for professional classroom performance. In this context, professional vision is regarded as an important practice-oriented competency (Baumgartner et al., 2020; Blömeke et al., 2015; Kaiser et al., 2017; Krauss et al., 2020). Professional vision includes the cognitive processes of noticing relevant events, reasoning on them (van Es & Sherin, 2002), and thereupon generating alternatives of action (Dückers et al., 2022; Jacobs et al., 2010). Furthermore, expert teachers have been shown to apply concepts of teaching quality, focus on student learning and engagement, draw inferences instead of mere descriptions, and adopt multiple perspectives when observing and analyzing classrooms (Berliner, 2001; Stahnke & Blömeke, 2021). In this vein, the focused observation and analysis of the teaching quality dimensions of classroom management, instructional support, and emotional support (Pianta & Hamre, 2009; Praetorius et al., 2018) is critical. Given the importance of professional vision, its development and enhancement are a crucial part of teacher education.

The development of professional vision has been frequently investigated with reference to models of teacher expertise and competency development. Models of teacher expertise development (Berliner, 1988) suggest not only several stages of expertise but also plateaus and stagnations in competency development. Initial research has identified a linear increase at university in professional vision but stagnations for future teachers entering teaching practice (Barenthien et al., 2023; Bastian et al., 2022). At the same time, models of competency development in teacher education (e.g., Kaiser & König, 2019) have highlighted the central role of learning opportunities. However, research on how learning opportunities affect professional vision development throughout teacher education is lacking. Therefore, an initial goal of this dissertation is to investigate the development of professional vision with a focus on classroom management and to examine the effect of learning opportunities in teacher education.

Against the background of models on teacher expertise and competency development, Article I investigated the development of professional vision of classroom management throughout the first teacher education phase at university and the second phase in the induction program. Participants were 34 bachelor student teachers, assessed at the beginning and at the end of their bachelor's studies, and 102 master student teachers, assessed at the beginning and at the end of their master's studies and after the induction program. Multi-level models did not show a linear increase in bachelor's studies, indicating that some basic knowledge is necessary for professional vision development. Nevertheless, the findings replicated the stagnation in professional vision found for future teachers entering teaching practice. Furthermore, the findings reveal no effect of learning opportunities but a negative effect of reflection. These findings confirm the proposed expertise stages and highlight the differences between the characteristics and demands of the teacher education phases. The null effect of theoretical and practical learning opportunities on professional vision may be due to the fact that aside from the quantity the quality of learning opportunities plays a crucial role in competency development.

Teacher education has been frequently criticized for its lack of practical orientation and relevance; thus, a possible remedy to these findings in Article I could be practice-oriented learning opportunities (Renkl & Nückles, 2006). Therefore, the more prominent goal of this dissertation is to investigate how learning opportunities have to be designed to effectively enhance professional vision. Recent research has predominantly highlighted the importance of including classroom videos (Gaudin & Chaliès, 2015) as representations of practice (Grossman, 2021) in teacher education. Video-based analyses of authentic classroom videos embedded within adequate instructional settings (Blomberg et al., 2013; Santagata et al., 2021) serve as approximations of practice (Grossman, 2021) and have been shown to effectively foster professional vision (Santagata et al., 2021). Several frameworks provide broad guidelines on how to implement video-based analyses in teacher education (e.g., Santagata & Angelici, 2010), but disregard differing expertise stages and teacher education phases. Initial suggestions (Seidel, 2022; Seidel et al., 2024) have proposed that in the early stages of teacher education, the illustration and analysis of theoretical concepts may support future teachers in connecting knowledge to teaching practice. When future teachers switch from the perspective of a passive observer to an actual performer in the classroom, processes of reflection and deliberate practice become more important.

As a theoretical framework for the design of the instructional settings, Articles II, III, and IV of this dissertation draw on the theories of educational psychology, such as cognitive load theory (Sweller, 1994) and cognitive theory of multimedia learning (Mayer, 2001). The fundamental assumption of these theories is that working memory capacity is limited and unnecessary extrinsic load has to be reduced to free cognitive capacities for learning. From this assumption, several instructional principles have been identified that effectively enhance learning (Mayer & Moreno, 2003; Paas et al., 2004). However, central questions in educational psychology are how to transfer these findings, largely found in well-structured domains, to ill-structured domains such as teacher education and how to adapt instructional support based on the learners' expertise levels (van Merriënboer, 1997). Initial studies that transferred the instructional principles to teacher education to enhance professional vision yielded mixed results (e.g., Gabel et al., 2024; Grub et al., 2022a; Martin et al., 2022; Tannert et al., 2023). Most studies either focused on only one teaching quality dimension (e.g., classroom management) or reduced classroom complexity (e.g., through complexity-reduced situations). Only one study considered the differing teacher education phases and found no effects. Therefore, major research gaps emerge, which Articles II, III, and IV aim to address: How can instructional principles of educational psychology be transferred to the ill-structured domain of teacher education? How can instructional settings around video-based analyses be tailored to different teacher education phases? How can future teachers be supported in simultaneously focusing on all teaching quality dimensions?

Article II investigated whether the additional instructional support of a complete or faded double-content example enhances cognitive processes and expert features of future teachers' professional vision compared to a control group. Participants were 410 future teachers enrolled in online self-study video-based courses. Analysis of the covariance of residualized change scores showed a detrimental effect of the double-content examples on professional vision and the application of classroom management concepts. Findings from process data on the faded double-content example indicated that future teachers could not effectively self-explain the examples. The findings underscore the challenge of applying instructional principles to ill-structured domains such as teacher education, highlighting the high intrinsic load of complex classroom situations depicted in the videos that future teachers must navigate.

Article III investigated whether the analysis of the teaching quality dimensions in an isolated or integrated approach would enhance professional vision and the simultaneous focus on the teaching quality dimensions compared to a control group. Participants were 140 future teachers in video-based courses or the control group. Bayesian mixed models indicated that the isolated group increased in professional vision of emotional support and the integrated group in professional vision of classroom management and the simultaneous focus. However, the intervention groups merely differed in professional vision of emotional support. Interest and prior learning opportunities did not have an effect. These findings indicate that future teachers focus on pedagogical aspects, drawing on their general pedagogical knowledge, when they lack sufficient content and pedagogical content knowledge. Furthermore, the integrated group was overwhelmed with the task of simultaneously focusing on the teaching quality dimensions.

Article IV investigated whether presenting the theoretical concepts of teaching quality before or after video-based analyses would enhance professional vision depending on the teacher education phase. Participants were 140 university student teachers and 42 pre-service teachers in the induction program. Randomized linear mixed models revealed that future teachers could only improve in one teaching quality dimension. The findings also showed an expertise-reversal effect for the professional vision of instructional support. These findings highlight that effective professional vision enhancement may depend on the focus addressed and on the teacher education phase.

Overall, the findings indicated that future teachers at university were overwhelmed by the intrinsic load evoked by the complexity of the classrooms portrayed in the videos, and instructional principles did not remedy this overload. Moreover, depending on the expertise stages and teacher education phases, future teachers benefited from different instructional principles and developed in other foci of professional vision. In sum, this dissertation highlights the need to consider the divergent characteristics and demands of the teacher education phases in professional vision development and when designing practice-based learning opportunities. Additionally, the findings showed that transferring instructional principles to ill-structured domains is difficult and that future teachers struggle to connect pedagogical and content-related aspects. Hence, more research is necessary on how and under what conditions the instructional principles of educational psychology can be transferred to ill-structured domains and how future teachers can be supported to develop professional vision and connect pedagogy with content throughout teacher education.

Introduction

One of the major challenges of teacher education is to prepare future teachers for the multifaceted demands of teaching. Researchers generally concur that student learning is more successful when teachers are able to create effective learning environments, initiate student learning, and implement teaching quality (Baumert & Kunter, 2013; Seidel & Shavelson, 2007). Research on teacher education has consequently focused on two key areas: what competencies teachers require to professionally perform in classrooms and how teacher education can develop and enhance these competencies. Teacher education cannot provide future teachers with specific techniques that are applicable to every situation in classrooms; hence, recent research has identified professional vision as a crucial competency that aims to bridge the gap between knowledge and performance in the classroom (Baumgartner et al., 2020; Blömeke et al., 2015; Kaiser et al., 2017; Krauss et al., 2020). Professional vision entails noticing and reasoning on relevant events in classrooms (van Es & Sherin, 2002) from which teachers can generate alternatives of action (Blömeke et al., 2015; Jacobs et al., 2010). Thereby, experienced teachers have been shown to effectively analyze classrooms by drawing on their conceptual knowledge (J. Anderson & Taner, 2023; Wolff et al., 2021), focusing on student learning and engagement (J. Anderson & Taner, 2023; Sherin & van Es, 2009), interpreting instead of describing relevant classroom events (Stahnke & Blömeke, 2021; Wolff et al., 2015), adopting multiple perspectives of students and teachers (Stahnke & Blömeke, 2021; Wolff et al., 2015), and simultaneously focusing on several classroom situations (Sabers et al., 1991). Hence, expert teachers have been shown to focus on multiple teaching quality dimensions (Blömeke et al., 2016) of effective classroom management, instructional support, and emotional support (Kunter, Klusmann, et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018). Consequently, professional vision has been shown to positively affect teaching quality (Blömeke et al., 2022; Kersting et al., 2012; Roth et al., 2011) and student achievement (Kersting et al., 2012). The development and enhancement of professional vision therefore plays a crucial role throughout teacher education in effectively preparing future teachers for the demands they will encounter in classrooms.

Many studies have shown cross-sectional differences between teacher expertise stages (e.g., novice vs. experienced teachers); however, less is known about the longitudinal development of professional vision and the factors that affect its development. Prominent models of teacher expertise development (Berliner, 1988) have proposed stagnations and plateaus in teachers' competency development. Initial studies have indicated stagnations when entering teaching practice for professional vision of instructional support (Barenthien et al., 2023; Bastian, Kaiser, et al., 2024; Bastian et al., 2022). Furthermore, models on teacher competency development (Kaiser & König, 2019; Kunter, Klusmann, et al., 2013) and initial findings (Stürmer, Könings, & Seidel, 2015) proposed that the determinants of teacher education and especially learning opportunities play a decisive role in professional vision development. Therefore, the first goal of the present dissertation is to investigate how professional vision develops throughout teacher education and examine the role of learning opportunities in this development.

Next to professional vision development, the enhancement of professional vision is considered an important research strand that offers insights into how learning opportunities have to be designed to effectively foster professional vision in teacher education. A vast amount of evidence suggests that the analysis of classroom videos can enhance professional vision (Gold et al., 2021; Seidel et al., 2013), serving as a practice-oriented learning opportunity (Renkl & Nückles, 2006) and an approximation of practice (Grossman, 2021; Grossman et al., 2009). The instructional setting around video-based analysis is recognized as a pivotal element in the enhancement of professional vision (Blomberg et al., 2013; Santagata et al., 2021); thus, several initial recommendations on how to integrate classroom videos into teacher education have been proposed. However, less is known about the specific instructional design of learning opportunities including video-based analyses, and a theoretical framework on how to design video-based learning opportunities in different teacher education phases is lacking (Seidel, 2022; Seidel et al., 2024). Drawing on the prominent models of educational psychology, such as cognitive load theory (Sweller, 1988) and cognitive theory of multimedia learning (Mayer, 2001), evidence from educational psychology proposing instructional principles that support cognitive processing (e.g., worked examples and pre-training) may serve as a framework for informing instructional settings around video-based analyses. However, initial evidence yields inconsistent findings on the effectiveness of these instructional principles in enhancing professional vision in the ill-structured domain of teacher education (e.g., Farrell et al., 2024; Gabel et al., 2023; Grub et al., 2022a; Martin et al., 2022). Most studies that examined professional vision enhancement merely focused on one teaching quality dimension, predominantly classroom management (e.g., Gabel et al., 2023; Prilop et al., 2021; Tucholka & Gold, 2025), which does not reflect the demands of classrooms in which the teaching quality dimensions interact and simultaneously occur (Dunekacke, 2016; Klieme et al., 2009). Moreover, most evidence stems from university student teachers (e.g., Farrell et al., 2024; Gabel et al., 2023; Tucholka & Gold, 2025), but the issue of how instructional approaches have to be adapted to different teacher education phases remains unclear (Grub et al., 2022b). Hence, the more prominent aim of this dissertation is to investigate how instructional principles of educational psychology can be transferred to the ill-structured domain of teacher education, how instructional approaches have to be adapted to different teacher education phases, and how professional vision of multiple foci can be promoted.

The emphasis of this dissertation is on the investigation of the development and enhancement of professional vision in the context of teacher education. Thereby, the dissertation places the role and design of learning opportunities at the center of professional vision development and enhancement. The goal is to better understand the development of future teachers' professional vision throughout teacher education and examine the role of learning opportunities in this development. However, the second and more prominent goal of this dissertation is to offer insights into how to implement the instructional principles of educational psychology for the design of instructional settings around video-based analyses in learning opportunities that aim to enhance professional vision of future teachers.

The dissertation is structured into several chapters: In the first chapter of the theoretical background (Chapter 1.1), the importance of professional vision as a teacher competency, and its theoretical and empirical conceptualizations are explained. The second chapter (Chapter 1.2) explores the current research discourse and findings on the development and enhancement of professional vision in the context of teacher education. The third chapter (Chapter 1.3) discusses the important theoretical models of educational psychology (i.e., cognitive load theory and cognitive theory of multimedia learning) and empirical findings concerning instructional principles. This chapter also presents initial findings on the effectiveness of the instructional principles in enhancing professional vision, from which research gaps and implications for improvement are drawn. In the final part of the theoretical background (Chapter 1.4), the research questions of this dissertation are outlined based on the preceding theoretical deliberations and empirical findings. The succeeding chapter (Chapter 2) presents the empirical Articles of this dissertation that investigate the development (Article I) and enhancement (Articles II, III, and IV) of professional vision. In the general discussion (Chapter 3), the findings are critically examined and related to the current research discourse. Implications for future research and teacher education are also described. The dissertation concludes with a discussion of its limitations and provides an outlook for future work.

1. Background

1.1 Professional Vision as a Part of Teacher Competency and Teacher Expertise

Teachers' requirements for effective teaching have been studied from various perspectives and research traditions (Cramer, 2020). The most prominent approaches in current research discourse are the closely connected expertise and competency approaches (Krauss et al., 2020). The expertise approach has transferred findings from expert-novice comparisons of chess players and medical practicians (Gobet & Simon, 1996) to the teacher profession by identifying the features of teachers' knowledge and ability, which differentiate expert teachers from novice teachers (Berliner, 2001, 2004). According to this approach, expert teachers possess interconnected and integrated knowledge that is learnable and adaptable and can be flexibly applied in various teaching situations (Berliner, 2001). The competency approach similarly has highlighted the importance of teacher cognition (König & Kramer, 2016; Kunter, Klusmann, et al., 2013). Educational research often refers to the definition of competency by Weinert (2001), which states that competency includes not only the cognitive skills that can be acquired but also the ability to effectively handle professional challenges and the willingness to responsibly apply these skills in various situations. Definitions that are specifically related to teacher competency also highlight the importance of teachers' cognitions; these cognitions are not only learnable, but also emphatic of their domain and situation specificity (Klieme & Leutner, 2006). Building on this premise, many models of teacher competency over the past decades have identified teachers' professional knowledge as a central component of teacher competency, next to motivational orientations, beliefs, and self-regulation (Baumert & Kunter, 2013; Döhrmann et al., 2012). More recent teacher competency models (e.g., Blömeke et al., 2015) have increasingly drawn on the idea that competency also includes situation and domain specific aspects (Klieme & Leutner, 2006; Weinert, 2001). With the perception–interpretation–decision-making (PID) model (Blömeke et al., 2015) leading the way, current models suggest that cognitive and affective-motivational dispositions are modeled along a continuum toward performance through the processes of professional vision, which are at the center of the models (see also Baumgartner et al., 2020; Kaiser et al., 2017; Krauss et al., 2020). Hence, professional vision has been identified as a crucial competency for teachers to apply their knowledge for competent performance in classrooms (Baumgartner et al., 2020; Blömeke et al., 2015; Kaiser et al., 2017; Krauss et al., 2020); additionally, many features associated with teacher expertise are closely related to professional vision (J. Anderson & Taner, 2023; Carter et al., 1988; Sabers et al., 1991). The growing number of literature reviews focusing on professional vision and its development and enhancement (König et al., 2022; Wei et al., 2023; Weyers et al., 2023;

Weyers et al., 2024) through teacher education and professionalization (Amador et al., 2021; Santagata et al., 2021; Santagata et al., 2024) emphasizes its topicality, especially in the field of mathematics.

Professional vision is generally understood as a skill that allows teachers to effectively navigate the complexities of teaching situations effectively and to professionally act in these situations (Dindyal et al., 2021; Sherin et al., 2011); thus, professional vision helps teachers make sense of "the blooming buzzing confusion of sensory data with which they are faced" (Sherin et al., 2011, p. 7) in classrooms. Professional vision is not passive observation or everyday perceptual processing (Sherin et al., 2011). Instead, it is characterized by "a dynamic interplay of top–down and bottom–up processes" (Sherin, 2007, p. 384), meaning teachers use their knowledge and immediate sensory input to make sense of what they see (see also Gegenfurtner, 2020). Therefore, professional vision is considered a knowledge-based process in which the integrated knowledge of theories and concepts (Blömeke et al., 2015; Borko, 2004; Seidel et al., 2010) and its application to specific classroom situations becomes relevant (Berliner, 2001; Sherin & van Es, 2009).

Current discussions on professional vision demonstrate divergent ideas of the specific conceptualization of teachers' professional vision. Systematic literature reviews have suggested that present discussions and investigations around teachers' professional vision encompass four different perspectives: sociocultural perspective, discipline-specific perspective, cognitive-psychological perspective, and expertise-related perspective (König et al., 2022; Santagata et al., 2021; Santagata et al., 2024; Weyers et al., 2023; Weyers et al., 2024). First, the sociocultural perspective draws on the seminal work of Goodwin (1994), proposing that professional vision is socially situated and constructed. He highlighted that professional vision is specific to a particular profession or social group (Goodwin, 1994, p. 606). In the context of research on teaching, the term "professional vision" has been adapted to other perspectives, which do not necessarily include this sociocultural aspect. The discipline-specific perspective coined by Mason (2002) focuses on teacher education and professional development, emphasizing practices that enhance teachers' awareness of and sensitivity to their students' learning and engagement. He outlines the processes of systematically reflecting, recognizing, preparing, noticing, and validating with others (Mason, 2002, p. 95). This discipline-specific perspective also highlights the complex interplay between teachers' experiences, colleagues' insights, classroom sensory inputs, and the teachers' knowledge of classroom dynamics (Mason, 1998). However, the most frequently addressed perspectives are the closely related cognitive-psychological and expertise-related perspectives (König et al., 2022). The cognitive-psychological perspective investigated professional vision as teachers' cognitive processes that occur when teachers observe classrooms (van Es & Sherin, 2002), and the expertise-related perspective mainly involves expert–novice comparisons to identify those features that contrast expert teachers from novices when observing classrooms (Berliner, 2001). The different cognitive processes and expert features that are concerned with professional vision will be addressed in the Articles of this dissertation. The cognitive-psychological perspective, in conjunction with the expertise-related perspective, serve as a theoretical framework for the conceptualization of professional vision, as these two perspectives draw on the current research discourse on teacher competency.

1.1.1 Conceptualization of Professional Vision

The present understanding of the underlying processes of professional vision has been largely informed by cognitive-psychological and expertise-related perspectives (König et al., 2022; Santagata et al., 2021; Weyers et al., 2023). From a cognitive-psychological perspective, various cognitive processes of professional vision have been conceptualized. The underlying processes of professional vision can be grouped into the concepts of *noticing*, *reasoning*, and generating *alternatives of action* (based on the PID model; Blömeke et al., 2015). In their seminal work, van Es and Sherin suggest that professional vision entails the closely interrelated cognitive processes of *noticing* and *reasoning* on relevant classroom events (Sherin, 2007; van Es & Sherin, 2002). Noticing involves "learning to identify what is noteworthy about a particular situation" (van Es & Sherin, 2002, p. 573), which has been suggested to include perceiving (Kaiser et al., 2015), attending (Jacobs et al., 2010; Santagata & Guarino, 2011), detecting (Jamil et al., 2015), or recognizing (Barth, 2017) relevant events. Reasoning entails "the ability to make connections between specific events and the broader ideas they represent" (van Es & Sherin, 2002, p. 574) and "using what one knows about the context to reason about situations" (van Es & Sherin, 2002, p. 574). Based on van Es and Sherin's work, research from the cognitive-psychological perspective has started to investigate the internal structure of professional vision with advanced statistical methods (Gold et al., 2024) such as factor analysis (e.g., Dückers et al., 2022; Gold & Holodynski, 2017; Seidel & Stürmer, 2014) or item response theory (e.g., Bastian et al., 2022; König et al., 2014). Furthermore, many studies have proposed different aspects of reasoning, such as describing (Gold & Holodynski, 2017; Seidel & Stürmer, 2014), interpreting (Gold & Holodynski, 2017; Seidel & Stürmer, 2014), explaining (Dückers et al., 2022; Seidel & Stürmer, 2014), predicting (Seidel & Stürmer, 2014), and evaluating classroom events (Blomberg et al., 2011). Some of these studies have shown that the internal structure of reasoning displays a one-dimensional structure between the facets of describing and interpreting (Gold & Holodynski, 2017; Meschede et al., 2015) or reveals strong correlations between describing, interpreting, and predicting (Seidel & Stürmer, 2014). Although noticing and reasoning are generally considered conceptually distinct, they are suggested to interact in a dynamic interplay (i.e., the relevant events that teachers notice influence their reasoning, and their reasoning also affects what they notice; Santagata & Yeh, 2014) and are hardly distinguishable in teaching practice (Sherin, 2007).

In addition to noticing and reasoning, some frameworks have incorporated an action-oriented cognitive process of professional vision. However, systematic literature reviews have identified only a limited number of studies that address these action-oriented cognitive processes, which clarifies the issue of why many heterogeneous conceptualizations of this action-oriented process can be found in the literature. The spectrum stretches from shaping new opportunities for noticing and reasoning on classroom events (van Es & Sherin, 2024), decision-making (Blömeke et al., 2015; Jacobs et al., 2010), explained decision-making (Barth, 2017), and evaluating (Dückers et al., 2022) to generating alternatives of action (Barth, 2017; Dückers et al., 2022; Junker et al., 2020) or suggesting improvements (Kersting et al., 2012). In the context of teacher education, most studies implement a rather theoretical operationalization of the action-oriented process in their frameworks (Dückers et al., 2022; Junker et al., 2020). For example, Dückers et al. (2022) show that the combination of evaluating classroom events and generating alternatives of action by naming them, giving explanations, discussing them, and providing adequate terminology is an action-oriented process of professional vision. Student teachers can learn to apply their knowledge to discuss different courses of action and explain their decision-making processes (Shulman, 1986), which are closely related to the evaluation of classroom events (Bromme, 1992). Generating alternatives of action is also closely linked to classroom performance, as it precedes actual decision-making in the classroom (Blömeke et al., 2015), thereby serving as a critical connection between reflecting on practice and taking action (Santagata & Guarino, 2011).

Many studies from an expertise-related perspective have linked their research to findings by Berliner and his research group (e.g., Stahnke & Blömeke, 2021; Wolff et al., 2015), which exhibits strong parallels to professional vision. By integrating findings from general expertise research into the study of teacher expertise, Berliner (2001, 2004) and his research group's work (Carter et al., 1988; Sabers et al., 1991) can be considered foundational, serving as "precursors" to later research on teachers' professional vision (Lachner et al., 2016, p. 198). Evidence from an expertise-related perspective suggests that expert teachers demonstrate certain expert features that differentiate them from novice teachers when noticing and reasoning on classroom situations (Berliner, 2001; Stahnke & Blömeke, 2021; Wolff et al., 2017; Wolff et al., 2015) and support them in analyzing classrooms more productively (Santagata et al., 2007). Evidence from an expertise-related perspective on professional vision can be roughly categorized into four features that distinguish expert teachers from novices when they observe classrooms.

First, based on their knowledge and experience (Carter et al., 1987), expert teachers possess organized, integrated, and interconnected *schemata and scripts* that are easily accessible, relating to concepts relevant to teaching, such as teaching quality (J. Anderson & Taner, 2023; Berliner, 2001; Wolff et al., 2021). Berliner postulates that "expert teachers perceive more meaningful patterns in the domain in which they are experienced" (Berliner, 2001, p. 472). These patterns or concepts enable expert teachers to quickly perceive, predict, categorize, evaluate, and reflect on relevant events and relate them to abstract categories (Berliner, 2001; Tsui, 2013). Contrastively, novice teachers lack these cognitive schemata, scripts, and classroom experience, and they must build a conceptual understanding of teaching (Berliner, 2004). Novice teachers consequently analyze classrooms superficially and focus on irrelevant aspects (e.g., seating arrangements) (see also Stahnke & Blömeke, 2021; Wolff et al., 2015). Hence, expert teachers' knowledge, in contrast to novices, is flexibly and effectively organized to support the cognitive processes of noticing and reasoning, reinforcing the notion that professional vision is a knowledge-based competency.

Second, expert teachers *focus on student learning and engagement* instead of classroom disruptions or students' off-task behaviors (J. Anderson & Taner, 2023; Sherin & van Es, 2009; Wolff et al., 2017; Wolff et al., 2015). Expert teachers focus on the way that students interact with the task at hand, whereas novices focus on students' superficial activity levels (Carter et al., 1988). Moreover, expert teachers use information on individual students, whereas novices emphasize general features of the classroom (Berliner, 2001; Calderhead, 1981; Carter et al., 1988), such as the noise level. Instead of focusing on teachers' actions, as novices typically do, expert teachers predominantly include students' actions in their considerations (Sabers et al., 1991). Research indicates that when teachers analyze student thinking and accordingly tailor their instruction, student achievement can improve (see Carpenter & Fennema, 1992; Kersting et al., 2012); thus, the focus on student learning and engagement is an important aspect of teacher expertise. When teachers concentrate on student engagement and learning, they can better understand the factors that influence their behavior and learning and develop potential strategies for enhancing both (Simonsen et al., 2008).

Third, expert teachers go beyond simply describing situations; they draw inferences based on their observations (Berliner, 2001; Stahnke & Blömeke, 2021; Wolff et al., 2017; Wolff et al., 2015). Evidence indicates that expert teachers make assumptions about cognitive and affective states of both students and teachers (e.g., Wolff et al., 2015). Expert teachers are skilled in predicting student learning and behavior and anticipating the progression of lessons (Carter et al., 1988; Stahnke et al., 2016; Wolff et al., 2015). Additionally, they justify their inferences by clearly explaining their ideas (Copeland et al., 1994; Wolff et al., 2015). By contrast, novice teachers tend to describe classroom events without drawing inferences or interpreting the situations. Instead, they often offer simplistic interpretations that disregard the progression of the lesson (Carter et al., 1988; Sabers et al., 1991; Wolff et al., 2015), which results in a superficial understanding of classroom dynamics.

Fourth, expert teachers can *take multiple perspectives* of students and teachers (Stahnke & Blömeke, 2021; Wolff et al., 2017; Wolff et al., 2015). Expert teachers have demonstrated an ability to incorporate various viewpoints from both students and teachers into their deliberations, whereas novice teachers often focus on only one singular perspective (Hogan et al., 2003; Stahnke & Blömeke, 2021; Wolff et al., 2015). By including multiple perspectives in their analyses, experienced teachers better understand the different needs of the students involved, enabling them to make informed decisions about their actions (Goeze et al., 2014; Könings et al., 2014).

Models of teaching competency suggest that these cognitive processes and expert features of professional vision are indicators of teachers' applicable and integrated knowledge (Baumgartner et al., 2020; Blömeke et al., 2015; Kaiser et al., 2015; Krauss et al., 2020). Supporting this idea, research has shown that professional vision is a crucial aspect of teaching competency (König et al., 2022; Santagata et al., 2021), with studies revealing positive correlations with various outcomes, including teaching quality, student learning, and academic achievement (Blömeke et al., 2022; Kersting et al., 2012; Roth et al., 2011; Stahnke et al., 2016). Given that implementing teaching quality has been identified as a key task of teaching (Baumert & Kunter, 2013), the focus on teaching quality plays a vital role when observing and analyzing classroom situations, which is explained in the subsequent sections.

1.1.2 Foci of Teaching Quality in Professional Vision

Professional vision is often regarded as a situated skill that is specific to certain situations (Blömeke et al., 2015), thereby highlighting the deeply contextual nature of teaching expertise. Many situations in the teaching profession relate to events that are relevant to teaching quality. Implementing teaching quality has been identified as a central task for teachers

(Baumert & Kunter, 2013), as research has underscored that many aspects of teaching are related to teaching quality (e.g., establishing and enforcing rules, implementing cognitively activating tasks, or encouraging students) (Brophy, 2000; Hattie, 2008; Helmke & Schrader, 2009; Seidel & Shavelson, 2007). Although the terminology used to conceptualize the teaching quality dimensions varies across the literature, the dimensions consistently pertain to aspects of classroom management, instructional support, and emotional support. (Kunter, Klusmann, et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018). For example, Pianta and Hamre (2009) conceptualized teaching quality comprising the dimensions of classroom organization, instructional support, and emotional support. The three basic dimensions framework by Praetorius et al. (2018), which is popular in German-speaking countries, similarly consists of the dimensions of classroom management, cognitive activation, and individual student support. Many of these frameworks have been investigated in the context of mathematics classrooms and more recent models have shown that the dimensions can also be transferred to other subjects (Praetorius et al., 2020). Although these frameworks do not fully consider subject-specific aspects that are largely found in the dimension of instructional support, their broad focus and thus their economic and easy applicability make them an adequate framework for teacher evaluation or research purposes because they focus on teaching quality at a broad level (Charalambous & Praetorius, 2018; Schlesinger & Jentsch, 2016).

Classroom Management

Studies on professional vision focusing on classroom management have based their conceptualizations on classic research on effective classroom management (Dückers et al., 2022; Gold & Holodynski, 2017). Noticing and reasoning on situations related to classroom management is crucial for effective classroom management (Wolff et al., 2021) and mainly trigger the general pedagogical knowledge of teachers (Shulman, 1986, 1987). Situations related to classroom management include "the actions teachers take to create an environment that supports and facilitates both academic and social-emotional learning" (Evertson & Weinstein, 2006, p. 4) and securing time for student learning (Brophy, 1979; Emmer & Stough, 2001). Effective classroom management has been shown to contribute to students' learning, motivation, and emotions (Korpershoek et al., 2016; Kunter, Baumert, et al., 2013).

In his seminal work, Kounin (1970) suggested that actions of classroom management entail preventive rather than reactive strategies. These strategies have been confirmed to be effective (Korpershoek et al., 2016) and predict student achievement (Kyriakides et al., 2013). First, the establishment and enforcement of *rules*, which are "statements that teachers present to describe acceptable or unacceptable behavior" (Alter & Haydon, 2017, p. 115), and *routines*, which are "fluid, paired, scripted segments of behavior that help movement toward a shared goal" (Leinhardt et al., 1987, p. 136), can provide students with clear transparency about the lesson's procedure (Klieme et al., 2009). Establishing and enforcing rules and routines may include explicitly teaching them, providing clear examples and counterexamples of appropriate behavior, explaining the function of the established rules and routines, and outlining the associated reinforcements and consequences associated (Alter & Haydon, 2017). Another preventive strategy is *monitoring* the classroom to gain valuable information on students' engagement and attention (van Tartwijk et al., 2009; Wubbels et al., 2006). Studies using eye-tracking methodology (for a meta-analytic literature review, see Keskin et al., 2024) have indicated that expert teachers can evenly distribute their gaze across the entire classroom. Monitoring strategies relate to the gaze distribution of teachers and their adequate position within the classroom (Simonsen et al., 2008). These strategies convey to students that the teacher is attentive to everything that occurs in the classroom (withitness, Kounin, 1970) while allowing the teacher to simultaneously manage multiple activities (overlapping, Kounin, 1970). This approach maintains the smooth progression of the lesson promptly and seamlessly (Witt et al., 2004). Furthermore, upholding the *group focus* and implementing *group mobilization* can support students' engagement and attention (Kounin, 1970; Leflot et al., 2010). Related situations entail securing students' attention and engagement by increasing the scope of persistent participation (e.g., through interdependent group work; group focus), encouraging students to engage with the material and participate in classroom discussions (group mobilization), and holding students accountable for their learning (Kounin, 1970). Another effective preventive strategy is *managing momentum*. This strategy involves teachers skillfully coordinating time, ensuring smooth transitions between activities, and adapting the lesson pace to align with students' learning and attention levels, which allows teachers to maintain student engagement (Charles, 2013; Kounin, 1970). The critical components of this strategy include using activity signals, providing clear instructions for upcoming tasks, ensuring that students understand the lesson's objectives (Doyle, 2006), preparing the classroom, and gathering the necessary materials before the lesson begins (Evertson & Emmer, 2012). More recent literature has identified the establishment of positive student-teacher relationships as a facet of effective classroom management (van Tartwijk et al., 2009; Wubbels et al., 2006), highlighting the socio-emotional aspects of Evertson and Weinstein's definition of classroom management (Evertson & Weinstein, 2006, p. 4). However, many frameworks of teaching quality have conceptualized this facet as part of the dimension of emotional support (e.g., Pianta & Hamre, 2009; Praetorius et al., 2018); therefore, this aspect will be elaborated in more depth later in the dissertation.

Finally, classroom disruptions sometimes occur despite these preventive strategies, and teachers have to resort to reactive strategies. Effectively *dealing with disruptions* is therefore another facet of effective classroom management. Situations where teachers effectively handle classroom disruptions may involve ignoring minor inappropriate behavior and proceeding with the lesson or deciding to intervene and address the disruptive behavior (Doyle, 2006; Ophardt & Thiel, 2017).

Teachers typically do not address these aspects of classroom management in isolation; instead, they skillfully integrate them. Therefore, this dissertation conceptualizes teachers' professional vision of classroom management as their ability to notice and reason on situations related to teachers introducing and enforcing rules and routines, monitoring the classroom, establishing a group focus and group mobilization, and appropriately dealing with disruptions. These processes enable teachers to generate effective alternatives of action for successful classroom management.

Instructional Support

Professional vision of instructional support primarily triggers teachers' content knowledge and pedagogical content knowledge (Shulman, 1986, 1987); moreover, it has been shown to positively influence the implementation of adequate instruction (Kersting et al., 2012; Roth et al., 2011) as well as student learning and achievement (Kersting et al., 2012). Teachers' ability to notice and reason on effective instructional strategies (i.e., adequate tasks and implementation strategies) is considered a crucial component of teacher expertise (Jamil et al., 2015). Classroom situations associated with instructional support typically include cognitive learning activities that consider the cognitive prerequisites of learners and encourage them to engage in challenging cognitive activities that align with learning goals (Leuders & Holzäpfel, 2011). The teaching quality dimension of instructional support is generally considered a relatively recent construct (Lipowsky, 2009, p. 92); hence, research still disputes its conceptualization and operationalization (Schreyer, 2024). Studies on professional vision focusing on instructional support use constructivist theories and concepts from research on teaching and learning as a foundation for their theoretical frameworks (e.g., Seidel & Stürmer, 2014; Todorova et al., 2017). Cognitive-constructivist theories suggest that learners' active examination of their environment should be at the center of learning (Piaget, 1976). However, teachers can support and facilitate this examination by providing adequate problems and questions (Aebli, 1983). Social-constructivist theories propose that learning transpires through the exchange of ideas and opinions through which knowledge is generated, altered, and internalized by individual learners (Vygotskij, 1986; Woolfolk et al., 2008). Derived from these theoretical assumptions, teachers cannot directly control student learning and cognitive processing; they can offer cognitively activating learning environments and tasks that students have to make use of (Helmke, 2014). Hence, instructional support cannot be understood as the cognitive activity of students but rather as an intentional pedagogical act of a teacher to direct learners' activities toward the learning content (Niederkofler & Amesberger, 2016). Thus, instructional support primarily entails activities that enhance meaningful, active, and focused learning, in contrast to behavioral activities of attention and engagement (Meyer, 2003; Renkl, 2009). Therefore, situations related to teachers' implementation of instructional support in the classroom include teachers promoting deeper reflection among students and fostering a more comprehensive engagement with the subject matter (Lipowsky, 2009; Lipowsky et al., 2009). Furthermore, teachers should encourage learners to actively engage with the learning content at a level that is suitable for their individual needs (Leuders & Holzäpfel, 2011).

Strategies of instructional support mainly involve the selection of specific tasks by the teacher, as well as the organization and implementation of these tasks in the classroom (Fauth et al., 2014; Kunter, Klusmann, et al., 2013; Pianta & Hamre, 2009), which have been shown to contribute to student learning and achievement (Fauth et al., 2014; Lipowsky et al., 2009), interest (Klieme & Clausen, 1999; Moser et al., 1997), as well as engagement and self-efficacy (Moser et al., 1997). *Cognitively activating task*s are characterized by complex problem-solving activities with interconnected elements that offer many possible solution strategies. These tasks often trigger learners' problem-solving processes, create cognitive conflict, and elicit learners' prior knowledge to apply it in new contexts and situations (Kunter, Klusmann, et al., 2013; Lotz, 2015). Effective strategies for teachers organizing and implementing these tasks include several key aspects (based on Kunter, Klusmann, et al., 2013; Lotz, 2015). First, eliciting students' *prior knowledge* is important to enable them to integrate new information into their existing knowledge base (Hasselhorn & Gold, 2009), which, for example, can be achieved through discussions around students' prior knowledge and personal experiences. Second, teachers should *explore students' thoughts and ideas* to understand their perspectives (Staub & Stern, 2002). Third, teachers can work with *students' contributions* to build on their understanding (derived from Woolfolk et al., 2008). Fourth, asking students to *explain their ideas and solution strategies* is essential, fostering deeper comprehension (Staub & Stern, 2002). Fifth, the lesson should aim to support *students' cognitive independence*, allowing them to think critically and independently (Baumert et al., 2011).

Based on these theoretical deliberations, this dissertation defines teachers' professional vision of instructional support as their capability to notice and reason on situations related to teachers implementing cognitively activating tasks, eliciting students' prior knowledge, exploring students' thoughts and ideas, incorporating students' contributions, demanding explanations, and fostering students' cognitive independence. Thereupon, teachers can develop effective alternatives of action for providing students with instructional support.

Emotional Support

Professional vision of emotional support predominantly triggers teachers' pedagogical-psychological knowledge (Shulman, 1986, 1987). Emotional support includes teachers promoting students' emotional well-being by creating a warm, safe, and connected environment characterized by high-quality interactions with both teachers and fellow students (Danielson, 2011). Emotional support in student–teacher interactions plays a key role in enhancing students' social and emotional development and learning (Brekelmans et al., 2005; Pianta & Hamre, 2009). Teacher emotional support has also been shown to increase student motivation and engagement (Reyes et al., 2012; Roorda et al., 2011; Ruzek et al., 2016) and contribute to academic achievement (Roorda et al., 2011). It plays a pivotal role in fostering and establishing an environment where students can thrive emotionally and academically.

Research on emotional support primarily draws on social behavioral theories, such as attachment theory (Ainsworth, 1978) and interpersonal theory (Horowitz & Strack, 2010), as well as motivational theories such as self-determination theory (Deci & Ryan, 1980). According to social-behavioral theories, the dynamics of student–teacher relationships are characterized by a combination of teacher authority and care. This perspective also recognizes the interrelated actions of students and teachers within the classroom (Pianta, 2007; Wubbels et al., 2006). Derived from social behavioral theories, emotional support in educational settings consequently involves fostering meaningful interactions between students and teachers (Jennings & Greenberg, 2009). Further, self-determination theory (Deci & Ryan, 1980) asserts that individuals strive to meet their basic needs by autonomously acting within a social context, feeling competent in that environment, and feeling connected with others. Thus, if teachers support students' basic needs for autonomy, competency, and social relatedness in the classroom, then such actions can create to positive emotional experiences and enhance emotional support (Niemiec & Ryan, 2009).

One strategy for teachers to implement emotional support in classrooms is to show genuine *respect* for students' views and emotions (Quin, 2017). Conveying respect towards the students can be achieved by teachers recognizing and appropriately addressing students' interests, concerns, and questions (Downer et al., 2010). Another strategy for providing emotional support is for teachers to *encourage students* (Rakoczy et al., 2008) in challenging situations and to show *sensitivity and empathy* (Pianta et al., 2008; Rakoczy et al., 2008). A sensitive and responsive relationship between students and teachers forms the foundation for positive interactions in the classroom (Pianta et al., 2008). In addition, from an instructional perspective, teachers can support students' learning processes by providing constructive feedback. However, from an emotional perspective, *constructive feedback* can motivate students to actively engage in the lesson (Deci & Ryan, 1980). This can be achieved by providing future-oriented corrective scaffolds for addressing shortcomings in a kind and supportive manner (Kobarg & Seidel, 2007; Rakoczy & Pauli, 2006). Another emotional support strategy involves teachers establishing a *positive error culture* in the classroom (Steuer & Dresel, 2015). When students are worried about making mistakes, they are less likely to actively engage with the lesson content (Turner et al., 1998). Therefore, an environment where students can openly express their thoughts and mistakes are welcome can emotionally support students within classrooms.

Hence, this dissertation defines teachers' professional vision of emotional support as their capability to notice and reason on situations related to teachers respecting students' emotions and opinions, encouraging students in challenging situations and expressing sensitivity, providing constructive feedback, and establishing a positive error culture. Thereupon, teachers can generate effective alternatives of action for emotional support.

Professional Vision of Teaching Quality

Classrooms are highly complex and multidimensional, which explains why several situations can become relevant at the same time. Most studies investigating professional vision have focused on only one teaching quality dimension (classroom management: Gold & Holodynski, 2017; instructional support: Meschede et al., 2015; emotional support: (Keppens et al., 2019) [in the context of inclusive education]). Similarly, the categories of teachers' professional knowledge have been shown to be empirically and conceptually separable (Baumert & Kunter, 2013; Döhrmann et al., 2012). However, in the multidimensionality, simultaneity, immediacy, unpredictability, and complexity of real-life classrooms (Doyle, 2006), teachers have to be able to focus on all teaching quality dimensions and use different categories of knowledge (Dunekacke, 2016). Evidence has shown that expert teachers can simultaneously observe and analyze relevant events, whereas student teachers typically focus on only one situation, usually related to classroom disruptions (Sabers et al., 1991). This happens because of expert teachers' increased automaticity when observing classroom situations and linking them to abstract concepts (Berliner, 2001). Hence, expert teachers have been shown to be able to *simultaneously focus* on various classroom situations that are relevant to student learning (derived from Sabers et al., 1991). Initial evidence has also indicated that expert teachers integrate different foci of teaching quality when observing classrooms (Blömeke et al., 2016). Therefore, current research debates whether professional vision is a focus-specific or a focus-integrated skill. Divergent findings have either conceptualized professional vision as a focus-specific construct, in which the foci on the different teaching quality dimensions are differentiated (Dückers et al., 2022; Steffensky et al., 2015) or a focus-integrated construct, in which the foci on the different teaching quality dimensions are integrated (Blömeke et al., 2016; Seidel & Stürmer, 2014). Nevertheless, research on teacher expertise has considered integrated knowledge as an indicator of both teacher expertise (Berliner, 2001) and an indicator of applicable knowledge (Blömeke et al., 2022). The simultaneous focus on the teaching quality dimensions may therefore support the integration of different categories of teachers' professional knowledge and thereby prevent 'inert knowledge' (Renkl et al., 1996) and foster action-oriented knowledge (Kersting et al., 2012).

Evidence that established positive associations between teachers' professional vision and the implementation of teaching quality (Blömeke et al., 2022; Roth et al., 2011) supported the assumption of the PID model (Blömeke et al., 2015) that the processes of professional vision form a crucial part of teaching competency to design and implement learning environments for effective student learning. Therefore, professional vision is an important competency to acquire for teachers. Given the frequent critiques on the ineffectiveness of teacher education, the questions arise regarding how professional vision develops and how it can be enhanced throughout teacher education.

1.2 Professional Vision and Teacher Education

As teacher competency is generally considered learnable (Klieme & Leutner, 2006; Weinert, 2001), teacher education has been ascribed a crucial role in its development and enhancement (Darling-Hammond, 2000; Kennedy et al., 2008). Research commonly agrees that if teacher education is effectively organized in terms of time, content, and courses, then it can support the development of teacher competency (Feiman-Nemser, 2001). The development and enhancement of professional vision is critical as teacher education cannot equip future teachers with a one-size-fits-all approach for every classroom scenario. By learning to observe and analyze classroom situations in teacher education, future teachers can develop professional vision, thereby enabling them to understand fundamental concepts and principles and flexibly apply them to classroom situations, providing a strong foundation for their future performance in the classroom (Korthagen, 2004). Currently, there are two main research strands investigating professional vision in the context of teacher education. The first strand examines how professional vision develops throughout the different phases of teacher education, and the second strand investigates how training can enhance future teachers' professional vision. These two research strands are the topic of the next sections of this dissertation.

1.2.1 Development of Professional Vision

The first strand of research investigates how professional vision develops throughout teacher education. Current research discourse on the development of professional vision has drawn on prominent models on the development of teacher expertise (Berliner, 1988; Gegenfurtner, 2020) and the development of teacher competency in teacher education (Kaiser & König, 2019; Kunter, Klusmann, et al., 2013; Yang & Kaiser, 2022). Research on the development of teacher expertise highlights experience as a key factor (Berliner, 2004; Gegenfurtner, 2020). Particularly important is the model by Berliner (1988), who transferred the model of the development of expertise by Dreyfus and Dreyfus (1986) to the teaching context. Berliner suggested five stages of expertise development: novices, advanced beginners, competent teachers, proficient teachers, and expert teachers. In this model, novice teachers are suggested to need to learn the essential concepts of teaching that will support their future practice. Advanced beginners can recognize similarities across different contexts but struggle to distinguish what is truly important. Both novice and advanced beginner teachers often lack a sense of responsibility for the impact of their actions on student learning (Berliner, 1988). By contrast, competent teachers make informed decisions and develop a stronger sense of accountability, although they may still lack fluidity and flexibility. Proficient teachers gain "an intuitive sense of the situation" (Berliner, 1988, p. 4), allowing them to predict classroom events more accurately, albeit in a conscious manner. At the expert stage, teachers demonstrate "arational" (Berliner, 1988, p. 5) behavior, instinctively responding to situations without analytical thought and merely reflecting on their actions when challenges arise. This development of expertise is suggested to evolve through experience in combination with continuous deliberate practice (Ericsson et al., 1993) by connecting knowledge with practice and processes of reflection. Therefore, the development is not linear; instead, it unfolds in a cyclical manner, characterized by phases of plateauing, changing, and solidifying competencies (Berliner, 2004).

In connection with this, research investigating the determinants that affect this development has placed learning opportunities at the center of their theoretical models (Kaiser & König, 2019; Kunter, Klusmann, et al., 2013; Yang & Kaiser, 2022). These models highlight the importance of learning opportunities in teacher education next to institutional characteristics, individual prerequisites, processes, and outcomes. In the context of teacher education, learning opportunities address aspects of general pedagogy, subject-specific content, and pedagogical content (Kaiser & König, 2019; König, Bremerich-Vos, et al., 2017), and they can be theoretical (e.g., seminars addressing theoretical concepts) or practical (e.g., actual teaching practice at school). Research shows clear evidence in different teacher education phases (e.g., Blömeke et al., 2008; Klemenz et al., 2019; König, Ligtvoet, et al., 2017) and in longitudinal developments (e.g., König et al., 2024) that learning opportunities significantly contribute to competency development. Therefore, learning opportunities are considered one of the most important factors for teachers' competency development in teacher education.

As the studies of this dissertation were conducted in Germany, the two-phase model of the German teacher education system and the way that learning opportunities are embedded within the model are briefly explained (Cortina & Thames, 2013). In the first phase, student teachers pursue a bachelor's and a master's degree, primarily attending theoretical subject-specific seminars and a few pedagogical ones (Terhart, 2021). In some federal states, student teachers may complete a school internship to observe teaching and gain initial teaching experience, complemented by university seminars for reflection (König, 2019). In the second phase, pre-service teachers engage in an induction program led by experienced teachers in state-organized *Studienseminare*. This program aims to link practical experiences and observations with theoretical knowledge, promoting reflection while mentors provide additional support (Eckhardt, 2021). Different learning opportunities are offered to develop and enhance teacher competency within this two-phase teacher education system. Learning opportunities should impart fundamental concepts about teaching and learning, connect them to classroom situations, and provide opportunities to reflect on situations encountered in teaching practice. Hence, an essential task of teacher education is to provide future teachers with learning opportunities that are intentional and aimed at acquiring necessary qualifications (e.g., a master's degree in teacher education). Many of these learning opportunities include theoretical seminars, where future teachers can discuss theoretical concepts, practice them in a safe environment, and reflect on them with their peers (Laschke & König, 2014). Furthermore, future teachers also encounter learning opportunities that do not follow formal standards and that emerge from specific situations, such as teaching situations in schools. In these learning opportunities, processes of reflection have been assigned a crucial role in teachers' competency development (Bastian, König, et al., 2024; Schlag & Glock, 2019; Weber et al., 2018). Many practical learning opportunities involve practical experiences where student teachers can observe concepts, apply them in real classroom settings, and reflect on their experiences with supervisors or mentors (Laschke & König, 2014).

Interest in the investigation of the development of professional vision throughout teacher education has recently increased. Overall, findings of cross-sectional comparisons between the teacher education phases demonstrate that with growing experience, teachers gain more professional vision (König et al., 2022; Stahnke et al., 2016). Specifically, these findings suggest that novices, in contrast to expert teachers, have difficulty noticing and reasoning on relevant classroom events and, as a result, struggle to generate appropriate alternatives for action (Stahnke et al., 2016) (see also Chapter 1.1.1). This premise aligns with the assumption by Berliner (1988) that growing experience results in increasing expertise. Specifically related to the first and second teacher education phases, research has frequently compared bachelor and master student teachers. Although not consistently replicable, studies generally showed that master student teachers displayed higher professional vision than bachelor student teachers (Gold & Holodynski, 2017; Meschede et al., 2015; Seidel & Stürmer, 2014). More recent cross-sectional studies supported these findings by showing stagnations in (future) teachers' professional vision when entering teaching practice (Bastian, Kaiser, et al., 2024; Bastian et al., 2022). Initial longitudinal studies found significant increases in professional vision throughout the bachelor's (Eßling et al., 2023) and master's studies (Barenthien et al., 2023; Orschulik, 2021). Only a limited number of longitudinal studies have explored developments in professional vision throughout the first and second phases of teacher education. A first longitudinal study indicates stagnation in the development of professional vision during the induction program (Barenthien et al., 2023). This finding aligns with the assumption by Berliner (1988; Berliner, 2004) that teacher expertise does not develop linearly but experiences plateaus, transformations, and solidifications. This initial longitudinal study addresses professional vision of instructional support, which predominantly draws on content and pedagogical content knowledge. A recent study on the development of general pedagogical knowledge has replicated the stagnation in the induction program (König et al., 2024). To the best of my knowledge, a longitudinal study that explicitly investigates the development of professional vision of classroom management is missing.

Regarding the effect of learning opportunities, research has revealed that the amount of content studied (i.e., in theoretical learning opportunities such as seminars) and the amount of teaching experience (i.e., practical learning opportunities) predicts competency development (Blömeke et al., 2017; König, Ligtvoet, et al., 2017; König & Rothland, 2018). However, findings specifically related to professional vision were somewhat inconsistent (Bastian, König, et al., 2024; Stürmer, Könings, & Seidel, 2015; Stürmer, Seidel, & Kunina-Habenicht, 2015; Todorova et al., 2017). Studies were primarily conducted in the first teacher education phase, and some revealed evidence for a positive effect of theoretical learning opportunities (Stürmer, Könings, & Seidel, 2013; Todorova et al., 2017) but some others also for practical learning opportunities (i.e., school internships or teaching experience) on professional vision (Mertens & Gräsel, 2018; Orschulik, 2021; Stürmer, Seidel, & Schäfer, 2013). The only study investigating the effect of learning opportunities in the second teacher education phase indicates that theoretical learning opportunities in the induction program do not affect professional vision (Stürmer, Seidel, & Kunina-Habenicht, 2015). Studies investigating the effect of learning opportunities in the second teacher education phase on the development of professional vision are missing. Investigating the longitudinal effect of practical and theoretical learning opportunities becomes even more important as research has recently considered the combination and alignment of theoretical and practical learning opportunities to be relevant for competency development (König, Bremerich-Vos, et al., 2017; König et al., 2018; Orschulik, 2021; Westphal et al., 2018). Furthermore, most evidence on learning opportunities stems from future teachers' self-reports on the length and number of learning opportunities (Stürmer, Könings, & Seidel, 2015; Todorova et al., 2017). However, research has also shown that aside the quantity or the length of learning opportunities, their quality is essential for competency development (Klemenz et al., 2019). To this date, not much is known about the learning opportunities or the direct correlation between the content covered in these learning opportunities and the development of competencies (König, 2012; Westphal et al., 2018). Initial evidence indicates that effectively designed learning opportunities have a positive effect on professional vision (e.g., Gold et al., 2021; Stürmer, Könings, & Seidel, 2013) and that the content covered in learning opportunities affects professional vision (Steffensky et al., 2015; Stürmer, Könings, & Seidel, 2013). However, research on how to implement theoretical and practical learning opportunities throughout teacher education to effectively enhance competency development remains unclear. Conclusively, our understanding of how learning opportunities in teacher education influence the development of professional vision throughout teacher education is still in its early stages.

In sum, existing research proposes that the development of professional vision may be influenced not only by the demands and characteristics of the particular teacher education phase but also by the quality and quantity of learning opportunities. Overall, higher expertise levels are associated with higher levels of professional vision. However, in line with the assumption by Berliner (2004) that teacher expertise does not develop linearly, initial findings reveal inconsistencies in the development of professional vision, specifically in the transition from the first to the second phase of teacher education. Moreover, although learning opportunities are ascribed a crucial role in teacher education, the way they affect future teachers' professional vision development remains somewhat unclear. Against this background, this dissertation's initial goal is to investigate how future teachers' professional vision develops throughout teacher education and how different learning opportunities affect this development. The aim is to uncover potential inconsistencies in professional vision development and examine how learning opportunities may contribute to this development.

1.2.2 Enhancement of Professional Vision

The second strand of research on professional vision in teacher education concerns the enhancement of professional vision through adequately designed trainings. Although research on teacher expertise shows that professional vision improves with experience and expertise, its development should be actively enhanced (Sherin & Han, 2004). Nonetheless, teacher education has been frequently criticized for its lack of practical orientation and relevance (Korthagen, 2010). Future teachers often learn theoretical concepts without having the opportunity to draw connections to teaching practice. Thus, many future teachers struggle to relate learned knowledge to teaching practice (Blomberg et al., 2011; Korthagen & Kessels, 1999), resulting in learned knowledge not being accessible when teaching; it remains inert (Renkl et al., 1996). To counteract this issue and make knowledge applicable in future teaching performance, professional vision should be enhanced in learning environments that include dynamic, authentic, and complex contexts. Therefore, research has suggested integrating practice-based learning opportunities in teacher education (Renkl & Nückles, 2006). These practice-based learning opportunities aim to connect knowledge with examples of teaching practice (Borko et al., 2008; Seidel & Thiel, 2017) so that future teachers can learn how to flexibly and rapidly apply their knowledge to teaching situations (Darling-Hammond, 2000; Stürmer & Seidel, 2017).

One of the most famous instructional frameworks in teacher education is The Framework for Teaching Practice in Professional Education, which emphasizes the importance of integrating decompositions, representations, and approximations of practice in teacher education (Grossman, 2021; Grossman et al., 2009). Decompositions of practice refer to learning materials that simplify complex theoretical concepts (e.g., preparatory texts, double-content examples, and step-by-step guides). These decompositions of practice can support future teachers in understanding teaching practice by breaking it down into more manageable parts. Representations of practice involve the use of artifacts (e.g., written cases, lesson plans, classroom videos, audio tracks, and student work products), which allow future teachers to observe actual teaching scenarios. Approximations of practice can mimic authentic teaching experiences and can therefore enable future teachers to practice their professional vision (e.g., case or video-based analysis).

Particularly, the integration of classroom videos as representations of practice in combination with accompanying analysis tasks as approximation of practice and learning materials as decompositions of practice into teacher education has been viewed as a potential remedy against the lack of practical orientation and relevance (Gaudin & Chaliès, 2015; Kang & van Es, 2019). Technological advancements have led to the increasing integration of classroom videos in teacher education (Gaudin & Chaliès, 2015; Krammer, 2020). Authentic classroom videos can display the multidimensionality, simultaneity, immediacy, unpredictability, and complexity of classrooms (Doyle, 1989). Thus, they can provide greater access to actual teaching practice while future teachers still consider them authentic (Roche & Gal-Petitfaux, 2015). For future teachers, the task of video analysis closely approximates the processes of professional vision, specifically noticing, reasoning, and generating alternatives of action during instruction. Video-based analyses allow learners to focus on specific aspects when observing classroom videos, which serve as representations of practice. Additionally, this process encourages future teachers to reflect on what they have noticed to deepen their understanding of those events (Kersting, 2008; Santagata & Angelici, 2010). Therefore, classroom videos have gained increasing attention because of their potential to enhance future teachers' professional vision (Gaudin & Chaliès, 2015; Santagata et al., 2021; Stürmer & Seidel, 2017). Many studies have confirmed the effectiveness of classroom videos in enhancing professional vision by analyzing and discussing them (Santagata et al., 2021). However, research has also emphasized that video-based analyses have to be embedded within adequate instructional settings and accompanied by adequate learning materials to enhance professional vision (Blomberg et al., 2013; Santagata et al., 2021). Therefore, several recommendations for integrating classroom videos into teacher education have been proposed.

Research has highlighted the selection of clear learning goals in conjunction with appropriate frameworks and instructional approaches to video-based analyses (Blomberg et al., 2013; Kang & van Es, 2019). Therefore, many frameworks have proposed ways to enhance professional vision (Frommelt et al., 2019; Goeze et al., 2014; Kumschick et al., 2017; Santagata, 2009). Two main approaches can be distinguished: (1) the cognitive approach, in which introduced theoretical concepts can be illustrated through classroom videos and guide perception when analyzing classroom videos, and (2) the situated approach, in which classroom videos can be used as a starting point for reflection and deliberate practice based on prior knowledge and experience (Roth McDuffie et al., 2014; Santagata et al., 2007; Seidel, 2022;

Seidel et al., 2024). First, classroom videos can be used to illustrate theoretical concepts and later allow future teachers to link concepts to teaching practice to guide their perception (Martin et al., 2023; Seidel et al., 2013). Thus, professional vision can be enhanced through top-down processing and drawing connections between classroom situations. This approach is based on the assumption that future teachers must develop a fundamental understanding of theoretical concepts before they can effectively notice and reason on teaching practice (derived from Berliner, 1988). For example, with the introduction of the concept of monitoring related to classroom management, future teachers' perceptions are guided toward the teachers' positioning and gaze behavior displayed in classroom videos. Second, classroom videos can represent teaching practice for reflection and deliberate practice based on existing knowledge and experience. In this sense, classroom videos provide opportunities for reflection, allowing teachers to gain a deeper understanding of their existing knowledge and strategies. This approach places social contexts, cultures, and interactions at the center of learning (Jacobs et al., 2010; Roth et al., 2011; Santagata et al., 2007; van Es & Sherin, 2008). For example, future teachers can analyze a classroom video and reflect on and refine existing knowledge and experience based on that video and in discussion with other teachers. This approach has been suggested to be more learner-centered and focus more on the application and transfer of professional vision to new classroom situations. Although these two approaches are deemed essential for effectively using classroom videos in teacher education, they lack concrete, evidence-based recommendations for adequately designing learning tasks and additional instructional materials.

Consequently, the two instructional approaches have been implemented throughout teacher education in very diverse and heterogeneous ways. An overarching theory of how to implement video-based analysis throughout teacher education is still missing. In a first step, Seidel (2022; Seidel et al., 2024) emphasized the importance of considering the different phases of teacher education when enhancing professional vision with classroom videos, recognizing the varying goals and demands tied to each phase. For example, novice teachers in the first phase of teacher education still have to acquire fundamental knowledge about theoretical concepts and learn how to observe them in classroom situations, which explains why the cognitive approaches could be more helpful. By contrast, pre-service teachers already acquired some theoretical knowledge at university and had initial teaching experience at school, which they can use when analyzing classroom videos to reflect on them, thereby deliberately practicing their professional vision. In current research, most instructional approaches to enhance professional vision have utilized situated approaches to enhance professional vision throughout teacher education (Santagata et al., 2021). These situated approaches require significant prior knowledge before classroom videos can be effectively analyzed to practice professional vision and reflect on classroom situations. This can be challenging for future teachers as they lack prior knowledge and experience (Stahnke & Blömeke, 2021; Wolff et al., 2015), struggle to relate transfer learned theoretical concepts to teaching practice (Blomberg et al., 2011; Korthagen & Kessels, 1999), and analyze classroom situations rather superficially.

Against this background, it can be inferred that classroom videos combined with video-based analyses can enhance future teachers' professional vision by illustrating theoretical concepts, guided observation, or reflection and deliberate practice. Intervention studies using video-based analyses emphasize the relevance of enhancing future teachers' professional vision: Teachers who conducted video-based analyses could implement teaching quality in classrooms (Kersting et al., 2012; Roth et al., 2011), and their students showed higher degrees of achievement (Kersting et al., 2012). However, clear guidelines on the design of instructional tasks and materials around video-based analyses as well as a theoretical framework for integrating video-based analyses throughout teacher education are still missing. Therefore, the question arises regarding the specific theoretical framework that could adequately inform the design of instructional settings around video-based analyses to support future teachers throughout teacher education to analyze and observe classrooms and develop professional vision.

1.3 Professional Vision and Instructional Principles of Educational Psychology

A promising research area that could more appropriately inform the design of instructional settings to video-based analyses throughout teacher education could be theories and evidence from educational psychology related to instructional design and multimedia learning. Only recently, research on teacher education has explicitly drawn on the theories of educational psychology connected to instruction and learning, such as cognitive load theory (Sweller, 1988; Sweller et al., 2011) or cognitive theory of multimedia learning (Mayer, 2001) when implementing video-based analyses to enhance professional vision (e.g., Farrell et al., 2024; Gabel et al., 2024; Kumschick et al., 2017; Moreno & Valdez, 2007). These theories may effectively inform the design of instructional settings for video-based analyses, as they have identified various approaches that enhance cognitive processing and learning (for an overview, see Mayer & Moreno, 2003; Paas et al., 2004). At the same time, these theories suggest that learners' prior knowledge influences cognitive processing and learning; hence, they can guide the design of instructional settings to video-based analyses for different phases of teacher education.

Cognitive load theory and cognitive theory of multimedia learning aim to explain how cognitive load induced by learning tasks or multimedia influences knowledge construction and learning achievement. Learning is generally assumed to transpire through an interaction of long-term memory and working memory. The fundamental premise is that working memory has limited capacity (Baddeley, 1992; Cowan, 2001) and a restricted duration (L. Peterson & Peterson M. J., 1959) so that learners can only hold a certain amount of information for a limited amount of time in their working memory. In both theories, different types of cognitive load compete for limited working memory capacity during learning. First, intrinsic load refers to the complexity of the learning content and the amount of information that must be processed simultaneously (i.e., element interactivity; Sweller, 1988). Intrinsic load is influenced by prior knowledge stored in long-term memory, as sufficient prior knowledge allows multiple elements to be connected and processed as a single, cohesive unit (Sweller, 1988). This, in turn, decreases element interactivity and reduces intrinsic load. Second, germane load is related to learning itself, resulting from cognitive and metacognitive learning activities and knowledge construction. The goal of germane load is to enhance schema construction by increasing the number and scope of complex schemata (Ericsson & Charness, 1994). In current conceptualizations, cognitive load theory considers germane load to be a component of intrinsic load, as it pertains to the working memory capacities allocated to managing intrinsic load (Sweller et al., 2019). In sum, working memory capacity is determined through characteristics of the learning task and available prior knowledge in long-term memory. Third, extraneous load is generally considered irrelevant to learning and emerges through the design of learning tasks and materials (Sweller, 1994). Extraneous and intrinsic load are considered additive and compete for working memory capacity (Sweller et al., 2011). Cognitive theory of multimedia learning (Mayer, 2001) has extended cognitive load theory to learning with multimedia materials, predominantly related to text–picture integration. This theory suggests that when learners engage with multimedia materials, their working memory can quickly become overloaded by excessive demands on both auditory and visual channels (see dual-channel assumption; Clark & Paivio, 1991). Therefore, fundamental to both theories is the proposition that the extraneous load of learning tasks and learning materials has to be reduced to free the cognitive capacities for learning, especially when intrinsic load is high.

Based on these assumptions, when learners deal with highly complex learning content, a carefully considered instructional design that reduces extraneous load and enhances learning is particularly important (van Merriënboer & Sweller, 2005). Therefore, instructional design research has proposed several instructional principles that decrease extraneous load and improve learning. The next section elaborates on these instructional principles.

1.3.1 Instructional Principles

According to cognitive load theory and cognitive theory of multimedia learning, learning tasks and materials should be effectively designed to promote learning. This design can be achieved by considering instructional principles derived from these theories. Instructional principles derived from cognitive load theory and cognitive theory of multimedia learning include worked examples, gradually fading support, isolating learning contents, prompting self-explanations, pre-trainings, and others (for an overview, see Sweller et al., 2019; Mayer & Moreno, 2003). Numerous experiments conducted in various research centers worldwide, using differing materials and participant groups, have confirmed the effectiveness of instructional principles. The basic assumption of these principles is that learners' attention must be shifted away from processes unrelated to learning and focused on those processes that are relevant to learning (van Merriënboer, 1997). For example, research on example-based learning has shown that implementing worked examples can focus learners' attention on the necessary solution steps to solve a problem (i.e., reducing extraneous load), thereby enabling learners to derive general principles for solving other problems from these examples (i.e., enhancing learning) (Sweller & Cooper, 1985).

Most findings for the effectiveness of instructional principles (e.g., worked examples, isolated instruction) have been found for well-structured domains such as mathematics or statistics. However, instructional principles are not universally effective and must be thoughtfully adapted to fit the specific contexts and objectives. Therefore, research has increasingly discussed how to transfer these findings to ill-structured domains such as training argumentation skills, diagnosing processes, or teacher education (Jonassen, 2000; Renkl et al., 2009). In well-structured domains, learners can apply systematic knowledge when solving well-defined problems with clear solution paths (Simon & Newell, 1971). Contrastively, ill-structured domains are characterized by multi-faceted problems with high complexity (Jonassen, 2000), in which the different categories of knowledge become relevant. Initial studies have yielded inconsistent findings. Some studies found beneficial effects of instructional principles on competencies in ill-structured domains (e.g., Harr et al., 2014, 2015; Lechner et al., 2024; Rourke & Sweller, 2009; Udvardi-Lakos et al., 2024), whereas other studies have reported inconsistent results, particularly for the application of knowledge (J. Meier et al., 2022; Papadopoulos et al., 2011; Schworm & Renkl, 2007).

Cognitive load theory posits that working memory capacity and intrinsic load are affected by learners' prior knowledge (Sweller, 1988); hence, a common agreement is that cognitive prerequisites impact the effectiveness of instructional principles. Instructional principles may be vital to learning for novice learners with less prior knowledge. In comparison, for more advanced learners with more prior knowledge, instructional principles may become redundant or even detrimental to learning (expertise-reversal effect). Hence, the beneficial effects of instructional principles may diminish, vanish, and ultimately reverse with growing expertise (Kalyuga et al., 2003). Evidence (for an overview, see Kalyuga, 2007) suggests that instructional principles implementing strong instructional support are highly beneficial for novice learners, as they aim to reduce cognitive load to free capacities for cognitive processing, whereas deliberate practice becomes more important as expertise increases. For example, studies have shown that worked examples can eliminate means–end analysis and focus learners' attention toward the relevant aspects of a learning task, freeing cognitive capacities for meaningful learning for novice learners. By contrast, more advanced learners already know the particular aspects that are relevant to the learning task (Atkinson & Renkl, 2007). Therefore, research has suggested that instructional support should gradually fade as expertise develops (Atkinson et al., 2003; Renkl et al., 2004). Notably, in the context of worked examples, fading procedures have been implemented by gradually reducing the final solution and/or individual solution steps. Learners have to complete faded information and thereby learn how to self-explain and transfer information from the instructional support to their own task processing (Atkinson et al., 2003; Renkl et al., 2004).

In sum, pressing questions related to research on instructional principles drawn from cognitive load theory and cognitive theory of multimedia learning relate to how the positive findings of instructional principles can be transferred from well-structured domains to ill-structured domains and how cognitive prerequisites have to be considered when implementing instructional principles. Research on teacher education has initiated efforts to answer these questions and connect them to their own open issues.

1.3.2 Instructional Principles and Professional Vision

Instructional principles derived from cognitive load theory and cognitive theory of multimedia learning have only recently been implemented to foster professional vision with video-based analyses of classroom videos in teacher education. In recent years, several projects, such as the TEVI project (Improvement of Teacher Education Videos), the ACTion project (The Acquisition of Core Practices in Teacher Education), and the Video.LinK project (Videos in Teacher Education – Teacher Education Phases in Cooperation), from which two Articles of this dissertation originate, provide several insights into how to transfer instructional principles of educational psychology to teacher education. Table 1 presents an overview of the studies conducted thus far. Overall, the studies have investigated three major themes: task instructions and instructional materials before video analysis, cues during video analysis, and feedback after video-based analyses. Studies related to task instructions aim to focus future teachers' attention on relevant aspects within the video to ease extraneous load and promote meaningful learning. These studies have predominantly implemented specific versus general task instructions or asked pre-service teachers to contrast different classroom videos. Studies that investigated contrasting classroom videos found positive effects on professional vision (Kaendler et al., 2016; Tucholka & Gold, 2025; Wilkes et al., 2022). Studies investigating specific against general task instruction yielded somewhat inconsistent results. Some studies indicated no significant differences (Gabel et al., 2023; Grub et al., 2022a, 2022b), whereas other studies revealed a positive effect (Barth et al., 2019; Gabel et al., 2024; Kumschick et al., 2017). Studies related to instructional materials largely implemented preparatory texts or pre-trainings related to the foci in video-based analyses (Martin et al., 2023; Seidel et al., 2013). These studies aimed to illustrate theoretical concepts addressed in the preparatory texts and pre-trainings with classroom videos in an effort to connect knowledge with teaching practice. Evidence showed that introductory texts or pre-training could significantly enhance student teachers' professional vision. Studies that implemented cues during video viewing aim to guide future teachers' attention by specifically highlighting what is important in the video, thereby reducing extraneous load. These studies have implemented different types of signaling, segmenting, or prompts. Studies investigating the effect of signaling on professional vision mostly found no effects on pre-service teachers' professional vision (Farrell et al., 2024; Moreno & Valdez, 2007; Tannert et al., 2023). Only one study showed that segmenting significantly enhanced student teachers' professional vision (Moreno & Valdez, 2007), whereas another study revealed only effects during learning (Martin et al., 2022). In contrast, prompts designed to focus learners' attention on relevant events in classroom videos seemed to have the most consistent impact on professional vision among all the instructional principles reviewed (Gabel et al., 2024; Gabel et al., 2023; Telgmann & Müller, 2023; Wilkes et al., 2022). However, studies from the TEVI project found no effect of prompts on professional vision (Farrell et al., 2024; Martin et al., 2022). Studies related to feedback on video-based analyses propose that feedback can promote schema construction by reflecting on video-based analyses. Studies implementing feedback on video-based analyses found overall positive effects for expert feedback (Prilop et al., 2021), specifically for adaptive expert feedback (Janeczko et al., 2024) and concise expert feedback (Prilop et al., 2025). In sum, most of the studies implementing instructional principles to enhance professional vision aimed to ease extraneous cognitive load on student teachers by guiding their attention toward relevant classroom aspects (e.g., specific task instruction, prompts, pre-trainings), whereas only a few studies aimed to increase germane load processing by enhancing learning engagement (e.g., contrasting classroom videos, expert feedback). The overall results of these studies were somewhat inconsistent regarding the effectiveness of instructional principles in enhancing professional vision.

Only a few studies have considered different expertise stages or teacher education phases when aiming to enhance professional vision using instructional principles. In this context, studies have predominantly considered prior knowledge about a relevant topic. Only two studies revealed a significant effect of prior knowledge on professional vision when learning with the instructional principles of specific versus general task instruction (Grub et al., 2022b) or classic versus instructed problem-based learning (Kumschick et al., 2017). All other studies that included prior knowledge as a measure did not show significant effects of prior knowledge (Gabel et al., 2023; Grub et al., 2022b; Tannert et al., 2023). Only one study has investigated how different stages of expertise can be affected by the implementation of instructional principles and found no effects of expertise on professional vision when learning with specific or general task instruction (Grub et al., 2022b).

Overall, the mixed findings of these studies suggest that before providing specific guidelines for the design of instructional settings to video-based analyses to enhance professional vision, further research is necessary. Based on the existing studies, some research gaps can be identified. First, only selected instructional principles were investigated in previous studies. Information on whether other instructional principles can effectively enhance professional vision development is lacking. For example, the well-proven worked-example effect (Sweller & Cooper, 1985) has not yet been implemented to foster future teachers' understanding of video-based analyses and enhance professional vision. This would provide more insights into how to transfer instructional principles to ill-structured domains with multi-faceted problems and no clear solution paths, such as teacher education. Second, most studies focused on classroom management or other individual teaching quality dimensions (e.g., Gabel et al., 2024; Grub et al., 2022a). However, the demands on teachers when observing classrooms are complex and multifaceted. As Dunekacke (2016) already claimed, teachers should be enabled to observe and analyze the teaching quality dimensions simultaneously (see also Klieme et al., 2009; also derived from research on teacher expertise; Sabers et al., 1991; see also Chapter 1.1.2). Therefore, insights into trainings that aim to enhance professional vision of multiple teaching quality dimensions and simultaneously focusing on these dimensions are missing. Third, although prior knowledge is considered highly important for cognitive processing, differences in expertise stages and teacher education phases have been scarcely considered. This would also comply with demands that call for adapting learning opportunities to the characteristics and demands of different teacher education phases (Seidel, 2022; Seidel et al., 2024). However, initial findings on implementing instructional principles in combination with video-based analyses in different teacher education phases revealed only inconsistent results (Grub et al., 2022b). Therefore, more research is necessary regarding the way of adapting instructional approaches and materials for video-based analyses in different teacher education phases and for individual needs and demands.

Given this background, Articles II, III, and IV of this dissertation aim to investigate how the findings on the effectiveness of instructional principles from well-structured domains can be transferred to the ill-structured domain of teacher education in the design of instructional settings around video-based analyses to enhance professional vision of teaching quality. Furthermore, the goal is to examine how professional vision can be enhanced throughout teacher education using video-based analyses and instructional principles.

Table 1

Studies Referring Educational Psychology When Enhancing Professional Vision With Classroom Videos in Teacher Education

Study	Description	Focus	Theory	Instructional Principles
Barth et al. (2019)	The study investigated the effect of self-directed learning compared to direct instruction on pre-service teachers' professional vision. Results showed higher reasoning scores for direct instruction compared to self-directed learning.	Classroom management	Cognitive load theory	– self-directed learning – direct instruction
Farrell et al. (2024)	The study examined the effect of signaling cues in the video and focused self-explanation prompts for video-analysis on pre-service teachers' professional vision and how situational interest affects this in a 2 × 2 design. Results indicated no superior effects of the instructional principles. Situational interest fostered professional vision when using signaling cues.	Pedagogical-psychological and pedagogical-content knowledge	Cognitive load theory/cognitive theory of multimedia learning	– signaling cues – focused prompts
Gabel et al. (2023)	The study examined how specific task instruction before the video, attention-guiding prompts during the video, and general task instruction before the video enhanced pre-service teachers' professional vision with eye-tracking methodology. Results revealed that prompts enhanced pre-service teachers' professional vision more than specific or general task instruction. Prior knowledge did not affect professional vision.	Classroom management	Cognitive theory of multimedia learning	– specific task instruction – attention-guiding prompts – general task instruction
Gabel et al. (2024)	The study investigated how specific task instruction before the video compared to prompts during the video enhanced pre-service teachers' professional vision with an eye-tracking methodology. Results revealed that both instructional principles had an equal effect on professional vision. Pre-service teachers' professional vision did not differ in prior knowledge.	Classroom management	Cognitive theory of multimedia learning	– specific task instruction before classroom video – prompts during the classroom video

Study	Description	Focus	Theory	Instructional Principles
Grub et al. (2022a)	The study examined whether specific compared to general task instruction enhanced professional vision of pre-service teachers with some teaching experience. Results indicated no significant differences between the principles but that professional vision is influenced by prior knowledge.	Classroom management	Cognitive load theory	– specific task instruction – general task instruction
Grub et al. (2022b)	The study examined whether specific compared to general task instruction enhanced professional vision of pre-service teachers compared to experienced teachers with eye-tracking methodology. Results revealed no significant differences between the instructional principles or expertise stages. Prior knowledge did not affect professional vision.	Classroom management	Cognitive load theory	– specific task instruction – general task instruction
Janeczko et al. (2024)	The study examined whether adaptive expert feedback or unified expert feedback enhanced pre-service teachers' professional vision compared to a control group. Both instructional principles outperformed the control group, but the adaptive feedback group performed considerably better.	Classroom management	Cognitive theory of multimedia learning	– adaptive expert feedback – unified expert feedback
Kaendler et al. (2016)	The study examined whether discussions and contrasting cases compared to a control group enhanced pre-service teachers' professional vision. Results indicated that professional vision significantly increased through the training.	Behavioral indicators of collaborative, cognitive, and meta-cognitive student activities	Cognitive load theory	– discussions and contrasting – control group
Kumschick et al. (2017)	The study examined how instructed problem-based learning enhanced pre-service teachers' professional vision compared to classic problem-based learning. Results showed that instructed problem-based learning enhances professional vision more than classic problem-based learning. Pre-service teachers with lower prior knowledge improved more than those with higher prior knowledge.	Classroom management	Cognitive load theory	– classic problem-based learning – instructed problem-based learning

Study	Description	Focus	Theory	Instructional Principles
Martin et al. (2022)	The study investigated whether segmenting and self-explanation prompts enhanced pre-service teachers' professional vision compared to a control group. Results indicated that the instructional principles enhanced professional vision during training, but they did not enhance professional vision in the post-test.	Pedagogical-psychological and pedagogical-content knowledge	Cognitive load theory	– self-explanation prompts – segmenting
Martin et al. (2023)	The study examined whether specific or general introductory texts enhanced pre-service teachers' professional vision. Results revealed that specific introductory texts significantly enhanced professional vision compared to general introductory texts.	Pedagogical-psychological and pedagogical-content knowledge	Cognitive load theory/cognitive theory of multimedia learning	– specific introductory text – general introductory text
Moreno and Valdez (2007)	The study investigated whether signaling or segmenting enhanced pre-service teachers' professional vision compared to a control group. Results showed that signaling and segmenting enhanced pre-service teachers' professional vision compared to a control group. Segmenting enhanced professional vision considerably more than no segmenting.	Attitudes, organization, communication, focus, feedback, questioning, review	Cognitive load theory/cognitive theory of multimedia learning	– signaling – segmenting
Prilop et al. (2021)	The study investigated whether expert feedback enhanced pre-service teachers' professional vision compared to a control group. Results indicated that expert feedback enhanced professional vision.	Classroom management	Cognitive load theory	– expert feedback – no expert feedback
Prilop et al. (2025)	The study examined whether concise or elaborate expert feedback enhanced future teachers' professional vision. Results show revealed that concise expert feedback more effectively enhanced professional vision than elaborate expert feedback.	Classroom management	Cognitive load theory	– concise expert feedback – elaborate expert feedback

Study	Description	Focus	Theory	Instructional Principles
Seidel et al. (2013)	The study investigated whether illustrating rules through videos (rule-example) or using video as a stimulus for rules (example-rule) enhances pre-service teachers' professional vision. Results showed that the rule-example group performed better in professional vision, whereas the example-rule group performed better in lesson planning.	Goal clarity and orientation, activation of student thinking, and learning climate	Cognitive science	– example-rule – rule-example
Tannert et al. (2023)	The study investigated whether with or without signaling and whether key phrase or beep signaling enhanced pre-service teachers' professional vision. It also investigated whether informed or uninformed signaling fostered professional vision. Results showed that none of the instructional principles enhanced professional vision. Prior knowledge did not affect professional vision when using signaling.	Learning strategies and self-regulated learning	Cognitive load theory/cognitive theory of multimedia learning	– key phrase signaling – frame tone signaling – informed signaling
Telgmann and Müller (2023)	The study investigated whether prompting before and during training compared to only training enhanced pre-service teachers' professional vision with eye-tracking methodology. Training and prompting significantly enhanced event-related professional vision but not global professional vision.	Classroom management	Cognitive load theory	– prompts and training – control
Thiel et al. (2023)	The study investigated whether video-based analyses of functional and dysfunctional classroom videos enhanced student teachers' professional vision. Results showed that both groups benefited from video-based analyses.	Classroom management	not applicable	– functional video examples – dysfunctional video examples
Tucholka and Gold (2025)	The study examined whether concepts before or after video-based analysis as well as whether comparing or not comparing classroom videos enhanced professional vision. Results indicated that concepts before video-based analysis enhanced reasoning, and comparing enhanced the generation of alternatives of action.	Classroom management	Cognitive load theory	– concepts before or after video-based analysis – comparing or not comparing classroom videos

Study	Description	Focus	Theory	Instructional Principles
Wilkes et al. (2022)	The study investigated different sequences of dysfunctional and functional classroom videos and whether prompts enhanced professional vision in a 2 × 2 design with written video analyses. Results revealed that the sequence of dysfunctional-functional classroom videos enhanced professional vision in the post-test. Both instructional principles had a positive effect on professional vision. Individual prerequisites of prior concept knowledge, prior application knowledge, attitudes toward the use of educational evidence, and academic self-concept did not yield significant results.	Classroom management	Cognitive load theory	– sequence of dysfunctional and functional video examples – with or without prompts

1.4 Aims of the Dissertation

In the previous chapter, different theoretical models and empirical findings were described regarding how professional vision develops throughout teacher education, how professional vision may be enhanced through video-based analyses using instructional principles of educational psychology to inform instructional settings, and how teacher education affects the development and enhancement of professional vision. This background serves as the framework for this dissertation and the foundation for its research questions.

Although research has frequently investigated differences in professional vision between expertise stages in teacher education (e.g., Stahnke et al., 2016; Wolff et al., 2015), initial evidence from longitudinal studies and theoretical models suggest that possible plateaus and stagnations may occur in the development of professional vision throughout teacher education (Barenthien et al., 2023; Bastian et al., 2022; Berliner, 1988). Moreover, models that identify the determinants affecting the development of professional vision in teacher education assume that the development of professional vision places learning opportunities related to general pedagogy, subject-related pedagogy, subjects, and teaching practice at the center, thereby assigning a crucial role to learning opportunities in competency development (e.g., Kaiser & König, 2019). Based on these models and described theoretical evidence, the first aim of this dissertation is to investigate the development of professional vision of classroom management throughout teacher education and examine how learning opportunities contribute to this development.

Furthermore, research on the development of professional vision throughout teacher education has not yet investigated how learning opportunities have to be designed to effectively enhance professional vision throughout teacher education. Teacher education is frequently criticized for its lack of practical orientation and relevance, and future teachers often struggle to deal with the complexities of a classroom. As described in Chapter 1.2.1, evidence suggests that the quantity but, more importantly, the quality of learning opportunities in teacher education affects the development of professional vision; hence, recent research has turned toward more practice-oriented approaches in which future teachers are confronted with actual teaching practice. A prominent framework related to these situated approaches is The Framework for Teaching Practice in Professional Education (Grossman, 2021; Grossman et al., 2009), which suggests that decompositions, representations, and approximations of practice have to be implemented in teacher education. Systematic reviews (Gaudin & Chaliès, 2015) have identified the inclusion of classroom videos as appropriate representations of practice and video-based analyses of classroom situations as appropriate approximations of practice.

However, classroom videos have to be embedded within effective instructional settings and accompanied by appropriate decompositions of practice (Blomberg et al., 2013; Santagata et al., 2021). Even more so, when implementing classroom videos in teacher education, they have to be adapted to different expertise levels: in the initial stages of teacher education, illustrating and analyzing theoretical concepts is essential to acquire a fundamental understanding of teaching and learning, whereas in the later stages of teacher education, reflection and deliberate practice becomes important (Seidel, 2022; Seidel et al., 2024). Findings of the effectiveness of instructional principles derived from theories from educational psychology (e.g., cognitive load theory, cognitive theory of multimedia learning) in well-structured domains could extend to the ill-structured domain of teacher education. Therefore, these principles may adequately inform instructional settings around video-based analyses. Initial studies implemented a vast array of instructional principles (e.g., prompts, segmenting, and expert feedback). Overall, evidence indicated inconsistent results regarding the effectiveness of instructional principles in enhancing professional vision with video-based analyses. Even less is known about how to implement the instructional principles around video-based analyses for different teacher education phases, and most of these studies focused only on the teaching quality dimension of classroom management and thereby did not address the multifaceted demands that teaching entails. Therefore, the second and more prominent aim of this dissertation is to investigate how learning opportunities can be designed to support future teachers in dealing with the complexities of a classroom and enhance professional vision throughout teacher education by using instructional principles of educational psychology to inform instructional settings around video-based analyses.

1.4.1 Research Questions of the Dissertation

This dissertation aims to provide insights into how professional vision develops and can be enhanced over the course of teacher education. A special focus of the dissertation thereby lies on how to design instructional settings around video-based analyses to enhance professional vision using theories and evidence from educational psychology because according to cognitive load theory or cognitive theory of multimedia learning, instructional principles such as double-content examples or pre-trainings foster cognitive processing. From the described theoretical models and empirical evidence with regard to existing research gaps, the following overarching research questions can be derived:

1) How does professional vision develop within the context of teacher education?
   - How does professional vision develop throughout teacher education? (Article I)

- How do the teacher education phases influence the development of professional vision? (Articles I and IV)
- How do learning opportunities play a role in the development of professional vision? (Article I and IV)

2) How can instructional principles of educational psychology inform instructional settings around video-based analyses to enhance professional vision?
   - How can instructional principles be transferred to the ill-structured domain of teacher education to enhance professional vision? (Articles II, III, and IV)
   - How should instructional principles be implemented in different teacher education phases to enhance professional vision? (Articles II, III, and IV)
   - How can instructional principles support future teachers in simultaneously focusing on multiple teaching quality dimensions? (Articles III and IV)

1.4.2 Overview of the Methodological Approach

Four independent studies were conducted to answer these research questions (see Table 2). All studies implemented multiple measurement time points: three (Article I) or two (Articles II, III and IV) measurement time points. Participants in the studies were all future elementary teachers. The classroom videos implemented in the interventions and for the assessment of professional vision related to elementary science education (Articles I and II) or elementary mathematics classrooms (Articles III and IV).

The first study (Article I) was conducted using a longitudinal design. It followed a cohort of bachelor student teachers throughout their bachelor's studies and a cohort of master student teachers throughout their master's studies and their induction program. Future teachers' professional vision was repeatedly assessed with a video test and situational judgment test at the beginning and the end of their bachelor's and master's studies, as well as at the end of the induction program. The uniqueness of this longitudinal design and its resulting data is that it considers inter- and intraindividual variability throughout teacher education. Therefore, these data are particularly suitable for investigating the research questions of this dissertation that relate to identifying possible plateaus or stagnations in the development of professional vision as well as examining how learning opportunities affect professional vision development (RQ1).

The other three studies were intervention studies that implemented weekly video-based sessions in which future teachers were encouraged to analyze differing aspects related to teaching quality (see Table 2). The quasi-experimental intervention studies were considerably shorter (2–4 weeks) and implemented pre-post-test designs. In the second and third studies (Articles II and III), only master student teachers at university participated. In the fourth study

(Article IV), master student teachers at university and pre-service teachers in the induction program participated. Quasi-experimental designs have the advantages of high levels of economy and practicality as well as a high external validity because they can be directly implemented in teacher education. Meanwhile, the advantage of pre-post-tests is the capacity to measure changes and account for individual variability, thereby providing an effective means of investigating the effects of interventions. Participants in Article II solely focused on classroom management, whereas Articles III and IV addressed both classroom management and instructional support. Additionally, Article III included a focus on emotional support. The design of the Articles II, III, and IV is therefore suitable for examining research questions concerning the implementation of instructional principles of educational psychology in the ill-structured domain of teacher education (RQ2). Additionally, by including not only student teachers at university but also pre-service teachers in an induction program in the sample, Article IV's design can effectively investigate how instructional principles should be implemented throughout teacher education. By including multiple foci on teaching quality dimensions, Articles III and IV can effectively investigate how instructional principles can support future teachers in focusing on multiple teaching quality dimensions.

Regarding the measurement of professional vision, research has suggested that standardized and unstandardized assessments can provide differentiated insights into professional vision development and enhancement (Gold et al., 2024). Therefore, all Articles of this dissertation used standardized and/or unstandardized measures to assess professional vision. Standardized measures of professional vision (for an overview, see Weyers et al., 2023) are typically video tests, which include closed-response items of descriptions and interpretations of classroom situations displayed in the video (Gold et al., 2024). Participants have to rate these items in terms of their appropriateness. To measure the cognitive process of alternatives of action, standardized assessments typically entail situational judgment tests (e.g., Gold & Holodynski, 2015), in which textual or video-based alternatives of action are provided and have to be evaluated by the participants. Unstandardized measures entail open-response formats that typically include written video-based analyses, in which participants describe and interpret classroom situations and thereupon generate alternatives of action (Gold et al., 2024). These measures include elaborate coding procedures with highly trained raters who analyze the data. The cognitive processes of noticing, reasoning, and generating alternatives of action are typically coded in relation to a master rating, or expert features within participants' video-based analyses are identified. Therefore, this approach can provide deep insights into future teachers' professional vision, but it is also time- and resource-intensive. Existing unstandardized measures of professional vision predominantly assess cognitive processes (e.g., Dückers et al., 2022) or expert features (e.g., Wolff et al., 2015) of professional vision within written video-based analyses.

Standardized and unstandardized measures of professional vision involve differing cognitive demands on participants. Unstandardized rating items are highly economic and objective (Weyers et al., 2023) because they are easy to implement and usually compare answers to a standardized master rating. However, unstandardized measures of professional vision predominantly assess only the cognitive process of reasoning because they already focus participants' attention on relevant situations in the classroom videos and therefore anticipate noticing by pre-selecting relevant events (Seidel & Stürmer, 2014). This may result in an overestimation of professional vision (Brovelli et al., 2014). In addition, unstandardized measures of professional vision are more cognitively demanding (Martinez, 1999) because participants have to select relevant events themselves from the classroom videos. Hence, in research on teacher education, open-response formats have assessed competencies that are necessary in complex and realistic settings (A. Seifert et al., 2009). Thus, the assessment format influences the measured construct by altering cognitive demands (derived from Martinez, 1999). Regarding PV assessment, studies have shown low correlations between video tests and written analyses (Gold et al., 2024; König et al., 2014; Müller & Gold, 2023), indicating that they assess PV differently. Therefore, a combination of standardized and unstandardized assessments may comprehensively provide insights into research questions addressing the development and enhancement of professional vision.

Articles I and IV implemented video tests (Bauersfeld et al., 2025; Gold & Holodynski, 2017) as a standardized assessment of professional vision; Article I additionally assessed the cognitive process of alternatives of action with a situational judgment test on knowledge about classroom management (Gold & Holodynski, 2015). Articles II, III, and IV assessed professional vision with unstandardized measures of professional vision with qualitative content analysis (Mayring, 2014). The cognitive processes of professional vision (i.e., noticing, reasoning, and generating alternatives of action) were measured with a simplified coding procedure based on Dückers et al. (2022) for each teaching quality dimension. Article II additionally assessed expert features of professional vision (i.e., application of concepts, student focus, inferences, and multiple perspectives) using qualitative content analysis including generated categories that were based on the expert features identified in the literature (e.g., Berliner, 2001; Stahnke et al., 2016; Wolff et al., 2015). Article III also measured the simultaneous focus on the teaching quality dimension. These diverse data sources provide a robust foundation for thoroughly investigating the development and enhancement of future teachers' professional vision.

Table 2

Overview of the Methodological Approaches Used in the Studies

Article	Design	Participants	Procedure	Focus	Instruments
Article I	Longitudinal design (two and three measurement time points)	Bachelor student teachers: *N* = 34 Master student teachers: *N* = 102	Cohort of bachelor student teachers t1: beginning bachelor's studies t2: end of bachelor's studies Cohort of master student teachers t1: beginning of master's studies t2: end of master's studies t3: end of induction program	Classroom management	*Standardized measurement of PV* Video test (Gold & Holodynski, 2017) Situational judgement test (Gold & Holodynski, 2015) *Determinants of teacher education* Learning opportunities (Laschke & König, 2014)
Article II	Quasi-experimental pre-post test design (two measurement time points)	Master student teachers: *N* = 410	Four-week video-based seminar, in which student teachers either studied no (CG), complete (IG1), or faded (IG2) double-content examples and then conducted video-based analyses.	Classroom management	*Unstandardized measurement of PV* Cognitive processes (based on Dückers et al., 2022) Expert features (based on Wolff et al., 2015)
Article III	Quasi-experimental pre-post test design (two measurement time points)	Master student teachers: *N* = 140	Three-week seminar, in which student teachers either analyzed classroom videos focusing on the teaching quality dimensions in an isolated (IG1) or integrated (IG2) approach or only read and discussed texts on teaching quality (CG).	Classroom management, instructional support, emotional support	*Unstandardized measurement of PV* Cognitive processes (based on Dückers et al., 2022) Simultaneous focus of PV *Determinants of teacher education* Prior learning opportunities (ye s= 1/no = 0) Prior interest (Transfer Interest Questionnaire; Gegenfurtner et al., 2020)
Article IV	Quasi-experimental pre-post test design (two measurement time points)	Master student teachers: *N* = 140 Pre-service teachers: *N* = 42	Two-week video-based seminar, in which university student teachers or pre-service teachers in an induction program received texts on teaching quality either before (IG1) or after (IG2) conducting video-based analyses.	Classroom management, instructional support	*Standardized measurement of PV* Video test (Bauersfeld et al., 2025, under review) *Unstandardized measurement of PV* Coding procedure (based on Dückers et al., 2022)

Note. PV = professional vision.

References I

Aebli, H. (1983). *Zwölf Grundformen des Lehrens: eine allgemeine Didaktik auf psychologischer Grundlage* [Twelve basic forms of teaching: A general didactics based on psychological principles] (2nd ed.). Klett-Cotta.

Ainsworth, M. D. S. (1978). The Bowlby-Ainsworth Attachment Theory. *Behavioral and Brain Sciences*, *1*(3), 436–438. https://doi.org/10.1017/s0140525x00075828

Alter, P., & Haydon, T. (2017). Characteristics of effective classroom rules: A review of the literature. *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*, *40*(2), 114–127. https://doi.org/10.1177/0888406417700962

Amador, J. M., Bragelman, J., & Superfine, A. C. (2021). Prospective teachers' noticing: A literature review of methodological approaches to support and analyze noticing. *Teaching and Teacher Education*, *99*, 103256. https://doi.org/10.1016/j.tate.2020.103256

Anderson, J., & Taner, G. (2023). Building the expert teacher prototype: A metasummary of teacher expertise studies in primary and secondary education. *Educational Research Review*, *38*, 100485. https://doi.org/10.1016/j.edurev.2022.100485

Atkinson, R. K., & Renkl, A. (2007). Interactive example-based learning environments: Using interactive elements to encourage effective processing of worked examples. *Educational Psychology Review*, *19*(3), 375–386. https://doi.org/10.1007/s10648-007-9055-2

Atkinson, R. K., Renkl, A., & Merrill, M. M. (2003). Transitioning from studying examples to solving problems: Effects of self-explanation prompts and fading worked-out steps. *Journal of Educational Psychology*, *95*(4), 774–783. https://doi.org/10.1037/0022-0663.95.4.774

Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556–559. https://doi.org/10.1126/science.1736359

Barenthien, J., Fiebranz, A., Todorova, M., Möller, K., & Steffensky, M. (2023). Development of professional vision and pedagogical content knowledge during initial teacher education. *International Journal of Educational Research*, *119*, 102186. https://doi.org/10.1016/j.ijer.2023.102186

Barth, V. L. (2017). *Professionelle Wahrnehmung von Störungen im Unterricht* [Professional vision of disruptions in the classroom]. Springer. https://doi.org/10.1007/978-3-658-16371-6

Barth, V. L., Piwowar, V., Kumschick, I. R., Ophardt, D., & Thiel, F. (2019). The impact of direct instruction in a problem-based learning setting. Effects of a video-based training program to foster preservice teachers' professional vision of critical incidents in the classroom. *International Journal of Educational Research*, *95*, 1–12. https://doi.org/10.1016/j.ijer.2019.03.002

Bastian, A., Kaiser, G., Meyer, D., & König, J. (2024). The link between expertise, the cognitive demands of teacher noticing and, experience in teaching mathematics in secondary schools. *International Journal of Science and Mathematics Education*, *22*(2), 257–282. https://doi.org/10.1007/s10763-023-10374-x

Bastian, A., Kaiser, G., Meyer, D., Schwarz, B., & König, J. (2022). Teacher noticing and its growth toward expertise: An expert–novice comparison with pre-service and in-service secondary mathematics teachers. *Educational Studies in Mathematics*, *110*(2), 205–232. https://doi.org/10.1007/s10649-021-10128-y

Bastian, A., König, J., Weyers, J., Siller, H.-S., & Kaiser, G. (2024). Effects of teaching internships on preservice teachers' noticing in secondary mathematics education. *Frontiers in Education*, *9*, 1360315. https://doi.org/10.3389/feduc.2024.1360315

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B. (2025). *Insights into the Standardized Assessment of Professional Vision of Multiple Foci of Teaching Quality Using a Classroom Video Clip of an Elementary Mathematics Classroom* [Manuscript under review]. TU Dortmund, University, Dortmund.

Baumert, J., & Kunter, M. (2013). Professionelle Kompetenz von Lehrkräften [Professional competence of teachers]. In I. Gogolin, H. Kuper, H.-H. Krüger, & J. Baumert (Eds.), *Stichwort: Zeitschrift für Erziehungswissenschaft* (pp. 277–337). Springer. https://doi.org/10.1007/978-3-658-00908-3_13

Baumert, J., Kunter, M., Blum, W., W., Klusmann, U., Krauss, S., & Neubrand, M. (2011). Professionelle Kompetenz von Lehrkräften, kognitiv aktivierender Unterricht und die mathematische Kompetenz von Schülerinnen und Schülern (COACTIV) – ein Forschungsprogramm. In M. Kunter, J. Baumert, & W. Blum (Eds.), *Professionelle Kompetenz von Lehrkräften: Ergebnisse des Forschungsprogramms COACTIV*. Waxmann Verlag.

Baumgartner, M., Oesterhelt, V., & Reuker, S. (2020). Konstruktion und Validierung eines multidimensionalen Beobachtungsinstruments zur Erfassung der klassenführungsbezogenen Performanzen von sportunterrichtenden Lehrkräften (KlaPe-Sport) [Construction and validation of a multidimensional observation instrument for assessing the classroom management performances of physical education teachers (KlaPe-Sport).]. *German Journal of Exercise and Sport Research*, *50*(4), 511–522. https://doi.org/10.1007/s12662-020-00675-6

Berliner, D. C. (1988). *The development of expertise in pedagogy*. AACTE Publications. https://eric.ed.gov/?id=ed298122

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research*, *35*(5), 463–482. https://doi.org/10.1016/s0883-0355(02)00004-6

Berliner, D. C. (2004). Expert teachers: Their characteristics, development and accomplishments. *Bulletin of Science Technology and Society*, *24*(3), 200–212.

Blomberg, G., Renkl, A., Gamoran Sherin, M., Borko, H., & Seidel, T. (2013). Five research-based heuristics for using video in pre-service teacher education. *Journal for Educational Research Online*, *5*(1), 90–114. https://doi.org/10.25656/01:8021

Blomberg, G., Stürmer, K., & Seidel, T. (2011). How pre-service teachers observe teaching on video: Effects of viewers' teaching subjects and the subject of the video. *Teaching and Teacher Education*, *27*(7), 1131–1140. https://doi.org/10.1016/j.tate.2011.04.008

Blömeke, S., Busse, A., Kaiser, G., König, J., & Suhl, U. (2016). The relation between content-specific and general teacher knowledge and skills. *Teaching and Teacher Education*, *56*, 35–46. https://doi.org/10.1016/j.tate.2016.02.003

Blömeke, S., Gustafsson, J.-E., & Shavelson, R. J. (2015). Beyond dichotomies. *Zeitschrift Für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Blömeke, S., Jenßen, L., Grassmann, M., Dunekacke, S., & Wedekind, H. (2017). Process mediates structure: The relation between preschool teacher education and preschool teachers' knowledge. *Journal of Educational Psychology*, *109*(3), 338–354. https://doi.org/10.1037/edu0000147

Blömeke, S., Jentsch, A., Ross, N., Kaiser, G., & König, J. (2022). Opening up the black box: Teacher competence, instructional quality, and students' learning progress. *Learning and Instruction*, *79*, 101600. https://doi.org/10.1016/j.learninstruc.2022.101600

Blömeke, S., Kaiser, G., & Lehmann, R. (Eds.). (2008). *Professionelle Kompetenz angehender Lehrerinnen und Lehrer: Wissen, Überzeugungen und Lerngelegeneiten deutscher Mathematikstudierender und -referendare: Erste Ergebnisse zur Wirksamkeit der Lehrerausbildung* [Professional competence of prospective teachers: Knowledge, beliefs, and learning opportunities of German mathematics students and teacher trainees: Initial results on the effectiveness of teacher education]. Waxmann.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15. https://doi.org/10.3102/0013189X033008003

Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education*, *24*(2), 417–436. https://doi.org/10.1016/j.tate.2006.11.012

Brekelmans, M., Wubbels, T., & van Tartwijk, J. (2005). Teacher–student relationships across the teaching career. *International Journal of Educational Research*, *43*(1-2), 55–71. https://doi.org/10.1016/j.ijer.2006.03.006

Bromme, R. (1992). *Der Lehrer als Experte: Zur Psychologie des professionellen Wissens* [The teacher as expert: On the psychology of professional knowledge]. Waxmann.

Brophy, J. E. (1979). Teacher behavior and its effects. *Journal of Educational Psychology*, *71*(6), 733–750. https://doi.org/10.1037/0022-0663.71.6.733

Brophy, J. E. (2000). *Teaching*. *Educational Practices Series: Vol. 1*. International Academy of Education/International Bureau of Education. https://mldbulletin.wordpress.com/wp-content/uploads/2015/03/teaching-by-jere-brophy.pdf

Brovelli, D., Bölsterli, K., Rehm, M., & Wilhelm, M. (2014). Using vignette testing to measure student science teachers' professional competencies. *American Journal of Educational Research*, *2*(7), 555–558. https://doi.org/10.12691/education-2-7-20

Calderhead, J. (1981). A psychological approach to research on teachers' classroom decision-making. *British Educational Research Journal*, *7*(1), 51–57. https://doi.org/10.1080/0141192810070105

Carpenter, T. P., & Fennema, E. (1992). Cognitively guided instruction: Building on the knowledge of students and teachers. *International Journal of Educational Research*, *17*(5), 457–470. https://doi.org/10.1016/S0883-0355(05)80005-9

Carter, K., Cushing, K., Sabers, D., Stein, P., & Berliner, D. (1988). Expert-novice differences in perceiving and processing visual classroom information. *Journal of Teacher Education*, *39*(3), 25–31. https://doi.org/10.1177/002248718803900306

Carter, K., Sabers, D., Cushing, K., Pinnegar, S., & Berliner, D. C. (1987). Processing and using information about students: A study of expert, novice, and postulant teachers. *Teaching and Teacher Education*, *3*(2), 147–157. https://doi.org/10.1016/0742-051x(87)90015-1

Charalambous, C. Y., & Praetorius, A.-K. (2018). Studying mathematics instruction through different lenses: Setting the ground for understanding instructional quality more comprehensively. *ZDM*, *50*(3), 355–366. https://doi.org/10.1007/s11858-018-0914-8

Charles, C. M. (2013). *Building classroom discipline* (11th ed.). Pearson Education UK.

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, *3*(3), 149–210. https://doi.org/10.1007/BF01320076

Copeland, W. D., Birmingham, C., DeMeulle, L., D'Emidio-Caston, M., & Natal, D. (1994). Making meaning in classrooms: An investigation of cognitive processes in aspiring teachers, experienced teachers, and their peers. *American Educational Research Journal*, *31*(1), 166–196. https://doi.org/10.3102/00028312031001166

Cortina, K. S., & Thames, M. H. (2013). Teacher education in Germany. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 49–62). Springer. https://doi.org/10.1007/978-1-4614-5149-5_3

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*, *24*(1), 87-185. https://doi.org/10.1017/s0140525x01003922

Cramer, C. (2020). Professionstheorien. Überblick, Entwicklung und Kritik [Professional theories: Overview, development, and critique]. In M. Harant, P. Thomas, & U. Küchler (Eds.), *Schriftenreihe der Tübingen School of Education: Vol. 1. Theorien! Horizonte für die Lehrerinnen und Lehrerbildung* (pp. 111–128). Tübingen University Press. http://dx.doi.org/10.15496/publikation-45602

Danielson, C. (2011). Evaluations that help teachers learn. *Educational Leadership*, *68*(4), 35–39.

Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education*, *51*(3), 166–173. https://doi.org/10.1177/0022487100051003002

Deci, E. L., & Ryan, R. M. (1980). Self-determination theory: When mind mediates behavior. *The Journal of Mind and Behavior*, *1*(1), 33–43. http://www.jstor.org/stable/43852807

Dindyal, J., Schack, E. O., Choy, B. H., & Sherin, M. G. (2021). Exploring the terrains of mathematics teacher noticing. *ZDM*, *53*(1), 1–16. https://doi.org/10.1007/s11858-021-01249-y

Döhrmann, M., Kaiser, G., & Blömeke, S. (2012). The conceptualisation of mathematics competencies in the international teacher education study TEDS-M. *ZDM*, *44*(3), 325–340. https://doi.org/10.1007/s11858-012-0432-z

Downer, J., Sabol, T. J., & Hamre, B. (2010). Teacher–child interactions in the classroom: Toward a theory of within- and cross-domain links to children's developmental outcomes. *Early Education & Development*, *21*(5), 699–723. https://doi.org/10.1080/10409289.2010.497453

Doyle, W. (1989). Classroom management techniques. In O. C. Moles (Ed.), *Strategies to reduce student misbehavior* (pp. 11–31). Office of Research, Office of Educational Research and Improvement, U.S. Department of Education.

Doyle, W. (2006). Ecological approaches to classroom management. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook of classroom management* (pp. 107–136). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203874783-11

Dreyfus, H., & Dreyfus, S. E. (1986). *Mind over machine*. Simon and Schuster.

Dückers, C., Hörter, P., Junker, R., & Holodynski, M. (2022). Professional vision of teaching as a focus-specific or focus-integrated skill – Conceptual considerations and video-based assessment. *Teaching and Teacher Education*, *117*, 103797. https://doi.org/10.1016/j.tate.2022.103797

Dunekacke, S. (2016). *Mathematische Bildung in Alltags- und Spielsituationen begleiten* [Supporting mathematics education in everyday and play situations] [Dissertation]. Humboldt-Universität zu Berlin, Berlin. https://doi.org/10.18452/17580

Eckhardt, T. (2021). *The education system in the Federal Republic of Germany 2018/2019: A description of the responsibilities, structures and developments in education policy for the exchange of information in Europe*. Secretariat of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany. https://www.kmk.org/fileadmin/Dateien/pdf/Eurydice/Bildungswesen-engl-pdfs/dossier_en_ebook.pdf

Emmer, E. T., & Stough, L. M. (2001). Classroom management: A critical part of educational psychology, with implications for teacher education. *Educational Psychologist*, *36*(2), 103–112. https://doi.org/10.1207/S15326985EP3602_5

Ericsson, K. A., & Charness, N. (1994). Expert performance: Its structure and acquisition. *American Psychologist*, *49*(8), 725–747. https://doi.org/10.1037//0003-066x.49.8.725
Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363–406. https://doi.org/10.1037//0033-295x.100.3.363
Eßling, I., Todorova, M., Sunder, C., Steffensky, M., & Meschede, N. (2023). The development of professional vision in pre-service teachers during initial teacher education and its relationship to beliefs about teaching and learning. *Teaching and Teacher Education*, *132*, 104250. https://doi.org/10.1016/j.tate.2023.104250
Evertson, C. M., & Emmer, E. T. (2012). *Classroom management for elementary teachers* (9th ed.). Addison Wesley.
Evertson, C. M., & Weinstein, C. S. (2006). Classroom management as a field of inquiry. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook of classroom management* (pp. 3–15). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203874783-6
Farrell, M., Martin, M., Böheim, R., 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*, *52*(6), 879–917. https://doi.org/10.1007/s11251-024-09662-y
Fauth, B., Decristan, J., Rieser, S., Klieme, E., & Büttner, G. (2014). Student ratings of teaching quality in primary school: Dimensions and prediction of student outcomes. *Learning and Instruction*, *29*, 1–9. https://doi.org/10.1016/j.learninstruc.2013.07.001
Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record: The Voice of Scholarship in Education*, *103*(6), 1013–1055. https://doi.org/10.1111/0161-4681.00141
Frommelt, M., Hugener, I., & Krammer, K. (2019). Fostering teaching-related analytical skills through case-based learning with classroom videos in initial teacher education. Advance online publication. https://doi.org/10.25656/01:18002
Gabel, S., Keskin, Ö., & Gegenfurtner, A. (2024). Comparing the effects of a specific task instruction and prompts on pre-service teachers' noticing of classroom management situations. *Zeitschrift Für Erziehungswissenschaft*, 1–19. https://doi.org/10.1007/s11618-024-01276-x
Gabel, S., Keskin, Ö., Kollar, I., Lewalter, D., & Gegenfurtner, A. (2023). Guiding pre-service teachers' visual attention through instructional settings: An eye-tracking study. *Frontiers in Education*, *8*, Article 1282848. https://doi.org/10.3389/feduc.2023.1282848
Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, *16*, 41–67. https://doi.org/10.1016/j.edurev.2015.06.001
Gegenfurtner, A. (2020). *Professional vision and visual expertise* [Habilitation]. University of Regensburg, Regensburg. https://doi.org/10.5283/epub.51267
Gegenfurtner, A., Knogler, M., & Schwab, S. (2020). Transfer interest: Measuring interest in training content and interest in training transfer. *Human Resource Development International*, *23*(2), 146–167. https://doi.org/10.1080/13678868.2019.1644002
Gobet, F., & Simon, H. A. (1996). Recall of random and distorted chess positions: Implications for the theory of expertise. *Memory & Cognition*, *24*(4), 493–503. https://doi.org/10.3758/BF03200937
Goeze, A., Zottmann, J. M., Vogel, F., Fischer, F., & Schrader, J. (2014). Getting immersed in teacher and student perspectives? Facilitating analytical competence using video cases in teacher education. *Instructional Science*, *42*(1), 91–114. https://doi.org/10.1007/s11251-013-9304-3

Gold, B., & Holodynski, M. (2015). Development and construct validation of a situational judgment test of strategic knowledge of classroom management in elementary schools. *Educational Assessment*, *20*(3), 226–248. https://doi.org/10.1080/10627197.2015.1062087

Gold, B., & Holodynski, M. (2017). Using digital video to measure the professional vision of elementary classroom management: Test validation and methodological challenges. *Computers & Education*, *107*, 13–30. https://doi.org/10.1016/j.compedu.2016.12.012

Gold, B., Müller, M. M., Weber, K. E., & Prilop, C. N. (2024). Characteristics and validation of video-based standardised instruments measuring professional vision: A closer look at the predictive validity of different task formats. In A. Gegenfurtner & R. Stahnke (Eds.), *Teacher professional vision: Theoretical and methodological advances* (pp. 89–108). Routledge. https://doi.org/10.4324/9781003370901-10

Gold, B., Pfirrmann, C., & Holodynski, M. (2021). Promoting professional vision of classroom management through different analytic perspectives in video-based learning environments. *Journal of Teacher Education*, *72*(4), 431–447. https://doi.org/10.1177/0022487120963681

Goodwin, C. (1994). Professional vision. *American Anthropologist*, *96*(3), 606–633. https://doi.org/10.1525/aa.1994.96.3.02a00100

Grossman, P. L. (2021). *Teaching core practices in teacher education*. Harvard Education Press.

Grossman, P. L., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching*, *15*(2), 273–289. https://doi.org/10.1080/13540600902875340

Grub, A.-S., Biermann, A., Lewalter, D., & Brünken, R. (2022a). Professional knowledge and task instruction specificity as influencing factors of prospective teachers' professional vision. *Teaching and Teacher Education*, *109*, 103517. https://doi.org/10.1016/j.tate.2021.103517

Grub, A.-S., Biermann, A., Lewalter, D., & Brünken, R. (2022b). Professional vision and the compensatory effect of a minimal instructional intervention: A quasi-experimental eye-tracking study with novice and expert teachers. *Frontiers in Education*, *7*, Article 890690. https://doi.org/10.3389/feduc.2022.890690

Harr, N., Eichler, A., & Renkl, A. (2014). Integrating pedagogical content knowledge and pedagogical/psychological knowledge in mathematics. *Frontiers in Psychology*, *5*, 924. https://doi.org/10.3389/fpsyg.2014.00924

Harr, N., Eichler, A., & Renkl, A. (2015). Integrated learning: Ways of fostering the applicability of teachers' pedagogical and psychological knowledge. *Frontiers in Psychology*, *6*, 738. https://doi.org/10.3389/fpsyg.2015.00738

Hasselhorn, M., & Gold, A. (2009). *Pädagogische Psychologie: Erfolgreiches Lernen und Lehren* [Educational psychology: Successful learning and teaching] (2nd ed.). Kohlhammer Verlag.

Hattie, J. (2008). *Visible learning*. Routledge. https://doi.org/10.4324/9780203887332

Helmke, A. (2014). Was wissen wir über guten Unterricht? [What do we know about good teaching?]. *PADUA*, *9*(2), 66–74. https://doi.org/10.1024/1861-6186/a000169

Helmke, A., & Schrader, F.-W. (2009). Qualitätsmerkmale „guten Unterrichts“ [Quality features of "good teaching"]. In C. Hof, V. Ladenthin, T. Fuhr, W. Plöger, W. Wittenbruch, S. Hellekamps, A. Kaiser, P. Gonon, P. Gonon, & J. Tinkloh (Eds.), *Handbuch der Erziehungswissenschaft* (pp. 701–712). Brill | Schöningh. https://doi.org/10.30965/9783657764969_068

Hogan, T., Rabinowitz, M., & Craven, J. A. (2003). Representation in teaching: Inferences from research of expert and novice teachers. *Educational Psychologist*, *38*(4), 235–247. https://doi.org/10.1207/S15326985EP3804_3

Horowitz, L. M., & Strack, S. (2010). *Handbook of interpersonal psychology: Theory, research, assessment, and therapeutic interventions*. John Wiley & Sons.
Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169–202. https://doi.org/10.5951/jresematheduc.41.2.0169
Jamil, F. M., Sabol, T. J., Hamre, B. K., & Pianta, R. C. (2015). Assessing teachers’ skills in detecting and identifying effective interactions in the classroom. *The Elementary School Journal*, *115*(3), 407–432. https://doi.org/10.1086/680353
Janeczko, J. M., Junker, R., Hörter, P., & Holodynski, M. (2024). Förderung der professionellen Wahrnehmung und Selbstwirksamkeitsüberzeugungen über Klassenführung mithilfe eines digitalen, videobasierten Mastery-Learning-Moduls [Promoting professional vision and self-efficacy beliefs about classroom management through a digital, video-based mastery learning module]. *Unterrichtswissenschaft*, 1–28. https://doi.org/10.1007/s42010-024-00197-2
Jennings, P. A., & Greenberg, M. T. (2009). The prosocial classroom: Teacher social and emotional competence in relation to student and classroom outcomes. *Review of Educational Research*, *79*(1), 491–525. https://doi.org/10.3102/0034654308325693
Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development*, *48*(4), 63–85. https://doi.org/10.1007/BF02300500
Junker, R., Rauterberg, T., Möller, K., & Holodynski, M. (2020). Videobasierte Lehrmodule zur Förderung der professionellen Wahrnehmung von heterogenitätssensiblem Unterricht [Video-based teaching modules for promoting professional vision of heterogeneous-sensitive teaching]. *Herausforderung Lehrer*innenbildung - Zeitschrift zur Konzeption, Gestaltung und Diskussion (HLZ)*, *3*(1), 236–255. https://doi.org/10.4119/hlz-2554
Kaendler, C., Wiedmann, M., Leuders, T., Rummel, N., & Spada, H. (2016). Monitoring student interaction during collaborative learning: Design and evaluation of a training program for pre-service teachers. *Psychology Learning & Teaching*, *15*(1), 44–64. https://doi.org/10.1177/1475725716638010
Kaiser, G., Blömeke, S., König, J., Busse, A., Döhrmann, M., & Hoth, J. (2017). Professional competencies of (prospective) mathematics teachers – Cognitive versus situated approaches. *Educational Studies in Mathematics*, *94*(2), 161–182. https://doi.org/10.1007/s10649-016-9713-8
Kaiser, G., Busse, A., Hoth, J., König, J., & Blömeke, S. (2015). About the complexities of video-based assessments: Theoretical and methodological approaches to overcoming shortcomings of research on teachers’ competence. *International Journal of Science and Mathematics Education*, *13*(2), 369–387. https://doi.org/10.1007/s10763-015-9616-7
Kaiser, G., & König, J. (2019). Competence measurement in (mathematics) teacher education and beyond: Implications for policy. *Higher Education Policy*, *32*(4), 597–615. https://doi.org/10.1057/s41307-019-00139-z
Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review*, *19*(4), 509–539. https://doi.org/10.1007/s10648-007-9054-3
Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist*, *38*(1), 23–31. https://doi.org/10.1207/s15326985ep3801_4
Kang, H., & van Es, E. A. (2019). Articulating design principles for productive use of video in preservice education. *Journal of Teacher Education*, *70*(3), 237–250. https://doi.org/10.1177/0022487118778549

Kennedy, M. M., Ahn, S., & Choi, J. (2008). The value added by teacher education. In M. Cochran-Smith, S. Feiman-Nemser, D. J. McIntyre, & K. E. Demers (Eds.), *Handbook of research on teacher education: Enduring questions in changing contexts* (Third edition, pp. 1247–1271). Routledge.

Keppens, K., Consuegra, E., Goossens, M., Maeyer, S. de, & Vanderlinde, R. (2019). Measuring pre-service teachers' professional vision of inclusive classrooms: A video-based comparative judgement instrument. *Teaching and Teacher Education*, *78*, 1–14. https://doi.org/10.1016/j.tate.2018.10.007

Kersting, N. B. (2008). Using video clips of mathematics classroom instruction as item prompts to measure teachers' knowledge of teaching mathematics. *Educational and Psychological Measurement*, *68*(5), 845–861. https://doi.org/10.1177/0013164407313369

Kersting, N. B., Givvin, K. B., Thompson, B. J., Santagata, R., & Stigler, J. W. (2012). Measuring usable knowledge: Teachers' analyses of mathematics classroom videos predict teaching quality and student learning. *American Educational Research Journal*, *49*(3), 568–589. https://doi.org/10.3102/0002831212437853

Keskin, Ö., Seidel, T., Stürmer, K., & Gegenfurtner, A. (2024). Eye-tracking research on teacher professional vision: A meta-analytic review. *Educational Research Review*, *42*, 100586. https://doi.org/10.1016/j.edurev.2023.100586

Klemenz, S., König, J., & Schaper, N. (2019). Learning opportunities in teacher education and proficiency levels in general pedagogical knowledge: New insights into the accountability of teacher education programs. *Educational Assessment, Evaluation and Accountability*, *31*(2), 221–249. https://doi.org/10.1007/s11092-019-09296-6

Klieme, E., & Clausen, M. (1999). *Identifying facets of problem solving in mathematics instruction.* Annual Meeting of the American Educational Research Association, Montreal, Quebec. https://eric.ed.gov/?id=ed432608

Klieme, E., & Leutner, D. (2006). Kompetenzmodelle zur Erfassung individueller Lernergebnisse und zur Bilanzierung von Bildungsprozessen. Beschreibung eines neu eingerichteten Schwerpunktprogramms der DFG [Competency models for capturing individual learning outcomes and assessing educational processes: Description of a newly established focus program by the DFG]. *Zeitschrift Für Pädagogik*, *52*(6), 876–903. https://doi.org/10.25656/01:4493

Klieme, E., Pauli, C., & Reusser, K. (2009). The Pythagoras study: Investigating effects of teaching and learning in Swiss and German mathematics classrooms. In J. Tomáš & T. Seidel (Eds.), *The power of video studies in investigating teaching and learning in the classroom* (pp. 137–160). Waxmann.

Kobarg, M., & Seidel, T. (2007). Prozessorientierte Lernbegleitung - Videoanalysen im Physikunterricht der Sekundarstufe I [Process-oriented learning support: Video analyses in physics instruction in lower secondary education]. *Unterrichtswissenschaft*, *35*(2), 148–168. https://doi.org/10.25656/01:5490

König, J. (2012). Pädagogisches Professionswissen von angehenden Grundschullehrkräften – Ergebnisse aus TEDS-M und der Ergänzungsstudie LEK [Pedagogical professional knowledge of prospective primary school teachers: Results from TEDS-M and the supplementary study LEK]. In F. Hellmich, S. Förster, & F. Hoya (Eds.), *Jahrbuch Grundschulforschung: Vol. 16. Bedingungen des Lehrens und Lernens in der Grundschule* (pp. 141–144). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-19137-9_23

König, J. (2019). Empirische Befunde zu Effekten von Praxisphasen in der Lehrerausbildung [Empirical findings on the effects of practical phases in teacher education]. In N. McElvany, F. Schwabe, W. Bos, & H. G. Holtappels (Eds.), *Lehrerbildung - Potentiale und Herausforderungen in den drei Phasen* (pp. 29–52). Waxmann.

König, J., Blömeke, S., Klein, P., Suhl, U., Busse, A., & Kaiser, G. (2014). Is teachers' general pedagogical knowledge a premise for noticing and interpreting classroom situations? A video-based assessment approach. *Teaching and Teacher Education*, *38*, 76–88. https://doi.org/10.1016/j.tate.2013.11.004

König, J., Bremerich-Vos, A., Buchholtz, C., Lammerding, S., Strauß, S., Fladung, I., & Schleiffer, C. (2017). Modelling and validating the learning opportunities of preservice language teachers: On the key components of the curriculum for teacher education. *European Journal of Teacher Education*, *40*(3), 394–412. https://doi.org/10.1080/02619768.2017.1315398

König, J., Darge, K., Kramer, C., Ligtvoet, R., Lünnemann, M., Podlecki, A.-M., & Strauß, S. (2018). Das Praxissemester als Lerngelegenheit: Modellierung lernprozessbezogener Tätigkeiten und ihrer Bedingungsfaktoren im Spannungsfeld zwischen Universität und Schulpraxis [The practical semester as a learning opportunity: Modeling learning process-related activities and their determinants in the tension between university and school practice]. In J. König, M. Rothland, & N. Schaper (Eds.), *Learning to practice, learning to reflect?* (pp. 87–114). Springer. https://doi.org/10.1007/978-3-658-19536-6_3

König, J., & Kramer, C. (2016). Teacher professional knowledge and classroom management: On the relation of general pedagogical knowledge (GPK) and classroom management expertise (CME). *ZDM*, *48*(1-2), 139–151. https://doi.org/10.1007/s11858-015-0705-4

König, J., Ligtvoet, R., Klemenz, S., & Rothland, M. (2017). Effects of opportunities to learn in teacher preparation on future teachers' general pedagogical knowledge: Analyzing program characteristics and outcomes. *Studies in Educational Evaluation*, *53*, 122–133. https://doi.org/10.1016/j.stueduc.2017.03.001

König, J., Ligtvoet, R., Klemenz, S., & Rothland, M. (2024). Discontinued knowledge growth: On the development of teachers' general pedagogical knowledge at the transition from higher education into teaching practice. *Teachers and Teaching*, 1–19. https://doi.org/10.1080/13540602.2024.2308895

König, J., & Rothland, M. (2018). Das Praxissemester in der Lehrerbildung: Stand der Forschung und zentrale Ergebnisse des Projekts Learning to Practice [The practical semester in teacher education: State of research and key findings of the Learning to Practice project]. In J. König, M. Rothland, & N. Schaper (Eds.), *Learning to practice, learning to reflect?* (pp. 1–62). Springer.

König, J., Santagata, R., Scheiner, T., Adleff, A.-K., Yang, X., & Kaiser, G. (2022). Teacher noticing: A systematic literature review of conceptualizations, research designs, and findings on learning to notice. *Educational Research Review*, *36*, 100453. https://doi.org/10.1016/j.edurev.2022.100453

Könings, K. D., Seidel, T., & van Merriënboer, J. J. G. (2014). Participatory design of learning environments: Integrating perspectives of students, teachers, and designers. *Instructional Science*, *42*(1), 1–9. https://doi.org/10.1007/s11251-013-9305-2

Korpershoek, H., Harms, T., Boer, H. de, van Kuijk, M., & Doolaard, S. (2016). A meta-analysis of the effects of classroom management strategies and classroom management programs on students' academic, behavioral, emotional, and motivational outcomes. *Review of Educational Research*, *86*(3), 643–680. https://doi.org/10.3102/0034654315626799

Korthagen, F. A. J. (2004). In search of the essence of a good teacher: Towards a more holistic approach in teacher education. *Teaching and Teacher Education*, *20*(1), 77–97. https://doi.org/10.1016/j.tate.2003.10.002

Korthagen, F. A. J. (2010). The relationship between theory and practice in teacher education. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (pp. 669–675). Elsevier. https://doi.org/10.1016/b978-0-08-044894-7.00638-2

Korthagen, F. A. J., & Kessels, J. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher*, *28*(4), 4–17. https://doi.org/10.3102/0013189X028004004

Kounin, J. S. (1970). *Discipline and group management in classrooms*. Holt, Rinehart & Winston.

Krammer, K. (2020). Videos in der Lehrerinnen- und Lehrerbildung [Videos in teacher education]. In C. Cramer, J. König, M. Rothland, & S. Blömeke (Eds.), *Handbuch Lehrerinnen- und Lehrerbildung* (pp. 691–699). Verlag Julius Klinkhardt. https://doi.org/10.35468/hblb2020-083

Krauss, S., Bruckmaier, G., Lindl, A., Hilbert, S., Binder, K., Steib, N., & Blum, W. (2020). Competence as a continuum in the COACTIV study: The “cascade model”. *ZDM*, *52*(2), 311–327. https://doi.org/10.1007/s11858-020-01151-z

Kumschick, I. R., Piwowar, V., Ophardt, D., Barth, V. L., Krysmanski, K., & Thiel, F. (2017). Optimierung einer videobasierten Lerngelegenheit im Problem Based Learning Format durch Cognitive Tools. Eine Interventionsstudie mit Lehramtsstudierenden [Optimization of a video-based learning opportunity in problem-based learning format through cognitive tools: An intervention study with pre-service teachers]. *Zeitschrift Für Erziehungswissenschaft*, *20*(93), 93–113. https://doi.org/10.1007/s11618-017-0728-4

Kunter, M., Baumert, J., Blum, W., Klusmann, U., Krauss, S., & Neubrand, M. (Eds.). (2013). *Cognitive activation in the mathematics classroom and professional competence of teachers*. Springer.

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal of Educational Psychology*, *105*(3), 805–820. https://doi.org/10.1037/a0032583

Kyriakides, L., Christoforou, C., & Charalambous, C. Y. (2013). What matters for student learning outcomes: A meta-analysis of studies exploring factors of effective teaching. *Teaching and Teacher Education*, *36*, 143–152. https://doi.org/10.1016/j.tate.2013.07.010

Lachner, A., Jarodzka, H., & Nückles, M. (2016). What makes an expert teacher? Investigating teachers’ professional vision and discourse abilities. *Instructional Science*, *44*(3), 197–203. https://doi.org/10.1007/s11251-016-9376-y

Laschke, C., & König, J. (2014). Erfassung der Lerngelegenheiten (opportunities to learn, OTL) [Assessing learning opportunities (opportunities to learn, OTL)]. In C. Laschke & S. Blömeke (Eds.), *Teacher education and development study: Learning to teach mathematics (TEDS-M 2008) Dokumentation der Erhebungsinstrumente* (pp. 45–108). Waxmann.

Lechner, M., Moser, S., Pander, J., Geist, J., & Lewalter, D. (2024). Learning scientific observation with worked examples in a digital learning environment. *Frontiers in Education*, *9*, Article 1293516. https://doi.org/10.3389/feduc.2024.1293516

Leflot, G., van Lier, P. A. C., Onghena, P., & Colpin, H. (2010). The role of teacher behavior management in the development of disruptive behaviors: An intervention study with the good behavior game. *Journal of Abnormal Child Psychology*, *38*(6), 869–882. https://doi.org/10.1007/s10802-010-9411-4

Leinhardt, G., Weidman, C., & Hammond, K. M. (1987). Introduction and integration of classroom routines by expert teachers. *Curriculum Inquiry*, *17*(2), 135–176. https://doi.org/10.1080/03626784.1987.11075284

Leuders, T., & Holzäpfel, L. (2011). Kognitive Aktivierung im Mathematikunterricht [Cognitive activation in mathematics lessons]. *Unterrichtswissenschaft*, *39*, 213–230.

Lipowsky, F. (2009). Unterricht [Teaching]. In E. Wild & J. Möller (Eds.), *Pädagogische Psychologie* (pp. 69–118). Springer. https://doi.org/10.1007/978-3-662-61403-7_4

Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E., & Reusser, K. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and Instruction*, *19*(6), 527–537. https://doi.org/10.1016/j.learninstruc.2008.11.001

Lotz, M. (2015). *Kognitive Aktivierung im Leseunterricht der Grundschule: Eine Videostudie zur Gestaltung und Qualität von Leseübungen im ersten Schuljahr* [Cognitive activation in primary school reading instruction: A video study on the design and quality of reading exercises in the first school year]. Springer.

Martin, M., Farrell, M., Seidel, T., Rieß, W., Könings, K. D., van Merriënboer, J. J. G., & Renkl, A. (2022). Focused self-explanation prompts and segmenting foster pre-service teachers' professional vision - but only during training! *International Journal of Educational Technology in Higher Education*, *19*(1), 1–29. https://doi.org/10.1186/s41239-022-00331-z

Martin, M., Farrell, M., Seidel, T., Rieß, W., Könings, K. D., van Merriënboer, J. J., & Renkl, A. (2023). Knowing what matters: Short introductory texts support pre-service teachers' professional vision of tutoring interactions. *Teaching and Teacher Education*, *124*, 104014. https://doi.org/10.1016/j.tate.2023.104014

Martinez, M. E. (1999). Cognition and the question of test item format. *Educational Psychologist*, *34*(4), 207–218. https://doi.org/10.1207/s15326985ep3404_2

Mason, J. (1998). Enabling teachers to be real teachers: Necessary levels of awareness and structure of attention. *Journal of Mathematics Teacher Education*, *1*(3), 243–267. https://doi.org/10.1023/A:1009973717476

Mason, J. (2002). *Researching your own practice*. Routledge. https://doi.org/10.4324/9780203471876

Mayer, R. E. (2001). *Multimedia learning*. Cambridge University Press.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 43–52. https://doi.org/10.1207/S15326985EP3801_6

Mayring. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution*. Available at Social Science Open Access Repository (SSOAR). https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173

Meier, J., Spliethoff, L., Hesse, P., Abele, S., Renkl, A., & Glogger-Frey, I. (2022). Promoting car mechatronics apprentices' diagnostic strategy with modeling examples: Development and evaluation of a simulation-based learning environment. *Studies in Educational Evaluation*, *72*, 101117. https://doi.org/10.1016/j.stueduc.2021.101117

Mertens, S., & Gräsel, C. (2018). Entwicklungsbereiche bildungswissenschaftlicher Kompetenzen von Lehramtsstudierenden im Praxissemester [Development areas of educational science competencies of pre-service teachers during the practical semester]. *Zeitschrift für Erziehungswissenschaft*, *21*(6), 1109–1133. https://doi.org/10.1007/s11618-018-0825-z

Meschede, N., Steffensky, M., Wolters, M., & Möller, K. (2015). Professionelle Wahrnehmung der Lernunterstützung im naturwissenschaftlichen Grundschulunterricht [Professional vision of learning support in science education in primary schools]. *Unterrichtswissenschaft*, *43*(4), 317–335.

Meyer, H. (2003). Zehn Merkmale guten Unterrichts [Ten characteristics of good teaching]. *Pädagogik*, *10*, 36–43.

Moreno, R., & Valdez, A. (2007). Immediate and delayed effects of using a classroom case exemplar in teacher education: The role of presentation format. *Journal of Educational Psychology*, *99*(1), 194–206. https://doi.org/10.1037/0022-0663.99.1.194

Moser, U., Ramseier, E., & Keller, C. (1997). *Schule auf dem Prüfstand: Eine Evaluation der Sekundarstufe I auf der Grundlage der "Third International Mathematics and Science Study"* [School under scrutiny: An evaluation of lower secondary education based on the "Third International Mathematics and Science Study"]. *Kultur-Urbanität-Moderne. Differenzierungen der Moderne in Zentraleuropa um 1900*. Rüegger Verlag.

Müller, M. M., & Gold, B. (2023). Videobasierte Erfassung wissensbasierten Verarbeitens als Teilprozess der professionellen Unterrichtswahrnehmung – Analyse eines geschlossenen und offenen Verfahrens [Video-based assessment of knowledge-based processing as a subprocess of professional vision: Analysis of closed and open formats]. *Zeitschrift für Erziehungswissenschaft*, *26*(1), 7–29. https://doi.org/10.1007/s11618-022-01128-6

Niederkofler, B., & Amesberger, G. (2016). Kognitive Handlungsrepräsentationen als Strukturgrundlage zur Definition von kognitiver Aktivierung im Sportunterricht [Cognitive action representations as a structural basis for defining cognitive activation in physical education]. *Sportwissenschaft*, *46*(3), 188–200. https://doi.org/10.1007/s12662-016-0414-3

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom. *Theory and Research in Education*, *7*(2), 133–144. https://doi.org/10.1177/1477878509104318

Ophardt, D., & Thiel, F. (2017). Klassenmanagement als Basisdimension der Unterrichtsqualität [Classroom management as a generic dimension of teaching quality]. In D. Ophardt & F. Thiel (Eds.), *Lehrer-Schüler-Interaktion* (pp. 245–266). Springer. https://doi.org/10.1007/978-3-658-15083-9_11

Orschulik, A. B. (2021). *Entwicklung der Professionellen Unterrichtswahrnehmung* [Development of professional vision]. Springer. https://doi.org/10.1007/978-3-658-33931-9

Paas, F., Renkl, A., & Sweller, J. (2004). Cognitive Load Theory: Instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science*, *32*(1/2), 1–8. https://doi.org/10.1023/b:truc.0000021806.17516.d0

Papadopoulos, P. M., Demetriadis, S. N., Stamelos, I. G., & Tsoukalas, I. A. (2011). The value of writing-to-learn when using question prompts to support web-based learning in ill-structured domains. *Educational Technology Research and Development*, *59*(1), 71–90. https://doi.org/10.1007/s11423-010-9167-0

Peterson, L., & Peterson M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, *58*(3), 193–198. https://doi.org/10.1037/h0049234

Piaget, J. (1976). *Die Äquilibration der kognitiven Strukturen* [The equilibration of cognitive structures]. Klett.

Pianta, R. C. (2007). Teacher-child relationships and early literacy. In D. K. Dickinson & S. B. Neuman (Eds.), *Handbook of early literacy research* (pp. 149–162). Guilford Press.

Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. *Educational Researcher*, *38*(2), 109–119. https://doi.org/10.3102/0013189X09332374

Pianta, R. C., Mashburn, A. J., Downer, J. T., Hamre, B. K., & Justice, L. (2008). Effects of web-mediated professional development resources on teacher-child interactions in pre-kindergarten classrooms. *Early Childhood Research Quarterly*, *23*(4), 431–451. https://doi.org/10.1016/j.ecresq.2008.02.001

Praetorius, A.-K., Herrmann, C., Gerlach, E., Zülsdorf-Kersting, M., Heinitz, B., & Nehring, A. (2020). Unterrichtsqualität in den Fachdidaktiken im deutschsprachigen Raum – zwischen Generik und Fachspezifik [Teaching quality in subject didactics in German-speaking countries – Between generality and subject specificity]. *Unterrichtswissenschaft*, *48*(3), 409–446. https://doi.org/10.1007/s42010-020-00082-8

Praetorius, A.-K., Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: The German framework of Three Basic Dimensions. *ZDM*, *50*(3), 407–426. https://doi.org/10.1007/s11858-018-0918-4

Prilop, C. N., Rotsaert, T., & Vanderlinde, R. (2025). Fostering pre-service teachers' classroom management knowledge, self-efficacy, and professional vision: The effect of different expert feedback and pre-service teachers' feedback perceptions during online video analysis. *Teaching and Teacher Education*, *157*, 104949. https://doi.org/10.1016/j.tate.2025.104949

Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2021). The role of expert feedback in the development of pre-service teachers' professional vision of classroom management in an online blended learning environment. *Teaching and Teacher Education*, *99*, 103276. https://doi.org/10.1016/j.tate.2020.103276

Quin, D. (2017). Longitudinal and contextual associations between teacher–student relationships and student engagement. *Review of Educational Research*, *87*(2), 345–387. https://doi.org/10.3102/0034654316669434

Rakoczy, K., Klieme, E., & Pauli, C. (2008). Die Bedeutung der wahrgenommenen Unterstützung motivationsrelevanter Bedürfnisse und des Alltagsbezugs im Mathematikunterricht für die selbstbestimmte Motivation [The importance of perceived support for motivation-relevant needs and the connection to everyday life in mathematics instruction for self-determined motivation]. *Zeitschrift für Pädagogische Psychologie*, *22*(1), 25–35. https://doi.org/10.1024/1010-0652.22.1.25

Rakoczy, K., & Pauli, C. (2006). Hoch inferentes Rating: Beurteilung der Qualität unterrichtlicher Prozesse [Highly inferential rating: Assessment of the quality of instructional processes]. In E. Klieme, C. Pauli, & K. Reusser (Eds.), *Dokumentation der Erhebungs-und Auswertungsinstrumente zur schweizerisch-deutschen Videostudie "Unterrichtsqualität, Lernverhalten und mathematisches Verständnis"* (pp. 206–233). GFPF.

Renkl, A. (2009). Wissenserwerb [Knowledge acquistion]. In E. Wild & J. Möller (Eds.), *Pädagogische Psychologie* (pp. 3–24). Springer.

Renkl, A., Atkinson, R. K., & Große, C. S. (2004). How fading worked solution steps works – A cognitive load perspective. *Instructional Science*, *32*(1/2), 59–82. https://doi.org/10.1023/B:TRUC.0000021815.74806.f6

Renkl, A., Hilbert, T., & Schworm, S. (2009). Example-based learning in heuristic domains: A Cognitive Load Theory account. *Educational Psychology Review*, *21*(1), 67–78. https://doi.org/10.1007/s10648-008-9093-4

Renkl, A., Mandl, H., & Gruber, H. (1996). Inert knowledge: Analyses and remedies. *Educational Psychologist*, *31*(2), 115–121. https://doi.org/10.1207/s15326985ep3102_3

Renkl, A., & Nückles, M. (2006). Träge Kompetenzen? - Gründe für die Kontextgebundenheit von beruflichen Handlungskompetenzen [Inert competencies? Reasons for the context dependence of professional action competencies]. *Bildung Und Erziehung*, *59*(2), 179–192. https://doi.org/10.7788/bue.2006.59.2.179

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, *104*(3), 700–712. https://doi.org/10.1037/a0027268

Roche, L., & Gal-Petitfaux, N. (2015). A video-enhanced teacher learning environment based on multimodal resources: A case study in PETE. *Journal of E-Learning and Knowledge Society*, *11*(2), 91–110.
Roorda, D. L., Koomen, H. M. Y., Spilt, J. L., & Oort, F. J. (2011). The influence of affective teacher–student relationships on students' school engagement and achievement. *Review of Educational Research*, *81*(4), 493–529. https://doi.org/10.3102/0034654311421793
Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal of Research in Science Teaching*, *48*(2), 117–148. https://doi.org/10.1002/tea.20408
Roth McDuffie, A., Foote, M. Q., Bolson, C., Turner, E. E., Aguirre, J. M., Bartell, T. G., Drake, C., & Land, T. (2014). Using video analysis to support prospective K-8 teachers' noticing of students' multiple mathematical knowledge bases. *Journal of Mathematics Teacher Education*, *17*(3), 245–270. https://doi.org/10.1007/s10857-013-9257-0
Rourke, A., & Sweller, J. (2009). The worked-example effect using ill-defined problems: Learning to recognise designers' styles. *Learning and Instruction*, *19*(2), 185–199. https://doi.org/10.1016/j.learninstruc.2008.03.006
Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y., & Pianta, R. C. (2016). How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence. *Learning and Instruction*, *42*, 95–103. https://doi.org/10.1016/j.learninstruc.2016.01.004
Sabers, D. S., Cushing, K. S., & Berliner, D. C. (1991). Differences among teachers in a task characterized by simultaneity, multidimensional, and immediacy. *American Educational Research Journal*, *28*(1), 63–88. https://doi.org/10.3102/00028312028001063
Santagata, R. (2009). Designing video-based professional development for mathematics teachers in low-performing schools. *Journal of Teacher Education*, *60*(1), 38–51. https://doi.org/10.1177/0022487108328485
Santagata, R., & Angelici, G. (2010). Studying the impact of the Lesson Analysis Framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education*, *61*(4), 339–349. https://doi.org/10.1177/0022487110369555
Santagata, R., & Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *ZDM*, *43*(1), 133–145. https://doi.org/10.1007/s11858-010-0292-3
Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A.-K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z
Santagata, R., Liu, J., Schreiner, t., König, J., & Kaiser, G. (2024). Longitudinal studies on video-based interventions for mathematics teacher noticing: A review and future directions. In M. Blikstad-Balas & I. Staal Jenset (Eds.), *Using video to foster teacher development: Improving professional practice through adaptation and reflection* (pp. 113–130). Routledge. https://doi.org/10.4324/9781003427414-11
Santagata, R., & Yeh, C. (2014). Learning to teach mathematics and to analyze teaching effectiveness: Evidence from a video- and practice-based approach. *Journal of Mathematics Teacher Education*, *17*(6), 491–514. https://doi.org/10.1007/s10857-013-9263-2

Santagata, R., Zannoni, C., & Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Mathematics Teacher Education*, *10*(2), 123–140. https://doi.org/10.1007/s10857-007-9029-9

Schlag, S., & Glock, S. (2019). Entwicklung von Wissen und selbsteingeschätztem Wissen zur Klassenführung während des Praxissemesters im Lehramtsstudium. *Unterrichtswissenschaft*, *47*(2), 221–241. https://doi.org/10.1007/s42010-019-00037-8

Schlesinger, L., & Jentsch, A. (2016). Theoretical and methodological challenges in measuring instructional quality in mathematics education using classroom observations. *ZDM*, *48*(1-2), 29–40. https://doi.org/10.1007/s11858-016-0765-0

Schreyer, P. (2024). *Kognitive Aktivierung in der Unterrichtsinteraktion: Eine qualitativ-rekonstruktive Analyse zu Passungsverhältnissen im Mathematikunterricht* [Cognitive activation in classroom interaction: A qualitative reconstructive analysis of alignment in mathematics instruction]. Waxmann.

Schworm, S., & Renkl, A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology*, *99*(2), 285–296. https://doi.org/10.1037/0022-0663.99.2.285

Seidel, T. (2022). Professionelle Unterrichtswahrnehmung als Teil von Expertise im Lehrberuf [Professional vision as a part of expertise in the teaching profession]. In R. Junker, V. Zucker, M. Oellers, T. Rauterberg, S. Konjer, N. Meschede, & M. Holodynski (Eds.), *Lehren und Forschen mit Videos in der Lehrkräftebildung* (17-35). Waxmann.

Seidel, T., Blomberg, G., & Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, *34*, 56–65. https://doi.org/10.1016/j.tate.2013.03.004

Seidel, T., Blomberg, G., & Stürmer, K. (2010). „Observer“ – Validierung eines videobasierten Instruments zur Erfassung der professionellen Wahrnehmung von Unterricht. Projekt OBSERVE ["Observer" – Validation of a video-based instrument for capturing professional vision of teaching. Project OBSERVE]. In E. Klieme, D. Leutner, & M. Kenk (Eds.), *Zeitschrift für Pädagogik: Beiheft 56. Kompetenzmodellierung.Zwischenbilanz des DFG-Schwerpunktprogramms und Perspektiven des Forschungsansatzes* (pp. 296–306). Beltz. https://doi.org/10.25656/01:3438

Seidel, T., Kosel, C., Böheim, R., Gegenfurtner, A., & Stürmer, K. (2024). The cognitive perspective on teachers' professional vision: How teachers' professional knowledge shapes a professional vision. In A. Gegenfurtner & R. Stahnke (Eds.), *Teacher professional vision: Theoretical and methodological advances* (pp. 43–56). Routledge.

Seidel, T., & Shavelson, R. J. (2007). Teaching effectiveness research in the past decade: The role of theory and research design in disentangling meta-Analysis results. *Review of Educational Research*, *77*(4), 454–499. https://doi.org/10.3102/0034654307310317

Seidel, T., & Stürmer, K. (2014). Modeling and measuring the structure of professional vision in preservice teachers. *American Educational Research Journal*, *51*(4), 739–771. https://doi.org/10.3102/0002831214531321

Seidel, T., & Thiel, F. (2017). Standards und Trends der videobasierten Lehr-Lernforschung. *Zeitschrift Für Erziehungswissenschaft*, *20*(1), 1–21. https://doi.org/10.1007/s11618-017-0726-6

Seifert, A., Hilligus, A. H., & Schaper, N. (2009). Entwicklung und psychometrische Überprüfung eines Messinstruments zur Erfassung pädagogischer Kompetenzen in der universitären Lehrerbildung [Development and psychometric validation of an instrument for measuring pedagogical competencies in university teacher education]. Advance online publication. https://doi.org/10.25656/01:14700

Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 383–395). Routledge. https://doi.org/10.4324/9780203877258-27

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Sherin, M. G., Jacobs, V. R., & Philipp, R. A. (2011). Situating the study of teacher noticing. In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 1–15). Routledge. https://doi.org/10.4324/9780203832714

Sherin, M. G., & van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, *60*(1), 20–37. https://doi.org/10.1177/0022487108328155

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Simon, H. A., & Newell, A. (1971). Human problem solving: The state of the theory in 1970. *American Psychologist*, *26*(2), 145–159. https://doi.org/10.1037/h0030806

Simonsen, B., Fairbanks, S., Briesch, A., Myers, D., & Sugai, G. (2008). Evidence-based practices in classroom management: Considerations for research to practice. *Education and Treatment of Children*, *31*(1), 351–380. https://doi.org/10.1353/etc.0.0007

Stahnke, R., & Blömeke, S. (2021). Novice and expert teachers' situation-specific skills regarding classroom management: What do they perceive, interpret and suggest? *Teaching and Teacher Education*, *98*, 103243. https://doi.org/10.1016/j.tate.2020.103243

Stahnke, R., Schueler, S., & Roesken-Winter, B. (2016). Teachers' perception, interpretation, and decision-making: A systematic review of empirical mathematics education research. *ZDM*, *48*(1-2), 1–27. https://doi.org/10.1007/s11858-016-0775-y

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology*, *94*(2), 344–355. https://doi.org/10.1037//0022-0663.94.2.344

Steffensky, M., Gold, B., Holdynski, M., & Möller, K. (2015). Professional vision of classroom management and learning support in science classrooms – Does professional vision differ across general and content-specific classroom interactions? *International Journal of Science and Mathematics Education*, *13*(2), 351–368. https://doi.org/10.1007/s10763-014-9607-0

Steuer, G., & Dresel, M. (2015). A constructive error climate as an element of effective learning environments. *Psychological Test and Assessment Modeling*, *57*(2), 262–275.

Stürmer, K., Könings, K. D., & Seidel, T. (2013). Declarative knowledge and professional vision in teacher education: Effect of courses in teaching and learning. *The British Journal of Educational Psychology*, *83*(Pt 3), 467–483. https://doi.org/10.1111/j.2044-8279.2012.02075.x

Stürmer, K., Könings, K. D., & Seidel, T. (2015). Factors within university-based teacher education relating to preservice teachers' professional vision. *Vocations and Learning*, *8*(1), 35–54. https://doi.org/10.1007/s12186-014-9122-z

Stürmer, K., & Seidel, T. (2017). Connecting generic pedagogical knowledge with practice. *Teacher Noticing: Bridging and Broadening Perspectives, Contexts, and Frameworks*, 137–149. https://doi.org/10.1787/9789264270695-8-en

Stürmer, K., Seidel, T., & Kunina-Habenicht, O. (2015). Unterricht wissensbasiert beobachten. Unterschiede und erklärende Faktoren bei Referendaren zum Berufseinstieg [Knowledge-based observation of classrooms: Differences and explaining factors for pre-service teacher in their early career phase]. Advance online publication. https://doi.org/10.25656/01:15366

Stürmer, K., Seidel, T., & Schäfer, S. (2013). Changes in professional vision in the context of practice. *Gruppendynamik Und Organisationsberatung*, *44*(3), 339–355. https://doi.org/10.1007/s11612-013-0216-0

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction*, *4*(4), 295–312. https://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Springer.

Sweller, J., & Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction*, *2*(1), 59–89. https://doi.org/10.1207/s1532690xci0201_3

Sweller, J., van Merriënboer, J. J. G., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review*, *31*(2), 261–292. https://doi.org/10.1007/s10648-019-09465-5

Tannert, S., Eitel, A., Marder, J., Seidel, T., Renkl, A., & Glogger-Frey, I. (2023). How can signaling in authentic classroom videos support reasoning on how to induce learning strategies? *Frontiers in Education*, *8*, Article 974696. https://doi.org/10.3389/feduc.2023.974696

Telgmann, L., & Müller, K. (2023). Training & prompting pre-service teachers' noticing in a standardized classroom simulation – a mobile eye-tracking study. *Frontiers in Education*, *8*, Article 1266800. https://doi.org/10.3389/feduc.2023.1266800

Terhart, E. (2021). Zukunftsthemen der Schulforschung [Future themes of school research]. In D. Fickermann, B. Edelstein, J. Gerick, & K. Racherbäumer (Eds.), *Schule und Schulpolitik während der Corona-Pandemie: Nichts gelernt?* (pp. 147–175). Waxmann. https://doi.org/10.31244/9783830994589.07

Thiel, F., Böhnke, A., Barth, V. L., & Ophardt, D. (2023). How to prepare preservice teachers to deal with disruptions in the classroom? Differential effects of learning with functional and dysfunctional video scenarios. *Professional Development in Education*, *49*(1), 108–122. https://doi.org/10.1080/19415257.2020.1763433

Todorova, M., Sunder, C., Steffensky, M., & Möller, K. (2017). Pre-service teachers' professional vision of instructional support in primary science classes: How content-specific is this skill and which learning opportunities in initial teacher education are relevant for its acquisition? *Teaching and Teacher Education*, *68*, 275–288. https://doi.org/10.1016/j.tate.2017.08.016

Tsui, A. B. (2013). Distinctive qualities of expert teachers. In M. Ben-Peretz & G. McCulloch (Eds.), *International perspectives on veteran teachers* (pp. 19–37). Routledge. https://doi.org/10.4324/9781315874982-3

Tucholka, I., & Gold, B. (2025). Analysing classroom videos in teacher education – How different instructional settings promote student teachers' professional vision of classroom management. *Learning and Instruction*, *97*, 102084. https://doi.org/10.1016/j.learninstruc.2025.102084

Turner, J. C., Thorpe, P. K., & Meyer, D. K. (1998). Students' reports of motivation and negative affect: A theoretical and empirical analysis. *Journal of Educational Psychology*, *90*(4), 758–771. https://doi.org/10.1037//0022-0663.90.4.758

Udvardi-Lakos, N., Weirich, M., Asbrand, J., & Renkl, A. (2024). Example-based learning in heuristic domains: Can using relevant content knowledge support the effective allocation of intrinsic, extraneous, and germane cognitive load? *Frontiers in Psychology, 15,* 1387095. https://doi.org/10.3389/fpsyg.2024.1387095

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*(4), 571–596.

van Es, E. A., & Sherin, M. G. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education*, *24*(2), 244–276. https://doi.org/10.1016/j.tate.2006.11.005

van Es, E. A., & Sherin, M. G. (2024). Correction: Expanding on prior conceptualizations of teacher noticing. *ZDM,* 1. https://doi.org/10.1007/s11858-024-01570-2

van Merriënboer, J. J. G. (1997). *Training complex cognitive skills: A four-component instructional design model for technical training*. Educational Technology.

van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive Load Theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, *17*(2), 147–177. https://doi.org/10.1007/s10648-005-3951-0

van Tartwijk, J., Brok, P. den, Veldman, I., & Wubbels, T. (2009). Teachers' practical knowledge about classroom management in multicultural classrooms. *Teaching and Teacher Education*, *25*(3), 453–460. https://doi.org/10.1016/j.tate.2008.09.005

Vygotskij, L. S. (1986). *Denken und Sprechen* [Thinking and speaking]. Fischer.

Weber, K. E., Gold, B., Prilop, C. N., & Kleinknecht, M. (2018). Promoting pre-service teachers' professional vision of classroom management during practical school training: Effects of a structured online- and video-based self-reflection and feedback intervention. *Teaching and Teacher Education*, *76*, 39–49. https://doi.org/10.1016/j.tate.2018.08.008

Wei, Y., Zhang, Q., Guo, J., & Chen, M. (2023). Learning to teach through noticing: A bibliometric review of teacher noticing research in mathematics education during 2006–2021. *Humanities and Social Sciences Communications*, *10*(1). https://doi.org/10.1057/s41599-023-01718-7

Weinert, F. E. (2001). Concept of competence: A conceptual clarification. In Rychen, Dominique, Simone & L. H. Salganik (Eds.), *Definition and selection of key competencies* (pp. 45–65). Hogrefe & Huber.

Westphal, A., Lohse-Bossenz, H., Vock, M., & Lenske, G. (2018). Was wissen Studierende über Klassenführung? Lerngelegenheiten und Lerngewinne in Studium und Praxissemester [What do university students know about classroom management? Learning opportunities and learning achievements in university studies and practical experiences]. In M. Rothland & N. Schaper (Eds.), *Lehrerbildung auf dem Prüfstand: 11 (1). Forschung zum Praxissemester in der Lehrerbildung* (pp. 132–151). Verlag Empirische Pädagogik.

Weyers, J., König, J., Santagata, R., Scheiner, T., & Kaiser, G. (2023). Measuring teacher noticing: A scoping review of standardized instruments. *Teaching and Teacher Education*, *122*, 103970. https://doi.org/10.1016/j.tate.2022.103970

Weyers, J., König, J., Scheiner, T., Santagata, R., & Kaiser, G. (2024). Teacher noticing in mathematics education: A review of recent developments. *ZDM*, *56*(2), 103–133. https://doi.org/10.1007/s11858-023-01527-x

Wilkes, T., Stark, L., Trempler, K., & Stark, R. (2022). Contrastive video examples in teacher education: A matter of sequence and prompts. *Frontiers in Education*, *7*, Article 869664. https://doi.org/10.3389/feduc.2022.869664

Witt, J. C., VanDerHeyden, A. M., & Gilbertson, D. (2004). Instruction and classroom management: Prevention and intervention research. In R. B. Rutherford, M. M. Quinn, & S. R. Mathur (Eds.), *Handbook of research in emotional and behavioral disorders* (pp. 426–445). The Guilford Press.

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. (2017). See and tell: Differences between expert and novice teachers' interpretations of problematic classroom management events. *Teaching and Teacher Education*, *66*, 295–308. https://doi.org/10.1016/j.tate.2017.04.015

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. A. (2021). Classroom management scripts: A theoretical model contrasting expert and novice teachers' knowledge and awareness of classroom events. *Educational Psychology Review*, *33*(1), 131–148. https://doi.org/10.1007/s10648-020-09542-0

Wolff, C. E., van den Bogert, N., Jarodzka, H., & Boshuizen, H. P. A. (2015). Keeping an eye on learning: Differences between expert and novice teachers' representations of classroom management events. *Journal of Teacher Education*, *66*(1), 68–85. https://doi.org/10.1177/0022487114549810

Woolfolk, A. E., Hoy, A. W., Hughes, M., & Walkup, V. (2008). *Psychology in education*. Pearson Education.

Wubbels, T., Brok, P. den, Veldman, I., & van Tartwijk, J. (2006). Teacher interpersonal competence for Dutch secondary multicultural classrooms. *Teachers and Teaching*, *12*(4), 407–433. https://doi.org/10.1080/13450600600644269

Yang, X., & Kaiser, G. (2022). The impact of mathematics teachers' professional competence on instructional quality and students' mathematics learning outcomes. *Current Opinion in Behavioral Sciences*, *48*, 101225. https://doi.org/10.1016/j.cobeha.2022.101225

2. Articles of the Dissertation

2.1 Article I

Development of Classroom Management Competencies: A Longitudinal Study

Bauersfeld, J. L., Gold, B., & Holodynski, M. (2025). Development of classroom management competencies throughout teacher education: a longitudinal study. *Teacher Development*, 1–21. https://doi.org/10.1080/13664530.2025.2455113

Funding sources: This research was funded by the Federal Ministry of Education and Research (BMBF, 01 JH 1202 A).

TEACHER DEVELOPMENT
https://doi.org/10.1080/13664530.2025.2455113

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Development of classroom management competencies throughout teacher education: a longitudinal study

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ABSTRACT

This study investigates the development of competencies of knowledge about classroom management (KCM) and professional vision of classroom management (PVCM), their interrelation throughout teacher education, and the contribution of learning opportunities to their development. KCM and PVCM of 34 bachelor's and 102 master's student teachers from Germany were measured before and after their bachelor's and master's studies and after the induction program. Multilevel models indicate an increase in master's student teachers' KCM and PVCM, although their PVCM decreased during the induction program. Cross-lagged panel analyses showed that PVCM at the end of the master's program predicted KCM after the induction program. Theoretical and practical learning opportunities did not affect the development of KCM and PVCM during the induction program; reflection even proved to have detrimental effects on the development of KCM. These results indicate the peculiarity of the induction program for developing KCM and PVCM.

ARTICLE HISTORY
Received 11 July 2023
Accepted 10 July 2024

KEYWORDS
Professional vision; teacher education; teacher competencies; classroom management

Introduction

Effective classroom management is a crucial component of teaching quality, alongside instructional and emotional support (Kunter et al. 2013; Pianta and Hamre 2009; Praetorius et al. 2018). Studies have indicated that effective classroom management is linked to students' cognitive and motivational development (Korpershoek et al. 2016; Kunter et al. 2013), as well as teachers' health (Friedman 2006) and job satisfaction (Dicke et al. 2015). In Germany, teacher education aims to equip student teachers with the necessary competencies for effective classroom management in the first academic phase at university, followed by a practice-oriented induction program. However, many student teachers still struggle with classroom management, and teacher education has been criticized for its ineffective preparation and lack of practical orientation (He and Cooper 2011; Korthagen 2010).

To address this concern, research on teacher education has refocused on the knowledge and skills of classroom management that aim to bridge the gap between theory and practice. In line with the perception–interpretation–decision-making (PID) model (Blömeke, Gustafsson,

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and Shavelson 2015), these competencies include knowledge about classroom management (KCM) and professional vision of classroom management (PVCM), which are closely connected concepts (Kersting et al. 2010). KCM entails knowledge about theoretical concepts of classroom management and how to implement them when teaching (Berliner 2001) to evaluate appropriate alternatives of action (Fenstermacher 1994). PVCM mediates KCM toward performance in the classroom through processes of perception, interpretation, and decision-making (Blömeke et al. 2022), which involve not only cognitive but also affective-motivational dispositions (Blömeke, Gustafsson, and Shavelson 2015).

To comply with demands formulated by debates on reforms in teacher education (e.g. Wilson, Floden, and Ferrini-Mundy 2001), teacher education has started implementing theoretical and practical learning opportunities in an induction program. These learning opportunities aim to support student teachers in building on the knowledge they acquire at university (Chitpin, Simon, and Galipeau 2008; Zeichner 2010), developing teacher expertise (Berliner 2001), and applying principles of reflective practice (Schön 1983). In these learning opportunities, student teachers can learn about concepts of classroom management, which they can then apply in the classroom and discuss with their supervisors for reflection (Cortina and Thames 2013). Hence, developing KCM and PVCM throughout teacher education could redress the deplored theory–practice division with the help of learning opportunities in the induction program.

Given these deliberations, the development of KCM and PVCM and their interrelation appears to be a crucial task of teacher education in preparing student teachers for effective classroom management. However, the development of competencies for bridging the gap between theory and practice has only recently been investigated. Although the PID model (Blömeke, Gustafsson, and Shavelson 2015) frames knowledge as a prerequisite of PVCM, their interrelation of KCM and PVCM throughout teacher education has hardly been investigated. Furthermore, it remains unclear how learning opportunities contribute to developing KCM and PVCM. Information on the longitudinal development of classroom management competencies could offer insight into individual trajectories and the interrelation of KCM and PVCM throughout teacher education. Analyzing learning opportunities in the induction program as predictors of this development can help us understand how contemporary teacher education contributes to competency development (Terhart 2012).

Classroom management

Along with instructional and emotional support, classroom management is a generic dimension of teaching quality (Pianta and Hamre 2009; Praetorius et al. 2018). Based on several studies on classroom management that implemented classroom observations or classroom videos (e.g. Kounin 1970; Van Tartwijk et al. 2009), Gold and Holodynski (2017) conceptualized three facets of effective classroom management:

(1) *Monitoring*: The teacher constantly *monitors* the classroom and demonstrates awareness of all events happening in the classroom (*withitness;* Kounin 1970; Wolff et al. 2016).
(2) *Managing momentum*: The group focus can be sustained by actively encouraging the students to contribute to the lesson and maintaining their attention (Doyle

2006). Students' attention is maximized through their involvement, while the smoothness of the lesson is supported (Kounin 1970).

(3) *Rules and routines*: A teacher must express clear expectations of students' behavior (Evertson and Emmer 2012). Establishing *rules and routines* can help manage social processes while supporting the lesson's structure.

Expert teachers orchestrate these facets systematically and comprehensively to prevent disruptions while supporting students' cognitive engagement (Emmer and Stough 2001), which in turn supports students' learning and motivation (Korpershoek et al. 2016; Kunter et al. 2013). Therefore, teacher education should prepare student teachers to implement effective classroom management.

German teacher education

German teacher education aims to impart competencies necessary for effective classroom management in a two-phase model (Cortina and Thames 2013). During the first academic phase at university, student teachers acquire knowledge about their subjects during their bachelor's and subsequent master's studies. The few pedagogical seminars in the first phase focus on theoretical concepts of classroom management (König 2012). In the second phase, student teachers participate in an induction program that lasts about a year, depending on the federal state, before beginning their early career phase. In this phase, student teachers gain practical experience in schools, accompanied by theoretical learning opportunities intended to connect knowledge with teaching experiences (Cortina and Thames 2013).

Although this two-phase model in teacher education is designed to build knowledge in the first phase and bridge the gap from theory to practice in the second phase, student teachers still struggle to implement effective classroom management (He and Cooper 2011). Therefore, the two-phase model has long been under discussion (Korthagen 2010). In an effort to enhance competency development, continuity in teacher education has been called for (Wilson, Floden, and Ferrini-Mundy 2001) to connect acquired knowledge from the academic phase at university with teaching practice at school. In response, research on teacher education has argued for a renewed focus on the competencies necessary to overcome the gap between theory and practice.

KCM and PVCM as classroom management competencies

According to the PID model, these important competencies entail cognitive dispositions (knowledge) and processes of professional vision, which are modeled along a continuum toward teaching performance (Blömeke, Gustafsson, and Shavelson 2015). Hence, to be able to implement effective classroom management, teachers need the cognitive dispositions of KCM and PVCM. These competencies are situated in nature (for a conceptualization, see Brown, Collins, and Duguid 1989) and meet the need to develop more practical and usable competencies in the context of teacher education (Korthagen 2010). KCM encompasses declarative knowledge about concepts of classroom management and knowledge regarding how to implement these concepts (Berliner 2001; 'wisdom of practice'; Shulman 1986, 13). This includes strategic KCM, which prompts teachers to use their knowledge about concepts of classroom management to be able to evaluate and judge alternatives of action

(Fenstermacher 1994). In comparison, PVCM entails processes of *perception*, *interpretation*, and *decision-making* (i.e. PID; Blömeke, Gustafsson, and Shavelson 2015; Sherin and van Es 2009), which are influenced and guided by both cognitive and affective-motivational dispositions. Hence, knowledge and professional vision are proposed to form an interrelated system (Kersting et al. 2010; König et al. 2014), and PVCM mediates between cognitive dispositions (KCM) and teaching performance (i.e. the implementation of classroom management) (Blömeke et al. 2022). Therefore, with the development of KCM and PVCM, teacher education could support student teachers in dealing with reported challenges of classroom management and could mitigate the theory–practice divide in teacher education. However, research on teacher education has only recently taken an interest in investigating the development of these competencies.

Development of KCM and PVCM throughout teacher education

How does KCM develop?

To investigate the development of KCM throughout teacher education, the internationally designed study 'TEDS-M' assessed KCM alongside aspects of general pedagogical knowledge in the cognitive processes of recalling, understanding/analyzing, and creating (König and Blömeke 2009). Cross-sectional studies investigating KCM with the TEDS-M instrument have suggested a linear development throughout teacher education (König 2012; König and Kramer 2016; see also Lenske et al. 2015). Looking at the different phases of teacher education, student teachers seem to acquire KCM concepts in the first phase of teacher education and knowledge regarding how to apply these concepts in the second phase (König 2012). Westphal et al. (2018) confirmed these results in a study measuring KCM exclusively in the first phase of teacher education. This indicates the transformation of declarative knowledge into more practice-oriented knowledge throughout teacher education.

While cross-sectional studies provide information about a particular time point, longitudinal studies can provide valuable insight into how individuals change over time. Therefore, researchers have implemented longitudinal designs to consider these individual differences when investigating the development of KCM. For instance, König (2012) replicated the findings from cross-sectional studies when the development of KCM was assessed using the TEDS-M instrument. Longitudinal studies measuring KCM exclusively have confirmed these findings (Schlag and Glock 2019; Westphal et al. 2018). For instance, Schlag and Glock (2019) found a significant increase in KCM in the first phase of teacher education. However, a more recent longitudinal study investigating KCM in the context of general pedagogical knowledge found a decrease after pre-service teachers entered the induction program (König et al. 2024).

How does PVCM develop?

Existing studies on the development of professional vision have primarily investigated cross-sectional expert–novice differences and have focused on classroom management (Stahnke, Schueler, and Roesken-Winter 2016). These studies have suggested that professional vision develops over time (Jacobs, Lamb, and Philipp 2010; Santagata and Yeh 2016) and that higher professional vision is linked to higher degrees of expertise (Berliner 2001; Gold and Holodynski 2017; König and Kramer 2016). For example, Jacobs, Lamb, and Philipp (2010) and Yang, König, and Kaiser (2021) found a linear development of professional vision throughout teacher education based on cross-sectional differences between different teachers' expertise levels (student, early career, and practicing teachers). To confirm these results using longitudinal designs, Orschulik (2021) conducted a study with student teachers in the first phase of teacher education and found a significant increase in professional vision. However, studies including the induction program have found a decrease in professional vision (e.g. Barenthien et al. 2023; Bastian et al. 2022) and have suggested that, during transitions between career stages throughout teacher education (e.g. into the induction program), teachers' competence development could be prone to decrease (Patterson 2019).

How are KCM and PVCM interrelated throughout teacher education?

Because knowledge guides perception, research on teacher expertise has suggested that, with growing expertise and deliberate practice, teachers develop flexible and interconnected knowledge structures (Berliner 2001), which can help them perceive and interpret relevant classroom situations quickly and purposefully (Wolff et al. 2016). Therefore, the PID model (Blömeke, Gustafsson, and Shavelson 2015) assumes that teachers need the knowledge to perceive and interpret classroom situations and thus develop professional vision. However, only a few studies have addressed how KCM and PVCM predict each other in terms of their development throughout teacher education. Initial findings have indicated positive correlations between the development of knowledge and professional vision, with a stronger interrelation during the first phase of teacher education than during the second phase (Barenthien et al. 2023). Moreover, König et al. (2014) found that knowledge after the induction program did not predict the ability to interpret classroom situations four years later and found correlations between the two competencies only after the induction program. This indicates that the induction program seems peculiar for developing competencies that aim to bridge the gap between theory and practice. Hence, the interrelation of KCM and PVCM and how they predict each other remain unclear.

How do learning opportunities contribute to the development of KCM and PVCM?

To develop KCM and PVCM, teacher education has implemented learning opportunities. The induction program primarily implements theoretical and practical learning opportunities that aim to develop KCM and PVCM. Practical learning opportunities (school experiences), along with theoretical learning opportunities (seminars), aim to link theory and practice (Korthagen 2010; Zeichner 2010) to help student teachers connect KCM to classroom situations mediated by PVCM. In theoretical learning opportunities, student teachers can talk about these concepts, try them out in a safe environment, and reflect on them with other student teachers (Laschke and König 2014). In practical learning opportunities, student teachers can observe these concepts, try them out in an actual classroom environment, and reflect on them with supervisors (Laschke and König 2014).

Most studies on the influence of learning opportunities on knowledge and professional vision were conducted in the first phase of teacher education (e.g. Mertens and Gräsel 2018; Orschulik 2021; Schlag and Glock 2019; Westphal et al. 2018; Weyers, Felske, and König 2022). Practical and theoretical learning opportunities have been found to positively affect KCM as a facet of general pedagogical knowledge (König et al. 2017; Weyers, Felske, and König 2022) or KCM exclusively (Schlag and Glock 2019; Westphal et al. 2018). To our knowledge, the only study in the induction program revealed that student teachers increased KCM significantly because of the higher number of practical learning opportunities (Voss, Kunter, and Baumert 2011).

Regarding the development of professional vision, research has suggested that, with deliberate practice, professional vision increases (Berliner 2001; Ericsson, Krampe, and Tesch-Römer 1993). Taking up this idea, Orschulik's (2021) longitudinal study in the first phase of teacher education showed that practical learning opportunities positively affect professional vision development. In contrast, in a cross-sectional design, Todorova et al. (2017) found only positive effects of theoretical learning opportunities on professional vision. However, studies on how learning opportunities in the induction program affect professional vision are missing.

Aim of the study

The goal of this study was to understand student teachers' development of KCM and PVCM throughout teacher education. Using a longitudinal design, we assessed a cohort of bachelor's student teachers throughout their bachelor's studies and a cohort of master's student teachers throughout their master's studies and their induction program. Our first research question addressed how KCM and PVCM develop throughout teacher education (*RQ1*). We expect KCM (*hypothesis 1a*) and PVCM (*hypothesis 1b*) to increase throughout teacher education. We also conducted exploratory analyses to investigate deviations from the linear development of PVCM, as recent studies have indicated such deviations (Barenthien et al. 2023; Bastian et al. 2022). Given that KCM is a prerequisite for PVCM, we were interested in how KCM and PVCM are interrelated throughout teacher education (*RQ2*). Based on previous findings, we assume that KCM and PVCM are positively correlated and that KCM predicts PVCM at a later measurement time point for bachelor's (*hypothesis 2a*) and master's student teachers (*hypothesis 2b*). Given that teacher education implements learning opportunities to develop KCM and PVCM in the induction program, we additionally analyzed how learning opportunities affect the development of KCM and PVCM in the induction program (*RQ3*). We expect learning opportunities to positively affect the development of KCM (*hypothesis 3a*) and PVCM (*hypothesis 3b*).

Method

Design and sample

The sample consisted of elementary school student teachers from four different universities in Germany. Two cohorts were investigated. The first cohort was examined at the beginning (t1) and the end (t2) of the student teachers' bachelor's studies. It consisted of $N = 34$ bachelor's student teachers (85.3% female, age: $M = 23.67$ [$SD = 5.40$]) enrolled in a three-year bachelor's program in teacher education. The second cohort was examined at the beginning of their master's studies (t1), after nine months at the end of their master's studies (t2), and after 27 months at the end of the induction program (t3). A total of $N = 102$ master's student teachers (89.2% female; age: $M = 27.84$ [$SD = 3.88$]) participated. At t1 $n = 99$, t2 $n = 80$ (18.6% dropouts), and t3 $n = 46$ master's student teachers (51.0% dropouts) participated in the study.

The study's participants voluntarily took part in the study and provided their informed consent. As the study posed no potential harm or discomfort to the participants and was therefore considered low-risk research, it did not require any formal approval from an institutional or governing board. We adhered to the ethical guidelines set forth by the American Psychological Association and the Code of Ethics of the World Medical Association (Declaration of Helsinki) for conducting research involving human subjects. We excluded the individual measurement time points of two bachelor's and three master's student teachers because their test processing time was lower than the required minimum (e.g. assessed by viewing a video in the professional vision test). We treated these as missing data in the statistical analyses.

We conducted independent *t*-tests to account for differences between the participants and the dropouts in the master's cohort and found that the dropouts' KCM at t2, $t(97) = 0.91$, $p = .368$, and t3, $t(97) = 0.56$, $p = .578$, did not significantly differ from the participants. Similarly, for PVCM, we found no differences between the participants and the dropouts at t2, $t(97) = 1.82$, $p = .074$, and t3, $t(97) = 0.96$, $p = .342$.

Measures

KCM

A situational judgment test by Gold and Holodynski (2015) assessed student teachers' KCM by eliciting the use of their knowledge of classroom management concepts (monitoring, managing momentum, and establishing rules and routines) to judge and evaluate different alternatives of action. Therefore, each item consisted of a short description of a classroom scenario with several accompanying alternatives of action that the participants rated for effectiveness on a scale from *very good* (A) to *failed* (F). Each scenario was a complexity-reduced situation description that concentrated on information relevant to one specific classroom management aspect. The test included 10 items: three for *monitoring*, three for *managing momentum*, and four for *establishing rules and routines.*

The student teachers' answers were compared to the master rating developed by Gold and Holodynski (2015). If a participant's answer matched the master rating regarding the relationship between two strategies (e.g. [a] *giving a succinct command* is less appropriate than [c] a *nonverbal intervention*), 1 point was awarded. Otherwise, they received zero

Table 1. Internal consistency (Cronbach's α) of tests on KCM and PVCM.

	Bachelor's student teachers		Master's student teachers		
Scale	t1	t2	t1	t2	t3
KCM	.770	.763	.859	.811	.800
PVCM	.915	.917	.862	.898	.896

KCM = knowledge about classroom management, PVCM = professional vision of classroom management.

points. The internal consistency for the situational judgment test was good for bachelor's and master's student teachers across all measurement time points (see Table 1).

PVCM

A video-based test by Gold and Holodynski (2017) was used to assess PVCM with four video clips (2–5 minutes) of authentic classroom situations at an elementary school and 47 rating items describing (16 items) and interpreting (31 items) the teacher's classroom management behavior. Different items tapped into three facets of classroom management (monitoring [15 items], managing momentum [16 items], and establishing rules and routines [16 items]) (see Table 2) on a 4-point scale from *agree* (1) to *disagree* (4). In contrast with the situation descriptions in the KCM test, the videos displayed the complexity, multidimensionality, and simultaneity of a classroom to challenge student teachers to notice and interpret relevant classroom management situations out of a wide range of information.

Student teachers' answers were compared to the master rating from Gold and Holodynski (2017). They received 1 point if their answer matched the master rating and zero points if they chose another option. The PVCM test's overall internal consistencies were high (see Table 1).

Learning opportunities

Based on Laschke and König's (2014) survey on learning opportunities in teacher education from the TEDS-M study, we developed a survey to rate learning opportunities regarding classroom management. Five different facets of classroom management were assessed: *monitoring*, *managing momentum*, *smoothness*, *group mobilization*, and *establishing rules and routines*. At the end of the induction program, on three different scales of learning opportunities, master's student teachers rated *theoretical learning opportunities*

Table 2. Example items of perceiving and interpreting the three facets of classroom management.

Perceiving	Interpreting
	Monitoring
'The teacher reprimanded one inattentive student.'	'Some students were distracted because the teacher did not succeed in preventing all interruptions quickly enough.'
	Managing Momentum
'The teacher uses a sign to initiate the transition from individual work to joint work.'	'Some students could not follow the lesson because the teacher explained too quickly.'
	Establishing Rules and Routines
'The teacher reminds the class about the rules on how to behave in the lesson.'	'The teacher has successfully established classroom rules.'

Adapted from 'Using Digital Video to Measure the Professional Vision of Elementary Classroom Management: Test Validation and Methodological Challenges,' by Gold and Holodynski (2017), *Computers & Education* 107, 18. (doi:/10.1016/j.compedu.2016.12.012).

(whether they [1] addressed the facet theoretically in the seminar, [2] tried to implement the facet in the seminar, [3] reflected on the facet in the seminar),[1] *practical learning opportunities* (whether they [4] could observe the facet in the classroom context, [5] tried out the facet in the classroom context), and *reflection* (whether they [6] reflected on the facet with other teachers) for each of the five abovementioned facets of classroom management on a 5-point scale from *never* (1) to *very frequently* (5).

The internal consistency of the items relating to theoretical (1–3; Cronbach's α = .91) and practical learning opportunities (4–5; Cronbach's α = .91) across the five facets of classroom management was very satisfactory. The item regarding reflection across the five facets displayed high internal consistency (6, Cronbach's α = .90).

Procedure

For each measurement time point, student teachers repeatedly completed all tests in the context of an online survey with the *Unipark* tool.

Statistical analyses

To model the development of KCM and PVCM, we estimated longitudinal multilevel models in *Mplus*, with measurement time points at level 1 and bachelor's and master's student teachers at level 2. Longitudinal multilevel models have advantages over analyses of variance in specifying the variance–covariance structure of errors in paired measurements (Bryk and Raudenbush 1987; Singer and Willett 2003). To account for interindividual differences, we allowed free estimation of parameter variances and covariances in the random effects model (Heck, Thomas, and Tabata 2013). Missing data were estimated using the maximum likelihood method, which yields unbiased results.

To assess the development of KCM and PVCM (*RQ1*), we fitted separate longitudinal multilevel models for bachelor's and master's student teachers as linear trends (time-linear). This resulted in four models: two models for bachelor's student teachers (KCM and PVCM) and two models for master's student teachers (KCM and PVCM). For bachelor's student teachers, we adjusted the measurement time points to 0 (t1) and 1 (t2). For master's student teachers, we coded the three measurement time points on a scale of 0–1. The initial measurement time point at the start of the master's program (t1) was coded as 0, while the third measurement time point 27 months after (t3) the end of the induction program was coded as 1. The second measurement time point nine months after the first (t2) was assigned a value of 0.33.

Because recent studies have indicated deviations from this linear development (e.g. Bastian et al. 2022), we additionally modeled a quadratic development of master's student teachers' PVCM (time-quadratic). The fixed effects showed intraindividual development of KCM and PVCM, whereas random effects displayed interindividual differences.

To investigate the interrelation between KCM and PVCM for bachelor's and master's student teachers (*RQ2*), we modeled paths and cross-paths using a cross-lagged panel design (CLP). CLPs consider (1) the lagged collection of dependent and independent variables, (2) the covariation over time, and (3) the exclusion of alternative explanations through concurrent cross-paths (Reinders 2006). Thus, a variable at one measurement time point can predict another variable at a later measurement time point (Nachtigall et al. 2003) while regarding intraindividual stability, mean interrelation, and cross-correlations across all measurement time points. We calculated two CLPs: one for bachelor's student teachers with two measurement time points and one for master's student teachers with three measurement time points.

To investigate the effect of learning opportunities on the development of KCM and PVCM (*RQ3*), we calculated another longitudinal multilevel model for the master's student teachers from t2 to t3 and included the scales of learning opportunities (theoretical learning opportunities, practical learning opportunities, and reflection) as predictors at the student teacher level.

Results

The means and standard deviations are displayed in Table 3.

Development of KCM and PVCM

Table 4 shows the models' estimates for bachelor's and master's student teachers' development of KCM and PVCM (*RQ1*). The results for the fixed effects revealed no significant development of bachelor's student teachers' KCM and PVCM, while master's student teachers were found to have significantly increased KCM and PVCM (time-linear). Because we were interested in possible deviations from linear development, we conducted explorative analyses in a quadratic model and found that master's student teachers' positive development of PVCM decreased during the induction program (time-quadratic). Random effects revealed interindividual

Table 3. Descriptive statistics of KCM and PVCM.

	Bachelor's student teachers				Master's student teachers					
	t1		t2		t1		t2		t3	
Scale	*M(SD)*	*n*	*M(SD)*	*n*	*M(SD)*	*n*	*M(SD)*	*n*	*M(SD)*	*n*
KCM	0.74 (0.10)	31	0.76 (0.11)	32	0.78 (0.09)	99	0.79 (0.08)	80	0.82 (0.06)	43
PVCM	0.35 (0.19)	31	0.41 (0.23)	32	0.47 (0.17)	99	0.54 (0.21)	80	0.53 (0.21)	46

KCM = knowledge about classroom management; PVCM = professional vision of classroom management; standard deviations are in parentheses.

Table 4. Multilevel analyses of the development of KCM and PVCM throughout teacher education.

	Model KCM Bachelor		Model PVCM Bachelor		Model KCM Master		Model PVCM Master	
Effect	Value[a]	*p*	Value[a]	*p*	Value[a]	*p*	Value[a]	*p*
Fixed Effects								
Intercept	0.735	<.001	0.357	<.001	0.779	<.001	0.466	<.001
Time-linear	0.022	.248	0.054	.080	0.040	.001	0.353	<.001
Time-quadratic							−0.291	<.001
Random Effects								
Intercept	0.006	.009	0.030	.001	0.004	.001	0.022	<.001
Time-linear	0.002	.523	0.013	.279	0.002	.494	0.015	.595
Time-quadratic							0.020	.333

KCM = knowledge about classroom management; PVCM = professional vision of classroom management [a]Fixed effects are nonstandardized regression coefficients; random effects are estimated variances.

differences between bachelor's and master's student teachers' KCM and PVCM at the beginning of their bachelor's and master's studies (intercept) but no interindividual differences in the development of KCM and PVCM (time-linear and time-quadratic).

Interrelation of KCM and PVCM throughout teacher education

Figure 1 displays estimates of the CLP analyses of the interrelation of bachelor's student teachers' KCM and PVCM (*RQ2*). However, a nonsignificant correlation at t1 and t2 and nonsignificant cross-paths indicated no relationship between KCM and PVCM for student teachers during their bachelor's studies.

The CLP analyses of master's student teachers' interrelation of KCM and PVCM are displayed in Figure 2 (*RQ2*). Significant correlations between KCM and PVCM at t1 and t2 indicated a positive interrelation between KCM and PVCM during their master's studies. However, a nonsignificant correlation at t3 suggested no interrelation between KCM and PVCM at the end of the induction program. Both cross-paths between t1 and t2 were nonsignificant, indicating no predictive interrelation between KCM and PVCM throughout their master's studies. In contrast with our assumptions and the PID model, one significant cross-path from t2 to t3 indicated that PVCM at the end of the master's program predicted KCM at the end of the induction program. Because the cross-path between KCM at t2 and PVCM at t3 was nonsignificant, our assumption that KCM predicted PVCM could not be confirmed.

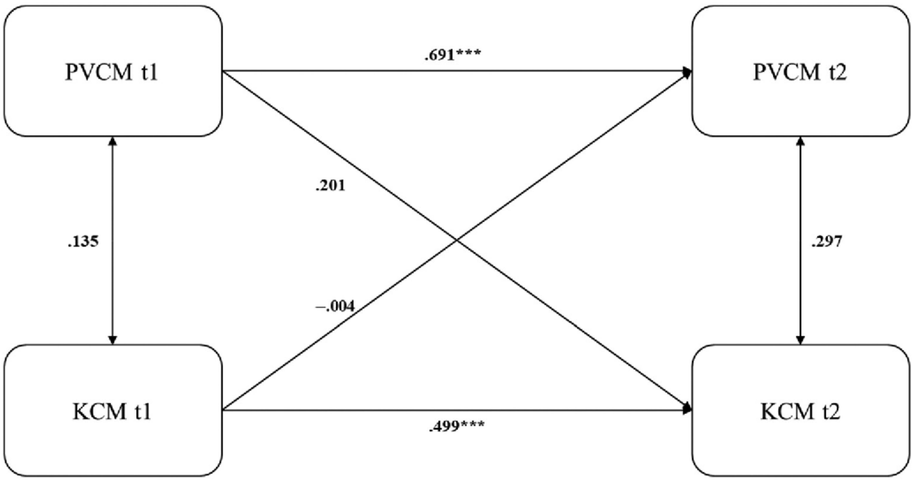

Figure 1. Interrelation between Bachelor's student teachers' PVCM and KCM. Note. KCM = knowledge about classroom management; PVCM = professional vision of classroom management; *$p < .05$. **$p < .01$. ***$p < .001$.

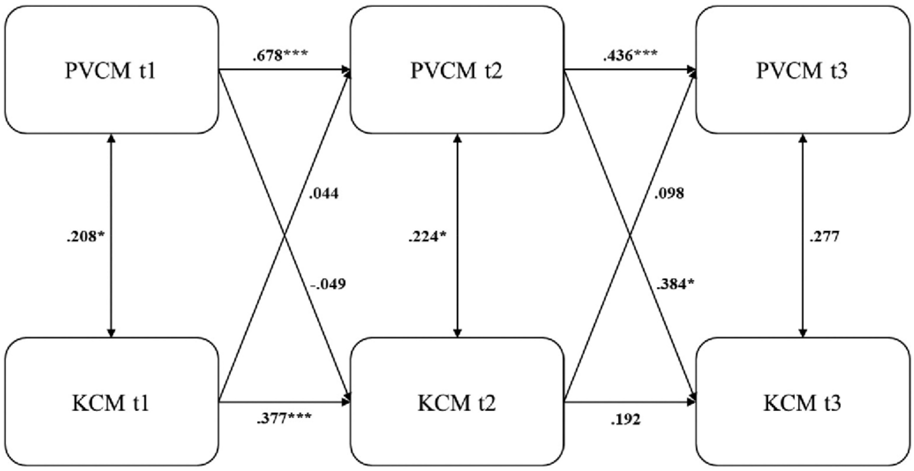

Figure 2. Interrelation between master's student teachers' PVCM and KCM. Note. KCM = knowledge about classroom management; PVCM = professional vision of classroom management; *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5. Multilevel analyses of the effect of learning opportunities on the development of KCM and PVCM in the induction program.

	Model KCM		Model PVCM	
Effect	Value[a]	*p*	Value[a]	*p*
Fixed Effects				
Theoretical learning opportunities	−0.017	.387	−0.071	.299
Practical learning opportunities	0.033	.104	0.043	.541
Reflection	−0.026	.042	−0.008	.859

KCM = knowledge about classroom management; PVCM = professional vision of classroom management,
[a]Fixed effects are nonstandardized regression coefficients.

The effect of learning opportunities on the development of KCM and PVCM

Table 5 shows the estimates of the effects of theoretical and practical learning opportunities on the development of KCM and PVCM during the induction program. The fixed effects revealed no significant effect of theoretical and practical learning opportunities on the development of KCM or PVCM. Thus, neither theoretical nor practical learning opportunities seemed to contribute to the development of KCM and PVCM. However, the negative significant fixed effect of reflection on the development of KCM indicated that learning opportunities involving reflection had a detrimental impact on the development of KCM. The effect of reflection on PVCM was nonsignificant.

Discussion

The present study longitudinally investigated the development of KCM and PVCM throughout teacher education. Since longitudinal research on the development of KCM and PVCM and their interrelation is scarce, our study aimed to examine how KCM and PVCM develop and how they are interrelated throughout teacher education.

The study also provided insights into the effects of learning opportunities on the development of KCM and PVCM. The study involved bachelor's student teachers in their bachelor's studies and master's student teachers in their master's studies and their induction program.

Development of KCM and PVCM

For *RQ1*, we investigated how KCM and PVCM develop throughout teacher education. We could only partially confirm the hypothesized linear development of KCM (*hypothesis 1a*) and PVCM (*hypothesis 1b*) found in previous studies (e.g. König 2012; Yang, König, and Kaiser 2021). KCM and PVCM did not significantly increase throughout the bachelor's program, but master's student teachers significantly developed KCM throughout their master's studies and the induction program. However, the explorative analyses of the development of PVCM indicated a decrease during the induction program following an initial increase during the master's program. Overall, bachelor's and master's student teachers developed similarly in KCM and PVCM throughout teacher education.

The missing development during bachelor's studies could be because bachelor's student teachers have not yet acquired sufficient declarative knowledge about concepts of classroom management (see also König 2012). KCM is conceptualized as the use of knowledge about concepts of classroom management (Shulman 1986) for evaluating alternatives of action in a classroom situation (Gold and Holodynski 2015). Sufficient knowledge about concepts of classroom management is a prerequisite for bachelor's student teachers to transform this knowledge into usable knowledge (derived from Anderson and Krathwohl 2001) to evaluate alternatives of action. Because professional vision is another indicator of usable knowledge (Blömeke, Gustafsson, and Shavelson 2015), bachelor's student teachers' insufficient KCM might also have a restraining effect on their development of PVCM. In contrast, master's student teachers in the induction program might have already acquired sufficient knowledge for transformation processes into KCM.

Developments in the transition of student teachers from the first phase into the induction program generally indicate the extent to which KCM and PVCM acquired in the first phase at university support pre-service teachers in teaching practice. However, pre-service teachers face the challenge of acting in real-life classrooms based on the classroom management competencies acquired at university. Because of their experience with teaching practice, teachers often have already unified and automatized processes of perception and interpretation into decision-making (Berliner 2001; Wolff, Jarodzka, and Boshuizen 2021). It is possible that because pre-service teachers in the induction program have gained experience in the classroom context, they may have already automatized processes of perception and interpretation over the course of the induction program and, therefore, have decreased in PVCM, as assessed by the video test. This is supported by the fact that pre-service teachers mainly develop in the PVCM facet of decision-making when faced with real-world classroom situations in the induction program (König 2012). While the PVCM test did not capture decision-making as a facet of PVCM, the situational judgment test assessed the decision-making component as part of KCM by requiring participants to evaluate alternatives of action. This could explain why pre-service teachers developed in KCM but decreased in PVCM during the induction program.

Nevertheless, studies have indicated that experienced teachers perform significantly better in perceiving and interpreting classroom situations (PVCM; e.g. Gold and Holodynski 2017; Jacobs, Lamb, and Philipp 2010) than student or pre-service teachers. Because there remains a disconnection between theoretical learning at university and teaching practice at school (Tatto, Rodriguez, and Reckase 2020), pre-service teachers are highly challenged when transitioning from the academic environment of the university to teaching practice (Stokking et al. 2003). They must switch from the passive perspective of the observer to actors in real-life classroom situations. Therefore, PVCM acquired at university may be 'inert' (Renkl, Mandl, and Gruber 1996); thus, pre-service teachers can articulate it when passively observing classrooms but struggle to use it actively in teaching practice. Perhaps the development of PVCM may not be fully linear but has 'stops, starts, and digressions' (Patterson 2019, 4). Further studies should investigate longer periods of time to capture the development of PVCM throughout teacher education with more differentiated instruments or methods suggested to measure professional vision (Nückles 2021).

Interrelation between KCM and PVCM throughout teacher education

For *RQ2*, we examined the interrelation between KCM and PVCM throughout teacher education. We assumed that positive correlations would be found between KCM and PVCM and that KCM would predict PVCM during the bachelor's program (*hypothesis 2a*) and during the master's program and the induction program (*hypothesis 2b*). The findings from the CLP analyses revealed no correlations between KCM and PVCM, and KCM did not predict PVCM, or vice versa, for the bachelor's program. In the master's cohort, we could only confirm the expected positive correlations between KCM and PVCM for the master's program, but this was not the case for the induction program. In contrast with our assumptions, the only significant cross-path interrelation indicated that PVCM at the end of the master's program (t2) predicted KCM at the end of the induction program (t3).

Although many studies have found positive correlations between knowledge and professional vision at various stages throughout teacher education (e.g. König et al. 2014), we could not replicate these results for the bachelor's student teachers and not after the induction program. The nonsignificant correlations for the bachelor's program could indicate that student teachers have not yet built up an interconnected KCM knowledge base (Berliner 2001). Presumably, student teachers need minimum KCM to guide the processes of PVCM; therefore, PVCM does not develop during the bachelor's program. Moreover, the nonsignificant correlation between KCM and PVCM after the induction program could be associated with the decrease in PVCM during the induction program.

Our cross-path results also could not replicate Blömeke, Gustafsson, and Shavelson's (2015) assumption that KCM is a prerequisite for PVCM. However, Santagata and Yeh (2016) suggested a bi-directionality in the interrelation between knowledge and professional vision. With the increasing deliberate practice of teaching in the induction program, student teachers improve their abilities to perceive, interpret, and make decisions while also expanding their knowledge through valuable classroom experience (Santagata and Yeh 2016). Since PVCM is a prerequisite for teaching practice (Blömeke et al. 2022; Blömeke, Gustafsson, and Shavelson 2015), the ability to perceive and interpret classroom situations might help in evaluating alternatives of action in classroom situations (see also König et al. 2014). Hence, Santagata and Yeh's (2016) claim that the development of professional vision could also lead to increases in knowledge could be shown in our study.

The effect of learning opportunities on the development of KCM and PVCM

RQ3 investigated the effect of learning opportunities on the development of KCM (*hypothesis 3a*) and PVCM (*hypothesis 3b*) during the induction program. Contrary to our hypotheses and previous studies from the first phase (e.g. Mertens and Gräsel 2018; Schlag and Glock 2019; Weyers, Felske, and König 2022), neither theoretical nor practical learning opportunities affected the development of KCM or PVCM during the induction program. In terms of reflection, a negative significant effect indicated a detrimental effect on KCM in the induction program, whereas the effect of reflection on PVCM was nonsignificant.

One explanation for the nonsignificant effects of theoretical and practical learning opportunities on the development of KCM and PVCM could be that we surveyed only the quantity. However, several studies have shown that the quality of learning opportunities affects the development of competencies (e.g. Klemenz, König, and Schaper 2019). Furthermore, research has also suggested that, when student and pre-service teachers encounter practical experiences at school, the accompanying theoretical and practical learning opportunities must be aligned for effective competency development (e.g. Westphal et al. 2018). Pre-service teachers attending theoretical learning opportunities usually experience practical learning opportunities at different schools. Accordingly, it is difficult to align pre-service teachers' school experiences with the contents of the theoretical learning opportunities, or vice versa. This nonalignment of theoretical and practical learning opportunities in the induction program could have caused pre-service teachers to be unable to translate KCM and PVCM from theoretical to practical learning opportunities, or vice versa.

An explanation for the negative effect of reflection on KCM could be that the disparity between the academic environment of university versus teaching practice (Tatto, Rodriguez, and Reckase 2020), as well as the different philosophies of the two phases, may be an obstacle that pre-service teachers face in the induction program (Bullough and Draper 2004). Due to the necessity for pre-service teachers to adapt to a community of teaching practice, they may become disconnected from the practices of the academic community and the learned theoretical concepts (e.g. Chitpin, Simon, and Galipeau 2008). Consequently, student teachers might encounter challenges transferring knowledge from the first phase to teaching practice (Korthagen 2010). However, debates on reforms in teacher education have argued for continuity between the two phases of teacher education (Wilson, Floden, and Ferrini-Mundy 2001). Pre-service teachers must be supported to enhance their competencies (Chitpin, Simon, and Galipeau 2008; Zeichner 2010) for the development of teacher expertise (Berliner 2001) and to become reflective practitioners (Schön 1983). It is a serious challenge for teacher education to close the gap between the two phases of teacher education and to mediate between the two philosophies encountered at university and in teaching practice at schools.

Limitations

Some methodological limitations of this study should be discussed. First, because the study implemented no real control group, the development of KCM and PVCM could result from test repetition effects, which might impair the interpretation of the results. However, the intervals between measurement time points were relatively long; thus, repetition effects are very unlikely. Second, the sample of bachelor's student teachers only barely exceeded the requirement of 30 for multilevel analyses (Singer and Willett 2003), which might lead to impaired reliability of the results. Nevertheless, while previous studies have found significant development, particularly in declarative knowledge about concepts of classroom management (e.g. König 2012), our study implemented instruments investigating competencies that aim to bridge the gap between theory and practice (Gold and Holodynski 2015, 2017). It is an important finding that bachelor's student teachers do not develop classroom management competencies during their bachelor's studies, because this shows that a sufficient foundation of knowledge of concepts about classroom management must be imparted by teacher education before classroom management competencies can develop. Third, although we could successfully obtain data on learning opportunities from the induction program ratings, it was based solely on self-reports; therefore, bias could be involved. Furthermore, due to organizational obstacles, we have no information on the curricula of the induction program or on the quality of the learning opportunities, which differ among different locations. Additional data on the curricula and quality of learning opportunities throughout teacher education (e.g. data from teacher educators, observation ratings on the quality of learning opportunities, or a subset of interviews with student teachers participating in the induction program) could provide insights into how learning opportunities affect the development of KCM and PVCM.

Although our study was conducted specifically in the context of German teacher education, it should be noted that only a few studies have conducted multilevel and CLP analyses to investigate the development of classroom management competencies throughout teacher education. This exceptional feature of the present study provides insight into the development of student teachers' KCM and PVCM, their interrelation, and the effect of learning opportunities on their development. It is an important finding that KCM and PVCM might not develop fully linearly and that learning opportunities in the induction program do not positively affect the development of KCM and PVCM, as this finding shows the peculiarity of the induction program in the context of teacher education. Future research should increasingly focus on competency development and the effectiveness of learning opportunities in the context of the induction program.

Note

1. Another rating item surveyed whether master's student teachers in the induction program watched classroom videos in connection with classroom management. Descriptive data revealed that hardly any classroom videos were implemented in learning opportunities in the induction program ($M = 1.41$, $SD = 0.66$). Thus, we excluded this item from further analyses.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded by the Federal Ministry of Education and Research [BMBF, 01 JH 1202 A].

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References

Anderson, L. W., and D. R. Krathwohl. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York. NY: Longman.

Barenthien, J., A. Fiebranz, M. Todorova, K. Möller, and M. Steffensky. 2023. "Development of Professional Vision and Pedagogical Content Knowledge During Initial Teacher Education." *International Journal of Educational Research* 119:102186. https://doi.org/10.1016/j.ijer.2023.102186.

Bastian, A., G. Kaiser, D. Meyer, B. Schwarz, and J. König. 2022. "Teacher Noticing and Its Growth Toward Expertise: An Expert–Novice Comparison with Pre-Service and In-Service Secondary Mathematics Teachers." *Educational Studies in Mathematics* 110 (2): 205–232. https://doi.org/10.1007/s10649-021-10128-y.

Berliner, D. C. 2001. "Learning About and Learning from Expert Teachers." *International Journal of Educational Research* 35 (5): 463–482. https://doi.org/10.1016/S0883-0355(02)00004-6.

Blömeke, S., J. E. Gustafsson, and R. J. Shavelson. 2015. "Beyond Dichotomies: Competence Viewed as a Continuum." *Zeitschrift für Psychologie* 223 (1): 3–13. https://doi.org/10.1027/2151-2604/a000194.

Blömeke, S., A. Jentsch, N. Ross, G. Kaiser, and J. König. 2022. "Opening Up the Black Box: Teacher Competence, Instructional Quality, and Students' Learning Progress." *Learning & Instruction* 79: 79. https://doi.org/10.1016/j.learninstruc.2022.101600.

Brown, J. S., A. Collins, and P. Duguid. 1989. "Situated Cognition and the Culture of Learning." *Educational Researcher* 18 (1): 32–42. https://doi.org/10.3102/0013189X018001032.

Bryk, A. S., and S. W. Raudenbush. 1987. "Application of Hierarchical Linear Models to Assessing Change." *Psychological Bulletin* 101 (1): 147–158. https://doi.org/10.1037/0033-2909.101.1.147.

Bullough, R. V., and R. J. Draper. 2004. "Making Sense of a Failed Triad: Mentors, University Supervisors, and Positioning Theory." *Journal of Teacher Education* 55 (55): 407–420. https://doi.org/10.1177/0022487104269804.

Chitpin, S., M. Simon, and J. Galipeau. 2008. "Pre-Service Teachers' Use of the Objective Knowledge Framework for Reflection During Practicum." *Teaching & Teacher Education* 24 (8): 2049–2058. https://doi.org/10.1016/j.tate.2008.04.001.

Cortina, K. S., and M. H. Thames. 2013. "Teacher Education in Germany." In *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers*, edited by M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, and M. Neubrand, 49–62. Boston, MA: Springer. https://link.springer.com/chapter/10.1007/978-1-4614-5149-5_3.

Dicke, T., J. Elling, A. Schmeck, and D. Leutner. 2015. "Reducing Reality Shock: The Effects of Classroom Management Skills Training on Beginning Teachers." *Teaching & Teacher Education* 48:1–12. https://doi.org/10.1016/j.tate.2015.01.013.

Doyle, W. 2006. "Ecological Management and Classroom Management." In *Handbook of Classroom Management: Research, Practice, and Contemporary Issues*, edited by C. M. Evertson and C. S. Weinstein, 97–126. Malwah, NJ: Routledge.

Emmer, E. T., and L. M. Stough. 2001. "Classroom Management: A Critical Part of Educational Psychology, with Implications for Teacher Education." *Educational Psychologist* 36 (2): 103–112. https://doi.org/10.1207/S15326985EP3602_5.

Ericsson, K. A., R. T. Krampe, and C. Tesch-Römer. 1993. "The Role of Deliberate Practice in the Acquisition of Expert Performance." *Psychological Review* 100 (3): 363–406. https://doi.org/10.1037/0033-295X.100.3.363.

Evertson, C. M., and E. T. Emmer. 2012. *Classroom Management for Elementary Teachers*. Needham Heights, MA: Allyn & Bacon.

Fenstermacher, G. 1994. "Chapter 1: The Knower and the Known: The Nature of Knowledge in Research on Teaching." *Review of Research in Education* 20 (1): 3–56. https://doi.org/10.3102/0091732X020001003.

Friedman, I. A. 2006. "Classroom Management and Teacher Stress and Burnout." In *Handbook of Classroom Management: Research, Practice, and Contemporary Issues*, edited by C. M. Evertson and C. Weinstein, 935–954. New York: Routledge. https://doi.org/10.4324/9780203874783.

Gold, B., and M. Holodynski. 2015. "Development and Construct Validation of a Situational Judgment Test of Strategic Knowledge of Classroom Management in Elementary Schools." *Educational Assessment* 20 (3): 226–248. https://doi.org/10.1080/10627197.2015.1062087.

Gold, B., and M. Holodynski. 2017. "Using Digital Video to Measure the Professional Vision of Elementary Classroom Management: Test Validation and Methodological Challenges." *Computers & Education* 107:13–30. https://doi.org/10.1016/j.compedu.2016.12.012.

He, Y., and J. Cooper. 2011. "Struggles and Strategies in Teaching: Voices of Five Novice Secondary Teachers." *Teacher Education Quarterly* 38 (2): 97–116.

Heck, R. H., S. L. Thomas, and L. N. Tabata. 2013. *Multilevel and Longitudinal Modeling with IBM SPSS*. New York, NY: Routledge.

Jacobs, V. R., L. L. Lamb, and R. A. Philipp. 2010. "Professional Noticing of Children's Mathematical Thinking." *Journal for Research in Mathematics Education* 41 (2): 169–202. https://doi.org/10.5951/jresematheduc.41.2.0169.

Kersting, N. B., K. B. Givvin, F. L. Sotelo, and J. W. Stigler. 2010. "Teachers' Analyses of Classroom Video Predict Student Learning of Mathematics: Further Explorations of a Novel Measure of Teacher Knowledge." *Journal of Teacher Education* 61 (1–2): 172–181. https://doi.org/10.1177/0022487109347875.

Klemenz, S., J. König, and N. Schaper. 2019. "Learning Opportunities in Teacher Education and Proficiency Levels in General Pedagogical Knowledge: New Insights into the Accountability of Teacher Education Programs." *Educational Assessment, Evaluation and Accountability* 31 (2): 221–249. https://doi.org/10.1007/s11092-019-09296-6.

König, J. 2012. "Die Entwicklung von pädagogischem Unterrichtswissen: Theoretischer Rahmen, Testinstrument, Skalierung und Ergebnisse" [The development of pedagogical/psychological knowledge: Theory, instrument, scaling and results]. In *Lehramtsstudierende erwerben* *pädagogisches Professionswissen. Ergebnisse der Längsschnittstudie LEK zur Wirksamkeit der erziehungswissenschaftlichen Lehrerausbildung*, edited by J. König and A. Seifert, 143–182. Münster: Waxmann.

König, J., and S. Blömeke. 2009. "Pädagogisches Wissen von angehenden Lehrkräften" [General pedagogical knowledge of student teachers]. *Zeitschrift für Erziehungswissenschaft* 12 (3): 499–527. https://doi.org/10.1007/s11618-009-0085-z.

König, J., S. Blömeke, P. Klein, U. Suhl, A. Busse, and G. Kaiser. 2014. "Is Teachers' General Pedagogical Knowledge a Premise for Noticing and Interpreting Classroom Situations? A Video-Based Assessment Approach." *Teaching & Teacher Education* 38:76–88. https://doi.org/10.1016/j.tate.2013.11.004.

König, J., and C. Kramer. 2016. "Teacher Professional Knowledge and Classroom Management: On the Relation of General Pedagogical Knowledge (GPK) and Classroom Management Expertise (CME)." *International Journal on Mathematics Education* 48 (1): 139–151. https://doi.org/10.1007/s11858-015-0705-4.

König, J., R. Ligtvoet, S. Klemenz, and M. Rothland. 2017. "Effects of Opportunities to Learn in Teacher Preparation on Future Teachers' General Pedagogical Knowledge: Analyzing Program Characteristics and Outcomes." *Studies in Educational Evaluation* 53:122–133. https://doi.org/10.1016/j.stueduc.2017.03.001.

König, J., R. Ligtvoet, S. Klemenz, and M. Rothland. 2024. "Discontinued Knowledge Growth: On the Development of Teachers' General Pedagogical Knowledge at the Transition from Higher Education into Teaching Practice." *Teachers & Teaching* 1–19. https://doi.org/10.1080/13540602.2024.2308895.

Korpershoek, H., H. Truus, H. de Boer, M. van Kuijk, and S. Doolaard. 2016. "A Meta-Analysis of the Effects of Classroom Management Strategies and Classroom Management Programs on Students' Academic, Behavioral, Emotional, and Motivational Outcomes." *Review of Educational Research* 86 (3): 643–680. https://doi.org/10.3102/0034654315626799.

Korthagen, F. A. 2010. "Situated Learning Theory and the Pedagogy of Teacher Education: Towards an Integrative View of Teacher Behavior and Teacher Learning." *Teaching & Teacher Education* 26 (1): 98–106. https://doi.org/10.1016/j.tate.2009.05.001.

Kounin, J. S. 1970. *Discipline and Group Management in Classrooms*. New York, NY: Holt, Rinehart, & Winston.

Kunter, M., U. Klusmann, J. Baumert, D. Richter, T. Voss, and A. Hachfeld. 2013. "Professional Competence of Teachers: Effects on Instructional Quality and Student Development." *Journal of Educational Psychology* 105 (3): 805–820. https://doi.org/10.1037/a0032583.

Laschke, C., and J. König. 2014. "Erfassung der Lerngelegenheiten" [Assessing opportunities to learn]." In *Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M 2008). Dokumentation der Erhebungsinstrumente*, edited by C. Laschke and S. Blömeke, 45–108. Münster: Waxmann.

Lenske, G., H. Thillmann, J. Wirth, T. Dicke, and D. Leutner. 2015. "Pädagogisch-psychologisches Professionswissen von Lehrkräften: Evaluation des ProwiN-Tests [Pedagogical/Psychological Knowledge of Teachers: Evaluation of the ProwiN-Test]. *Zeitschrift für Erziehungswissenschaft* 18 (2): 225–245. https://doi.org/10.1007/s11618-015-0627-5.

Mertens, S., and C. Gräsel. 2018. "Entwicklungsbereiche bildungswissenschaftlicher Kompetenzen von Lehramtsstudierenden im Praxissemester" [Developmental areas of pedagogical/psychological competences of student teachers in school internships]. *Zeitschrift für Erziehungswissenschaft* 21 (6): 1109–1133. https://doi.org/10.1007/s11618-018-0825-z.

Nachtigall, C., U. Kroehne, F. Funke, and R. Steyer. 2003. "(Why) Should We Use SEM? Pros and Cons of Structural Equation Modeling." *Methods of Psychological Research Online* 8 (2): 1–22.

Nückles, M. 2021. "Investigating Visual Perception in Teaching and Learning with Advanced Eye-Tracking Methodologies: Rewards and Challenges of an Innovative Research Paradigm." *Educational Psychology Review* 33 (1): 149–167. https://doi.org/10.1007/s10648-020-09567-5.

Orschulik, A. B. 2021. *Entwicklung der professionellen Unterrichtswahrnehmung: Eine Studie zur Entwicklung Studierender in universitären Praxisphasen* [Development of Professional Vision in

Teaching: A Study on Student Teachers' Development Throughout School Internships in Initial Teacher Education]. Wiesbaden: Springer. https://doi.org/10.1007/978-3-658-33931-9.
Patterson, C. 2019. *Enacted Personal Professional Learning: Re-Thinking Teacher Expertise with Story-Telling and Problematics*. Singapore: Springer.
Pianta, R. C., and B. K. Hamre. 2009. "Conceptualization, Measurement, and Improvement of Classroom Processes: Standardized Observation Can Leverage Capacity." *Educational Researcher* 38 (2): 109–119. https://doi.org/10.3102/0013189x09332374.
Praetorius, A. K., E. Klieme, B. Herbert, and P. Pinger. 2018. "Generic Dimensions of Teaching Quality: The German Framework of Three Basic Dimensions." *ZDM – Mathematics Education* 50 (3): 407–426. https://doi.org/10.1007/s11858-018-0918-4.
Reinders, H. 2006. "Kausalanalysen in der Längsschnittforschung: Das Cross-Lagged Panel Design" [Causal Analyses in Longitudinal Research Designs. The Cross-Lagged Panel Design].; *Diskurs Kindheits-und Jugendforschung* 1 (4): 569–587. https://doi.org/10.25656/01:1001.
Renkl, A., H. Mandl, and H. Gruber. 1996. "Inert Knowledge: Analyses and Remedies." *Educational Psychologist* 31 (2): 115–121. https://doi.org/10.1207/s15326985ep3102_3.
Santagata, R., and C. Yeh. 2016. "The Role of Perception, Interpretation, and Decision Making in the Development of Beginning Teachers' Competence." *International Journal on Mathematics Education* 48 (1): 153–165. https://doi.org/10.1007/s11858-015-0737-9.
Schlag, S., and S. Glock. 2019. "Entwicklung von Wissen und selbsteingeschätztem Wissen zur Klassenführung während des Praxissemesters im Lehramtsstudium" [Development of Knowledge and Self-Reported Knowledge About Classroom Management Throughout a School Internship During Initial Teacher Education]. *Unterrichtswissenschaft* 47 (2): 221–241. https://doi.org/10.1007/s42010-019-00037-8.
Schön, D. A. 1983. *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books.
Sherin, M. G., and E. A. van Es. 2009. "Effects of Video Club Participation on Teachers' Professional Vision." *Journal of Teacher Education* 60 (1): 20–37. https://doi.org/10.3102/0013189X015002004 .
Shulman, L. S. 1986. "Those Who Understand: Knowledge Growth in Teaching." *Educational Researcher* 15 (2): 4–14. https://doi.org/10.3102/0013189X015002004.
Singer, J. D., and J. B. Willett. 2003. "Introducing the Multilevel Model for Change." In *Applied Longitudinal Data Analysis. Modeling Change and Event Outcome*, edited by J. D. Singer and J. B. Willett, 45–74. New York, NY: Oxford University Press.
Stahnke, R., S. Schueler, and B. Roesken-Winter. 2016. "Teachers' Perception, Interpretation, and Decision-Making: A Systematic Review of Empirical Mathematics Education Research." *International Journal on Mathematics Education* 48 (1): 1–27. https://doi.org/10.1007/s11858-016-0775-y.
Stokking, K., F. Leenders, J. De Jong, and J. Van Tartwijk. 2003. "From Student to Teacher: Reducing Practice Shock and Early Dropout in the Teaching Profession." *European Journal of Teacher Education* 26 (3): 329–350. https://doi.org/10.1080/0261976032000128175.
Tatto, M. T., M. C. Rodriguez, and M. Reckase. 2020. "Early Career Mathematics Teachers: Concepts, Methods, and Strategies for Comparative International Research." *Teaching & Teacher Education* 96:103–118. https://doi.org/10.1016/j.tate.2020.103118.
Terhart, E. 2012. "Wie wirkt Lehrerbildung? Forschungsprobleme und Gestaltungsfragen" [How does teacher education take effect? Research problems and design questions]. *Zeitschrift Für Bildungsforschung* 2 (1): 3–21. https://doi.org/10.1007/s35834-012-0027-3.
Todorova, M., C. Sunder, M. Steffensky, and K. Möller. 2017. "Pre-Service Teachers' Professional Vision of Instructional Support in Primary Science Classes: How Content-Specific is This Skill and which Learning Opportunities in Initial Teacher Education are Relevant for Its Acquisition?" *Teaching & Teacher Education* 68:275–288. https://doi.org/10.1016/j.tate.2017.08.016.
Van Tartwijk, J., P. den Brok, I. Veldman, and T. Wubbels. 2009. "Teachers' Practical Knowledge About Classroom Management in Multicultural Classrooms." *Teaching & Teacher Education* 25 (3): 453–460. https://doi.org/10.1016/j.tate.2008.09.005.

Voss, T., M. Kunter, and J. Baumert. 2011. "Assessing Teacher Candidates' General Pedagogical/ Psychological Knowledge: Test Construction and Validation." *Journal of Educational Psychology* 103 (4): 952–969. https://doi.org/10.1037/a0025125.

Westphal, A., H. Lohse-Bossenz, M. Vock, and G. Lenske. 2018. "Was wissen Studierende über Klassenführung? Lerngelegenheiten und Lerngewinne in Studium und Praxissemester" [What Do Student Teachers Know About Classroom Management? – Opportunities to Learn and Learning Gains in Initial Teacher Education and School Internships]. *Lehrerbildung auf dem Prüfstand* 11 (1): 132–151.

Weyers, J., C. Felske, and J. König. 2022. "Die Bedeutung von Lerngelegenheiten für das Erreichen von Kompetenzniveaus im pädagogischen Wissen bei angehenden Mathematiklehrkräften" [The relevance of opportunities to learn for student teachers' attainment of levels of competence in general pedagogical knowledge in mathematics]." In *Initiationen mathematikdidaktischer Forschung*, edited by N. Buchholtz, B. Schwarz, and K. Vorhölter, 247–266. Wiesbaden: Springer. https://doi.org/10.1007/978-3-658-36766-4_13.

Wilson, S., R. Floden, and J. Ferrini-Mundy. 2001. *Teacher Preparation Research: Current Knowledge, Gaps, and Recommendations*. Center for the Study of Teaching and Policy, University of Washington.

Wolff, C. E., H. Jarodzka, and H. P. Boshuizen. 2021. "Classroom Management Scripts: A Theoretical Model Contrasting Expert and Novice Teachers' Knowledge and Awareness of Classroom Events." *Educational Psychology Review* 33 (1): 131–148. https://doi.org/10.1007/s10648-020-09542-0.

Wolff, C. E., H. Jarodzka, N. van den Bogert, and H. P. Boshuizen. 2016. "Teacher Vision: Expert and Novice Teachers' Perception of Problematic Classroom Management Scenes." *Instructional Science* 44 (3): 243–265. https://doi.org/10.1007/s11251-016-9367-z.

Yang, X., J. König, and G. Kaiser. 2021. "Growth of Professional Noticing of Mathematics Teachers: A Comparative Study of Chinese Teachers Noticing with Different Teaching Experience." *ZDM Mathematics Education* 53 (1): 29–42. https://doi.org/10.1007/s11858-020-01217-y.

Zeichner, K. 2010. "Rethinking the Connections Between Campus Courses and Field Experiences in College-And University-Based Teacher Education." *Journal of Teacher Education* 61 (1/2): 89–99. https://doi.org/10.1177/0022487109347671.

2.2 Article II

Can Double-content Examples of Video-based Analyses Foster Student Teachers' Professional Vision of Classroom Management?

Bauersfeld, J. L., & Gold, B (2025). *Can double-content examples of video-based analyses foster student teachers' professional vision of classroom management?* [Manuscript under review]. Institute of School Pedagogy and General Didactics, TU Dortmund University.

Acknowledgments: We would like to thank Christian Schinköthe and Tanja Lindacher for their organizational support as well as our student research assistants for their help with collecting and coding the data.

Funding sources: The authors did not receive support from any organization for the submitted work.

Note: This preprint has not undergone peer review or any post-submission improvements or corrections. The Version of Record of this article is published in Instructional Science, and is available online at https://doi.org/10.1007/s11251-025-09738-3

Can Double-content Examples of Video-based Analyses Foster Student Teachers' Professional Vision of Classroom Management?

Abstract

Professional vision (PV) enables teachers to act competently in the classroom. PV is a situated cognitive skill that encompasses the cognitive processes of noticing, reasoning, and generating alternatives of action. Research on teacher expertise has also regarded the expert features of applying concepts, focusing on students, drawing inferences, and taking multiple perspectives as part of PV. PV can be fostered with video-based analyses, for which student teachers need instructional support. Double-content examples of video-based analyses with prompts and instructional explanations could support them when analyzing classroom videos. By self-explaining indicators of PV from the double-content examples, student teachers could transfer them to their own video-based analyses. *N* = 410 student teachers were enrolled in online self-study seminars, in which they either studied with or without complete or faded double-content examples and all conducted video-based analyses. In pre-post-tests, PV of cognitive processes and expert features were measured. We further assessed process data of self-explanations from faded double-content examples. Results showed no significant differences between the groups for alternatives of action, focusing on students, inferences, and multiple perspectives. Yet, double-content examples had detrimental effects on noticing + reasoning and application of concepts, indicating that merely presenting double-content examples did not foster situated cognitive skills of PV and possibly led to cognitive overload. Complete and faded double-content examples did not differ in student teachers' change of PV. Further, process data suggest that student teachers generally struggled to self-explain from these examples.

Introduction

Professional vision (PV) has been identified as a core competency for teachers (Grossman et al., 2009). Various research on cognitive psychology has conceptualized that PV encompasses the cognitive processes of *noticing* and *reasoning* (König et al., 2022; van Es & Sherin, 2002) on relevant classroom situations leading to the generation of *alternatives of action* (Blömeke et al., 2015; Jacobs et al., 2010; Kaiser et al., 2015). These cognitive processes have been recognized as essential to teacher expertise and develop throughout teacher education. Therefore, research on PV has emphasized differences between experts and novices (Berliner, 2001; König et al., 2022). It has been shown that experts display certain expert features when they notice and reason on classroom situations. They use *concepts of classroom management*, *focus on students*, *draw inferences* instead of superficial descriptions, and take *multiple perspectives* (Stahnke et al., 2021; Wolff et al., 2015, 2017). Both cognitive processes and expert features of PV represent usable knowledge (Kersting et al., 2012), enabling them to perform professionally in the classroom (e.g., for effective classroom management; Blömeke et al., 2022). However, student teachers have frequently deplored ineffective preparation through teacher education. Specifically, they have reported difficulties implementing effective classroom management (Flower et al., 2017; O'Neill & Stephenson, 2012).

Several studies have shown that video-based analyses can foster PV of classroom management (PVCM) in teacher education (e.g., Gold et al., 2021; van Es & Sherin, 2002). The situated approach of analyzing classroom videos can support student teachers in analyzing classroom situations and developing PV (Santagata et al., 2021; Seidel et al., 2013). However, because student teachers are novices, they typically possess limited knowledge (e.g., Gold et al., 2015) and classroom experience (Carter et al., 1988) and may be therefore overwhelmed with classrooms' complexity displayed in videos (Star & Strickland, 2008; Syring et al., 2015). Hence, it is essential to provide increased instructional support to student teachers when fostering PVCM through video-based analyses (Blomberg et al., 2013; Llinares & Valls, 2009; Santagata et al., 2021).

A well-known and frequently demonstrated effect of instructional support, particularly for novice and intermediate learners, is the worked example effect (Renkl, 2014), which has been frequently shown for well-structured domains (e.g., van Gog et al., 2011). In the context of ill-structured domains, worked examples are double-content examples that include the level of the learning domain (e.g., analyzing a classroom situation) and the exemplifying domain level (e.g., classroom management) (Renkl et al., 2009). The examples facilitate learning by allowing learners to focus cognitive resources on studying a provided example and thereby help them construct cognitive schemas for solving similar problems (Sweller et al., 2010). This has been shown to promote cognitive skill acquisition (e.g., Hefter et al., 2014; Hilbert & Renkl, 2008; Schworm & Renkl, 2007; van Gog et al., 2008). However, double-content examples are highly complex and demand a great amount of cognitive load (Renkl et al., 2009). Therefore, suggested design features to double-content examples (e.g., instructional explanations) may become redundant (van Gog et al., 2008) and even detrimental (Schworm & Renkl, 2006) over time. Hence, a fading procedure that gradually fades out relevant information and thereby may enhance self-explanation processes could remedy this effect (Renkl et al., 2004).

Based on these findings and deliberations, double-content examples containing written video-based analyses of classroom management by an expert teacher may support student teachers in learning how to analyze classroom situations. By studying how expert teachers analyze classroom situations, student teachers may develop in applying concepts about classroom management, focusing on students, drawing inferences, and considering multiple perspectives. This may improve their classroom video analyses and enhance PVCM (Santagata et al., 2007, 2021; Wolff et al., 2015).

Hence, the present study investigates whether double-content examples of expert teachers' video-based analyses can prompt student teachers to conduct more sophisticated video-based analyses and whether this leads to enhanced PVCM. A control group studied without double-content examples, whereas the intervention groups studied with double-content examples (with vs. without). We further varied the level of support by presenting student teachers with complete or faded double-content examples (complete vs. faded). This study aims to give insight into the transferability of findings from worked examples in well-structured domains to ill-structured domains, particularly in the context of teacher education. Further, the study proposes a practical approach to providing instructional support for student teachers engaged in video-based analyses in teacher education.

Professional Vision of Classroom Management

PV is a core competence for teachers (Grossman et al., 2009), enabling them to act professionally in a classroom (Blömeke et al., 2015, 2022). PV draws on usable knowledge (Kersting et al., 2012), which is situated in nature (McDonald et al., 2013), and recognizes the contextual quality of teaching expertise (Kaiser et al., 2015). In the past decades, there has been considerable debate about the conceptualization of PV. In their systematic literature review, König et al. (2022) have addressed that research has investigated PV from a cognitive-psychological perspective as well as from an expertise-related perspective. The cognitive-psychological perspective conceptualized PV "as a set of cognitive processes or processes that occur in the minds of individual teachers" (König et al., 2022, p. 3). In that sense, many conceptualizations have proposed *noticing*, *reasoning* (van Es & Sherin, 2002), as well as generating *alternatives of action* (Blömeke et al., 2015; Blömeke et al., 2022; Kaiser et al., 2015) as cognitive processes pertaining to PV. Noticing encompasses the perception and selection of relevant events, and reasoning addresses interpreting and evaluating these events. While noticing and reasoning are different in concept, they operate together during perception, making them inseparable in practice (Sherin, 2007). Together, they form the foundation for an informed generation of alternatives to action (Blömeke et al., 2015; Jacobs et al., 2010; Kaiser et al., 2015). Therefore, studies have reported high correlations between noticing and reasoning (Bastian et al., 2021) and suggested generating alternatives of action as a separate dimension (Weyers et al., 2023).

Considering these findings from the cognitive-psychological perspective, the expertise-related perspective has investigated differences between novice and expert teachers within these cognitive processes (e.g., Berliner, 2001; Stahnke et al., 2021; Wolff et al., 2015). Studies suggested that when noticing and reasoning on classroom management, expert teachers exhibit certain expert features, which contrast with novices (Berliner, 2001; Wolff et al., 2015) and support them in analyzing classrooms more productively (Santagata et al., 2007). These expert features encompass the application of *concepts about classroom management*, *focus on students*, *inferences*, and *multiple perspectives*. Expert teachers make use of highly interconnected and flexible cognitive schemata and scripts about classroom management (Berliner, 2001; Wolff et al., 2021) and rely on their experience (Carter et al., 1988) when analyzing classrooms. Student teachers lack cognitive schemata, scripts, and classroom experience; hence, they analyze classroom situations superficially and focus on irrelevant aspects (e.g., classroom arrangements) (Stahnke et al., 2021; Wolff et al., 2015). Therefore, novices still need to acquire theoretical concepts of classroom management (Berliner, 2004). Further, expert teachers *focus on student* learning and on-task behavior, whereas student teachers predominantly focus on students' off-task behavior and discipline (van Es & Sherin, 2002; Wolff et al., 2015). Moreover, expert teachers draw *inferences* from classroom situations by interpreting student and teacher cognitions, analyzing classroom situations in an open-ended and unbiased way, predicting student behavior, learning, and classroom management, and explaining (Stahnke et al., 2021; Wolff et al., 2015). Contrastively, student teachers often provide descriptions and dead-end interpretations while rarely predicting the progress of classroom situations (Wolff et al., 2015). Finally, expert teachers adopt *multiple perspectives* and include different viewpoints (e.g., of students and teachers) in their analyses, while student teachers rarely focus on more than one viewpoint (Hogan et al., 2003; Wolff et al., 2015). By integrating multiple perspectives in their analyses, expert teachers understand different wants and needs and, from there, make adequate decisions on how to act (Goeze et al., 2014; Könings et al., 2014).

These cognitive processes and expert features of PV support teachers in using their knowledge for professional performance in the classroom (e.g., for effective classroom management) (Blömeke et al., 2022; Kersting et al., 2012). However, student teachers have frequently criticized teacher education. Specifically, they have reported difficulties with effective classroom management (Flower et al., 2017; O'Neill & Stephenson, 2012). As a remedy, research on teacher education has shown that student teachers can learn how to use knowledge about classroom management and thereby develop PVCM through the situated approach of analyzing classroom videos (e.g., Gold et al., 2021). To analyze classroom videos focusing on classroom management, student teachers need knowledge about classroom management, which entails knowledge about "the actions teachers take to create an environment that supports and facilitates academic and social-emotional learning" (Evertson & Weinstein, 2006, p. 4). First, these actions encompass *monitoring* and *overlapping* (Kounin, 1970), in which teachers communicate awareness of what is happening in the classroom to students and deal with simultaneously occurring processes. This can be achieved through an adequate position within the classroom and identifying and addressing misbehavior early. Hence, warning and praising students in appropriate situations can be considered part of effective monitoring. Second, s*moothness* and *managing momentum* (Doyle, 2006; Kounin, 1970) are supported by controlling the pace, thoughtfully introducing rules and procedures, and clarity of instruction adaptive to students' needs. Third, the *group focus* and *group mobilization* (Doyle, 2006; Kounin, 1970) are secured by upholding students' on-task behavior and learning throughout the lesson and encouraging them to participate actively.

However, while student teachers value classroom videos to be authentic representations of classroom situations (Roche & Gal-Petitfaux, 2015), their complexity can also overwhelm student teachers when analyzing these videos (Star & Strickland, 2008; Syring et al., 2015) because they lack sufficient knowledge (Gold et al., 2015) and classroom experience (Carter et al., 1988). Further, student teachers frequently struggle to use their knowledge to analyze relevant classroom events (Blomberg et al., 2011), which could lead to detrimental effects on PV. Therefore, student teachers need additional instructional support to enhance the development of PVCM (Blomberg et al., 2013; Llinares & Valls, 2009; Santagata et al., 2021).

Double-content Examples as Instructional Support

A well-known and frequently demonstrated effect of instructional support, particularly for novice learners, is the worked example effect (Renkl, 2014). Worked examples include a problem formulation, individual solution steps, and the final solution. They facilitate learning by allowing learners to focus their cognitive resources on studying the provided solution and thereby help them construct cognitive schemas for solving similar problems (Sweller et al., 2010). When studying worked examples, learners can self-explain solution processes and relevant features for their own task processing (self-explanation effect; Chi et al., 1994). Consequently, worked examples have been shown to reduce learning time (Sweller & Cooper, 1995) and foster knowledge acquisition (Hilbert & Renkl, 2009; Schworm & Renkl, 2007).

Most of these findings stem from well-structured domains such as mathematics or physics (e.g., van Gog et al., 2011). Some studies have extended these findings to worked examples in ill-structured domains such as argumentation skills or diagnosing processes (Bichler et al., 2022; Kyun et al., 2013; Meier et al., 2022; Rourke & Sweller, 2009; Schworm & Renkl, 2007). First findings suggest that the positive effects found for worked examples can extend to ill-structured domains by presenting double-content examples to novices (Kyun et al., 2013; Lechner et al., 2024; Meier et al., 2022; Schworm & Renkl, 2007). Double-content examples include a level of the learning domain (e.g., analyzing a classroom situation) and the exemplifying domain level (e.g., classroom management). Like worked examples, double-content examples have been shown to promote cognitive skill acquisition (e.g., Hilbert & Renkl, 2008; Schworm & Renkl, 2007; van Gog et al., 2008).

To enable effective learning from double-content examples, some studies have shown that self-explanation prompts (e.g., Hilbert & Renkl, 2008; Schworm & Renkl, 2007; Rummel et al., 2006) and instructional explanations (e.g., van Gog et al., 2008) may be included within the examples. Self-explanation prompts have been shown to guide attention toward relevant aspects in the example and enhance learning outcomes (e.g., Hilbert & Renkl, 2006; Rummel et al., 2006; Schworm & Renkl, 2007). Instructional explanations present process information, explaining the steps' purpose through direct instruction (e.g., information on how and why teachers analyzed relevant classroom situations) (Kirschner et al., 2006; Sweller et al., 2007). However, findings on including instructional explanations within double-content examples show rather detrimental effects on learning outcomes (e.g., Hoogveld et al., 2005; Schworm & Renkl, 2006). Nevertheless, van Gog et al. (2008) found that presenting process information through instructional explanations might be beneficial in the initial stages of skill acquisition, but may become redundant in later stages. One explanation could be that double-content examples "usually demand complex and resource-demanding information processing" (Renkl et al., 2009; p. 2). In well-structured domains, fading procedures have been introduced, which gradually fade out relevant process information, enhancing self-explanation processes and supporting learners in deriving relevant features from the examples (Renkl et al., 2004). Therefore, fading of process information (i.e., instructional explanations) may help tackle this issue and allow learners to actively process examples (Hilbert et al., 2004) and prevent poor performance on transfer tasks (e.g., Meier et al., 2022; Schworm & Renkl, 2007). However, initial findings displayed that fading in double-content examples can enhance learning equally to complete double-content examples (Lechner et al., 2024).

In summary, double-content examples featuring written video-based analyses of classroom management could function as instructional support for student teachers by illustrating how an expert teacher analyzes a classroom video. By self-explaining how expert teachers analyze classroom situations from these double-content examples, student teachers may acquire the ability to analyze classroom videos more sophisticatedly (see also Santagata et al., 2021). Some studies have indicated that more sophisticated video-based analyses may enhance PV (Santagata et al., 2008; Wolff et al., 2015), which could lead to a higher development of student teachers' PVCM.

Aim of the Study

Given these considerations, the present study aims to replicate the worked-example effect and investigate whether a fading procedure is beneficial for double-content examples in the context of teacher education. Specifically, we implemented written video-based analyses of an expert teacher as double-content examples with prompts and instructional explanations addressing process information and investigated the effect on student teachers' PVCM from a cognitive-psychological and expertise-related perspective.

First, we investigated whether double-content examples (with vs. without) foster PVCM in student teachers' video-based analyses (RQ1). We expected the implementation of double-content examples to enhance PVCM more than just video-based analyses (double-content example hypothesis). Second, because previous findings on instructional explanations included in double-content examples yielded detrimental results, we also investigate whether complete or faded double-content examples (complete vs. faded) enhance student teachers' PVCM (RQ2). We suppose student teachers who studied faded double-content examples increased PVCM more than those who studied complete double-content examples (fading hypothesis). Lastly, the study gives further insights into how effective self-explanation processes in the faded double-content examples affect PVCM (RQ3). We expected self-explanation processes of the faded double-content examples to positively correlate with increases in PVCM (self-explanation hypothesis).

Method

Sample

A total of N = 466 student teachers participated in the study. We excluded n = 26 participants because they did not complete the survey at the second measurement time point and n = 30 because their processing time did not imply sincere task processing (e.g., to watch a video). Hence, the present quasi-experimental study in a pre-post design investigates N = 410 (M_{age} = 23.35, SD_{age} = 2.12; M_{term} = 2.05, SD_{term} = 0.50, 83.2% female) elementary student teachers in their master's degree from a German university. All participants were enrolled in one large online-based seminar that mainly involved self-study phases. The control group (CG) was assessed in spring 2020 (n = 74), intervention group 1 (IG1) in spring 2021 (n = 200), and intervention group 2 (IG2) in spring 2022 (n = 136). The groups did not differ significantly in tutoring experience, $F(2,407) = 0.28$, $p = .760$, $\eta^2 = .001$, and teaching experience, $F(2,405) = 1.93$, $p = .146$, $\eta^2 = .009$, but whether they have already attended seminars regarding classroom management, $F(2,407) = 5.31$, $p = .005$, $\eta^2 = .025$, with a small effect. Therefore, we included whether student teachers attended seminars regarding classroom management as a control variable. The online seminars were planned jointly by several instructors in spring 2020 and were conducted in a standardized way throughout spring 2020, 2021, and 2022. One instructor conducted the seminars except for the CG, in which two additional instructors also led the seminars. All participants gave written informed consent and were treated following ethical guidelines from the American Psychological Association and The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Materials

Development of Double-content Examples

We developed three text-based double-content examples based on video-based analyses of classroom management by an expert teacher with 38 years of teaching experience. The expert teacher watched two classroom videos and was asked for each video to write down noticed classroom management events, and reason on them as well as suggest alternatives of action in a table (see Figure 1). In the analysis for the first double-content example, the expert teacher focused on monitoring and overlapping; in the second analysis for the second double-content example, on smoothness and momentum; and in the third analysis for the third double-content example, on the group focus.

Figure 1

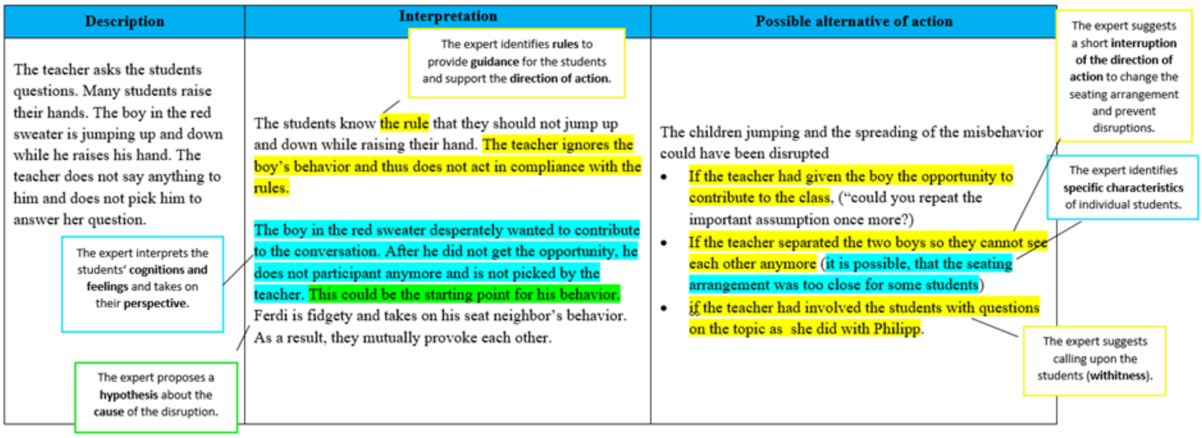
Example of one Event of the Expert Teachers' Video-based Analysis

Noticing	Knowledge-based reasoning	Alternative of action
The teacher asks the students questions. Many students raise their hands. The boy in the red sweater is jumping up and down while he raises his hand. The teacher does not say anything to him and does not pick him to answer her question.	The students know the rule that they should not jump up and down while raising their hands. The teacher ignores the boy's behavior and thus does not act in compliance with the rules. The boy in the red sweater desperately wanted to contribute to the conversation. After he did not get the opportunity, he does not participate anymore and is not picked by the teacher. This could be the starting point for his behavior. Ferdi is fidgety and takes on his seat neighbor's behavior. As a result, they mutually provoke each other.	The children jumping and the spreading of the misbehavior could have been disrupted • If the teacher had given the boy the opportunity to contribute to the class, ("Could you repeat the important assumption once more?) • If the teacher separated the two boys so they cannot see each other anymore (it is possible, that the seating arrangement was too close for some students) • If the teacher had involved the students with questions on the topic as he did with Philipp.

Based on research on teacher expertise (e.g., Berliner, 2001) and Wolff et al.'s (2015) more recent study using grounded theory, we searched for indicators of PV within the expert's analyses. These indicators encompassed the application of concepts of classroom management (Berliner, 2001; Wolff et al., 2021), focusing on students' learning and engagement (van Es & Sherin, 2002; Wolff et al., 2015), drawing inferences (Stahnke et al., 2021; Wolff et al., 2015), and considering multiple perspectives (Hogan et al., 2003; Wolff et al., 2015). To direct student teachers' attention, we highlighted text sequences, which included the indicators in the examples. Text sequences that included concepts of classroom management were highlighted in yellow, focusing on student learning and engagement and considering multiple perspectives in blue and inferences in green (see Figure 2). Correspondingly, we added instructional explanations, which addressed the respective indicator of sophistication in the highlighted text sequence (van Gog et al., 2008). Prompts, which guided student teachers (Schworm & Renkl, 2007) toward the respective highlighted expert features, were provided in the instruction before the double-content examples.

Figure 2

Example of a Double-content Example



Validation of Double-content Examples

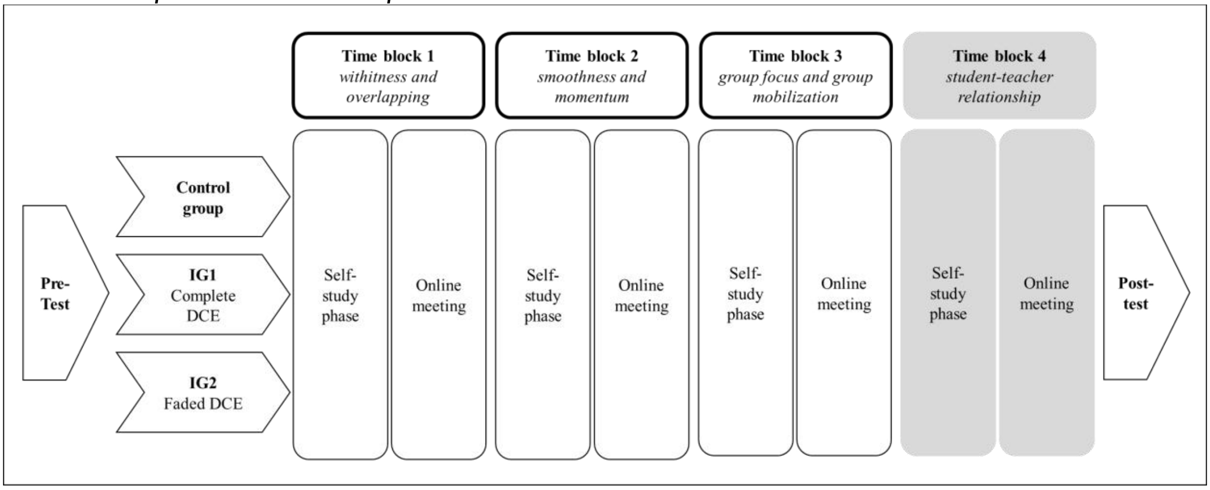
We validated the double-content examples to ensure their appropriateness as representations of an expert teacher's video-based analysis. The first example addressing monitoring and overlapping was validated separately. The second and third examples on the topics of smoothness and momentum and group focus were validated together because they were based on the same video. We engaged $N = 5$ teachers from different schools in Germany ($M_{age} = 48.8$, $SD_{age} = 6.34$) with $M_{exp} = 19.8$ years ($SD_{exp} = 6.83$) of teaching experience in cognitive think-aloud interviews about the double-content examples. Think-aloud interviews aim to display cognitive processes (Ericsson & Simon, 1998), providing an unfiltered view of the interviewee's perspectives and ideas. In the interview, the teachers were asked to watch each video on which the double-content examples were based and to verbalize every thought about classroom management. It was possible to pause the video or talk while it played. After, we asked the teachers to comment on relevant events identified in the examples, which they did not mention in the interview, and asked whether they agreed or disagreed with the expert. We counted the number of times teachers agreed with the examples and calculated the mean agreement average. Overall, the teachers agreed with the expert teacher's analysis (M = 81.08%, SD = 20.52%) on the first double-content example (monitoring and overlapping) (M = 85.10%, SD = 14.72%) and on the second example and third example together (smoothness, momentum, group focus) (M = 77.06%, SD = 26.32%). Therefore, we regarded the examples as appropriate representations of expert video-based analyses.

Procedure

All participating student teachers attended an eight-week video-based course consisting of four two-week time blocks (see Figure 3). Time block 1 addressed monitoring and overlapping, time block 2 smoothness and momentum, and time block 3 group focus and group mobilization. In the last two-week time block, the course additionally addressed student–teacher relationships.

Figure 3

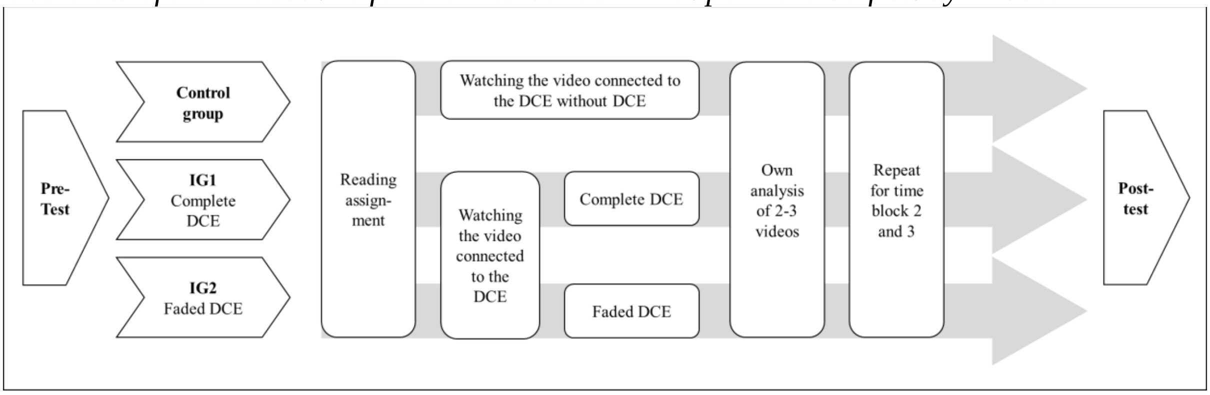
Overview of the Procedure of the Video-based Seminars



Note. IG = intervention group, DCE = double-content examples.

Figure 4

Overview of the Procedure for the Intervention Groups in the Self-study Phases



Note. IG = intervention group; DCE = double-content example.

Each time block consisted of two weeks with an online self-study phase and an online meeting (see Figure 4). The self-study phase was conducted in the first week of each time block. Student teachers completed reading assignments on the respective aspects of classroom management. After, we varied whether student teachers studied complete, faded, or without double-content examples. Then, all student teachers analyzed two to three classroom videos in connection with the respective aspects of classroom management. In the second week of each time block, student teachers could meet online with an instructor to discuss their video-based analyses. This procedure was repeated for time blocks 2 and 3. In time block 4, the procedure was similar to the previous time blocks; however, studying the example was optional. Both IGs received the following instructions (see Figure 5).

Figure 5
Instruction for each Double-content Example

> *"Following you will find an expert teacher's video-based analysis. In addition to insights you can gain from the analysis, you can also use it as an example for your own analysis. The teacher conducting this video analysis has 38 years of teaching experience.*
> *When studying the expert model, pay attention to the…*
> *… aspects of classroom management the expert addresses,*
> *… individuals or groups of people the expert focuses on, and*
> *… approach the expert takes and the analysis' characteristics."*

For each time block, student teachers in IG1 received a complete double-content example, including highlights and instructional explanations to study before video-based analyses.

IG2 also received a complete double-content example in time block 1 to study before video-based analyses. In time blocks 2 and 3, individual parts of the example were gradually faded. In time block 2, student teachers received a double-content example without any process information (i.e., instructional explanations) but with highlights on the application of concepts of classroom management and inferences. They were instructed to complete the faded instructional explanations and to highlight the focus on students' learning and engagement and the consideration of multiple perspectives (see Supplement S1). In time block 3, student teachers received a double-content example merely including highlights of the concepts of classroom management. They were instructed to complete faded instructional explanations on the concepts of classroom management and highlight the focus on students' learning and engagement, the consideration of multiple perspectives, and inferences (see Supplement S2).

Instruments

We conducted the survey via Unipark. First, we asked for student teachers' demographic data (age, gender, instructor, term, teaching experience, courses on classroom management). Then, student teachers watched a carefully selected and validated four-minute video clip from Gold and Holodynski's (2017) video test, covering all classroom management aspects addressed in the seminar. Afterward, student teachers were asked to analyze classroom management in written analyses.

Cognitive Processes of PVCM

For the cognitive-psychological measure of PVCM, we used a simplified version of Dückers et al.'s (2022) coding procedure, which is based on qualitative content analysis (Mayring, 2014) and facilitated the analysis of the three cognitive processes of PV through a rating scale (see Supplement S3). Two trained raters coded PV regarding the cognitive processes of *noticing* and *reasoning* in student teachers' written analyses compared to a master rating developed by the authors and two further experts on classroom management. For *noticing*, the coders counted the number of relevant events student teachers noticed in their written video-based analyses based on the master rating. For *reasoning*, the raters coded whether student teachers' interpretation was in accordance with the master rating (1 point) or not (0 points). They also coded whether the student teachers explained their interpretation (1 point) or not (0 points). We counted the number of points student teachers achieved for PV. Interrater reliability, $\kappa = .78$, and internal consistencies (t1: $\alpha = .70$; t2: $\alpha = .76$) of PV (noticing + reasoning) were satisfactory.

Similarly, for *alternatives of action*, the raters coded whether student teachers provided an alternative of action (1 point) or not (0 points) and whether they explained the alternative of action (1 point) or not (0 points). If student teachers noticed an event not mentioned by the master rating, we did not incorporate the corresponding generating alternatives of action into the score. We counted the points student teachers achieved for alternatives of action. Interrater reliability, $\kappa = .84$, and internal consistencies were satisfactory, t1: $\alpha = .69$; t2: $\alpha = .71$.

Expert Features

For the expertise-related measure, we analyzed student teachers' written analyses using Mayring's (2014) qualitative content analysis. We deductively derived categories based on research on teacher expertise: *concepts of classroom management*, *focus on students*, *inferences*, and *multiple perspectives* (e.g., Wolff et al., 2015) (see Supplement S4). The categories consisted of individual features that were brought together to form the categories. The category *concepts of classroom management* was indicated if student teachers' video-based analyses used terms of theoretical concepts of classroom management, the category *focus on students* was indicated if students' on-task behavior and learning was addressed, and the category *inferences* was indicated if student teachers drew conclusions about the teacher or students, analyzed in an open-ended and unbiased way, used predictions, or gave explanations. Further, the category *multiple perspectives* was indicated if student teachers adopted at least two perspectives (e.g., teacher and student perspectives) in their video-based analyses. For each category, the raters gave one point per feature the student teachers applied in their video-based analyses (1 point) or not (0 points) (Wolff et al., 2015; κ = .77). We counted the number of points student teachers achieved for each category.

Self-explanation Processes of the Faded Double-content Example

Student teachers in IG2 submitted solutions to the faded double-content examples from time blocks 2 (n = 58) and 3 (n = 60). Based on qualitative content analysis (Mayring, 2014) and on the complete examples from time blocks 2 and 3, the raters coded whether the student teachers identified expertise-related aspects in the faded examples as an indicator for *self-explanation processes* (κ = .89). For time block 2, raters coded whether student teachers completed the correct aspect of the application of concepts of classroom management and inferences in the faded instructional explanations and whether they highlighted the focus on students' learning and engagement as well as considering multiple perspectives. In time block 3, the raters coded whether student teachers completed the correct aspect of the application of concepts of classroom management in the faded instructional explanations and whether they highlighted the focus on students' learning and engagement, the drawing of inferences, and the consideration of multiple perspectives. The raters coded whether the student teachers identified the correct aspect in the faded instructional explanations or highlighted the correct passage in the examples (1 point) or whether the faded instructional explanation was not completed, the highlight was missing, or the wrong aspect was identified (0 points). For the faded double-content example from time block 2, student teachers could receive 27 points, and for the double-content example from time block 3, 28 points. We calculated the overall means for each category.

Analysis Plan and Preliminary Analyses

Dependent variables were PVCM, which consisted of the cognitive processes of noticing + reasoning and alternatives of action, as well as the expert features of the application of *concepts of classroom management*, *focusing on students*, *inferences*, and *multiple perspectives*.[1] We first investigated in preliminary analyses whether our data met the statistical requirements for analyses of variances (ANOVAs). Shapiro-Wilk tests and

[1] Prior to analyses of differences between groups, we examined differences between instructors in the CG for student teachers' pre-test scores and in increases of PVCM and expert features. We did not find any significant differences in the pre-test scores or in increases in PVCM and expert features. Hence, we proceed to treat the CG as a single group.

investigations of the histograms indicated serious violations against normality for the cognitive-psychological measure (ten of twelve distributions (2 variables × 3 groups × 2 measurement time points)) and the expertise-related measure (all of the twenty-four distributions (4 variables × 3 groups × 2 measurement time points)). Further, Kruskal-Wallis tests showed significant differences between the groups in the pre-test scores of the cognitive-psychological measure with a moderate effect for noticing + reasoning, $\chi^2(2) = 53.14$, $p < .001$, $p_{FDR} < .001$, $r = .126$, and a small effect for alternatives of action, $\chi^2(2) = 16.37$, $p < .001$, $p_{FDR} < .001$, $r = .035$. We also found significant differences between the groups in the pre-test scores of the expertise-related measure with small effects for inferences, $\chi^2(2) = 9.62$, $p = .008$, $p_{FDR} = .016$, $r = .019$, and multiple perspectives, $\chi^2(2) = 7.57$, $p = .023$, $p_{FDR} = .034$, $r = .014$.

Hence, we decided to model the change between the first and second measurement time points using residualized change scores. Residualized change scores have the advantage that they can consider and accommodate individual differences in the pre-test scores and are relatively robust against violations of the normality assumption (Rogosa et al., 1982; MacKinnon, 2008). We assessed the homogeneity of variances using Levene's test. The residualized change scores of alternatives of action ($p = .083$), inferences ($p = .382$), and multiple perspectives ($p = .925$) met the assumption of equal variances. However, the tests revealed no equal variances for the residualized change scores of noticing + reasoning ($p = .007$), concepts of classroom management ($p < .001$), and focus on students ($p = .003$). Therefore, we decided to double-check analyses regarding these variables with the non-parametric Kruskal-Wallis test, which is based on ranks, and, thus, homogeneity of variances is not required (Chacko, 1963). We controlled for false discovery rate (FDR; Benjamini & Hochberg, 1995) to avoid an increased likelihood of Type 2 errors while preserving power. Because the groups differed in whether they had attended classroom management seminars, we included the variable as a covariate in the following analyses.

To answer RQ1 and RQ2, we conducted one-way ANOVAs using residualized change scores of each dependent variable. Next, we conducted Helmert contrasts to compare the residualized change scores between the control and intervention groups (RQ1; with vs. without double-content examples) and between the intervention groups (RQ2; complete vs. faded double-content examples). For the variables PVCM, concepts of classroom management, and student focus, we also calculated Kruskal-Wallis tests and investigated group differences using Dunn-tests. To investigate RQ3, we conducted multiple regression analyses with the self-explanation scores of concepts of classroom management, student focus, inferences, and multiple perspectives as predictors and the residualized change scores of PVCM as criteria. All analyses were conducted using the software R.

Results

Mean scores and standard deviations are displayed in Table 1. Data and analysis scripts can be accessed via https://osf.io/fxe4k/?view_only=49e9543de7f6419ab356e4fba4c6d3b3.

Table 1

Descriptive Data on Cognitive Processes of PVCM and Expert Features

Scale	CG: without double-content example (*n* = 74)			IG1: complete double-content example, (*n* = 200)			IG2: faded double-content example, (*n* = 136)		
	t1	t2	RCS	t1	t2	RCS	t1	t2	RCS
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*
Cognitive processes of PVCM									
Noticing + reasoning	8.73(3.18)	10.61(3.69)	1.91(3.64)	5.44(2.96)	6.73(3.79)	−0.31(3.60)	6.10(3.05)	6.79(3.14)	−0.58(2.86)
Alternatives of action	5.93(2.79)	5.64(2.78)	0.31(2.76)	4.54(2.57)	4.81(2.71)	−0.16(2.64)	5.18(2.44)	5.21(2.20)	0.07(2.07)
Expert features									
CCM	0.97(1.36)	3.65(2.66)	1.44(2.66)	0.72(1.17)	1.89(1.90)	−0.22(1.82)	0.76(1.12)	1.67(1.68)	−0.46(1.65)
Focus on students	0.47(0.83)	0.50(0.97)	0.19(0.94)	0.38(0.65)	0.30(0.58)	0.01(0.56)	0.35(0.67)	0.18(0.45)	−0.11(0.46)
Inferences	5.42(2.83)	5.43(2.62)	0.23(2.59)	4.34(2.73)	4.88(2.63)	−0.05(2.56)	4.25(2.55)	4.86(2.93)	−0.05(2.81)
Multiple perspectives	0.24(0.49)	0.15(0.39)	−0.04(0.40)	0.10(0.32)	0.18(0.40)	0.01(0.40)	0.12(0.41)	0.18(0.38)	<0.01(0.38)

Note. CG = control group, IG = intervention group; RCS = residualized change score; PVCM = professional vision of classroom management; CCM = concepts of classroom management.

Double-content Example Effect (RQ1 & RQ2)

In the *double-content example hypothesis*, we were interested in whether student teachers studying double-content examples displayed significant differences in increases in PVCM compared to a control group (with vs. without; RQ1). One-way ANOVAs showed significant differences between the groups in noticing + reasoning with a medium effect, concepts of classroom management with a large effect, and the focus on students with a small effect (see Table 3). However, Kruskal-Wallis tests, which were conducted because of violations of homogeneity, showed no significant differences between the groups for the variable focus on students, χ^2 (5) = 7.66, p = .176. Descriptive statistics indicate that the CG outperformed the IGs in these measures. This was supported by Helmert contrasts (see Table 3), which showed significant differences between the student teachers studying with or without double-content examples for noticing + reasoning and concepts of classroom management. Although Helmert contrasts were significant for the variable focus on students, Dunn-tests indicated no significant differences between student teachers studying with or without double-content examples.

In the *fading hypothesis*, we were interested in whether student teachers studying faded double-content examples displayed significant differences in change in PVCM compared to student teachers studying complete double-content examples (complete vs. faded; RQ2). However, the second set of Helmert contrasts showed no significant differences between student teachers studying with complete or faded double-content examples.

Table 2

One-way ANOVAs Controlling for the Number of Courses on Classroom Management

Effect	*F*	*df*	*p*	p_{FDR}	η^2
Cognitive Processes of PVCM					
Noticing + reasoning[a]	14.68	2,406	<.001	<.001	.068
Alternatives of action	1.03	2,406	.358	.537	.005
Expert features					
CCM[a]	25.30	2,406	<.001	<.001	.111
Focus on students[b]	5.60	2,406	.004	.008	.025
Inferences	0.33	2,406	.717	.717	.002
Multiple perspectives	0.48	2,406	.617	.717	.002

Note. PVCM = professional vision of classroom management; CCM = concepts of classroom management; [a]Kruskal-Wallis tests for the variables PVCM and concepts of classroom management did not show differences to the results of the ANOVAs; [b]Kruskal-Wallis test for the variable focus on students did not show any significant differences between the groups χ^2 (5) = 7.66, *p* = .176.

Table 3

Helmert-contrasts of PVCM

Scale	with (–1) vs. without (0.5, 0.5) double-content examples		complete (–1) vs. faded (1) double-content examples	
	t	*p*	*t*	*p*
Cognitive Processes of PVCM				
Noticing + reasoning[a]	–5.41	<.001	–.754	.451
Alternatives	–1.11	.268	0.69	.488
Expert Features				
CCM[a]	–7.11	<.001	–1.19	.233
Focus on students[b]	–3.00	.003	–1.51	.133
Inferences	–0.80	.427	0.19	.848
Multiple perspectives	.930	.353	–.210	.826

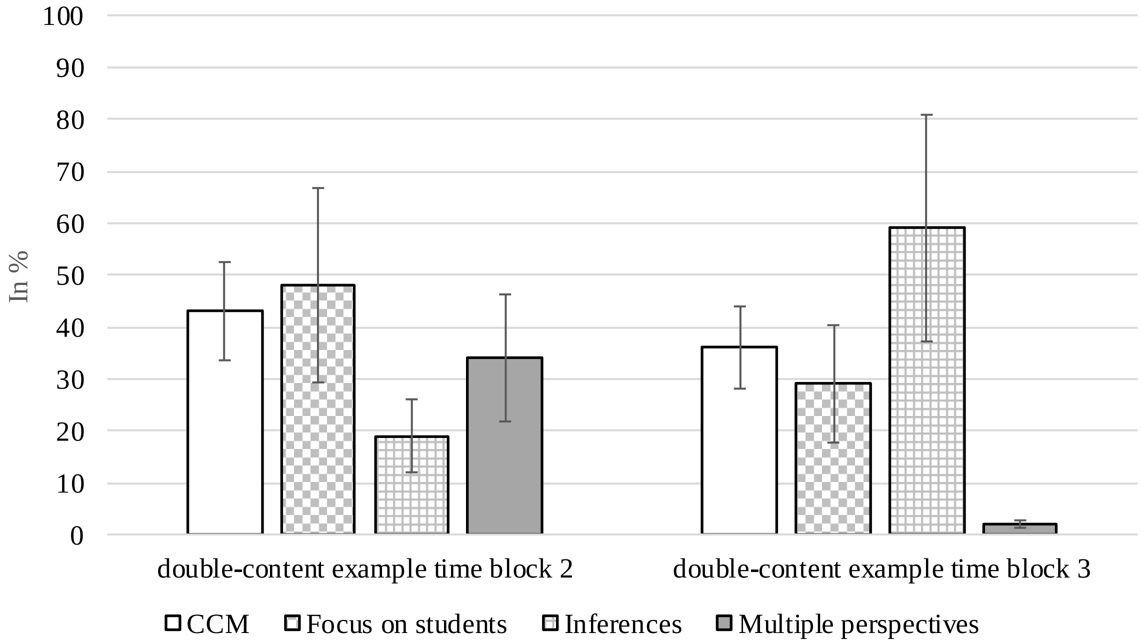
Note. PVCM = professional vision of classroom management; CCM = concepts of classroom management; [a]Kruskal-Wallis tests with Dunn-tests for the variables PVCM and concepts of classroom management did not show differences to the results of the ANOVAs; [b]Kruskal-Wallis test with Dunn-tests for the variable focus on students did not show any significant differences between the groups.

Self-explanation Effect (RQ3)

In the *self-explanation hypothesis*, we were interested in whether effective self-explanation during learning with faded double-content examples correlated with increases in PVCM. Descriptive statistics indicated that student teachers struggled to self-explain the expert features from the double-content examples (see Figure 6).

Figure 6

Means and Standard Deviations of Self-explanations from the Faded Double-content Examples



Note. CCM = Concepts of classroom management.

Multiple regression analyses (see Table 4) showed that the self-explanations did not predict change in noticing + reasoning, $F(8,49) = 1.61$, $p = .145$, alternatives of action, $F(8,49) = 0.48$, $p = .865$, concepts of classroom management, $F(8,49) = 0.47$, $p = .874$, focus on students, $F(8,49) = 1.07$, $p = .402$, inferences, $F(8,49) = 1.37$, $p = .232$, or multiple perspectives, $F(8,49) = 0.90$, $p = .533$. Nevertheless, we found that self-explaining aspects of concepts of classroom management from the double-content example in time block 2 significantly predicted the change in multiple perspectives. However, we also found that self-explanations of the focus on students negatively predicted the change in the focus on students.

Table 4
Multiple Regression Analyses of the Change in PVCM on Self-explanations

Model	*B*	95% CI [LL, UL]	beta	*t*	*p*	R^2
Noticing + reasoning						.209
double-content example time block 2						
CCM	–.064	[–5.62, 4.11]	–0.76	–0.31	.756	
Focus on students	.088	[–1.81, 3.01]	0.60	0.50	.621	
Inferences	.339	[–0.59, 7.62]	3.52	1.72	.092	
Multiple perspectives	–.083	[–3.17, 1.94]	–0.61	–0.48	.631	
double-content example time block 3						
CCM	.080	[–2.74, 4.74]	1.00	0.54	.593	
Focus on students	–.248	[–6.32, 1.03]	–2.65	–1.45	.154	
Inferences	.191	[–1.00, 3.70]	1.35	1.15	.255	
Multiple perspectives	.243	[–0.63, 10.32]	4.85	1.78	.082	
Alternatives of action						.073
double-content example time block 2						
CCM	.148	[–2.93, 5.80]	1.44	0.66	.511	
Focus on students	.047	[–1.90, 2.43]	0.26	0.25	.807	
Inferences	–.094	[–4.49, 2.88]	–0.81	–0.44	.662	
Multiple perspectives	.056	[–1.95, 2.63]	0.34	0.30	.767	
double-content example time block 3						
CCM	.043	[–2.91, 3.80]	0.44	0.27	.791	
Focus on students	–.106	[–4.23, 2.36]	–0.93	–0.57	.573	
Inferences	.250	[–0.64, 3.57]	1.46	1.40	.169	
Multiple perspectives	.011	[–4.73, 5.09]	0.18	0.07	.941	
CCM						.071
double-content example time block 2						
CCM	.171	[–1.95, 4.34]	1.19	0.76	0.45	
Focus on students	–.084	[–1.89, 1.22]	–0.34	–0.44	.666	
Inferences	–.103	[–3.29, 2.02]	–0.64	–0.48	.632	
Multiple perspectives	.053	[–1.42, 1.88]	0.23	0.28	.779	
double-content example time block 3						
CCM	.121	[–1.51, 3.32]	0.90	0.75	.456	
Focus on students	.086	[–1.82, 2.92]	0.55	0.47	.644	
Inferences	.108	[–1.06, 1.97]	0.45	0.60	.551	
Multiple perspectives	–.087	[–4.57, 2.51]	–1.03	–0.59	.561	
Focus on students						.148
double-content example time block 2						
CCM	.041	[–0.72, 0.87]	0.08	0.19	.849	
Focus on students	–.052	[–0.45, 0.34]	–0.06	–0.28	.779	
Inferences	–.014	[–0.69, 0.65]	–0.02	–0.07	.945	
Multiple perspectives	.079	[–0.32, 0.51]	0.09	0.44	.659	
double-content example time block 3						
CCM	.051	[–0.51, 0.71]	0.10	0.33	.741	
Focus on students	–.385	[–1.24, –0.05]	–0.64	–2.16	.036	
Inferences	.199	[–0.16, 0.60]	0.22	1.16	.253	
Multiple perspectives	.151	[–0.42, 1.37]	0.47	1.07	.292	

Model	B	95% CI [LL, UL]	beta	t	p	R^2
Inferences						.183
double-content example time block 3						
CCM	.117	[–3.79, 6.72]	1.46	0.56	.579	
Focus on students	.155	[–1.49, 3.72]	1.11	0.86	.394	
Inferences	–.225	[–6.92, 1.95]	–2.48	–1.13	.266	
Multiple	–.076	[–3.35, 2.16]	–0.60	–0.44	.665	
double-content example time block 3						
CCM	.194	[–1.47, 6.60]	2.57	1.28	.207	
Focus on students	.011	[–3.84, 4.10]	0.13	0.07	.948	
Inferences	.045	[–2.20, 2.88]	0.34	0.27	.789	
Multiple	.254	[–0.53, 11.30]	5.38	1.83	.074	
Multiple perspectives						.127
double-content example time block 3						
CCM	–.007	[–0.78, 0.76]	–0.01	–0.03	.973	
Focus on students	.092	[–0.29, 0.47]	0.09	0.49	.625	
Inferences	.017	[–0.62, 0.68]	0.03	0.08	.934	
Multiple	–.104	[–0.52, 0.29]	–0.12	–0.58	.567	
double-content example time block 3						
CCM	.347	[0.06, 1.24]	0.65	2.21	.032	
Focus on students	–.204	[–0.91, 0.25]	–0.33	–1.13	.264	
Inferences	.153	[–0.21, 0.53]	0.16	0.88	.384	
Multiple	–.170	[–1.38, 0.36]	–0.51	–1.18	.243	

Note. LL = lower level; UL = upper level; CCM = concepts of classroom management.

Discussion

The present study investigated whether double-content examples functioned as instructional support for student teachers' video-based analyses of classroom management and fostered PVCM. We hypothesized that double-content examples (with vs. without) fostered PVCM from pre- to post-tests. Moreover, we assumed a fading procedure promoted self-explanation processes of the double-content examples (complete vs. faded) and enhanced PVCM. Further, we investigated self-explanation processes within the faded double-content examples and their effect on the change of student teachers' PVCM.

Although we suggested in RQ1 that double-content examples (with vs. without) fostered PVCM (double-content example hypothesis), the results were non-significant or even detrimental to student teachers' change in PVCM. Student teachers studying without double-content examples (CG) performed significantly better in noticing and reasoning and applied more concepts of classroom management in video-based analyses compared to student teachers studying with double-content examples (IGs). Hence, our study could not replicate the double-content example effect other studies have found for cognitive skills (Lechner et al., 2024; Schworm & Renkl, 2006; van Gog et al., 2008) and knowledge acquisition (Meier et al., 2022; Schworm & Renkl, 2007). One possible reason could be that student teachers are cognitively overloaded (Sweller et al., 2011) and struggle to integrate knowledge learned from texts, double-content examples, and video-based analyses. Typically, novice learners are overwhelmed when they have to integrate multiple sources of information, which can hinder the development of knowledge and skills (Brush & Saye, 2009). Moreover, research has suggested that using prompts (Hilbert et al., 2008) and instructional explanations (Hoogveld et al., 2005; van Gog et al., 2008) in double-content examples can harm learning. As a result, learners may fail to self-explain the examples productively (Kalyuga, 2008; Sweller, 2006) and may therefore struggle to acquire knowledge. Because PV is a knowledge-based process (Blömeke et al., 2015; Kersting et al., 2012), this lack of knowledge could lead to unproductive video-based analyses, resulting in detrimental effects on PV.

Moreover, student teachers studying with or without double-content examples did not differ in alternatives of action, focusing on students, drawing inferences, and taking multiple perspectives. Schworm and Renkl’s (2007) study has shown that the mere presentation of double-content examples does not enhance cognitive skill acquisition, but they have to be combined with prompts regarding the learning domain. In contrast to Schworm and Renkls’ (2007) study, we did not ask student teachers to respond to the prompts we provided. Hence, it is possible that student teachers disregarded the prompts and focused on the instructional explanations within the double-content examples, which may have resulted in ineffective self-explanation processes (Kalyuga, 2008; Sweller, 2006).

Nevertheless, the type of knowledge measured differs between most of the studies and our study. Many studies found positive effects of double-content examples on declarative knowledge using mostly paper-pencil tests (e.g., Hefter et al., 2014; Meier et al., 2022; Schworm & Renkl, 2007). However, studies that investigated more usable types of knowledge, as in our study, assessed in the context of simulations (Meier et al., 2022) or field experiences (Lechner et al., 2024), yielded somewhat inconsistent results. The video-based assessment using classroom videos is a more situated approach to measuring competencies necessary for teaching skills (Borko, 2016; Kaiser et al., 2015). Because of the classroom videos’ transience and complexity (McDonald et al., 2013), which have been shown to overwhelm student teachers (Star & Strickland, 2008; Syring et al., 2015), it is possible that student teachers cannot transfer learned heuristics and concepts from the double-content examples to their video-based analyses. Therefore, more research on using double-content examples to foster more usable types of knowledge measured with more situated approaches is necessary.

In line with initial research on double-content examples (Lechner et al., 2024), student teachers studying with faded double-content examples did not differ from those studying with complete double-content examples (RQ2; *fading hypothesis*). This contrasts findings from studies in well-structured domains, which suggested that fading promoted self-explanation and performance on transfer tasks (e.g., Atkinson et al., 2003; Renkl et al., 2004). However, Reisslein et al. (2006) have also found no effects on learning using a fading procedure within a worked example, but their findings further suggested that complete worked examples were particularly helpful for learners with low prior knowledge, whereas high prior knowledge learners benefited from faded worked examples. This aligns with van Gog et al.'s (2008) finding, suggesting a redundancy effect of instructional explanations in double-content examples after initial skill acquisition. Hence, future studies may consider learners' prior knowledge when investigating complete and faded double-content examples.

Results of RQ3 (*self-explanation hypothesis*) suggested that student teachers generally struggled to self-explain expert features from the faded double-content examples and transfer them to develop PVCM. This contrasts the self-explanation effect (Chi et al., 1994), in which effective self-explanations from examples predict learning outcomes. However, other studies have also found that neither the quality of self-explanations (Bichler et al., 2022) nor the number of self-explanations (Schwonke et al., 2009) predicted learning. Our study even indicated that correct self-explanations of the focus on students negatively predicted the change in focusing on students for student teachers' studying with faded double-content examples. Nevertheless, results also indicated that correct self-explanations of concepts of classroom management could positively predict the change in taking multiple perspectives. This finding is in line with research on teacher expertise, suggesting that more integrated and flexible knowledge (Berliner, 2001) can help teachers integrate multiple perspectives when analyzing classroom situations (e.g., of students and the teacher; Hogan et al., 2003; Wolff et al., 2015, 2017). Therefore, in our study, the self-explanation of concepts of classroom management may have helped student teachers take multiple perspectives when analyzing classroom videos.

Implications and Improvement Areas

The results indicate that double-content examples of expert teachers' video-based analyses seem to have no or detrimental effects on student teachers' PVCM. However, there are several implications and areas of improvement. First, student teachers were possibly overwhelmed with integrating information from texts, double-content examples, and video-based analyses. Second, student teachers struggled to self-explain faded double-content examples. Student teachers predominantly studied the double-content examples by themselves and did not have the chance to discuss or talk about them in detail. An interactive discussion led by an instructor could help them integrate the three information sources and self-explain the double-content examples more effectively. Studies have shown that discussions around video-based analyses seemed to contribute to the development of PV (van Es & Sherin, 2010). Within these discussions, student teachers could also get the opportunity to practice self-explanation from double-content examples. Thereby, they can learn how to transfer self-explanations to their own video-based analyses and refine their understanding of video-based analyses (Chi, 2000).

Conclusion and Limitations

We conclude that the mere presentation of double-content examples of expert teachers' video-based analyses does not enhance student teachers' PVCM and may even be detrimental to the development of situated cognitive skills. The threefold integration of information from texts, double-content examples, and video-based analyses seemed to have overwhelmed student teachers for their change in noticing and reasoning and in applying concepts of classroom management. Further, faded double-content examples did not differ from complete double-content examples concerning student teachers' PVCM. However, initial findings suggest that student teachers struggle to self-explain from faded double-content examples.

Certain limitations of the study have to be addressed. First, because each group was part of a cohort, it is possible that the cohort effect overshadowed the effects of the double-content examples. We considered this issue by investigating and controlling for differences between the cohorts in teaching experience, tutoring, and attendance of seminars regarding classroom management. Further, we controlled for differences between the instructors in the CG and implemented a highly standardized online self-learning environment led by the same instructor for the IGs. Second, although we aimed to channel student teachers' attention to the relevant aspects of the double-content examples using prompts and instructional explanations, the double-content examples were highly complex. This complexity could have caused student teachers to apply a great amount of cognitive load to process and self-explain the examples, which may have hindered knowledge acquisition. Future research should aim to reduce cognitive load on learners when studying double-content examples. Third, although we conducted analyses with process data from the faded double-content examples, we finally do not know how student teachers interacted with the examples. Future research should explore self-explanation processes when student teachers study double-content examples in more depth to understand underlying learning processes and prerequisites for effective self-explanation.

Nevertheless, one must consider that only few studies (Kyun et al., 2013; Meier et al., 2022; Schworm & Renkl, 2007) have investigated the effects of double-content examples in highly complex ill-structured domains, and only few have implemented fading procedures (Binder et al., 2022; Lechner et al., 2024). It is an important finding that double-content examples may be detrimental for situated cognitive skills such as PV, that complete and faded double-content examples do not differ in enhancing these skills, and that student teachers generally struggle to self-explain from faded double-content examples.

Appendix A

Table A1

Spearman Correlations Between Measures of PVCM for the Control Group (No Double-content Examples)

	1	2	3	4	5	6	7	8	9	10	11
t1											
(1) Noticing + reasoning											
(2) Alternatives of action	.40***										
(3) CCM	.29*	.22									
(4) Focus on students	<.01	.30**	.16								
(5) Inferences	.24*	.32**	.23*	.37**							
(6) Multiple perspectives	.03	.11	.05	.27**	.49***						
t2											
(7) Noticing + reasoning	.22	−.04	−.02	−.03	.01	−.04					
(8) Alternatives of action	.11	.20	−.03	.16	.31**	.15	.37**				
(9) CCM	.32**	.05	.12	.08	.13	−.01	.60***	.38***			
(10) Focus on students	<.01	.19	.06	.26*	.20	.32**	−.05	.16	.11		
(11) Inferences	.32**	.44***	.20	.27*	.10	.17	.33**	.36**	.20	.25*	
(12) Multiple perspectives	−.01	.17	.07	.09	.05	.07	.12	.14	.02	−.02	.26*

Note. CCM = concepts of classroom management; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A2

Spearman Correlations Between Measures of PVCM for the Intervention Group 1 (Complete Double-content Examples)

	1	2	3	4	5	6	7	8	9	10	11
t1											
(1) Noticing + reasoning											
(2) Alternatives of action	.47***										
(3) CCM	.44***	.33***									
(4) Focus on students	−.05	.01	−.02								
(5) Inferences	.55***	.50***	.28***	.11							
(6) Multiple perspectives	<.01	.09	.10	.08	.23***						
t2											
(7) Noticing + reasoning	.32***	.24***	.09	−.04	.25***	.04					
(8) Alternatives of action	.21**	.18**	.03	−.03	.21**	.11	.62***				
(9) CCM	.24***	.21**	.15*	−.04	.17*	.05	.73	.55***			
(10) Focus on students	−.03	−.03	−.09	.24***	−.03	−.12	−.10	−.10	−.09		
(11) Inferences	.18*	.18*	.08	.09	.26***	.02	.38***	.41***	.33***	−.03	
(12) Multiple perspectives	.06	.07	−.02	.05	.09	.20**	.21**	.22	.15*	−.11	.37***

Note. CCM = concepts of classroom management; *$p < .05$. ** $p < .01$. ***$p < .001$.

Table A3

Spearman Correlations Between Measures of PVCM for the Intervention Group 2 (Faded Double-content Examples)

	1	2	3	4	5	6	7	8	9	10	11
t1											
(1) Noticing + reasoning											
(2) Alternatives of action	.55***										
(3) CCM	.48***	.42***									
(4) Focus on students	.04	.10	−.04								
(5) Inferences	.41***	.35***	.27**	−.02							
(6) Multiple perspectives	.17*	.12	.03	−.08	.30***						
t2											
(7) Noticing + reasoning	.45***	.33***	.23**	.13	.21*	.06					
(8) Alternatives of action	.27**	.37***	.13	.10	.19*	.03	.59***				
(9) CCM	.22**	.19*	.16	.14	.22**	.10	.50***	.41***			
(10) Focus on students	.07	.07	−.05	.07	.03	.06	$<.01$	.03	−.06		
(11) Inferences	.40***	.31***	.14	.10	.26**	−.02	.51***	.51***	.31***	.10	
(12) Multiple perspectives	.10	.02	.02	.04	.03	.04	.17	.05	.05	−.04	.36***

Note. CCM = concepts of classroom management; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

References

Atkinson, R. K., Renkl, A., & Merrill, M. M. (2003). Transitioning from studying examples to solving problems: Effects of self-explanation prompts and fading worked-out steps. *Journal of Educational Psychology*, *95*(4), 774 –783. https://doi/10.1037/0022-0663.95.4.774

Bastian, A., Kaiser, G., Meyer, D., Schwarz, B., & König, J. (2021). Teacher noticing and its growth toward expertise: An expert–novice comparison with pre-service and in-service secondary mathematics teachers. *Educational Studies in Mathematics*, *110*(2), 205–232. https://doi.org/10.1007/s10649-021-10128-y

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society. Series B (Methodological)*, *57*(1), 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research*, *35*(5), 463–482. https://doi.org/10.1016/s0883-0355(02)00004-6

Berliner, D. C. (2004). Describing the behavior and documenting the accomplishments of expert teachers. *Bulletin of Science, Technology & Society*, *24*(3), 200–212. https://doi.org/10.1177/0270467604265535

Bichler, S., Stadler, M., Bühner, M., Greiff, S., & Fischer, F. (2022). Learning to solve ill-defined statistics problems: Does self-explanation quality mediate the worked example effect?. *Instructional Science*, *50*(3), 335–359. https://doi.org/10.1007/s11251-022-09579-4

Blomberg, G., Renkl, A., Gamoran Sherin, M., Borko, H., & Seidel, T. (2013). Five research-based heuristics for using video in pre-service teacher education. *Journal for Educational Research Online*, *5*(1), 90–114. https://doi.org/10.25656/01:8021

Blomberg, G., Stürmer, K., & Seidel, T. (2011). How pre-service teachers observe teaching on video: Effects of viewers' teaching subjects and the subject of the video. *Teaching and Teacher Education*, *27*(7), 1131–1140. https://doi.org/10.1016/j.tate.2011.04.008

Blömeke, S., Gustafsson, J. E., & Shavelson, R. J. (2015). Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Blömeke, S., Jentsch, A., Ross, N., Kaiser, G., & König, J. (2022). Opening up the black box: Teacher competence, instructional quality, and students' learning progress. *Learning and Instruction*, *79*. https://doi.org/10.1016/j.learninstruc.2022.101600

Borko, H. (2016). Methodological contributions to video-based studies of classroom teaching and learning: A commentary. *ZDM*, *48*, 213–218. https://doi.org/10.1007/s11858-016-0776-x

Brush, T., & Saye, J. (2009). Strategies for preparing preservice social studies teachers to effectively integrate technology: Models and practices. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 46–59.

Carter, K., Cushing, K., Sabers, D., Stein, P., & Berliner, D. (1988). Expert-novice differences in perceiving and processing visual classroom information. *Journal of Teacher Education*, *39*(3), 25–31. https://doi.org/10.1177/002248718803900306

Chacko, V. J. (1963). Testing homogeneity against ordered alternatives. *The Annals of Mathematical Statistics*, 945–956.

Chi, M. T. (2000). Self-explaining expository texts: The dual processes of generating inferences and repairing mental models. In M. T. Chi, & R. Glaser (Eds.), *Advances in instructional psychology*, Vol. 5 (pp. 161–238). Lawrence Erlbaum Associates.

Chi, M. T., De Leeuw, N., Chiu, M. H., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science*, *18*(3), 439–477. https://doi.org/10.1016/0364-0213(94)90016-7

Doyle, W. (2006). Ecological management and classroom management. In C. M. Evertson, & C. S. Weinstein (Eds.), *Handbook of classroom management: Research, practice, and contemporary issues* (pp. 97–126). Routledge. https://doi.org/10.4324/9780203874783

Dückers, C., Hörter, P., Junker, R., & Holodynski, M. (2022). Professional vision of teaching as a focus-specific or focus-integrated skill–Conceptual considerations and video-based assessment. *Teaching and Teacher Education*, *117*, 103797. https://doi.org/10.1016/j.tate.2022.103797

Ericsson, K. A., & Simon, H. A. (1998). How to study thinking in everyday life: Contrasting think-aloud protocols with descriptions and explanations of thinking. *Mind, Culture, and Activity*, *5*(3), 178–186. https://doi.org/10.1207/s15327884mca0503_3

Evertson, C. M., & Weinstein, C. (2006). Classroom management as a field of inquiry. In C. M. Evertson, & C. Weinstein (Eds.), *Handbook of classroom management: Research, practice, and contemporary issues* (pp. 3–15). Routledge. https://doi.org/10.4324/9780203874783

Flower, A., McKenna, J. W., & Haring, C. D. (2017). Behavior and classroom management: Are teacher preparation programs really preparing our teachers? *Preventing School Failure: Alternative Education for Children and Youth*, *61*(2), 163–169. https://doi.org/10.1080/1045988X.2016.1231109

Goeze, A., Zottmann, J. M., Vogel, F., Fischer, F., & Schrader, J. (2014). Getting immersed in teacher and student perspectives? Facilitating analytical competence using video cases in teacher education. *Instructional Science*, *42*, 91–114. https://doi.org/10.1007/s11251-013-9304-3

Gold, B., & Holodynski, M. (2015). Development and construct validation of a situational judgment test of strategic knowledge of classroom management in elementary schools. *Educational Assessment*, *20*(3), 226–248. https://doi.org/10.1080/10627197.2015.1062087

Gold, B., & Holodynski, M. (2017). Using digital video to measure the professional vision of elementary classroom management: Test validation and methodological challenges. *Computers & Education*, *107*, 13–30. https://doi.org/10.1016/j.compedu.2016.12.012

Gold, B., Pfirrmann, C., & Holodynski, M. (2021). Promoting professional vision of classroom management through different analytic perspectives in video-based learning environments. *Journal of Teacher Education*, *72*(4), 431–447. https://doi.org/10.1177/0022487120963681

Grossman, P., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching: Theory and Practice*, *15*(2), 273–289. https://doi.org/10.1080/13540600902875340

Hefter, M. H., Berthold, K., Renkl, A., Riess, W., Schmid, S., & Fries, S. (2014). Effects of a training intervention to foster argumentation skills while processing conflicting scientific positions. *Instructional Science*, *42*, 929–947. https://doi.org/10.1007/s11251-014-9320-y

Hilbert, T. S., & Renkl, A. (2008). Concept mapping as a follow-up strategy to learning from texts: what characterizes good and poor mappers?. *Instructional Science*, *36*, 53–73. https://doi.org/10.1007/s11251-007-9022-9

Hilbert, T. S., & Renkl, A. (2009). Learning how to use a computer-based concept-mapping tool: Self-explaining examples helps. *Computers in Human Behavior*, *25*(2), 267–274. https://doi.org/10.1016/j.chb.2008.12.006

Hilbert, T. S., Schworm, S., & Renkl, A. (2004). Learning from worked-out examples: The transition from instructional explanations to self-explanation prompts. In P. Gerjets, J. Elen, R. Joiner, & P. Kirschner (Eds.), *Instructional design for effective and enjoyable computer-supported learning* (pp.184–192). Knowledge Media Research Center.

Hogan, T., Rabinowitz, M., & Craven III, J. A. (2003). Representation in teaching: Inferences from research of expert and novice teachers. *Educational Psychologist*, *38*(4), 235–247. https://doi.org/10.1207/S15326985EP3804_3

Hoogveld, A. W., Paas, F., & Jochems, W. M. (2005). Training higher education teachers for instructional design of competency-based education: Product-oriented versus process-oriented worked examples. *Teaching and Teacher Education*, *21*(3), 287–297.

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169–202. https://doi.org/10.5951/jresematheduc.41.2.0169

Kaiser, G., Busse, A., Hoth, J., König, J., & Blömeke, S. (2015). About the complexities of video-based assessments: Theoretical and methodological approaches to overcoming shortcomings of research on teachers' competence. *International Journal of Science and Mathematics Education*, *13*, 369-387. doi.org/10.1007/s10763-015-9616-7

Kalyuga, S. (2008). Schema acquisition and sources of cognitive load. In J. L. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive Load: Theory & Application*. New York: Cambridge University Press.

Kersting, N. B., Givvin, K. B., Thompson, B. J., Santagata, R., & Stigler, J. W. (2012). Measuring usable knowledge: Teachers' analyses of mathematics classroom videos predict teaching quality and student learning. *American Educational Research Journal*, *49*(3), 568–589. https://doi.org/10.3102/0002831212437853

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry based teaching. *Educational Psychologist*, *41*, 75–86. https://doi.org/10.1207/s15326985ep4102_1.

König, J., Santagata, R., Scheiner, T., Adleff, A. K., Yang, X., & Kaiser, G. (2022). Teacher noticing: A systematic literature review of conceptualizations, research designs, and findings on learning to notice. *Educational Research Review*, *36*, 100453. https://doi.org/10.1016/j.edurev.2022.100453

Könings, K. D., Seidel, T., & van Merriënboer, J. J. (2014). Participatory design of learning environments: Integrating perspectives of students, teachers, and designers. *Instructional Science*, *42*, 1–9. https://doi.org/10.1007/s11251-013-9305-2

Kounin, J. S. (1970). *Discipline and group management in classrooms*. Holt, Rinehart, & Winston.

Kyun, S., Kalyuga, S., & Sweller, J. (2013). The effect of worked examples when learning to write essays in English literature. *The Journal of Experimental Education*, *81*(3), 385–408. https://doi.org/10.1080/00220973.2012.727884

Lechner, M., Moser, S., Pander, J., Geist, J., & Lewalter, D. (2024, March). Learning scientific observation with worked examples in a digital learning environment. *Frontiers in Education*, *9*, 1293516. https://doi.org/10.3389/feduc.2024.1293516

Llinares, S., & Valls, J. (2009). The building of pre-service primary teachers' knowledge of mathematics teaching: interaction and online video case studies. *Instructional Science*, *37*, 247–271. https://doi.org/10.1007/s11251-007-9043-4

MacKinnon, D. P. (2008). *Introduction to statistical mediation analysis.* Erlbaum Psych Press.

Mayring, P., 2014. Qualitative content analysis: theoretical foundation, basic procedures and software solution. *Social Science Open Access Repository (SSOAR).* Klagenfurt.

McDonald, M., Kazemi, E., & Kavanagh, S. S. (2013). Core practices and pedagogies of teacher education: A call for a common language and collective activity. *Journal of Teacher Education*, *64*(5), 378–386. https://doi.org/10.1177/0022487113493807

Meier, J., Spliethoff, L., Hesse, P., Abele, S., Renkl, A., & Glogger-Frey, I. (2022). Promoting car mechatronics apprentices' diagnostic strategy with modeling examples: Development and evaluation of a simulation-based learning environment. *Studies in Educational Evaluation*, *72*, 101117. https://doi.org/10.1016/j.stueduc.2021.101117

O'Neill, S., & Stephenson, J. (2012). Does classroom management coursework influence pre-service teachers' perceived preparedness or confidence? *Teaching and Teacher Education*, *28*(8), 1131–1143. https://doi.org/10.1016/j.tate.2012.06.008

Reisslein, J., Atkinson, R. K., Seeling, P., & Reisslein, M. (2006). Encountering the expertise reversal effect with a computer-based environment on electrical circuit analysis. *Learning and Instruction*, *16*(2), 92–103. https://doi.org/10.1016/j.learninstruc.2006.02.008

Renkl, A. (2014). Toward an instructionally oriented theory of example-based learning. *Cognitive Science*, *38*(1), 1–37. https://doi.org/10.1111/cogs.12086

Renkl, A., Atkinson, R. K., & Große, C. S. (2004). How fading worked solution steps works– a cognitive load perspective. *Instructional Science*, *32*, 59–82. https://doi.org/10.1023/B:TRUC.0000021815.74806.f6

Renkl, A., Hilbert, T., & Schworm, S. (2009). Example-based learning in heuristic domains: A cognitive load theory account. *Educational Psychology Review*, *21*(1), 67–78. https://doi.org/10.1007/s10648-008-9093-4

Roche, L., & Gal-Petitfaux, N. (2015). A video-enhanced teacher learning environment based on multimodal resources: A case study in PETE. *Journal of E-learning and Knowledge Society*, *11*(2).

Rogosa, D., Brandt, D., & Zimowski, M. (1982). A growth curve approach to the measurement of change. *Psychological Bulletin*, *92*(3), 726–748.

Rourke, A., & Sweller, J. (2009). The worked-example effect using ill-defined problems: Learning to recognise designers' styles. *Learning and Instruction*, *19*(2), 185–199. https://doi.org/10.1016/j.learninstruc.2008.03.006

Rummel, N., Spada, H., & Hauser, S. (2006). Learning to collaborate in a computer-mediated setting: observing a model beats learning from being scripted. In S. Barab, K. Hay, & D. Hickey (Eds.), *Proceedings of the 7th International Conference of the Learning Sciences*. (pp. 634–640). Mahwah: Erlbaum.

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A. K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM–Mathematics Education*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

Santagata, R., Zannoni, C., & Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of mathematics teacher education*, *10*, 123–140. https://doi.org/10.1007/s10857-007-9029-9

Schwonke, R., Renkl, A., Krieg, C., Wittwer, J., Aleven, V., & Salden, R. (2009). The worked-example effect: Not an artefact of lousy control conditions. *Computers in Human Behavior*, *25*(2), 258–266. https://doi.org/10.1016/j.chb.2008.12.011

Schworm, S., & Renkl, A. (2006). Computer-supported example-based learning: When instructional explanations reduce self-explanations. *Computers & Education*, *46*(4), 426–445. https://doi.org/10.1016/j.compedu.2004.08.011

Schworm, S., & Renkl, A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology*, *99*(2), 285 –296. https://doi.org/10.1016/j.learninstruc.2008.03.006

Seidel, T., & Stürmer, K. (2014). Modeling and measuring the structure of professional vision in preservice teachers. *American Educational Research Journal*, *51*(4), 739–771. https://doi.org/10.3102/0002831214531321

Seidel, T., Blomberg, G., & Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, *34*, 56–65. https://doi.org/10.1016/j.tate.2013.03.004

Stahnke, R., & Blömeke, S. (2021). Novice and expert teachers' situation-specific skills regarding classroom management: What do they perceive, interpret and suggest? *Teaching and Teacher Education*, *98*, 103243. https://doi.org/10.1016/j.tate.2020.103243

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*, 107–125. https://doi.org/10.1007/s10857-007-9063-7

Sweller, (2006). The worked example effect and human cognition. *Learning and Instruction*, 16, 165–169.

Sweller, J. (2010). Cognitive load theory: Recent theoretical advances. In J. L. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive load theory* (pp. 29–47). Cambridge University Press. https://doi.org/10.1017/CBO9780511844744.004

Sweller, J., & Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction, 2*, 59–89. https://doi.org/10.1207/s1532690xci0201_3

Sweller, J., Kirschner, P. A., & Clark, R. E. (2007). Why minimally guided teaching techniques do not work: a reply to commentaries. *Educational Psychologist, 42*, 115–12. https://doi.org/10.1080/00461520701263426

Syring, M., Bohl, T., Kleinknecht, M., Kuntze, S., Rehm, M., & Schneider, J. (2015). Video or text in case-based teacher education? An examination of the effects of different media on cognitive load and motivational-emotional processes in case-based learning. *Zeitschrift für Erziehungswissenschaft*, *18*, 667–685. https://doi.org/10.1007/s11618-015-0631-9

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571–596.

van Es, E. A., & Sherin, M. G. (2010). The influence of video clubs on teachers' thinking and practice. *Journal of Mathematics Teacher Education*, *13*, 155–176. https://doi.org/10.1007/s10857-009-9130-3

van Gog, T., Kester, L., & Paas, F. (2011). Effects of worked examples, example-problem, and problem-example pairs on novices' learning. *Contemporary Educational Psychology*, *36*(3), 212–218. https://doi.org/10.1016/j.cedpsych.2010.10.004

van Gog, T., Paas, F., & Van Merriënboer, J. J. (2008). Effects of studying sequences of process-oriented and product-oriented worked examples on troubleshooting transfer efficiency. *Learning and Instruction*, *18*(3), 211–222. https://doi.org/10.1016/j.learninstruc.2007.03.003

Weyers, J., König, J., Scheiner, T., Santagata, R., & Kaiser, G. (2023). Teacher noticing in mathematics education: a review of recent developments. *ZDM–Mathematics Education*, 1–16. https://doi.org/10.1016/j.tate.2022.103970

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. (2017). See and tell: Differences between expert and novice teachers' interpretations of problematic classroom management events. *Teaching and Teacher Education*, *66*, 295–308. https://doi.org/10.1016/j.tate.2017.04.015

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. (2021). Classroom management scripts: A theoretical model contrasting expert and novice teachers' knowledge and awareness of classroom events. *Educational Psychology Review*, *33*, 131–148. https://doi.org/10.1007/s10648-020-09542-0

Wolff, C. E., van den Bogert, N., Jarodzka, H., & Boshuizen, H. P. (2015). Keeping an eye on learning: Differences between expert and novice teachers' representations of classroom management events. *Journal of Teacher Education*, *66*(1), 68–85. https://doi.org/10.1177/0022487114549810

Can Double-content Examples of Video-based Analyses Foster Student Teachers' Professional Vision of Classroom Management?

Supplemental Materials

Supplement S1

Figure S1

Example for the Faded Double-content Example From Time Block 2

Description	Interpretation	Alternative of action
The teacher asks the students questions. Many students raise their hands. The boy in the red sweater is jumping up and down while he raises his hand. The teacher does not say anything to him and does not pick him to answer her question.	The students know the rule that they should not jump up and down while raising their hand. The teacher ignores the boy's behavior and thus does not act in compliance with the rules. The boy in the red sweater desperately wanted to contribute to the conversation. After he did not get the opportunity, he does not participant anymore and is not picked by the teacher. This could be the starting point for his behavior. Ferdi is fidgety and takes on his seat neighbor's behavior. As a result, they mutually provoke each other.	The children jumping and the spreading of the misbehavior could have been disrupted • If the teacher had given the boy the opportunity to contribute to the class, ("could you repeat the important assumption once more?) • If the teacher separated the two boys so they cannot see each other anymore (it is possible, that the seating arrangement was too close for some students) • if the teacher had involved the students with questions on the topic as she did with Philipp.

Supplement S2

Figure S2

Example for the Faded Double-content Example From Time Block 3

Description	Interpretation	Alternative of action
The teacher asks the students questions. Many students raise their hands. The boy in the red sweater is jumping up and down while he raises his hand. The teacher does not say anything to him and does not pick him to answer her question.	The students know the rule that they should not jump up and down while raising their hand. The teacher ignores the boy's behavior and thus does not act in compliance with the rules. The boy in the red sweater desperately wanted to contribute to the conversation. After he did not get the opportunity, he does not participant anymore and is not picked by the teacher. This could be the starting point for his behavior. Ferdi is fidgety and takes on his seat neighbor's behavior. As a result, they mutually provoke each other.	The children jumping and the spreading of the misbehavior could have been disrupted • If the teacher had given the boy the opportunity to contribute to the class, ("could you repeat the important assumption once more?) • If the teacher separated the two boys so they cannot see each other anymore (it is possible, that the seating arrangement was too close for some students) • if the teacher had involved the students with questions on the topic as she did with Philipp.

Supplement S3

Table S3

Measure of Cognitive Processes of PVCM (Simplified and Adapted from Dückers et al., 2022)

Cognitive process of PVCM	Points	Definition
Noticing + reasoning	0	The relevant noticed event was not addressed in the video-based analysis.
	1	The relevant noticed event was addressed at least once in the video-based analysis.
	0	The relevant noticed event was not reasoned on or the reasoning did not match the expert rating.
	1	The relevant noticed event was reasoned on matching the master rating.
	0	The reasoning was not explained or the explanation did not match the master rating.
	1	The reasoning was explained matching the master rating.
Alternatives of action	0	No alternative of action was provided for the noticed relevant event.
	1	An alternative of action was provided for the noticed relevant event.
	0	No explanation for the generated alternative of action was provided.
	1	An explanation for the generated alternative of action was provided.

Note. PVCM = Professional Vision of Classroom Management; we counted the number of points achieved for noticing + reasoning and alternatives of action.

Supplement S4

Table S4

Measure of Expert Features (Adapted from Wolff et al., 2015)

Category	Points	Definition
Concepts of classroom management	1	Scientific terms (withitness, smoothness, momentum, group focus, group mobilization) are used.
Focus on students	1	Students' engagement, attention, listening, or learning in the classroom situation is addressed.
Interpretations	1	Inferences about students or teachers, predictions of classroom management, and explanations are provided.
Multiple perspectives	1	More than one point of view is addressed (e.g., that of students and teachers).

Note. For each category, we counted the number of expert features used in the video-based analysis.

2.3 Article III

Isolated or Integrated? – Instructional Approaches to Foster Professional Vision of Teaching Quality

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B (2024). *Isolated or integrated? – Instructional approaches to foster professional vision of teaching quality* [Manuscript under review]. Institute of School Pedagogy and General Didactics, TU Dortmund University.

***Acknowledgments*:** We would like to thank Nadine Puschner and Nadine Böhme for helping us conduct this study in their seminars as well as our student research assistants for their help coding the data.

Funding sources: This work was supported by the Thüringer Ministerium für Wirtschaft, Wissenschaft und Digitale Gesellschaft [grant number 5575/10-2].

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ISOLATED OR INTEGRATED? – INSTRUCTIONAL APPROACHES TO FOSTER PROFESSIONAL VISION OF TEACHING QUALITY

Abstract

Background: Student teachers must develop professional vision (PV) related to classroom management (CM), instructional support (IS), and emotional support (ES). PV can be enhanced through video-based analyses within adequate instructional approaches. Research suggests that isolated and integrated approaches may foster learning, with student teachers in an integrated approach analyzing all dimensions simultaneously and in an isolated approach analyzing them separately.

Aims: The study examines whether an isolated or integrated approach fosters PV better compared to a control group (CG) and how individual prerequisites influence this development.

Sample: Participants were 140 student teachers.

Method: In a quasi-experimental pre-post-test study, participants attended three-week seminars, preparing each session with texts on teaching quality. The intervention groups analyzed classroom videos. The CG and the isolated group focused on a different teaching quality dimension weekly, whereas the integrated group focused on all dimensions. Pre-post-tests measured PV and the simultaneous focus. Prior learning opportunities and interest were assessed in the pre-test.

Results: The CG was outperformed by the isolated approach in PVES and by the integrated approach in PVCM and the simultaneous focus. Comparing the intervention groups, the isolated approach performed better in PVES, whereas the integrated approach performed better in the simultaneous focus. Prior learning opportunities or interest did not affect PV or the simultaneous focus.

Conclusions: Student teachers in video-based analyses improved in PVCM and PVES, emphasizing pedagogy. The isolated approach focused on the most recent dimension (recency effect), while the integrated approach may have been cognitively overloaded by addressing all dimensions simultaneously.

Keywords: Teacher Education; Professional Vision; Instructional Design; Video-based Analysis

1. Introduction

In order to act competently in the classroom, teachers must develop professional vision (PV), which involves *noticing* and *reasoning* on relevant classroom events to generate adequate *alternatives of action* (van Es & Sherin, 2002; Blömeke et al., 2015). PV has been shown to be a focus-specific competency that can relate to different dimensions of teaching quality (Dückers et al., 2022; Steffensky et al., 2015). Teaching quality encompasses the dimensions of effective classroom management, instructional support, and emotional support (Kunter et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018).

Studies have shown that PV can be enhanced through video-based analyses of teaching (Gold et al., 2021; Seidel et al., 2013) that must be embedded in a suitable instructional environment (Blomberg et al., 2013; Santagata et al., 2021). Research has shown that *isolated* and *integrated* instructional approaches can effectively foster learning processes (Kramer et al., 2021; Spada et al., 2014). The approaches differ in the sequence of addressing various learning contents. In an integrated approach, learners focus on different learning contents simultaneously, which supports concurrent activation and retrieval (Anderson, 1983) and promotes applicability (inferred from Renkl et al., 1996). Therefore, an integrated instructional approach, in which all three teaching quality dimensions are analyzed simultaneously, could foster applicability and retrieval of the teaching quality dimensions. Contrastively, in an isolated approach, learners concentrate on one learning content at a time, reducing cognitive load by deconstructing complex tasks into individual sub-tasks (van Merriënboer, 2002). Hence, an isolated approach may ease student teachers' cognitive load in video-based analyses.

Further, the development of PV is suggested to depend on individuals' prerequisites (Kaiser & König, 2019; Stürmer et al., 2015); for example, knowledge as a cognitive prerequisite (Stürmer et al., 2015; Todorova et al., 2017) and interest as a motivational prerequisite (Farrell et al., 2023; Stürmer et al., 2015). Therefore, individual prerequisites have to be considered when investigating the enhancement of PV in teacher education.

Given these deliberations, this study examines how analyzing classroom videos has to be instructionally embedded to enhance student teachers' PV of teaching quality. We varied whether student teachers analyzed the teaching quality dimensions in an isolated or integrated way. Learners from a math didactics course served as a control group (CG). The study also sheds light on whether knowledge and interest influence the change of PV within the instructional approaches. Hence, the study contributes to recent research on instructional approaches to video-based analyses and provides a concrete approach to fostering PV of teaching quality in teacher education.

1.1 PV of Teaching Quality

Teaching quality entails the dimensions of classroom management, instructional and emotional support (Kunter, Klusmann, et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018)[2]. *Classroom management* is defined as effectively regulating students' behavior and attention through effective time management and socio-emotional learning (Emmer & Stough, 2001). For effective classroom management, teachers need predominantly pedagogical-psychological knowledge (König & Kramer, 2016). Actions teachers can take for effective classroom management include monitoring the classroom to convey that they are aware of everything happening in the classroom ("withitness"; Kounin, 1970; Wubbels et al., 2006). Further, teachers should uphold the group focus, which entails mobilizing students' attention, holding them accountable for their learning, and increasing their engagement (Kounin, 1970; Wubbels et al., 2006). Effective classroom management also includes managing disruptions by regulating students' behavior and establishing rules and routines (Evertson & Emmer, 2012; van Tartwijk et al., 2009). Moreover, effectively managing transitions can enable the lessons' smoothness and flow (Arlin, 1979; Doyle, 1980).

For students to engage with learning material, teachers must provide *instructional support*, conceptualized as actions teachers take to evoke active and elaborate processing (Leuders & Holzäpfel, 2011; Lipwosky et al., 2009) as well as cognitive development (Pianta & Hamre, 2009). Therefore, instructional support is assumed to draw predominantly from pedagogical content and content knowledge (Baumert et al., 2010; Lipowsky et al., 2009). Instructional support can be achieved by activating students' prior knowledge and asking about their ideas and opinions (Böheim et al., 2021), thereby exploring cognitive thought processes (Staub & Stern, 2002). Further, teachers can enable deep and elaborate thought processes by implementing cognitively activating tasks and establishing problem-based learning environments (Neubrand et al., 2013; Lipowsky et al., 2009).

Providing *emotional support* is related to meaningful student-teacher interactions and socio-emotional learning (Jennings & Greenberg, 2009). Therefore, emotional support predominantly relies on teachers' pedagogical-psychological knowledge (König & Pflanzl, 2016). To provide emotional support, teachers must encourage students in challenging

[2] Terminology regarding teaching quality slightly differs between different research programs and derived models.

situations, provide constructive feedback, show sensitivity and empathy (Pianta & Hamre, 2009; Racozky et al., 2008), and establish a positive error culture (Steuer & Dresel, 2012).

Of course, many other demands involved in teaching are not covered by the teaching quality dimensions. Nevertheless, the teaching quality dimensions are particularly relevant because when teachers realize all three teaching quality dimensions in their classroom, they can positively influence student learning (Praetorius et al., 2018), student interest (Fauth et al., 2014), and motivation (Rakoczy et al., 2008).

To implement teaching quality, teachers need PV (Blömeke et al., 2022), which has also been shown to affect student learning (Kersting et al., 2012; Roth et al., 2011). Studies (Blömeke et al., 2015; van Es & Sherin, 2002) have suggested that PV entails the cognitive processes of *noticing* and *reasoning*. *Noticing* is the perception and selection of relevant classroom events. *Reasoning* is the adequate and knowledge-based interpretation of classroom events for which research has introduced different underlying cognitive processing such as describing, interpreting, explaining, evaluating, or predicting relevant classroom situations (e.g., König et al., 2014; Seidel & Stürmer, 2014). Nevertheless, many studies have shown a one-dimensional structure (e.g., Gold & Holodynski, 2017) or strong correlations (e.g., Seidel & Stürmer, 2014) of cognitive processes involved in reasoning. Other studies have extended the framework by including a facet with a more action-oriented process of PV, such as decision-making (Blömeke et al., 2015), justifying (König & Lebens, 2012), evaluating (Dückers et al., 2022), generating alternatives of action (Santagata & Guarino, 2011), or shaping opportunities to notice and reason on relevant events (van Es & Sherin, 2021). Further, studies have investigated PV with a domain-specific focus related to classroom management (Gold & Holodynski, 2017; König, 2015), instructional support (Meschede et al., 2015; Santagata & Guarino, 2011), or aspects of emotional support (Keppens et al., 2019; in the context of inclusive education). However, because classrooms are highly complex (Doyle, 2006) and teachers' competence requires a variety of different skills (Dunekacke, 2016; Klieme et al., 2009), these studies have been criticized for focusing only on one specific domain. Taking up this idea, more recent studies have suggested foci-integrated or foci-specific conceptualizations of PV (Dückers et al., 2022; Steffensky et al., 2015). For example, Dückers et al. (2022) have suggested reasoning is foci-specific to classroom management and instructional support (see also Dückers et al., 2022; Steffensky et al., 2015) but proposed that noticing and generating alternatives of action are foci-integrated skills.

1.2 Instructional Approaches to Foster PV Through Video-based Analyses

Video-based analyses have been shown to foster PV in teacher education (Gaudin & Chaliès, 2015; Weng et al., 2023). Similar to conceptualizations of PV, most studies promoted focus-specific PV by focusing on aspects of classroom management (Gold et al., 2021) or instructional support (Jacobs et al., 2010). However, because classrooms are complex (Doyle, 2006), teacher knowledge and competencies are highly multifaceted (Dunekacke, 2016; Klieme et al., 2009), and expert teachers possess the ability to *simultaneously focus* on all three teaching quality dimensions when observing classrooms (Wolff et al., 2015). For teacher education to prepare student teachers effectively, they have to be enabled to analyze all three teaching quality dimensions (Dunekacke, 2016). Hence, the three teaching quality dimensions of classroom management, instructional support, and emotional support can be observed separately or simultaneously within video-based analyses (see also Hörter et al., 2020).

Appropriate instructional approaches to video-based analyses are crucial to foster PV (Blomberg et al., 2013; Santagata et al., 2021). An *isolated* and *integrated* approach may both be beneficial to learning (Kramer et al., 2021; Spada et al., 2014). The two instructional approaches differ in the sequence of attention to different learning contents. In an *integrated approach*, learners focus on different learning contents simultaneously, which has been shown to foster learning effectively and sustainably (Harr et al., 2014, 2015). When different learning contents are presented simultaneously, they become encoded in an integrated way. Later, when one learning content is activated, it triggers the activation and recall of other related learning contents (spreading activation; Anderson, 1983). Therefore, integrated instruction enhances concurrent activation and retrieval (Anderson, 1983), promoting applicability (inferred from Renkl et al., 1996). In teacher education, an integrated approach, in which all teaching quality dimensions are focused simultaneously when analyzing classroom videos, could facilitate applicability and activation of knowledge on the teaching quality dimensions, which could foster PV and the simultaneous focus on the teaching quality dimensions.

However, integrating different learning contents evokes great cognitive load on learners (Ayres, 2013). Because working memory capacity is limited (Baddeley, 1992), cognitive load theory suggests instructional approaches should be designed to reduce cognitive load on working memory (van Merriënboer & Kirschner, 2018). Research has proposed that deconstructing complex tasks into individual and isolated sub-tasks (van Merrienboer, 2002) can reduce cognitive load and enhance learning outcomes (Ngu & Phan, 2016). Because student teachers are easily overwhelmed by classroom complexity displayed in videos (Star & Strickland, 2008; Syring et al., 2015), teacher education has aimed to reduce this complexity and decompose the teaching quality dimensions into separate learnable entities. Thus, presenting each teaching quality dimension separately to student teachers (*isolated approach*) could reduce student teachers' cognitive load and foster PV by breaking down classrooms' complexity.

1.3 The Influence of Individual Prerequisites

Research has highlighted the effect of cognitive and motivational individual prerequisites on the development of PV (Kaiser & König, 2019; Stürmer et al., 2015). Cognitive prerequisites are typically prior knowledge or teaching experience that student teachers may have gained in previous learning opportunities (e.g., seminars or internships) throughout their teacher education. Learning opportunities offered through university seminars seem to influence knowledge acquisition (König et al., 2024; Kleickmann et al., 2012) and can also impact PV (Stürmer et al., 2013; Todorova et al., 2017). A central motivational prerequisite is interest (Hidi & Renninger, 2006). Interest evokes more deep cognitive processing (Entwistle & Ramsden, 1983) and therefore stronger elaborations and interconnections between learning contents (Wigfield & Cambria, 2010) by fostering emotional engagement and a sense of value toward learning contents (Hidi & Renninger, 2006). Therefore, higher interest is associated with higher achievement (e.g., Wigfield & Cambria, 2010). In teacher education, studies (Farrell et al., 2023; Martin et al., 2023) have shown that when student teachers analyzed classroom videos, interest significantly impacted PV. Moreover, interest can influence the intention to apply learning content in professional settings (Testers et al., 2019). This is particularly relevant for teacher education, as there has been a strong demand for imparting more practical and applicable knowledge in the field (Korthagen, 2010).

1.4 The Present Study

In light of previous empirical findings and theoretical deliberations, the study's main goal was to investigate whether an isolated or integrated approach to video-based analyses would foster student teachers' PV more effectively. A condition enrolled in a math didactics course functioned as a CG. In RQ1, we suggested an isolated or integrated approach to video-based analyses would enhance PV of teaching quality and the simultaneous focus from pre- to post-test compared to the CG (*video-based analysis effect*). However, the study's central focus was to investigate whether the isolated or integrated approach would foster student teachers' PV of teaching quality in different ways (RQ2; *instructional approach effect*). Additionally, as a type of manipulation check, we assumed the integrated approach fosters the simultaneous focus more effectively than the isolated approach. Further, we examined whether individual prerequisites of prior learning opportunities and interest influenced student teachers' PV (RQ3). We suggested learning opportunities and interest to positively influence student teachers' PV (*individual prerequisite effect*).

2. Method

2.1 Sample and Design

The quasi-experimental pre-post test study was conducted with $N = 140$ student teachers (age: $M = 22.96$, $SD = 1.45$; 79.8% female) in a three-week video-based intervention. Six student teachers were excluded because their processing time of the pre- or post-test was insufficient, four because they completed the survey only at one measurement time point, and one because data suggested insincere task processing. From the remaining participants, $n = 45$ student teachers were assigned to the isolated approach to video-based analyses, $n = 45$ to the integrated approach, and $n = 39$ to the CG. The student teachers were enrolled in six courses randomly distributed across two instructors, each conducting one course per condition. We collected informed written consent and treated participants following ethical guidelines and principles by the American Psychological Association and the Declaration of Helsinki.

2.2 Procedure and Materials

Classroom Videos

Classroom videos used for the intervention and measuring PV were thoughtfully selected from a video collection accessible to the research team based on their potential to portray the teaching quality dimensions. Selection criteria were based on situations typical for each teaching quality dimension based on literature (Lotz et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018). The video had to represent authentic and comprehensive situational information in which a teacher implemented effective classroom management (withitness, group focus, managing disruptions, and establishing rules and routines), instructional support (activating prior knowledge, cognitively activating tasks, students' contributions, demanding an explanation, exploring students' thought processes, and problem-based learning environments), and emotional support (encouraging students, sensitivity and empathy, positive error culture). The videos had to display good visual and acoustic quality.

One of the authors pre-selected videos by rating whether the videos displayed features of the teaching quality dimensions. Three teaching quality experts discussed eleven pre-selected videos regarding their potential to portray features of the teaching quality dimensions. The experts selected four 10-minute videos, which displayed math lessons from the 1st grade involving themes of arithmetic and stochastics. The videos displayed whole-class interactions and individual learning phases. Three video clips were used for the intervention, and one was selected for measuring PV.

2.2.1 Preparatory Materials

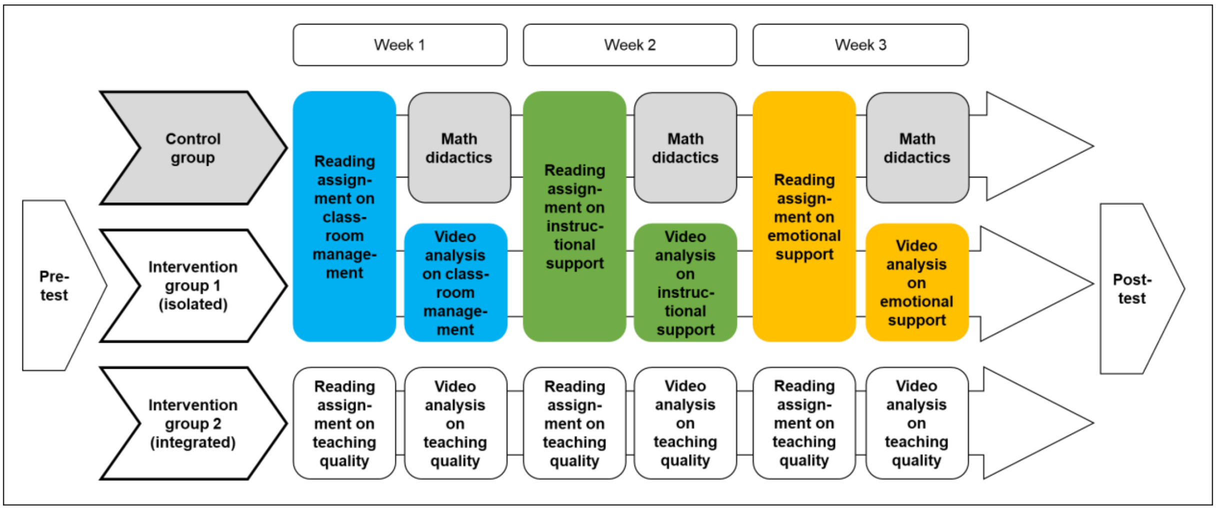
We implemented preparatory texts because they have been shown to support student teachers in video-based analyses (Martin et al., 2023). The three preparatory texts and handouts were based on the technical report of the PERLE video studies (see Lotz et al., 2013) and aspects of each teaching quality dimension (see supplement Table S1). For the isolated and control conditions, we compiled texts on one teaching quality dimension for each session. The texts for the integrated condition provided information on different aspects of all teaching quality dimensions in every session. The addressed aspects were selected based on situational information on the teaching quality dimensions in the videos. The texts were categorized as non-fictional literature (LIX from 50 to 65) and were comparable in difficulty between groups across all sessions (see supplement Table S2). Additionally, student teachers received handouts listing and briefly describing different aspects of the teaching quality dimensions to support subsequent video-based analyses.

2.2.2 Procedure

Before each session, student teachers read the preparatory texts and handouts (see Figure 1). The isolated condition read about classroom management in the first week, instructional support in the second week, and emotional support in the third week. The integrated condition read texts on selected aspects of all teaching quality dimensions in all three weeks of the intervention (see supplement Table S1). In the session, the isolated group analyzed one teaching quality dimension per session, whereas the integrated group focused on all teaching quality dimensions simultaneously. A mathematics didactics course functioned as a CG. Like the isolated group, CG received preparatory texts on the teaching quality dimensions and talked about them in the sessions but did not conduct video-based analyses.

Figure 1

Intervention Procedure



2.3 Instruments and Measures

2.3.1 Professional Vision (PV)

In pre-post-tests, student teachers were asked to watch a video, describe and interpret all relevant events concerning all teaching quality dimensions, and provide alternatives of action in written analyses.

2.3.1.1 Instrument and Master Rating

To measure *PV*, categories were created deductively based on theoretical concepts of teaching quality (Lotz et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018). Each category was related to one of the teaching quality dimensions (see supplement Table S3). Hence, we ended up with four categories for classroom management, six for instructional support, and three for emotional support. The categories were analyzed using Mayring's (2014) qualitative content analysis. This procedure aims to assess and evaluate cases based on selected categories, making it a reliable method for analyzing qualitative data.

Six teaching quality experts were asked to describe and interpret teaching quality in the video for a master rating. The experts identified 43 descriptions and interpretations of teaching quality: 22 related to classroom management, 12 to instructional support, and 9 to emotional support.

2.3.1.2 Coding Procedure

We used a simplified and adapted version of Dückers et al.'s (2022) coding procedure (see supplement Table S3). Based on the master rating, two trained raters coded one score for *noticing* the number of descriptions in a category (1 point each) (κ=.77). For *reasoning*, raters coded two scores, namely the number of interpretations that corresponded with the master rating (1 point each) and the number of explanations student teachers provided as indicators of an elaborated understanding of the classroom situation (1 point each) (κ=.78). If student teachers provided an interpretation but no description, they still received a point for the noticing score. If a coding was not part of the master rating, it was not further considered in the coding process. We calculated the number of points student teachers achieved for noticing, interpreting, and explaining for each category.

For the *alternative of action* measure, the raters coded the number of alternatives of action student teachers provided (1 point each). The raters also coded the number of explanations for their provided alternative of action (1 point each) and the number of discussions of the provided alternative of action (1 point each) as indicators of student teachers' deep and careful deliberations (κ=.84). For each alternative of action score, we calculated the number of points student teachers achieved.

2.3.2 Simultaneous Focus

In written analyses, the raters also coded whether student teachers focused on the teaching quality dimensions simultaneously (κ=.77). The raters coded whether they analyzed only one teaching quality dimension (0 points), two dimensions (1 point), or three dimensions (2 points). We calculated the number of points student teachers achieved for the simultaneous focus.

2.3.3 Prior Seminars Related to Teaching Quality

To assess whether student teachers have already attended seminars addressing teaching quality, we asked in the pre-test, "Have you already been enrolled in seminars addressing teaching quality?". Student teachers could answer *yes* (1) or *no* (0).

2.3.4 Prior Interest

We measured student teachers' interest in the pre-test with the Transfer Interest Questionnaire (Gegenfurtner et al., 2020). Student teachers received statements on interest (e.g., "What we learn in this course will be interesting"; Gegenfurtner et al., 2020, p. 157), which they rated on a seven-point Likert scale whether they *strongly disagreed* (1) or *strongly agreed* (7). Reliability was very good (α = .95).

2.4 Analysis Plan and Preliminary Analyses

2.4.1 Confirmatory Factor Analyses for Measuring Professional Vision

First, the instrument measuring PV was tested for reliability and dimensionality using confirmatory factor analysis (CFA) with robust maximum likelihood estimation. Because of the small sample size, we constructed domain representative parcels (Little et al., 2013) for each teaching quality dimension: the first parcel entailed noticing scores, the second parcel interpretations scores, and the third parcel scores on explanations. Based on previous findings and theoretical deliberations (Dückers et al., 2022; Steffensky et al., 2015), we included the alternative of action scores in the model. We specified a four-factorial focus-specific model with the factors PV of classroom management, PV of instructional support, PV of emotional support, and alternatives of actions. The first three factors consisted of the parcels of noticing, interpreting, and explaining. Alternatives of action were specified as a separate factor, including the number of alternatives of action, explanations, and discussions.

The CFA (see supplement Table S4) displayed a good fit for a four-dimensional model of PV ($\chi^2(47) = 85.04$, $p = .001$, CFI = .976, TLI = .967, RMSEA = .056, SRMR = .047).[3] Latent variables displayed low correlations ($r < .35$). Tests of measurement invariance across time points (see supplement Table S5) confirmed configural, metric, and scalar measurement invariance (Cheung & Rensvold, 2002). Hence, we calculated sum scores of the factors PV (noticing + interpreting + explaining) of classroom management (t1: $\alpha = .69$, t2: $\alpha = .75$), instructional support (t1: $\alpha = .63$, t2: $\alpha = .66$), emotional support (t1: $\alpha = .72$, t2: $\alpha = .79$), and alternatives of action (t1: $\alpha = .84$, t2: $\alpha = .79$) as dependent variables.

2.4.2 Preliminary Analyses

Next, because all distributions were non-normally distributed ($p < .05$), we used Kruskal-Wallis tests with a Bonferroni-corrected α-level of $p = .01$ to investigate differences in pre-test scores between the groups. Results showed that the groups did not differ in pre-test scores (see supplement Table S6).

2.4.3. Bayes Multi-Level Modeling

We conducted longitudinal Bayesian multi-level modeling (BMLM) with MCAR estimation using the brms package by Bürkner (2017). BMLM can model complex data structures in which observations are nested within different levels (i.e., measurement time points nested within individual participants), thereby incorporating random intercepts and slopes for different levels (Hamaker & Klugist, 2011). It also has the advantage against common multi-level models in that it can effectively deal with violations against normality and accommodate various distributions. In our case, we used Poisson regression because we used count data. Further, BMLM can deal with smaller sample sizes by setting appropriate priors based on previous theoretical and empirical deliberations and descriptive data. Because measurement time points were nested within participants, we first specified a random intercept

[3]We had to allow error covariances between the items “explaining of classroom management” and “explaining of instructional support” for the model to converge.

model (model A), which only included the participants with random intercepts at level 2 and measurement time points as fixed effects at level 1. Second, we included random slopes in the model (model B), which accounted for inter-individual differences over time. Fourth, we included the interaction between measurement time points and groups as a level 2 predictor and fixed effect to investigate differences between groups (model C). Lastly, we included level 2 predictors of prior learning opportunities addressing teaching quality and interest (model D). We specified weakly informed priors for fixed effects (b * $N(1, 5)$) to suggest an increase in PV of teaching quality and simultaneous focus, that the intervention groups outperform the CG, and that individual prerequisites positively influence PV. We also specified weakly informed priors for random effects (b * $N(0, 5)$) to allow for variability in intercept and slopes. We compared and evaluated the models with the leave-one-out criterion (Vehtari et al., 2017). To answer RQ2, we conducted Bayesian multiple comparisons between groups to identify differences between the isolated and integrated approaches.

All analyses were conducted using *R*. Data and syntax can be found (https://osf.io/8q6fs/?view_only=6257f14f638d4cf386541d7b79d94460).

3. Results

Descriptive data are displayed in Table 1. Investigations of BMLM models (see Table 2) with the leave-one-out criterion showed that including random intercepts and random slopes was necessary, as model B indicated a considerably better model fit than model A. An even better model fit was achieved when the interaction between time × groups was included, indicating that some variance can be attributed to differences between groups. The best model fit was achieved by including predictors of learning opportunities and interest. The full table on models A–D can be found in the supplement (see supplement S7).

Table 1
Descriptive Data on PV of Teaching Quality, Simultaneous Focus, and Individual Prerequisites

Scale	Control group				Intervention group 1 (isolated approach)				Intervention group 2 (integrated approach)			
	t1		t2		t1		t2		t1		t2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
PVCM	4.95	2.67	5.90	4.30	4.87	3.14	5.96	3.34	4.11	2.81	6.78	3.96
PVIS	2.38	2.23	2.38	2.25	2.53	2.35	3.53	2.76	3.20	2.78	3.09	2.60
PVES	2.44	2.35	2.38	2.95	2.42	2.48	3.73	3.06	2.31	2.18	2.58	2.65
Alternatives of action	6.05	3.22	7.21	3.89	6.80	3.95	9.02	4.71	7.84	3.90	8.98	5.22
Simultaneous focus	0.74	0.91	0.87	1.30	0.98	1.18	1.27	1.36	0.73	1.05	2.16	1.93
Prior seminars	.31	.47			.24	.43			.29	.46		
Prior interest	5.89	1.16			5.88	0.74			5.83	0.69		

Note. PVCM = professional vision of classroom management; PVIS = professional vision of instructional support; PVES = professional vision of emotional support.

Table 2
Model Fit Statistics of the Longitudinal Bayesian Multi-Level Models

Model	LOOIC	SE	ΔLOOIC	ΔSE	Right side of the formula
Model A	5688.3	67.6	0.0	0.0	time + (1|id)
Model B	5621.4	59.5	66.9	8.1	time + (1 + time|id)
Model C	5613.2	59.6	8.2	–0.1	time * group + (1 + time|id)
Model D	5034.8	56.3	578.4	3.3	time * group + prior seminars + prior interest + (1 + time|id)

Note. LOOIC = leave-one-out information criterion; SE = standard error.

3.1 Video-based analysis effect

Regarding RQ1, descriptive statistics suggest that student teachers in the isolated approach outperformed the CG in all measures. In contrast, student teachers in the integrated approach outperformed the CG only in PV of classroom management, PV of emotional support, and the simultaneous focus. Results of Model D (see Table 3) showed no significant effect of time on dependent measures. However, a significant interaction effect on PV of emotional support indicated that student teachers in the isolated approach improved significantly more in PV of emotional support than the CG (see Figure 2). Further, we found significant interaction effects on PV of classroom management and the simultaneous focus, indicating that student teachers in the integrated approach outperformed the CG (see Figure 2). However, student teachers in the isolated or integrated approach did not outperform the CG in PV of instructional support or alternatives of action.

Table 3
Results of the Longitudinal Bayesian Multi-Level Model D

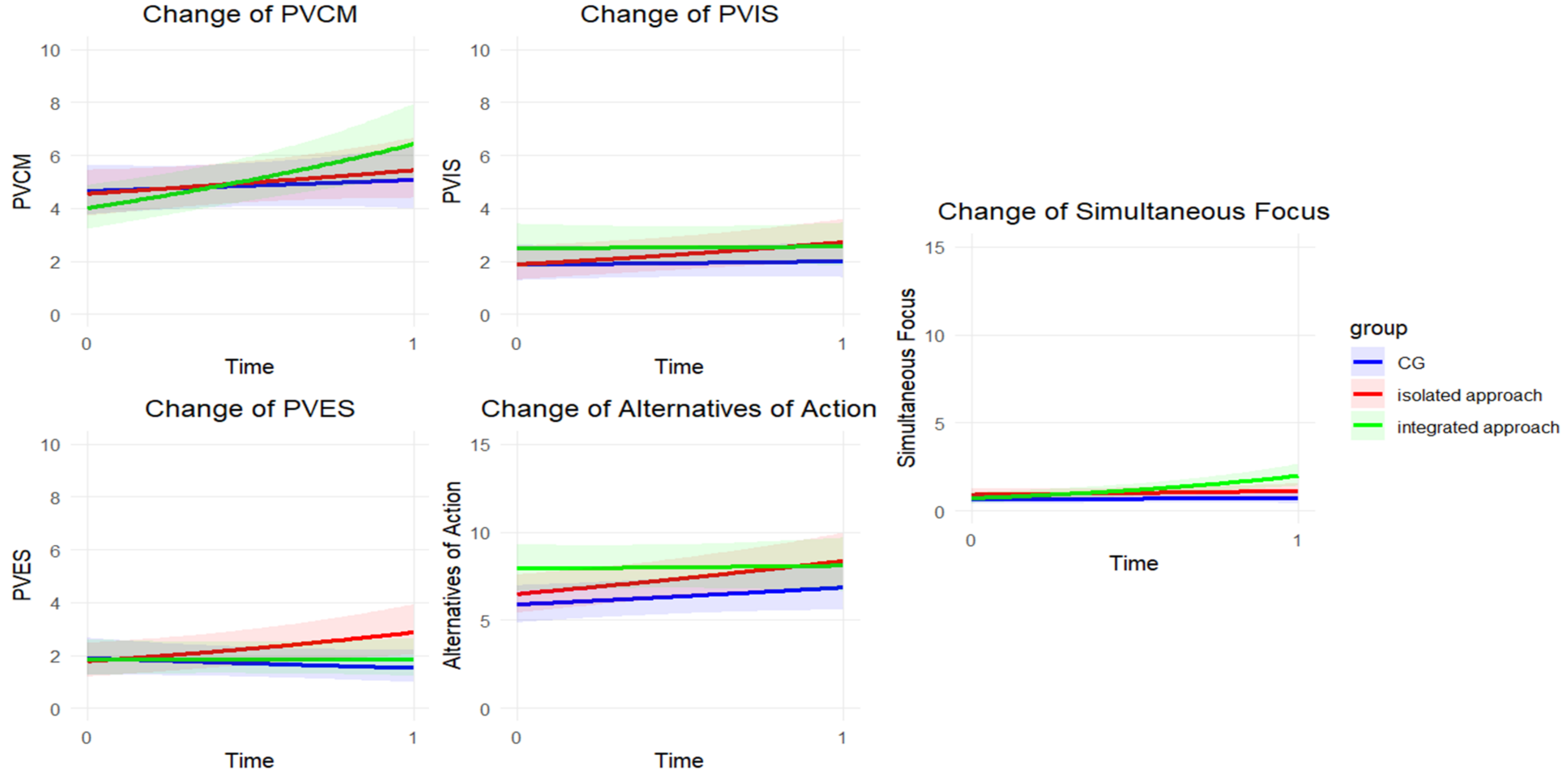
Effect	Model D	
	Estimate (*SD*)	95% *CI* [LL,UL]
Fixed Effects		
PV of classroom management		
Intercept	1.37(0.34)	[0.71,2.04]
Time	0.09(0.14)	[–0.19,0.35]
Isolated	–0.02(0.14)	[–0.30,0.26]
Integrated	–0.15(0.14)	[–0.43,0.14]
Time × Isolated	0.09(0.18)	[–0.27,0.45]
Time × Integrated	0.39(0.19)	[0.02,0.76]
Seminars	–0.05(0.10)	[–0.25,0.15]
Interest	<0.01(0.01)	[–0.01,0.01]
PV of instructional support		
Intercept	0.66(0.59)	[–0.52,1.78]
Time	0.07(0.18)	[–0.28,0.41]
Isolated	0.01(0.24)	[–0.47,0.48]
Integrated	0.29(0.24)	[–0.19,0.76]
Time × Isolated	0.31(0.22)	[–0.11,0.75]
Time × Integrated	–0.04(0.22)	[–0.47,0.40]
Seminars	–0.22(0.18)	[–0.58,0.14]
Interest	<0.01(0.01)	[–0.02,0.02]
PV of emotional support		
Intercept	0.75(0.64)	[–0.52,1.99]
Time	–0.22(0.21)	[–0.64,0.18]
Isolated	–0.06(0.25)	[–0.56,0.43]
Integrated	–0.02(0.26)	[–0.52,0.48]
Time × Isolated	0.71(0.26)	[0.22,1.22]
Time × Integrated	0.22(0.27)	[–0.30,0.75]
Seminars	–0.28(0.20)	[–0.68,0.11]
Interest	>–0.01(0.01)	[–0.02,0.02]
Alternatives of action		
Intercept	1.53(0.33)	[0.88,2.17]
Time	0.15(0.10)	[–0.05,0.35]
Isolated	0.10(0.12)	[–0.15,0.34]
Integrated	0.30(0.12)	[0.06,0.55]
Time × Isolated	0.10(0.13)	[–0.16,0.37]
Time × Integrated	–0.13(0.13)	[–0.39,0.12]
Seminars	–0.05(0.10)	[–0.25,0.15]
Interest	<0.01(0.01)	[–0.01,0.01]
Simultaneous focus		
Intercept	–1.65(0.70)	[–3.06,–0.33]
Time	0.12(0.30)	[–0.46,0.71]
Isolated	0.36(0.28)	[–0.19,0.91]
Integrated	0.10(0.30)	[–0.49,0.68]
Time × Isolated	0.09(0.36)	[–0.60,0.81]
Time × Integrated	0.93(0.36)	[0.24,1.65]
Seminars	–0.06(0.18)	[–0.43,0.30]
Interest	0.02(0.01)	[>–0.00,0.04]

Effect	Model D	
	Estimate (*SD*)	95% *CI* [LL,UL]
Random Effects		
PV of classroom management		
Intercept	0.39(0.07)	[0.25,0.54]
Time	0.49(0.10)	[0.30,0.67]
PV of instructional support		
Intercept	0.78(0.10)	[0.59,1.00]
Time	0.31(0.18)	[0.02,0.66]
PV of emotional support		
Intercept	0.83(0.12)	[0.62,1.09]
Time	0.52(0.19)	[0.10,0.86]
Alternatives of action		
Intercept	0.37(0.05)	[0.28,0.48]
Time	0.20(0.09)	[0.02,0.38]
Simultaneous focus		
Intercept	0.56(0.17)	[0.22,0.89]
Time	0.41(0.25)	[0.02,0.92]

Note. CI = confidence interval; LL = lower level; UL = upper level; PV = professional vision.

Figure 2

Fixed Effects by Group of Bayesian Multi-level Models



Note. PVCM = professional vision of classroom management; PVIS = professional vision of instructional support; PVES = professional vision of emotional support; CG = control group.

3.2 Instructional Approach Effect

Concerning RQ2, Bayesian multiple comparisons (see Table 4) revealed significant differences between the isolated and integrated approach of PV of emotional support and the simultaneous focus. Descriptive statistics suggest that the isolated approach outperformed the integrated approach in PV of emotional support. In contrast, the integrated approach outperformed the isolated approach in simultaneously focusing on the teaching quality dimensions, indicating the manipulation's effectiveness. However, all other effects were non-significant.

Table 4

Bayesian Multiple Comparisons Between the Isolated and the Integrated Approach

Comparison: isolated vs. integrated approach	Estimate	95%-CI [LL,UL]
PV of classroom management	0.30	[−0.06,0.64]
PV of instructional support	−0.34	[−0.77,0.04]
PV of emotional support	−0.49	[−0.99,−0.02]
Alternatives of action	−0.24	[−0.48,0.01]
Simultaneous focus	0.83	[0.21,1.45]

Note. CI = confidence interval; LL = lower level; UL = upper level; PV = professional vision.

3.3 Individual Prerequisite Effect

Regarding RQ3, model D showed that the effects of predictors of prior seminars or interest were non-significant (see Table 3). This indicated that neither the prior seminars in teacher education nor student teachers' interest affected the change of PV of teaching quality or the simultaneous focus.

4. Discussion

The study investigated how different instructional approaches to video-based analyses may enhance student teachers' PV of teaching quality. Specifically, we investigated whether the isolated or integrated approach to video-based analyses differed in fostering student teachers' PV of teaching quality. Further, the study aimed to give insights into whether cognitive and affective-motivational individual prerequisites affected the change of PV.

4.1 Interpretation of Findings

Previous studies have shown that video-based analyses can significantly enhance student teachers' focus-specific PV (classroom management: Gold et al., 2021; instructional support: Jacobs et al., 2010). Our study aimed to consider classrooms' complexity (Doyle, 2006) by promoting PV of all teaching quality dimensions through video-based analyses and focusing on the dimensions in an isolated or integrated approach (RQ1). However, we could not fully replicate findings from previous studies. The results showed that student teachers who conducted video-based analyses in the isolated approach only improved in PV of emotional support, whereas student teachers conducting video-based analyses in the integrated approach improved in PV of classroom management and simultaneously focusing the teaching quality dimensions compared to the CG, which only read texts on teaching quality (*video-based analyses effect*). When comparing the isolated with the integrated approach (RQ2), we also found that student teachers in the isolated approach improved more in PV of emotional support. In contrast, student teachers in the integrated approach improved more in simultaneously focusing on the teaching quality dimensions (*instructional approach effect*).

Regarding RQ1, student teachers analyzing classroom videos performed only partially better in PV of teaching quality than the CG. Typically, novice learners with low prior knowledge process information separately (Kalyuga, 2008) to reduce cognitive load. Because PV is a knowledge-based process (Blömeke et al., 2015), one possible reason could be that if student teachers lack sufficient knowledge, they may struggle to analyze classroom videos focusing on all teaching quality dimensions. Hence, they may have mainly focused on only one teaching quality dimension to deal with the classroom's complexity in the video. The results and descriptive statistics showed that student teachers who conducted video-based analyses focused most on classroom management (integrated approach), a little less on emotional support (isolated approach), and least on instructional support. When teachers act in unfamiliar or new content areas for which they lack sufficient pedagogical content and content knowledge needed for PV of instructional support, they generally turn to pedagogical knowledge (Hashweh, 1987; see also Harr et al., 2014). Hence, it is possible that student teachers turned to PV of classroom management or emotional support in video-based analyses because they lack sufficient PV of instructional support.

However, the result that student teachers in the isolated approach improved in PV of emotional support compared to the CG could be attributed to a recency effect (Baddeley & Hitch, 1993). The recency effect in the context of learning suggests that learning outcomes increase when the information assessed aligns with content presented most recently, as it is freshest in memory for assessment (also found for texts and pictures; Shaw et al., 2012). Thus, student teachers in the isolated approach improved in PV of emotional support because they focused on emotional support in the last week of the intervention, which was most recent to the post-test.

Regarding RQ2, because a positive effect of the isolated approach was found for PV of emotional support compared to the integrated approach, the findings may indicate that the isolated approach to video-based analyses was possibly less cognitively demanding on student teachers by deconstructing the teaching quality dimensions into individual sub-tasks (van Merrienboer et al., 2002). Hence, simultaneously focusing on the teaching quality dimensions in video-based analyses cognitively overloaded student teachers (derived from Sweller, 2011) as finding interconnections generally draws on many cognitive resources (Ayres, 2013). The result was that student teachers in the integrated approach improved in simultaneously focusing on the teaching quality dimensions compared to the CG and the isolated approach, which served as evidence for the effectiveness of the manipulation. Further, it is also possible that due to the traditional division between subject matter and pedagogy, which is still deeply engrained in many teacher education systems (Ball, 2000), student teachers may not be used to connect aspects of pedagogy (i.e., classroom management and emotional support) with aspects of subject matter (i.e., instructional support). However, from a cognitive-psychological perspective, this division may lead to the compartmentalization of focus-specific PV, risking its storage in largely unconnected memory segments with minimal interconnection (Spiro & Jehng, 1990), which may result in a limited understanding of how concepts are interconnected and an oversimplification when applying these concepts in real-life situations (Anderson, 1983). Because there has been a call for teacher education to avoid 'inert knowledge' (Renkl et al., 1996) and foster usable knowledge (Kersting et al., 2012), teaching student teachers how to connect PV of classroom management, PV of instructional support, and PV of emotional support may support them when acting in real-life classroom situations in the future.

Regarding RQ3, although student teachers were generally interested in transferring content from the seminar to teaching practice, we could not find effects of individual prerequisites on PV found in previous studies (Farrell et al., 2023; Stürmer et al., 2015; Todorova et al., 2017) in the context of the intervention. PV was neither influenced by student teachers' interest nor learning opportunities (*individual prerequisite effect*). One explanation for the lack of effects could be that some student teachers may have attended more seminars regarding one teaching quality dimension or may be more interested in applying different teaching quality dimensions (e.g., classroom management or instructional support).

4.2 Limitations

Some limitations have to be discussed. First, our study displayed a relatively short intervention time. Other studies have conducted interventions throughout months, an entire semester, or even a year (Santagata et al., 2021). Therefore, our study can only give insights into short-term effects. As knowledge integration typically takes time and practice, this may be a reason for the ineffectiveness of the integrated approach. Second, the quasi-experimental design implemented in university seminars does not meet the rigorous standards of laboratory studies (Kember, 2003). Therefore, further variation sources may be possible. However, few studies (Farrell et al., 2023) investigating instructional approaches to video-based analyses included cognitive or motivational individual prerequisites in their studies. By including whether student teachers attended seminars addressing teaching quality and interest, this study contributed to insights into whether other factors could account for variation sources in the intervention groups. Third, student teachers presumably experienced a high cognitive load focusing on all three teaching quality dimensions (derived from Sweller, 2011). Since PV is a knowledge-based process encompassing cognitive processes (Blömeke et al., 2015), measures of cognitive load during learning could give insights into how student teachers experience video-based analyses. Despite these limitations, this study could be a first step towards a stronger integration of subject-related and pedagogical domains in teacher education (see also Hörter et al., 2020).

Appendix A

Table A1a

Correlations Between the Dependent Variables for the Control Group

Scale	1	2	3	4	5	6	7	8	9	10	11
t1											
(1) PV of classroom management											
(2) PV of instructional support	−.20										
(3) PV of emotional support	.18	.01									
(4) Alternatives of action	−.01	.01	.11								
(5) Simultaneous focus	−.08	.23	.07	.26							
(6) Prior seminars	−.34*	.09	−.29	.04	−.13						
(7) Prior interest	−.07	.51**	.08	.19	.48**	−.16					
t2											
(8) PV of classroom management	.38*	−.01	<.01	.29	.08	.12	−.05				
(9) PV of instructional support	.12	.42**	.26	−.10	.13	.25	.11	.04			
(10) PV of emotional support	.27	−.07	.42**	−.03	.14	−.10	−.05	.12	.34*		
(11) Alternatives of action	−.08	.08	.29	.42**	.12	.12	−.04	.24	.14	.33*	
(12) Simultaneous focus	.02	−.01	.18	.21	.10	.09	.24	.31	−.09	−.14	.20

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A2a

Correlations Between the Dependent Variables for the Isolated Approach

Scale	1	2	3	4	5	6	7	8	9	10	11
t1											
(1) PV of classroom management											
(2) PV of instructional support	–.20										
(3) PV of emotional support	.27	.09									
(4) Alternatives of action	.01	–.06	.11								
(5) Simultaneous focus	.18	–.30*	–.03	.30*							
(6) Prior seminars	–.14	–.18	–.09	–.09	–.20						
(7) Prior interest	.39*	–.22	.17	–.03	–.12	.15					
t2											
(8) PV of classroom management	–.01	.18	.29*	.14	.03	<.01	–.25				
(9) PV of instructional support	.08	.45**	.13	.07	–.03	–.29	–.20	–.07			
(10) PV of emotional support	.06	.18	.53***	.15	–.04	.02	.04	.44**	.19		
(11) Alternatives of action	.02	.05	.09	.51***	.19	–.09	–.10	.27	.19	.17	
(12) Simultaneous focus	.06	–.05	.01	.19	.07	.21	.06	<.01	–.09	–.09	.10

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A3a

Correlations Between the Dependent Variables for the Integrated Approach

Scale	1	2	3	4	5	6	7	8	9	10	11
t1											
(1) PV of classroom management											
(2) PV of instructional support	−.52***										
(3) PV of emotional support	.04	<.01									
(4) Alternatives of action	.21	−.04	<.01								
(5) Simultaneous focus	.06	<.01	.07	.30*							
(6) Prior seminars	.17	−.26	−.09	.10	−.01						
(7) Prior interest	.03	−.04	−.01	.22	−.07	.01					
t2											
(8) PV of classroom management	.09	.19	<.01	.04	−.04	.07	−.12				
(9) PV of instructional support	−.31*	.27	−.05	−.09	−.07	−.11	.07	.19			
(10) PV of emotional support	−.02	.12	.32**	−.12	.04	−.14	−.03	.24	.02		
(11) Alternatives of action	.16	−.09	−.02	.32*	.16	.14	.26	−.03	.11	−.27	
(12) Simultaneous focus	−.01	.13	−.05	.34*	.30*	<.01	.10	−.09	−.11	.01	.21

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

References

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior*, *22*(3), 261–295. https://doi.org/10.1016/S0022-5371(83)90201-3

Arlin, M. (1979). Teacher transitions can disrupt time flow in classrooms. *American Educational Research Journal*, *16*(1), 42–56. https://doi.org/10.3102/00028312016001042

Ayres, P. (2013). Can the isolated-elements strategy be improved by targeting points of high cognitive load for additional practice?. *Learning and Instruction*, *23*, 115–124. https://doi.org/10.1016/j.learninstruc.2012.08.002

Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556–559. https://doi.org/10.1126/science.1736359

Baddeley, A. D., & Hitch, G. (1993). The recency effect: Implicit learning with explicit retrieval?. *Memory & Cognition*, *21*, 146–155. https://doi.org/10.3758/BF03202726

Ball, D. L. (2000). Bridging practices: Intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education*, *51*(3), 241–247. https://doi.org/10.1177/0022487100051003013

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y. M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal*, *47*(1), 133–180. https://doi.org/10.3102/0002831209345157

Blomberg, G., Renkl, A., Gamoran Sherin, M., Borko, H., & Seidel, T. (2013). Five research-based heuristics for using video in pre-service teacher education. *Journal for Educational Research Online*, *5*(1), 90–114. https://doi.org/10.25656/01:8021

Blömeke, S., Gustafsson, J. E., & Shavelson, R. J. (2015). Beyond dichotomies. *Zeitschrift für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Blömeke, S., Jentsch, A., Ross, N., Kaiser, G., & König, J. (2022). Opening up the black box: Teacher competence, instructional quality, and students' learning progress. *Learning and Instruction*, *79*, 101600. https://doi.org/10.1016/j.learninstruc.2022.101600

Böheim, R., Schnitzler, K., Gröschner, A., Weil, M., Knogler, M., Schindler, A. K., Alles, M., & Seidel, T. (2021). How changes in teachers' dialogic discourse practice relate to changes in students' activation, motivation and cognitive engagement. *Learning, Culture and Social Interaction*, *28*, 100450. https://doi.org/10.1016/j.lcsi.2020.100450

Bürkner, P. C. (2017). brms: An R package for Bayesian multilevel models using Stan. *Journal of Statistical Software*, *80*, 1–28.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling*, *9*(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5

Doyle, W. (1980). *Classroom management*. Kappa Delta Pi.

Doyle, W. (2006). Ecological management and classroom management. In C. M. Evertson, & C. S. Weinsteing (Eds.). *Handbook of classroom management: Research, practice, and contemporary issues*. (p. 97–126). Routledge.

Dückers, C., Hörter, P., Junker, R., & Holodynski, M. (2022). Professional vision of teaching as a focus-specific or focus-integrated skill–Conceptual considerations and video-based assessment. *Teaching and Teacher Education*, *117*, 103797. https://doi.org/10.1016/j.tate.2022.103797

Dunekacke, S. (2016). *Mathematische Bildung in Alltags- und Spielsituationen begleiten: Handlungsnahe Erfassung mathematikdidaktischer Kompetenz angehender frühpädagogischer Fachkräfte durch die Bearbeitung von Videovignetten* [Supporting mathematical education in everyday and play situations: Practice-oriented assessment of the mathematics didactic competence of prospective early childhood educators through the use of video vignettes] (Doctoral dissertation, Dissertation, Berlin, Humboldt Universität zu Berlin, 2016).

Emmer, E. T., & Stough, L. M. (2001). Classroom management: A critical part of educational psychology, with implications for teacher education. *Educational Psychologist, 36*, 103–112.

Entwistle, N.J., & Ramsden, P. (1983). *Understanding Student Learning.* Croom Helm.

Evertson, C. M., & Emmer, E. T. (2012). *Classroom Management for Elementary Teachers.* Pearson.

Farrell, M., Martin, M., Böheim, R., Renkl, A., Rieß, W., Könings, K. D., Merrienboer, 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,* 1–39. https://doi.org/10.1007/s11251-024-09662-y

Fauth, B., Decristan, J., Rieser, S., Klieme, E., & Büttner, G. (2014). Student ratings of teaching quality in primary school: Dimensions and prediction of student outcomes. *Learning and Instruction*, *29*, 1–9. https://doi.org/10.1016/j.learninstruc.2013.07.001

Gegenfurtner, A., Knogler, M., & Schwab, S. (2020). Transfer interest: Measuring interest in training content and interest in training transfer. *Human Resource Development International*, *23*(2), 146–167. https://doi.org/10.1080/13678868.2019.1644002

Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, *16*, 41–67. https://doi.org/10.1016/j.edurev.2015.06.001

Gold, B., & Holodynski, M. (2017). Using digital video to measure the professional vision of elementary classroom management: Test validation and methodological challenges. *Computers & Education*, *107*, 13–30. https://doi.org/10.1016/j.compedu.2016.12.012

Gold, B., Pfirrmann, C., & Holodynski, M. (2021). Promoting professional vision of classroom management through different analytic perspectives in video-based learning environments. *Journal of Teacher Education*, *72*(4), 431–447. https://doi.org/10.1177/0022487120963681

Hamaker, E. L., & Klugkist, I. (2011). Bayesian estimation of multilevel models. In J. Hox & K. Roberts (Eds.). *Handbook of advanced multilevel analysis* (pp. 137–161). Routledge. https://doi.org/10.4324/9780203848852

Harr, N., Eichler, A., & Renkl, A. (2014). Integrating pedagogical content knowledge and pedagogical/psychological knowledge in mathematics. *Frontiers in Psychology*, *5*, 924. https://doi.org/10.3389/fpsyg.2014.00924

Harr, N., Eichler, A., & Renkl, A. (2015). Integrated learning: Ways of fostering the applicability of teachers' pedagogical and psychological knowledge. *Frontiers in Psychology*, *6*, 738. https://doi.org/10.3389/fpsyg.2015.00738

Hashweh, M. Z. (1987). Effects of subject-matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education*, *3*(2), 109–120. https://doi.org/10.1016/0742-051X(87)90012-6

Hidi, S., & Renninger, K. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4

Hörter, P., Gippert, C., Holodynski, M., & Stein, M. (2020). Klassenführung und Fachdidaktik im (Anfangs-) Unterricht Mathematik erfolgreich integrieren– Konzeption einer videobasierten Lehrveranstaltung zur Förderung der professionellen Unterrichtswahrnehmung [Successfully integrating classroom Management and subject didactics in (initial) mathematics lessons – design of a video-based course to promote professional lesson observation]. *Herausforderung Lehrer* innenbildung-Zeitschrift zur Konzeption, Gestaltung und Diskussion (HLZ)*, *3*(1), 256–282. https://doi.org/10.4119/hlz-2551

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169–202. https://doi.org/10.5951/jresematheduc.41.2.0169

Jennings, P. A., & Greenberg, M. T. (2009). The prosocial classroom: Teacher social and emotional competence in relation to student and classroom outcomes. *Review of Educational Research*, *79*(1), 491–525. https://doi.org/10.3102/0034654308325693

Kaiser, G., & König, J. (2019). Competence measurement in (mathematics) teacher education and beyond: Implications for policy. *Higher Education Policy*, *32*(4), 597–615. https://doi.org/10.1057/s41307-019-00139-z

Kalyuga, S. (2008). Relative effectiveness of animated and static diagrams: An effect of learner prior knowledge. *Computers in Human Behavior*, *24*(3), 852–861. https://doi.org/10.1016/j.chb.2007.02.018

Kember, D. (2003). To control or not to control: The question of whether experimental designs are appropriate for evaluating teaching innovations in higher education. *Assessment & Evaluation in Higher Education*, *28*(1), 89–101. https://doi.org/10.1016/j.tate.2018.10.007

Keppens, K., Consuegra, E., Goossens, M., De Maeyer, S., & Vanderlinde, R. (2019). Measuring pre-service teachers' professional vision of inclusive classrooms: A video-based comparative judgement instrument. *Teaching and Teacher Education*, *78*, 1–14.

Kersting, N. B., Givvin, K. B., Thompson, B. J., Santagata, R., & Stigler, J. W. (2012). Measuring usable knowledge: Teachers' analyses of mathematics classroom videos predict teaching quality and student learning. *American Educational Research Journal*, *49*(3), 568–589. https://doi.org/10.3102/0002831212437853

Kleickmann, T., Richter, D., Kunter, M., Elsner, J., Besser, M., Krauss, S., & Baumert, J. (2013). Teachers' content knowledge and pedagogical content knowledge: The role of structural differences in teacher education. *Journal of Teacher Education*, *64*(1), 90–106. https://doi.org/10.1177/0022487112460398

Klieme, E., Pauli, C., & Reusser, K. (2009). The Pythagoras study: Investigating effects of teaching and learning in Swiss and German mathematics classrooms. In T. Janik, & T. Seidel (Eds.). *The power of video studies in investigating teaching and learning in the classroom*, (pp. 137–160). Münster, Germany: Waxmann.

König, J. (2015). Measuring classroom management expertise (CME) of teachers: A video-based assessment approach and statistical results. *Cogent Education*, 2(1), 991178. https://doi.org/10.1080/2331186X.2014.991178

König, J., & Lebens, M. (2012). Classroom Management Expertise (CME) von Lehrkräften messen: Überlegungen zur Testung mithilfe von Videovignetten und erste empirische Befunde [Measuring teachers' classroom management expertise (CME): considerations for testing using video vignettes and initial empirical findings]. *Lehrerbildung auf dem Prüfstand*, *5*(1), 3–28. https://doi.org/10.25656/01:14729

König, J., Blömeke, S., Klein, P., Suhl, U., Busse, A., & Kaiser, G. (2014). Is teachers' general pedagogical knowledge a premise for noticing and interpreting classroom situations? A video-based assessment approach. *Teaching and Teacher Education*, *38*, 76–88. https://doi.org/10.1016/j.tate.2013.11.004

König, J., Ligtvoet, R., Klemenz, S., & Rothland, M. (2024). Discontinued knowledge growth: on the development of teachers' general pedagogical knowledge at the transition from higher education into teaching practice. *Teachers and Teaching*, 1–19. https://doi.org/10.1080/13540602.2024.2308895

König, J., & Kramer, C. (2016). Teacher professional knowledge and classroom management: On the relation of general pedagogical knowledge (GPK) and classroom management expertise (CME). *ZDM*, *48*, 139–151. https://doi.org/10.1007/s11858-015-0705-4

König, J., & Pflanzl, B. (2016). Is teacher knowledge associated with performance? On the relationship between teachers' general pedagogical knowledge and instructional quality. *European Journal of Teacher Education*, *39*(4), 419–-436. https://doi.org/10.1080/02619768.2016.1214128

Korthagen, F. A. J. (2010). The relationship between theory and practice in teacher education. In P. L. Peterson, E. L. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (pp. 669–675). Academic Press.

Kounin, J. S. (1970). *Discipline and group management in classrooms*. Holt, Rinehart & Winston.

Kramer, M., Förtsch, C., & Neuhaus, B. J. (2021). Integrating or Not-Integrating—That is the Question. Effects of Integrated Instruction on the Development of Pre-Service Biology Teachers' Professional Knowledge. *Frontiers in Education*, *6*, 645227. https://doi.org/10.3389/feduc.2021.645227

Kunter, M., Baumert, J., Blum, W., Klusmann, U., Krauss, S., & Neubrand, M. (Eds.). (2013). *Cognitive activation in the mathematics classroom and professional competence of teachers: Results from the COACTIV project*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4614-5149-5

Leuders, T., & Holzäpfel, L. (2011). Kognitive Aktivierung im Mathematikunterricht [Cognitive Activation in Mathematics Lessons]. *Unterrichtswissenschaft*, *39*(3), 213–230.

Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E., & Reusser, K. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and Instruction*, *19*(6), 527–537. https://doi.org/10.1016/j.learninstruc.2008.11.001

Little, T. D., Rhemtulla, M., Gibson, K., & Schoemann, A. M. (2013). Why the items versus parcels controversy needn't be one. *Psychological Methods*, *18*(3), 285. https://doi.org/10.1037/a0033266

Lotz, M., Lipowsky, F., Faust, G. (2013). *Dokumentation der Erhebungsinstrumente des Projekts "Persönlichkeits-und Lernentwicklung von " (PERLE). 3. Technischer Bericht zu den PERLE-Videostudien. Materialien zur Bildungsforschung: Vol. 23,3* [Documentation of the survey instruments of the project 'Personality and Learning Development of' (PERLE). 3rd technical report on the PERLE video studies. Materials on educational research: Vol. 23,3]. Gesellschaft zur Förderung Pädagogischer Forschung [u.a.].

Martin, M., Farrell, M., Seidel, T., Rieß, W., Könings, K. D., van Merriënboer, J. J., & Renkl, A. (2023). Knowing what matters: Short introductory texts support pre-service teachers 'professional vision of tutoring interactions. *Teaching and Teacher Education*, *124*, 104014. https://doi.org/10.1016/j.tate.2023.104014

Mayring, P. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution*. Available at Social Science Open Access Repository (SSOAR).
Meschede, N., Steffensky, M., Wolters, M., & Möller, K. (2015). Professionelle Wahrnehmung der Lernunterstützung im naturwissen schaftlichen Grundschulunterricht [Professional perception of learning support in elementary school science lessons]. *Unterrichtswissenschaft*, *43*(4).
Neubrand, M., Jordan, A., Krauss, S., Blum, W., & Löwen, K. (2013). Task analysis in COACTIV: Examining the potential for cognitive activation in German mathematics classrooms. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.). *Cognitive activation in the mathematics classroom and professional competence of teachers: Results from the COACTIV project* (pp. 125–144). Springer. https://doi.org/10.1007/978-1-4614-5149-5
Ngu, B. H., & Phan, H. P. (2016). Unpacking the complexity of linear equations from a cognitive load theory perspective. *Educational Psychology Review*, *28*, 95–118. https://doi.org/10.1007/s10648-015-9298-2
Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. *Educational Researcher*, *38*(2), 109–119. https://doi.org/10.3102/0013189X09332374
Praetorius, A. K., Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: The German framework of three basic dimensions. *ZDM*, *50*, 407–426. https://doi.org/10.1007/s11858-018-0918-4
Rakoczy, K., Klieme, E., & Pauli, C. (2008). Die Bedeutung der wahrgenommenen Unterstützung motivationsrelevanter Bedürfnisse und des Alltagsbezugs im Mathematikunterricht für die selbstbestimmte Motivation [The importance of perceived support for motivation-relevant needs and real-world connections in mathematics lessons for self-determined motivation]. *Zeitschrift für Pädagogische Psychologie*, *22*(1), 25–35. https://doi.org/10.1024/1010-0652.22.1.25
Renkl, A., Mandl, H., & Gruber, H. (1996). Inert knowledge: Analyses and remedies. *Educational Psychologist*, *31*(2), 115–121. https://doi.org/10.1207/s15326985ep3102_3
Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal of Research in Science Teaching*, *48*(2), 117–148. https://doi.org/10.1002/tea.20408
Santagata, R., & Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *ZDM*, *43*, 133–145. https://doi.org/10.1007/s11858-010-0292-3
Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A. K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM–Mathematics Education*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z
Seidel, T., & Stürmer, K. (2014). Modeling and measuring the structure of professional vision in preservice teachers. *American Educational Research Journal*, *51*(4), 739–771. https://doi.org/10.1016/j.tate.2013.03.004
Seidel, T., Blomberg, G., & Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, *34*, 56–65.
Shaw, S., Nihalani, P., Mayrath, M., & Robinson, D. H. (2012). Graphic organizers or graphic overviews? Presentation order effects with computer-based text. *Educational Technology Research and Development, 60*, 807–820. doi:10.1007/s11423-012-9257-2

Spada, N., Jessop, L., Tomita, Y., Suzuki, W., & Valeo, A. (2014). Isolated and integrated form-focused instruction: Effects on different types of L2 knowledge. *Language Teaching Research*, *18*(4), 453–473. https://doi.org/10.1177/1362168813519883

Spiro, R. J., & Jehng, J. C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In D. Nix & R. Spiro (Eds.) *Cognition, education, and multimedia* (pp. 163–205). Routledge. https://doi.org/10.4324/9780203052174

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*, 107–125. https://doi.org/10.1007/s10857-007-9063-7

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology*, *94*(2), 344. https://doi.org/10.1037/0022-0663.94.2.344

Steffensky, M., Gold, B., Holdynski, M., & Möller, K. (2015). Professional vision of classroom management and learning support in science classrooms—Does professional vision differ across general and content-specific classroom interactions?. *International Journal of Science and Mathematics Education*, *13*, 351–368. https://doi.org/10.1007/s10763-014-9607-0

Steuer, G., & Dresel, M. (2015). A constructive error climate as an element of effective learning environments. *Psychological Test and Assessment Modeling*, *57*(2), 262–275.

Stürmer, K., Könings, K. D., & Seidel, T. (2015). Factors within university-based teacher education relating to preservice teachers' professional vision. *Vocations and Learning*, *8*, 35–54. https://doi.org/10.1007/s12186-014-9122-z

Stürmer, K., Könings, K. D., & Seidel, T. (2013). Declarative knowledge and professional vision in teacher education: Effect of courses in teaching and learning. *British Journal of Educational Psychology*, *83*(3), 467–483. https://doi.org/10.1111/j.2044-8279.2012.02075.x

Sweller (2011). Cognitive Load Theory. In J. P. Mestre & B. H. Ross (Eds.). *Psychology of Learning and Motivation* (pp. 37–76). Academic Press. https://doi.org/10.1016/B978-0-12-387691-1.00002-8

Syring, M., Bohl, T., Kleinknecht, M., Kuntze, S., Rehm, M., & Schneider, J. (2015). Video or text in case-based teacher education? An examination of the effects of different media on cognitive load and motivational-emotional processes in case-based learning. *Zeitschrift für Erziehungswissenschaft*, *18*, 667–685. https://doi.org/10.1007/s11618-015-0631-9

Testers, L. B. J. C. T., Gegenfurtner, A., van Geel, R., & Brand-Gruwel, S. (2019). From monocontextual to multicontextual transfer: Organizational determinants of the intention to transfer generic information literacy competences to multiple contexts. *Frontline Learning Research*, *7*(1), 23–42. https://doi.org/10.14786/flr.v7i1.359

Todorova, M., Sunder, C., Steffensky, M., & Möller, K. (2017). Pre-service teachers' professional vision of instructional support in primary science classes: How content-specific is this skill and which learning opportunities in initial teacher education are relevant for its acquisition?. *Teaching and Teacher Education*, *68*, 275–288. https://doi.org/10.1016/j.tate.2017.08.016

Van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571–596.

Van Es, E. A., & Sherin, M. G. (2021). Expanding on prior conceptualizations of teacher noticing. *ZDM–Mathematics Education*, *53*, 17–27. https://doi.org/10.1007/s11858-020-01211-4

Van Merriënboer, J. J., Clark, R. E., & De Croock, M. B. (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology Research and Development*, *50*(2), 39–61. https://doi.org/10.1007/BF02504993

Van Merriënboer, J. J., & Kirschner, P. A. (2018). 4C/ID in the context of instructional design and the learning sciences. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.) *International handbook of the learning sciences* (pp. 169–179). Routledge. https://doi.org/10.4324/9781315617572

Van Tartwijk, J., den Brok, P., Veldman, I., & Wubbels, T. (2009). Teachers' practical knowledge about classroom management in multicultural classrooms. *Teaching and Teacher Education*, *25*(3), 453–460. https://doi.org/10.1016/j.tate.2008.09.005

Vehtari, A., Gelman, A., & Gabry, J. (2017). Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. *Statistics and Computing*, *27*, 1413–1432. https://doi.org/10.1007/s11222-016-9696-4

Weng, X., Ng, O. L., & Chiu, T. K. (2023). Competency development of pre-service teachers during video-based learning: A systematic literature review and meta-analysis. *Computers & Education*, *199*, 104790. https://doi.org/10.1016/j.compedu.2023.104790

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review*, *30*(1), 1–35. https://doi.org/10.1016/j.dr.2009.12.001

Wolff, C. E., van den Bogert, N., Jarodzka, H., & Boshuizen, H. P. (2015). Keeping an eye on learning: Differences between expert and novice teachers' representations of classroom management events. *Journal of Teacher Education*, *66*(1), 68–85. https://doi.org/10.1177/0022487114549810

Wubbels, T., Brekelmans, M., Den Brok, P., Wijsman, L., Mainhard, T., & Van Tartwijk, J. (2014). Teacher–student relationships and classroom management. In E. Emmer & E. J. Sabornie (Eds.) *Handbook of classroom management* (pp. 363–386). Routledge. https://doi.org/10.4324/9780203074114

Supplement

S1. Overview of the Aspects of Teaching Quality Addressed in the Texts for each Group

S2. Word Count and Readability of the Texts for Each Group

S3. Coding Manual

S4. Item Statistics of Means and Standard Deviations (M[SD]) and Standardized Factors Loadings

S5. Tests of Measurement Invariance Across Measurement Time Points

S6. Results of Kruskal-Wallis Tests on Differences Between the Groups

S7. Results of Longitudinal Bayesian Multi-level Models

Table S1

Overview of the Aspects of Teaching Quality Addressed in the Texts for each Group

Group	Session 1	Session 2	Session 3
Control group and isolated approach	*Classroom management* withitness, group focus, managing transitions, time management, dealing with disruptions, rules and routines	*Instructional support* activating prior knowledge, cognitively activating tasks, students' contributions, demanding an explanation, exploring students' cognitive thought processes, problem-based learning environments	*Emotional support* encouraging students, sensitivity and empathy, positive error culture
Integrated approach	*Classroom management* rules and routines, dealing with disruptions *Instructional support* activating prior knowledge, taking up students' ideas, cognitively challenging tasks *Emotional support* encouraging students	*Classroom management* withitness, group focus, rules and routines *Instructional support* demanding an explanation *Emotional support* sensitivity and empathy, positive error culture	*Classroom management* withitness, group focus, managing transitions *Instructional support* exploring students' thought processes, students' contributions *Emotional support* encouraging students, positive error culture

Table S2

Word Count and Readability of the Texts for Each Group

	Session 1		Session 2		Session 3	
	word count	readability	word count	readability	word count	readability
Control group and isolated approach	2698	51.78	1947	62.95	1912	53.57
Integrated approach	3584	56.2	4025	55.21	3725	57.08

Note. For the integrated approach, some text passages were repeated in the texts of sessions 2 or 3.

Table S3

Coding Manual

Category	Number of events	Description	Points
PV of classroom management	22		
withitness	3	Student teachers noticed/reasoned on events in which the teacher displays that they are aware of everything happening in the classroom.	noticing 1 = event was described 0 = event was not described
group focus	5	Student teachers noticed/reasoned on events in which the teacher upholds students' attention and engagement by mobilizing them and making them accountable for their learning.	interpreting 1 = interpreted corresponding with the master rating 0 = not interpreted/interpreted not corresponding to the master rating
dealing with disruptions	9	Student teachers noticed/reasoned on events in which the teachers manage disruptions by regulating students' behavior.	explaining 1 = explained corresponding with the master rating 0 = not explained/explained not corresponding to the master rating
rules and routines	5	Student teachers noticed/reasoned on events where the teacher establishes and enforces rules and routines.	

Category	Number of events	Description	Points
PV of instructional support	12		<u>noticing</u> 1 = event was described 0 = event was not described <u>interpreting</u> 1 = interpreted corresponding with the master rating 0 = not interpreted/interpreted not corresponding to the master rating <u>explaining</u> 1 = explained corresponding with the master rating 0 = not explained/explained not corresponding to the master rating
prior knowledge	2	Student teachers noticed/reasoned on events in which the teacher activates students' prior knowledge.	
cognitively activating tasks	4	Student teachers noticed/reasoned on events in which the teacher implements cognitively challenging tasks.	
students' contributions	2	Student teachers noticed/reasoned on events in which the teacher uses the students' contributions in the classroom discourse.	
demanding an explanation	1	Student teachers noticed/reasoned on events in which the teacher demands an explanation for students' answers.	
exploring students' thought processes	2	Student teachers noticed/reasoned on events in which the teacher explores students' thought processes by asking questions about their ideas.	
problem-based learning environments	1	Student teachers noticed/reasoned on events in which the teacher implements an inductive, problem-based learning environment.	

Category	Number of events	Description	Points
PV of emotional support	9		
encouraging students	5	Student teachers noticed/reasoned on events in which the teacher encourages students in challenging situations and provides constructive feedback.	noticing 1 = event was described 0 = event was not described
sensitivity and empathy	3	Student teachers noticed/reasoned on events in which the teacher shows sensitivity and empathy to their students.	interpreting 1 = interpreted corresponding with the master rating 0 = not interpreted/interpreted not corresponding to the master rating
positive error culture	1	Student teachers noticed/reasoned on events in which the teacher establishes a positive error culture.	explaining 1 = explained corresponding with the master rating 0 = not explained/explained not corresponding to the master rating

Category	Number of events	Description	Points
Alternatives of action			
alternative provided		Student teachers provided an alternative of action.	1 = student teachers provided an alternative of action 0 = student teachers did not provide an alternative of action
alternative explained		Student teachers gave an explanation for their provided alternative of action.	1 = student teachers explained the provided alternative of action 0 = student teachers did not explain the provided alternative of action
alternative discussed		Student teachers discussed their provided alternative of action with other alternatives of action	1 = student teachers discussed the provided alternative of action 0 = student teachers did not discuss the provided alternative of action

Note. PV = professional vision.

Table S4

Item Statistics of Means and Standard Deviations (M [SD]) and Standardized Factors Loadings

Item	teaching quality dimension	cognitive process	M(SD)	λ
noticecm	CM	noticing	2.82(1.47)	.587[1]
interpretcm	CM	interpreting	1.16(1.06)	.951[1]
explaincm	CM	explaining	0.64(0.89)	.784[1]
noticeis	IS	noticing	1.31(1.18)	.778[2]
interpretis	IS	interpreting	0.87(0.85)	.987[2]
explainis	IS	explaining	0.54(0.75)	.737[2]
noticees	ES	noticing	1.04(1.00)	.838[3]
interpretes	ES	interpreting	0.84(0.87)	.982[3]
explaines	ES	explaining	0.50(0.66)	.818[3]
alternative		describing	3.34(1.49)	.939[4]
alternativeex		explaining	1.95(1.48)	.655[4]
alternativedis		discussing	1.65(1.37)	.697[4]

Note. CM = classroom Management; IS = instructional support; ES = emotional support; [1]factor 'PV of classroom management'; [2] factor 'PV of instructional support'; [3]factor 'PV of emotional support'; [4]factor 'Alternatives of action'.

Table S5

Tests of Measurement Invariance Across Measurement Time Points

Model	χ^2	df	CFI	TLI	RMSEA	SRMR
Configural invariance	137.64	94	.973	.962	.060	.059
Metric invariance	159.28	102	.964	.954	.066	.068
Scalar invariance	177.02	110	.958	.950	.069	.071

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximations.

Table S6

Results of Kruskal-Wallis Tests on Differences Between the Groups

Variable	χ^2	df	*p*	*r*
PV of classroom management	2.69	2	.261	.005
PV of instructional support	2.02	2	.364	<.001
PV of emotional support	0.02	2	.989	–.016
Alternatives of action	5.05	2	.080	.024
Simultaneous focus	1.05	2	.592	–.008
Seminars	0.45	2	.801	–.012
Interest	1.24	2	.539	–.006

Note. PV = professional vision; Bonferroni-corrected α-level of $p = .01$.

Table S7

Results of Longitudinal Bayesian Multi-level Models

Effect	Model A		Model B		Model C		Model D	
	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]
<u>Fixed Effects</u>								
PV of classroom management								
Intercept	1.47(0.05)	[1.36,1.57]	1.44(0.06)	[1.32,1.56]	1.51(0.10)	[1.30,1.71]	1.37(0.34)	[0.71,2.04]
Time	0.30(0.06)	[0.19,0.40]	0.27(0.08)	[0.12,0.43]	0.13(0.13)	[−0.14,0.39]	0.09(0.14)	[−0.19,0.35]
Isolated					−0.02(0.14)	[−0.29,0.25]	−0.02(0.14)	[−0.30,0.26]
Integrated					−0.19(0.14)	[−0.47,0.09]	−0.15(0.14)	[−0.43,0.14]
Time × Isolated					0.07(0.18)	[−0.28,0.42]	0.09(0.18)	[−0.27,0.45]
Time × Integrated					0.36(0.18)	[0.01,0.72]	0.39(0.19)	[0.02,0.76]
Seminars							−0.05(0.10)	[−0.25,0.15]
Interest							<0.01(0.01)	[−0.01,0.01]
PV of instructional support								
Intercept	0.79(0.08)	[0.62,0.95]	0.75(0.10)	[0.55,0.94]	0.61(0.17)	[0.27,0.93]	0.66(0.59)	[−0.52,1.78]
Time	0.11(0.07)	[−0.03,0.26]	0.14(0.10)	[−0.07,0.34]	0.03(0.18)	[−0.32,0.37]	0.07(0.18)	[−0.28,0.41]
Isolated					0.07(0.22)	[−0.36,0.50]	0.01(0.24)	[−0.47,0.48]
Integrated					0.32(0.22)	[−0.10,0.75]	0.29(0.24)	[−0.19,0.76]
Time × Isolated					0.34(0.22)	[−0.08,0.77]	0.31(0.22)	[−0.11,0.75]
Time × Integrated					−0.03(0.22)	[−0.46,0.39]	−0.04(0.22)	[−0.47,0.40]
Seminars							−0.22(0.18)	[−0.58,0.14]
Interest							<0.01(0.01)	[−0.02,0.02]

Effect	Model A		Model B		Model C		Model D	
	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]
PV of emotional support								
Intercept	0.58(0.10)	[0.38,0.77]	0.56(0.11)	[0.33,0.77]	0.56(0.19)	[0.17,0.92]	0.75(0.64)	[–0.52,1.99]
Time	0.20(0.08)	[0.05,0.36]	0.17(0.12)	[–0.07,0.41]	–0.07(0.20)	[–0.47,0.32]	–0.22(0.21)	[–0.64,0.18]
Isolated					–0.01(0.25)	[–0.50,0.47]	–0.06(0.25)	[–0.56,0.43]
Integrated					–0.03(0.25)	[–0.52,0.46]	–0.02(0.26)	[–0.52,0.48]
Time × Isolated					0.54(0.24)	[0.07,1.03]	0.71(0.26)	[0.22,1.22]
Time × Integrated					0.16(0.25)	[–0.33,0.65]	0.22(0.27)	[–0.30,0.75]
Seminars							–0.28(0.20)	[–0.68,0.11]
Interest							>–0.01(0.01)	[–0.02,0.02]
Alternatives of action								
Intercept	1.86(0.05)	[1.76,1.95]	1.86(0.05)	[1.76,1.96]	1.73(0.09)	[1.55,1.91]	1.53(0.33)	[0.88,2.17]
Time	0.20(0.04)	[0.11, 0.29]	0.18(0.05)	[0.07,0.28]	0.15(0.10)	[–0.04,0.35]	0.15(0.10)	[–0.05,0.35]
Isolated					0.11(0.12)	[–0.13,0.35]	0.10(0.12)	[–0.15,0.34]
Integrated					0.26(0.12)	[0.02,0.50]	0.30(0.12)	[0.06,0.55]
Time × Isolated					0.11(0.13)	[–0.14,0.36]	0.10(0.13)	[–0.16,0.37]
Time × Integrated					–0.05(0.13)	[–0.29,0.20]	–0.13(0.13)	[–0.39,0.12]
Seminars							–0.05(0.10)	[–0.25,0.15]
Interest							<0.01(0.01)	[–0.01,0.01]
Simultaneous focus								
Intercept	–0.39(0.12)	[–0.63,–0.16]	–0.37(0.14)	[–0.67,–0.12]	–0.49(0.23)	[–0.96,–0.07]	–1.65(0.70)	[–3.06,–0.33]
Time	0.58 (0.12)	[0.35,0.82]	0.48(0.17)	[0.15,0.82]	0.12(0.28)	[–0.45,0.68]	0.12(0.30)	[–0.46,0.71]
Isolated					0.30(0.28)	[–0.24,0.85]	0.36(0.28)	[–0.19,0.91]
Integrated					–0.01(0.29)	[–0.58,0.56]	0.10(0.30)	[–0.49,0.68]
Time × Isolated					0.11(0.34)	[–0.55,0.79]	0.09(0.36)	[–0.60,0.81]
Time × Integrated					0.95(0.34)	[0.27,1.64]	0.93(0.36)	[0.24,1.65]
Seminars							–0.06(0.18)	[–0.43,0.30]
Interest							0.02(0.01)	[>–0.00,0.04]

Effect	Model A		Model B		Model C		Model D	
	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]	Estimate (*SD*)	95% *CI* [LL,UL]
<u>Random Effects</u>								
PV of classroom management								
Intercept	0.37(0.04)	[0.29,0.46]	0.43(0.07)	[0.30,0.56]	0.43(0.07)	[0.30,0.56]	0.39(0.07)	[0.25,0.54]
Time			0.53(0.09)	[0.36,0.71]	0.52(0.09)	[0.34,0.69]	0.49(0.10)	[0.30,0.67]
PV of instructional support								
Intercept	0.67(0.07)	[0.54,0.82]	0.74(0.10)	[0.56,0.94]	0.74(0.10)	[0.56,0.95]	0.78(0.10)	[0.59,1.00]
Time			0.40(0.18)	[0.03,0.72]	0.38(0.18)	[0.03,0.71]	0.31(0.18)	[0.02,0.66]
PV of emotional support								
Intercept	0.80(0.08)	[0.66,0.97]	0.83(0.11)	[0.63,1.06]	0.86 (0.12)	[0.65,1.10]	0.83(0.12)	[0.62,1.09]
Time			0.52(0.18)	[0.12,0.84]	0.53(0.18)	[0.11,0.86]	0.52(0.19)	[0.10,0.86]
Alternatives of action								
Intercept	0.41(0.04)	[0.34,0.49]	0.39(0.05)	[0.30,0.49]	0.38(0.05)	[0.29,0.48]	0.37(0.05)	[0.28,0.48]
Time			0.19(0.10)	[0.02,0.38]	0.21(0.10)	[0.02,0.38]	0.20(0.09)	[0.02,0.38]
Simultaneous focus								
Intercept	0.63(0.09)	[0.46,0.82]	0.58(0.16)	[0.26,0.90]	0.59(0.16)	[0.28,0.91]	0.56(0.17)	[0.22,0.89]
Time			0.56(0.25)	[0.07,1.02]	0.41(0.24)	[0.02,0.90]	0.41(0.25)	[0.02,0.92]

Note. Model A = random intercept model including time as predictor; Model B = random intercept model including time as predictor and allowing random slopes; Model C = random intercept model including the interaction of time × group as predictor and allowing for random slopes; Model D = random intercept model including the interaction of time × group as predictor with the covariates of seminars and interest and allowing for random slopes; LL = lower level; UL = upper level; PV = professional vision.

2.4 Article IV

Before or After? – Sequencing Concepts and Video-based Analyses for Different Teacher Education Phases

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B (2024). *Before or after? – Sequencing concepts and video-based analyses for different teacher education phases* [Manuscript under review]. Institute of School Pedagogy and General Didactics, TU Dortmund University.

Acknowledgments: We would like to thank Nadine Böhme, Nadine Puschner, Nora Kötter, and Christoph Thaller for helping us conduct this study in their seminars, as well as Heike Scheika and Kathrin Wieduwilt for their organizational help. Moreover, we want to thank our student research assistants for coding the data and all participating future teachers.

Funding sources: This work was supported by the Thüringer Ministerium für Wirtschaft, Wissenschaft und Digitale Gesellschaft [grant number 5575/10-2].

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BEFORE OR AFTER? – SEQUENCING CONCEPTS AND VIDEO-BASED ANALYSES FOR DIFFERENT TEACHER EDUCATION PHASES

Abstract

Background: Professional vision (PV) is a focus-specific competency that can relate to teaching quality dimensions of classroom management and instructional support. It entails noticing and reasoning on relevant events, from which alternatives of action can be generated. Video-based analyses of classroom examples embedded in instructional settings can foster future teachers' PV. Introducing theoretical concepts before video-based analyses (concept-example sequence) provides stronger support for novice teachers. Introducing them afterward (example-concept sequence) provides less instructional support, making it more effective for future teachers with prior knowledge and experience. Although instructional settings should consider learners' characteristics, most studies have investigated only the academic teacher education phase but not the induction program.

Aims: The study investigates how the two sequences foster future teachers' PV in different teacher education phases.

Sample: Participants were 140 university student teachers and 42 pre-service teachers in an induction program.

Method: We varied whether future teachers were enrolled in courses implementing the concept-example or the example-concept sequence. Written analyses and a video test assessed PV of classroom management, PV of instructional support, and alternatives of action.

Results: The results showed that the example-concept sequence fostered alternatives of action and that pre-service teachers benefited from the example-concept sequence while the concept-example sequence was detrimental for PV of instructional support (video test). University student teachers improved more in PV of classroom management and pre-service teachers more in PV of instructional support.

Conclusion: The findings give initial insights into how instructional approaches to video-based analyses may be adapted to different teacher education phases.

Keywords

Professional Vision; Teacher Education; Video; Instructional Design; Pre-Training

1. Introduction

Professional vision (PV)[4] is an important teacher competency for making knowledge-based decisions in mathematics classrooms (Blömeke et al., 2015; Blömeke et al., 2022). PV includes teachers *noticing* relevant events in classrooms, *reasoning* on them (van Es & Sherin, 2002), and, from there, generating *alternatives of action* (Sherin, 2007). PV is considered a domain- and focus-specific competency that can relate to several teaching quality dimensions (Dückers et al., 2022; Steffensky et al., 2015), for instance, to classroom management or instructional support (Pianta & Hamre, 2009; Praetorius et al., 2018), which are particularly relevant to student learning (Seidel & Shavelson, 2007).

To foster PV, analyzing classroom videos as examples of classroom situations (Blomberg et al., 2014; Seidel et al., 2013) has proven effective in teacher education (e.g., Gold et al., 2021). However, video-based analyses must be embedded into suitable instructional settings with clear learning goals in mind (Blomberg et al., 2013; Santagata et al., 2021). Research on instruction for video-based analyses has shown that introducing theoretical concepts before or after studying examples can enhance learning from classroom videos (Blomberg et al., 2014; Santagata et al., 2007; Seidel et al., 2013) while being fundamentally different instructional approaches.

From a cognitive-psychological perspective, introducing theoretical concepts before studying examples (concept-example sequence) can help illustrate concepts through examples and focus attention on central features within examples (Kirschner et al., 2006; Likourezos & Kalyuga, 2017; Tomlinson & Hunt, 1971), thereby reducing cognitive load through the pre-training effect (Mayer, 2002). Evidence has shown that introducing theoretical concepts before video-based analyses can effectively enhance future teachers' PV (Martin et al., 2023; Seidel et al., 2013). From a situated perspective, when theoretical concepts are introduced after video-based examples of classrooms (example-concept sequence), learners' prior knowledge and experience are activated while viewing a classroom video, preparing them for instruction (Llinares & Valls, 2009). Their understanding is refined by introducing theoretical concepts afterward (Blomberg et al., 2014; Champagne et al., 1982; Seidel et al., 2013). Research has shown that this approach can enhance future teachers' PV and, specifically, action-oriented knowledge (Blomberg et al., 2014; Santagata et al., 2007; Seidel et al., 2013).

Although studies comparing the two approaches provide valuable insights for designing instructional settings for video-based analyses, they do not examine whether one approach may be more suitable than the other for different teacher education phases. While

[4] PV = professional vision.

there is ample evidence for fostering PV through video-based analyses in the university phase of teacher education (Gold et al., 2021; Martin et al., 2023; Seidel et al., 2013), there remains a lack of evidence on subsequent phases. University student teachers typically lack knowledge and classroom experience (Carter et al., 1987), which is why they may benefit more from strong instructional support (Seidel, 2022). Introducing theoretical concepts as a pre-training may help student teachers acquire knowledge that directs their attention, thus freeing cognitive capacity for video-based analysis (Martin et al., 2023; Seidel et al., 2013; Tucholka & Gold, 2025). Conversely, pre-service teachers in an induction program usually have already gained some knowledge and classroom experience. Thus, the example-concept sequence may better support pre-service teachers in the induction program by activating their prior knowledge about teaching quality when analyzing classroom videos and then refining their understanding by introducing theoretical concepts afterward (Seidel, 2022).

The study investigates how to sequence teaching quality concepts and video-based analyses to enhance mathematics future teachers' PV. Hence, the study offers insights into the effectiveness of instructional approaches to video-based learning in teacher education and may also offer practical implications for their implementation in different teacher education phases, such as university or the induction program. Additionally, the study examines multiple foci of PV, thereby extending research that compares the two approaches, which have primarily focused on a specific aspect of teaching quality (e.g., classroom management; Tucholka & Gold, 2025) or reported overall results of cognitive processes of PV without considering different foci of teaching quality (Blomberg et al., 2014; Seidel et al., 2013).

1.1 Professional Vision of Teaching Quality

1.1.1 Professional Vision

PV is considered a crucial teacher competency (Blömeke et al., 2015; Kaiser et al., 2017; Krauss et al., 2020) for acting professionally and making informed decisions in classrooms (e.g., Blömeke et al., 2022). Specifically, PV is considered a knowledge-based process (Blömeke et al., 2015) encompassing the cognitive processes of *noticing* and *reasoning* (van Es & Sherin, 2002). Noticing involves selectively paying attention to relevant events in classrooms (Sherin, 2007), and reasoning includes processes of describing, explaining, interpreting, or reviewing (Blomberg et al., 2011; König et al., 2014). Sherin (2007) has proposed that noticing and reasoning "interact in a dynamic manner. On the one hand, what stands out to a teacher will certainly influence the reasoning that takes place." (Sherin, 2007, p. 385). Recent studies have extended this framework by including more action-oriented processes of PV, such as decision-making (e.g., Blömeke et al., 2015), evaluating (e.g., Dückers et al., 2022), generating alternatives of action (e.g., Santagata & Guarino, 2011), or shaping opportunities to notice and reason on relevant events (van Es & Sherin, 2024). Generating alternatives of action has been recognized as a crucial aspect as it indicates productive reflective practices (Davis, 2006) and links noticing and reasoning with action in classrooms (van Es & Sherin, 2002).

Most studies have examined PV with a focus on pedagogy (e.g., classroom management, Gold & Holodynski, 2017) or instruction (e.g., instructional support, Meschede et al., 2015). However, because classroom situations are highly complex (Doyle, 2006), they usually involve both foci, demanding their integration in concrete situations (Klieme et al., 2009). Studies investigating PV encompassing both foci together have shown that they are closely related but distinct constructs (Dückers et al., 2022; Steffensky et al., 2015).

1.1.2 Foci of Teaching Quality

Many demands addressed in classrooms relate to teaching quality dimensions of classroom management and instructional support (Pianta & Hamre, 2009; Praetorius et al., 2018). Indeed, teaching involves a variety of skills (Klieme et al., 2009), which are not covered by these teaching quality dimensions. Nevertheless, classroom management and instructional support are critical for student learning (Praetorius et al., 2018; Seidel & Shavelson, 2007), student engagement (Evertson & Weinstein, 2006), interest (Fauth et al., 2014), and motivation (Rakoczy et al., 2008).

1.1.2.1 Classroom Management

Effective classroom management maximizes learning time and structures academic tasks (Doyle, 2006; Emmer & Stough, 2001). Implementing classroom management strategies primarily relies on teachers' general pedagogical knowledge (Baumert et al., 2010; Shulman, 1986, 1987). Studies emphasize the importance of preventive rather than reactive strategies (Kounin, 1970; Shook, 2012), such as establishing and enforcing *rules and routines* to provide clear structure and expectations (Evertson & Emmer, 2012; Shook, 2012; van Tartwijk et al., 2009). Another preventive strategy involves creating a *group focus* (Kounin, 1970; Wubbels et al., 2006) that encourages students' active participation, such as assigning tasks to the entire class. Furthermore, *monitoring* is another strategy that ensures students' attention and engagement. It involves overseeing the whole classroom to create the impression of being continuously aware of all occurrences (Kounin, 1970; Wubbels et al., 2006) through proper positioning, supervising students' activities, interacting with students, and reinforcing appropriate behavior (Marder et al., 2023; Simonsen et al., 2008). Moreover, effective time management and seamless transitions help maintain *smoothness and momentum* to secure learning time and avoid potential disruptions (Charles, 2013; Kounin, 1970). Finally, effective *disruption management* and the involvement of inattentive students can be achieved by appropriate interventions and imposing consequences when disruptions occur (Doyle, 2006). Therefore, classroom management entails teacher actions that implement and uphold rules and routines, sustain the group focus, ensure momentum and smoothness, monitor the classroom, and effectively address disruptions.

1.1.2.2 Instructional Support

The lesson's content influences the implementation of instructional support as it involves providing instruction that engages students in exploring ideas, discussing and reflecting on learning materials, and applying learned contents to different contexts (Brophy, 2004). Typical mathematics lessons entail problem-solving activities, interactive exercises, step-by-step learning, visual aids, and critical thinking (Leuders & Holzäpfel, 2011). These characteristics are grounded in constructivist approaches (Staub & Stern, 2002), where teachers *explore students' thoughts* and *prior knowledge* (Brophy, 2000). To engage students in advanced cognitive processes, enhance metacognition, and trigger cognitive conflicts (Baumert et al., 2010; Lipowsky et al., 2009), teachers often implement *problem-based learning* and *cognitively activating tasks* (Maier et al., 2010). Moreover, fostering students' cognitive engagement helps students articulate ideas and build a conceptual understanding (Windschitl et al., 2012). Strategies involve considering students' *contributions* during classroom discussions, demanding *explanations* for their solutions, and promoting *students' cognitive independence* by creating learning environments where students can share their thoughts (Lotz et al., 2013). Therefore, instructional support draws on content and pedagogical content knowledge (Baumert et al., 2010; Shulman, 1986, 1987) and is conceptualized as teachers' actions to activate prior knowledge, explore thought processes, comprise contributions in classroom discussions, create problem-based learning environments using cognitively activating tasks, ask for explanations, and promote cognitive independence.

1.2 Instructional Approaches to Foster PV in Different Teacher Education Phases

Teacher education systems usually aim to develop future teachers' PV in an academic phase at university and a practical phase at school. In Germany, teacher education also consists of these two phases (Cortina & Thames, 2013). The first phase at university mainly focuses on developing evidence-based knowledge. Student teachers acquire knowledge in seminars predominantly addressing content knowledge about their subjects (e.g., mathematics), pedagogical and pedagogical content knowledge. In this phase, student teachers gain limited teaching experience in internships. The second phase focuses primarily on gaining teaching experience and reflecting on it. In an induction program, pre-service teachers observe and teach in real-life classrooms and attend accompanying seminars in which they can connect knowledge with teaching experiences (Cortina & Thames, 2013).

Although research on instruction has suggested that different instructional approaches may be more suitable for different learner characteristics, such as differing expertise stages (aptitude-treatment interaction; Glaser, 2021), the teacher education phases rarely have been considered when aiming to enhance future teachers' PV. In principle, research on teacher education has suggested that PV can be fostered using video-based analyses of classroom examples (e.g., Gold et al., 2021; Seidel et al., 2013) embedded within appropriate instructional settings that consider learning goals and demands on (future) teachers (Korthagen & Kessels, 1999; Santagata et al., 2021; Seidel et al., 2013). In this context, research on instruction has discussed different instructional approaches from cognitive-psychological or situated perspectives (Anderson et al., 1997; Greeno, 1997). Similarly, regarding video-based analyses in teacher education, Santagata et al. (2007) have differentiated between strongly and weakly guided approaches to video-based analyses.

The cognitive-psychological perspective based on cognitive load theory suggests that cognitive load has to be reduced (i.e., the complexity of an example) to free cognitive capacities for learning processes (i.e., studying the example) (Sweller et al., 2011). Pre-training is one option to reduce cognitive load when studying examples (Martin et al., 2023; Mayer, 2002). In a pre-training, learners receive an introduction to theoretical concepts before studying an example, which helps them focus their attention on the example's central features (concept-example sequence). Another advantage is that theoretical concepts can be actively linked to the example (Anderson et al., 1997; Tomlinson & Hunt, 1971), thereby consolidating learners' understanding of theoretical concepts (Kirschner et al., 2006; Likourezos & Kalyuga, 2017). Therefore, a pre-training could provide strong instructional guidance for video-based analyses (Santagata et al., 2007; Seidel et al., 2013). Typically, compared to more advanced learners, novice learners benefit more from strong instructional support (Kalyuga, 2007). Student teachers at university are novices who typically lack knowledge and experience (Carter et al., 1987) that could help them deal with the complexity and transience of classroom videos (Star & Strickland, 2008; Syring et al., 2015). Therefore, strong instructional support through a pre-training in which student teachers read preparatory texts on theoretical concepts of teaching quality may help them direct their attention to relevant events and illustrate theoretical concepts in classroom videos, thereby freeing cognitive capacities (see also Seidel, 2022). Therefore, the concept-example sequence may more effectively promote university student teachers' PV.

Contrastively, the situated perspective suggests that applying prior knowledge and experiences to an example and then refining conceptual understanding with theoretical concepts may effectively enhance knowledge acquisition (Anderson et al., 1997; Greeno, 1997) (example-concept sequence). This approach uses classroom videos as a starting point for exploring (Llinares & Valls, 2009), discussing, and reflecting on teaching practice (Blomberg et al., 2014; Santagata et al., 2007), which depends considerably on learners' prior knowledge. For instance, future teachers' prior knowledge about classroom management and instructional support can be elicited through analyzing classroom videos, and subsequent introduction of theoretical concepts can support future teachers in refining and adjusting their understanding (Derry et al., 2000; Llinares & Valls, 2009). Hence, this situated approach provides less instructional guidance for future teachers when analyzing classroom videos (Santagata et al., 2007; Seidel et al., 2013) and strongly depends on learners' prior knowledge and experience. It is proposed to foster a more abstract and heuristic understanding of theoretical concepts and has been associated with action-oriented knowledge (Anderson et al., 1997; Champagne et al., 1982). Pre-service teachers may have already acquired knowledge at university and have had some teaching experience in the induction program. Consequently, pre-service teachers can resort to their prior knowledge and practical experience when conducting video-based analyses of classroom examples, and afterward, they can refine their understanding by studying theoretical concepts of teaching quality (see also Seidel, 2022). Hence, the example-concept sequence may be more beneficial for enhancing pre-service teachers' PV.

Despite obvious differences between the two teacher education phases, most studies investigating instructional approaches to video-based analyses have examined only student teachers at university (Kumschick et al., 2017; Martin et al., 2023; Seidel et al., 2013; Tucholka & Gold, 2025). Evidence related to the cognitive-psychological perspective supports the assumption that university student teachers with limited knowledge and practical experience benefit from strong instructional support by showing that the concept-example sequence effectively enhanced PV more than the example-concept sequence (Barth et al., 2019; Martin et al., 2023; Seidel et al., 2013). In comparison, evidence related to the situated approach suggests that the example-concept sequence can more effectively enhance PV of student teachers with some practical experience (e.g., from an internship) than the concept-example sequence (Blomberg et al., 2014; Santagata & Angelici, 2010). Further, Seidel et al.

(2013) showed that the example-concept sequence enhanced lesson-planning skills, but other studies found no (Tucholka & Gold, 2025) or inconsistent effects specifically for generating alternatives of action (Santagata & Angelici, 2010).

1.4 Aim of the Study

Against this background, the study investigates how to sequence theoretical concepts and video-based analyses to foster mathematics future teachers' PV. We explored the overall effect of the sequences (concept-example vs. example-concept) on PV of classroom management, PV of instructional support, and generating alternatives of action. However, the study's main goal was to investigate whether the interaction between the two sequences (concept-example vs. example-concept) and the two teacher education phases (student teachers vs. pre-service teachers) affected PV of classroom management, PV of instructional support, and generating alternatives of action. We hypothesized that student teachers benefit more from the concept-example sequence, whereas pre-service teachers benefit more from the example-concept sequence.

2. Method

2.1 Design and Sample

The study implemented a 2 × 2 quasi-experimental pre-post-test design in a two-week video-based intervention. A total of N = 140 university student teachers of elementary mathematics at the beginning of their master's studies (age: M = 23.04, SD = 2.27; 98.6% female) and N = 42 pre-service teachers of elementary mathematics at the end of their induction program (age: M = 25.56, SD = 3.16; 97.6% female) participated. Informed written consent was collected from all participants, and we followed the ethical guidelines and principles of the American Psychological Association and the Declaration of Helsinki.

University student teachers in the concept-example sequence (n = 65, age: M = 23.43 [SD = 3.04]; semester: M = 7.97 [SD = 0.39]; 83.1% female) and in the example-concept sequence (n = 75; age: M = 22.69 [SD = 1.20]; semester: M = 8.04 [SD = 0.38]; 93.3% female) reported almost no prior teaching experience (concept-example: 6.2%; example-concept: 1.3%) and low tutoring experience (concept-example: 24.6%; example-concept: 22.7%). They mainly reported attending only individual sessions within courses often related to classroom management (concept-example: 83.1%; example-concept: 88.0%) and some related to instructional support (concept-example: 60.0%; example-concept: 69.3%).

Pre-service teachers in the concept-example sequence (n = 13, age: M = 25.77 [SD = 3.94]; semesters needed to complete the first teacher education phase: M = 9.63 [SD = 1.29]; 92.3% female) and in the example-concept sequence (n = 29; age: M = 25.46 [SD = 2.80];

semesters needed to complete the first teacher education phase: $M = 10.04$ [$SD = 0.88$]; 96.6% female) reported low prior teaching (concept-example: 30.8%; example-concept: 20.7%) and tutoring experience (concept-example: 38.5%; example-concept: 34.5%) before the induction program. They mainly reported attending at least one course related to classroom management (concept-example: 92.3%; example-concept: 79.3%) but only individual sessions related to instructional support (concept-example: 69.2%; example-concept: 51.7%).

2.1.1 Materials

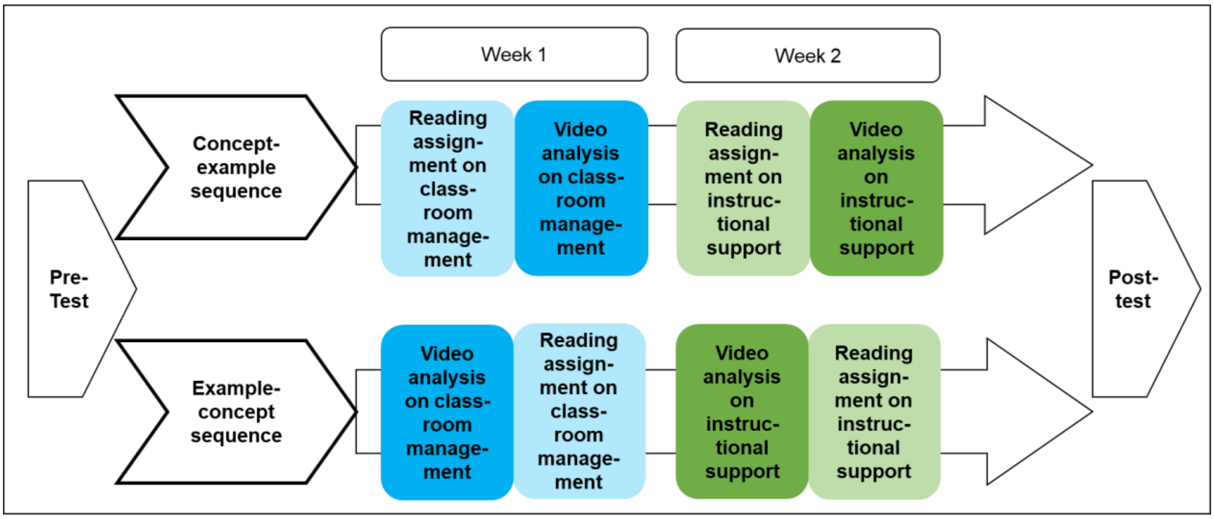
The two ten-minute classroom videos used for the intervention were carefully selected to demonstrate typical teaching quality situations. The videos authentically and comprehensively depicted real-life scenarios of elementary mathematics classrooms that demonstrated more or less effective classroom management (withitness, group focus, managing disruptions, and establishing rules and routines) and instructional support (prior knowledge, cognitively activating tasks, students' contributions, demanding an explanation, exploring students' thought processes, and problem-based learning environments) based on the literature (Pianta & Hamre, 2009; Praetorius et al., 2018).

The two texts on classroom management and instructional support were based on the technical report of the PERLE video studies (Lotz et al., 2013; see supplement S1). They were categorized as nonfictional literature (LIX from 50 to 60) and were comparable in difficulty across sessions (see supplement S2). Additionally, for an overview, student teachers received handouts that listed and briefly described aspects of the teaching quality dimensions.

2.1.2 Intervention Conditions

Similar to the study by Seidel et al. (2013), student and pre-service teachers were enrolled in video-based courses implementing the concept-example or the example-concept sequence. The conditions were randomly assigned to each course. In the first week, future teachers focused on classroom management (color blue; see Figure 1), and in the second week, instructional support (color green; see Figure 1). Despite a potential order effect, we chose this sequence because classroom management is usually more salient and observable in classroom situations (Praetorius et al., 2018) and is typically one of the first aspects future teachers focus on.

Figure 1
Intervention Procedure



2.1.2.1 Concept-example sequence

Future teachers in the concept-example sequence received a reading assignment on theoretical concepts of classroom management and instructional support before each session. In the sessions, instructors presented the theoretical concepts once again, and student teachers could discuss and ask questions. Afterward, instructors provided information on how to analyze classroom videos (e.g., by using theoretical concepts explicitly when analyzing the video and describing classroom situations without judgment). Afterward, future teachers worked in groups to analyze and discuss the classroom video in connection with the theoretical concepts. Each group documented their discussions and analyses. Instructional support was provided throughout. Lastly, student teachers shared their analyses with the class and discussed noticed events, interpretations, and alternatives of action.

Therefore, in the concept-example sequence, texts were used as a pre-training to help future teachers focus on specific aspects and illustrate concepts when conducting video-based analyses.

2.1.2.2 Example-concept sequence

Future teachers in the example-concept sequence did not receive preparatory materials before the sessions. In the session, the instructor highlighted the importance of analyzing the videos without judgment. Then, future teachers were asked to work in groups to analyze and discuss the classroom video without providing specific information on the teaching quality dimensions. Each group documented and shared their discussions and analyses with the class. Afterward, instructors asked future teachers to derive and identify important aspects regarding classroom management and instructional support. If necessary, instructors guided the discussion through questions prompting important aspects of classroom management or instructional support. Results were summarized on a blackboard. Afterward, future teachers received handouts briefly explaining theoretical concepts of classroom management and instructional support. In a plenary discussion, future teachers were prompted to link theoretical concepts to their video-based analyses. After the sessions, they further refined their understanding by reading texts on classroom management and instructional support.

Hence, future teachers in the example-concept sequence could first use their prior knowledge in video-based analyses, thereby generating their own understanding of teaching quality. Afterward, they could refine their understanding through introduced theoretical concepts in the texts.

2.2 Measures

In pre-post-tests, we measured PV with written analyses (Bauersfeld, Bourcevet, et al., 2025b) and a video test (Bauersfeld, Bourcevet, et al., 2025a). Both instruments use classroom situations as stimuli and incorporate different response formats. The first instrument is an open-response format (written analyses) involving an elaborate coding procedure (see also Dückers et al., 2022). The video test encompasses a closed-response format (video test) (Gold & Holodynski, 2017), including rating items that are compared to a master rating (see also Meschede et al., 2015; Seidel & Stürmer, 2014). Studies have shown low correlations between open- and closed-response formats (König et al., 2014; Müller & Gold, 2023), indicating that they assess PV differently, which is why their combination may provide a comprehensive picture of assessed PV.

Both measures used a ten-minute video clip from an elementary mathematics lesson in the first grade. In the video, the teacher brought the students together around the blackboard and introduced discovery packets, which are cognitively activating tasks that stimulate exploring, describing, and sensemaking of mathematical relationships (Lipowsky & Hess, 2019). Through this introduction, the teacher strives to capture students’ attention and enhance deeper engagement.

2.2.1 Written analysis

For the open-response assessment of PV, we used future teachers’ written video-based analyses (Bauersfeld, Bourcevet, et al., 2025b). For qualitative content analysis (Mayring, 2014), four categories of classroom management and six for instructional support were drawn up based on theoretical concepts of teaching quality (Lotz et al., 2013; Pianta & Hamre, 2009; Praetorius et al., 2018). A master rating by (Bauersfeld, Bourcevet, et al., 2025b) identified 20 events relevant to classroom management and 12 events relevant to instructional support in the ten-minute classroom video. Based on this master rating, two trained raters coded the data with an adapted version of Dückers et al. (2022) coding procedure. For *noticing*, they coded for each category the number of described events (κ_{cm} = .91; κ_{is} = .94). For *reasoning*, the raters coded the number of interpretations that aligned with the master rating (1 point each) and the number of explanations provided (1 point each) as an indicator for an elaborated understanding of the classroom situation (κ_{cm} = .88; κ_{is} = .95). For the *alternative of action* measure they coded 1 point per alternative of action, 1 point per explanation of the alternative, and 1 point per discussion of the alternative as indicators for thorough deliberation (κ = .90). We replicated a focus-specific three-dimensional structure already identified by (Bauersfeld, Bourcevet, et al., 2025b) (see supplement S3) and calculated sum scores for PV of classroom management (α_{t1} = .49; α_{t2} = .67), PV instructional support (α_{t1} = .61; α_{t2} = .66), and alternatives of action (α_{t1} = .68; α_{t2} = .66). Reliabilities are considered acceptable in PV research (König & Kramer, 2016).

2.2.2 Video Test

For the closed-response assessment, PV was assessed with a video test (Bauersfeld, Bourcevet, et al., 2025a). The test included 11 items on classroom management (4 descriptions and 7 interpretations; example item: "The misbehavior of some students spreads to others.") and 13 items on instructional support (6 descriptions and 7 interpretations; example item: "The teacher asks about students' thought processes."). Participants rated on a 4-point Likert scale whether they *agreed* (1) or *disagreed* (4) with the items. Based on a master rating (Bauersfeld, Bourcevet, et al., 2025a), future teachers received 2 points when they exactly corresponded with the master rating (e.g., master rating answered *agree* [1], and future teachers answered *agree* [1]) and 1 point if they showed correspondence tendency (e.g., master rating answered *agree* [1], and future teachers answered *rather agree* [2]). Reliabilities for PV of classroom management (α_{t1} = .71; α_{t2} = .71) and PV of instructional support (α_{t1} = .81; α_{t2} = .84) were good for both measurement time points. We calculated the number of points future teachers achieved for PV of classroom management and PV of instructional support.

2.3 Analysis Plan and Preliminary Analyses

Preliminary analyses showed non-normal distributions of all measures ($p < .05$). Kruskal-Wallis tests with a Bonferroni-corrected α-level of $p = .01$ (see Table 1) showed no significant differences between the concept-example and the example-concept sequence in pre-test scores.

Table 1
Results of Kruskal-Wallis Tests on Differences Between the Sequences for Student and Pre-service Teachers

Variable	χ^2	df	*p*	*r*
Student teachers				
Video test				
PV of classroom management	0.23	1	.632	–.006
PV of instructional support	0.83	1	.364	–.001
Written analysis				
PV of classroom management	0.12	1	.731	–.006
PV of instructional support	1.67	1	.196	.005
Alternatives of action	5.59	1	.018	.033
Pre-service teachers				
Video test				
PV of classroom management	0.37	1	.541	–.016
PV of instructional support	0.90	1	.344	–.003
Written analysis				
PV of classroom management	1.43	1	.232	.011
PV of instructional support	0.87	1	.351	–.003
Alternatives of action	2.17	1	.141	.029

Note. PV = professional vision; Bonferroni-corrected α-level $p = .01$.

Based on these preliminary analyses, we conducted generalized linear mixed models (GLMM) with Poisson regression and maximum likelihood estimation. These GLMMs have the advantage of handling unbalanced sample sizes and effectively dealing with count data, as used in our study. In an effort to consider differences between courses, we included random intercepts of course membership at level 2. Because of the small sample size of pre-service teachers and confounding between courses and conditions, we could not account for random slopes. We applied a Bonferroni-corrected α-level $p = .010$ for all measures. Analyses were conducted in *R*. Data, and syntax can be accessed via https://osf.io/326ux/?view_only=075f6b006d844caa9be0a34d6f547149

3. Results

Descriptive statistics can be found in Table 2. Overall, GLMMs revealed almost no effect of courses on all dependent variables, $\sigma^2 < .010$ (*SD* < 0.02). Future teachers significantly increased in PV of classroom management but not in PV of instructional support or alternatives of action. The example-concept sequence seemed to be descriptively better for PV of instructional support in written analyses and generating alternatives of action. The GLMM (see Table 3; see Figure 2) showed a significant interaction effect between time × sequence on alternatives of action, indicating that the example-concept sequence supported generating alternatives of action. There were no other significant time × sequence effects, indicating that overall, the sequences had an equal effect on future teachers' PV of classroom management and PV of instructional support in written analyses.

Table 2

Descriptive Data on PV Classroom Management and PV of Instructional Support

Scale	Concept-example sequence				Example-concept sequence			
	Student teachers		Pre-service teachers		Student teachers		Pre-service teachers	
	t1	t2	t1	t2	t1	t2	t1	t2
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*
Video test								
PV of classroom management	11.46 (4.24)	13.39 (4.31)	12.58 (3.96)	11.75 (2.70)	11.79 (4.19)	12.86 (4.14)	13.67 (3.55)	13.29 (4.20)
PV of instructional support	6.47 (4.55)	5.91 (4.60)	10.08 (7.14)	5.75 (3.31)	7.23 (4.86)	5.93 (4.51)	7.44 (4.72)	8.19 (6.13)
Written analysis								
PV of classroom management	4.52 (2.26)	6.46 (3.25)	3.67 (2.53)	2.73 (2.49)	4.64 (2.46)	6.26 (3.33)	4.89 (2.95)	4.73 (3.55)
PV of instructional support	1.87 (2.18)	2.38 (2.11)	0.25 (0.45)	1.18 (1.33)	2.03 (1.66)	3.10 (2.77)	0.56 (0.85)	2.73 (2.36)
Alternatives of action	7.27 (3.67)	7.03 (3.73)	3.50 (2.71)	3.73 (4.69)	5.84 (2.83)	7.40 (3.35)	5.04 (2.89)	4.19 (2.26)

Note. PV = professional vision; concept-example sequence: student teachers n = 65, pre-service teachers n = 13; example-concept sequence: student teachers n = 75, pre-service teachers n = 29.

Table 3

Fixed Effects of Generalized Linear Mixed Models

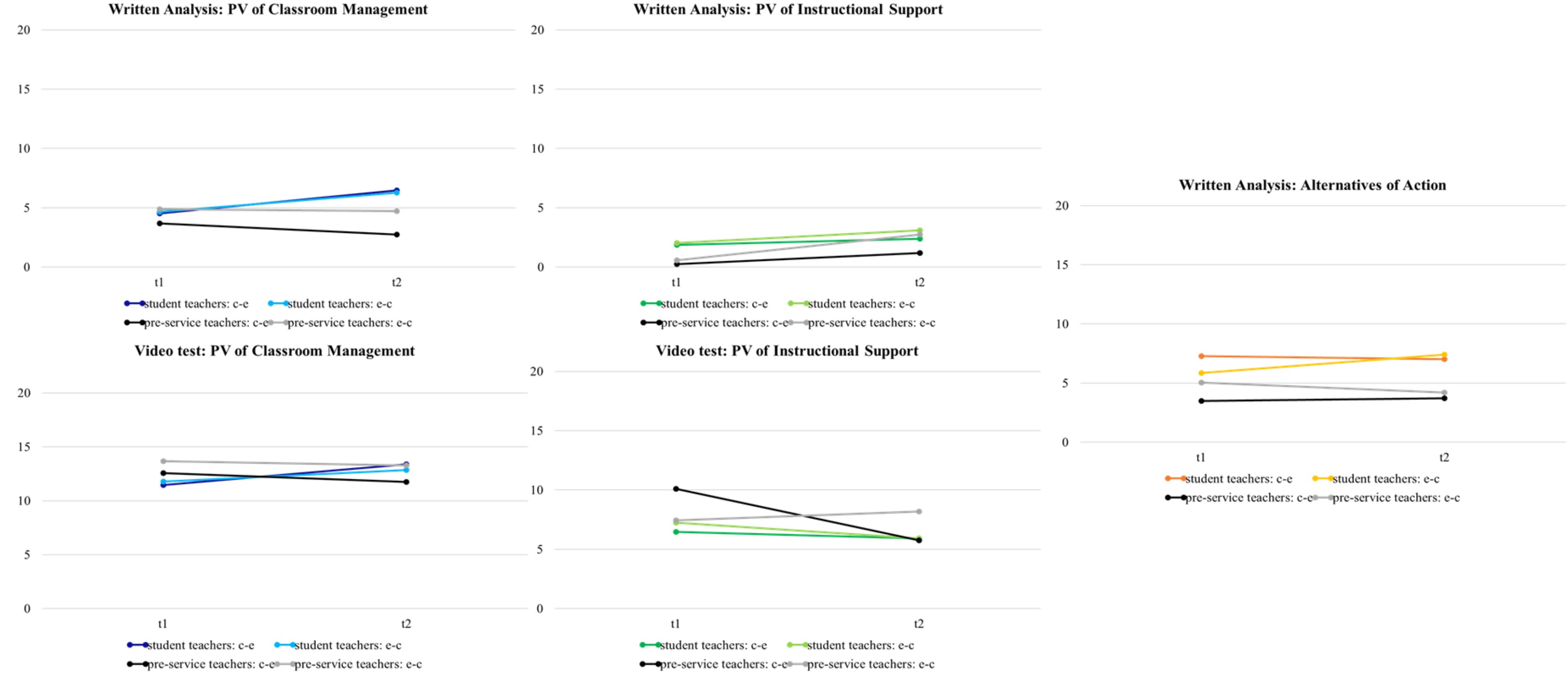
Effect	Estimate	*SE*	*z*	*p*
PV of classroom management (video test)				
Intercept	2.44	0.05	44.72	<.001
Time	0.16	0.05	3.03	.002
Sequence	0.01	0.08	0.15	.878
Phase	0.08	0.11	0.73	.465
Time × sequence	–0.06	0.07	–0.91	.365
Time × phase	–0.22	0.13	–1.76	.079
Sequence × phase	0.04	0.14	0.31	.759
Time × sequence × phase	0.10	0.16	0.67	.503
PV of instructional support (video test)				
Intercept	1.87	0.08	22.32	<.001
Time	–0.09	0.07	–1.19	.236
Sequence	0.10	0.12	0.88	.377
Phase	0.42	0.15	2.75	.006
Time × sequence	–0.11	0.10	–1.08	.280
Time × phase	–0.47	0.17	–2.81	.005
Sequence × phase	–0.46	0.21	–2.24	.025
Time × sequence × phase	0.76	0.21	3.67	<.001
PV of classroom management (written analysis)				
Intercept	1.52	0.10	15.14	<.001
Time	0.35	0.78	4.55	<.001
Sequence	<0.01	0.14	0.05	.960
Phase	–0.26	0.21	–1.23	.220
Time × sequence	–0.06	0.11	–0.52	.603
Time × phase	–0.64	0.25	–2.59	.010
Sequence × phase	0.19	0.27	0.69	.492
Time × sequence × phase	0.32	0.29	1.10	.270
PV of instructional support (written analysis)				
Intercept	0.63	0.09	6.82	<.001
Time	0.24	0.12	1.92	.055
Sequence	0.08	0.12	0.64	.521
Phase	–2.01	0.59	–3.45	<.001
Time × sequence	0.19	0.16	1.14	.254
Time × phase	1.32	0.65	2.02	.044
Sequence × phase	0.72	0.64	1.12	.264
Time × sequence × phase	–0.15	0.72	–0.21	.838
Alternatives of action (written analysis)				
Intercept	1.98	0.05	42.45	<.001
Time	–0.03	0.07	–0.49	.622
Sequence	–0.22	0.07	–3.27	.001
Phase	–0.73	0.16	–4.53	<.001
Time × sequence	0.27	0.09	2.89	.004
Time × phase	0.09	0.23	0.42	.676
Sequence × phase	0.58	0.19	3.09	.002
Time × sequence × phase	–0.52	0.27	–1.91	.057

Note. *SE* = standard error; PV = professional vision; Bonferroni-corrected α-level $p = .010$ for PV of classroom management, PV of instructional support and generating alternatives of action; sequence: concept-example (0) vs. example-concept (1); phase: student teachers (0) vs. pre-service teachers (1).

Regarding the two teacher education phases, university student teachers generally increased in PV of classroom management, while pre-service teachers in the induction program increased in PV of instructional support. A significant interaction effect (see Table 3; see Figure 2) of time × sequence × phase showed an aptitude-treatment interaction effect on PV of instructional support in the video test. Descriptive statistics indicated that the sequences were equally beneficial for student teachers, but the example-concept sequence was more beneficial than the concept-example sequence for pre-service teachers. Further, GLMMs showed that the sequences did not differ in PV of classroom management in written analyses or the video test, nor in PV of instructional support in written analyses. Lastly, GLMMs did not show a significant effect of time × sequence × phase on alternatives of action.

Figure 2

Fixed Effects of Generalized Linear Mixed Models



Note. PV = professional vision; c-e = concept-example sequence; e-c = example-concept sequence.

4. Discussion

The study investigated how to sequence theoretical concepts of teaching quality and video-based analyses to foster PV in different teacher education phases. First, we explored how the sequences affected PV of classroom management, PV of instructional support, and generating alternatives of action. However, the main goal was to examine whether this effect differs between the two teacher education phases.

The findings partially confirmed existing findings by showing that the example-concept sequence supported future teachers overall in generating alternatives of action. This finding is similar to Seidel et al. (2013) because they showed that the example-concept sequence fostered action-oriented learning (i.e., lesson planning). This supports the notion that this heuristic strategy for acquiring knowledge may have fostered action-oriented knowledge, thereby enhancing alternatives of action.

Considering the two phases, it is surprising that student teachers and pre-service teachers did not considerably differ in PV. This may be explained by findings that indicate PV does not further develop during the induction program (Barenthien et al., 2023; Bauersfeld, Gold, & Holodynski, 2025), resulting in no differences between pre-service teachers and master student teachers in PV. Moreover, the findings indicate that student teachers generally increase in PV of classroom management and pre-service teachers in PV of instructional support. One explanation could be that student teachers typically consider classroom management highly relevant to teaching (Fajet et al., 2005) and feel unprepared to implement it (He & Cooper, 2011). Therefore, they may place greater value on analyzing classroom management. Contrastively, pre-service teachers already gained some experience in implementing classroom management and may now focus on eliciting and fostering students' learning. Nevertheless, both teaching quality dimensions have to be observed and analyzed (Klieme et al., 2009). Future teachers often lack the integrated knowledge required for the simultaneous retrieval of multiple foci of PV. This issue is heightened by the profound divide between content and pedagogy in many teacher education systems (Ball, 2000). A possible remedy could be implementing distributed learning in teacher education, in which aspects of pedagogy and instruction are distributed rather than concentrated in a short period (Son & Simon, 2012), and interleaved learning, in which pedagogy and instruction are addressed alternately (Brunmair & Richter, 2019).

Furthermore, we found a detrimental effect of the concept-example sequence and a beneficial effect of the example-concept sequence on PV of instructional support for pre-service teachers in the video test. Possibly, integrating theoretical concepts of teaching quality and one's own experiences, which have to be related to examples of classroom situations in video-based analyses, may have caused cognitive overload through an expertise-reversal effect (Kalyuga, 2007). While strong instructional guidance is typically helpful for novice learners, it may become redundant for more advanced learners and cause additional cognitive load. Hence, the pre-training in the concept-example sequence may have caused detrimental effects on pre-service teachers because they may have already generated a conceptual understanding of teaching quality. Another explanation could be that pre-service teachers perceive discrepancies between what they experience at school and theoretical concepts. Because of the different philosophies of the teacher education phases (Chitpin et al., 2008; Tatto et al., 2020), this may have led to a disconnection between teaching experience and theoretical concepts, which may result in 'inert' knowledge (Renkl et al., 1996) not applicable for video-based analyses. However, we found no other aptitude-treatment interactions. Possibly the instructional approach of the example-concept sequence may still be a too structured instructional approach for pre-service teachers and, as a result, may not have led to the expected outcomes.

Further, no effects were shown for the sequences in the open-response assessments of PV. Video tests measuring PV typically use statements rated by participants, thereby focusing their attention on selected events (Seidel & Stürmer, 2014). Hence, it is possible that in the video test, the concept-example sequence facilitated future teachers' evaluation of pre-determined rating items (i.e., closed-response format) because the rating items were directly linked to classroom situations related to the theoretical concepts, thereby triggering future teachers' knowledge about these concepts and pronouncing sequencing effects. Contrastively, in written analyses (i.e., open-response format), future teachers had to select relevant events themselves, which caused a higher cognitive demand on participants (Müller & Gold, 2023), leading to less noticeable sequencing effects.

4.1 Limitations

Some limitations of the study have to be addressed. First, we could not control whether future teachers completed the reading assignments. Future teachers who are motivated and study theoretical concepts before or after sessions may show higher increases than students who did not prepare or review sessions. Therefore, future studies could consider affective-motivational aspects and processing time by implementing learning analytics. Initial studies using learning analytics have provided important insights into learners' uptake and individual trajectories of learning opportunities (Oellers et al., 2024). Second, the intervention time of two weeks was relatively short. Other studies have implemented more extended periods and therefore obtained larger effects (e.g., Seidel et al., 2013). Third, the small and unbalanced sample sizes of student teachers and pre-service teachers may have resulted in a lack of statistical power (PV of classroom management: $1 - \beta = .09$; PV of instructional support: $1 - \beta = .11$). This can be attributed to the fact that studies in the induction program are generally rare because of high organizational obstacles and lack of time. Fourth, it was ecologically impossible to compare the sequences of video-based courses to control groups without video analyses. Other studies have implemented text-based control groups as a baseline compared to video-based interventions and have shown beneficial effects of video-based analyses on PV (Stürmer et al., 2013). However, our study implemented seminars in different teacher education phases, which are highly ecologically valid and can serve as a starting point for further research on implementing video-based analyses in different teacher education phases. Despite these limitations, the study provides first insights into how video-based analyses may be implemented in different teacher education phases, adapting to particular needs and expertise differences between university student teachers and pre-service teachers in their induction program.

Appendix A

Table A1a

Correlations Between the Dependent Variables for Student Teachers in the Concept-example Sequence

Scale	1	2	3	4	5	6	7	8	9
t1									
(1) Video test: PV of classroom management									
(2) Video test: PV of instructional support	$.39^{**}$								
(3) Written analyses: PV of classroom management	−.05	.14							
(4) Written analyses: PV of instructional support	.01	−.01	.07						
(5) Alternatives of action	>−.01	−.07	$.39^{**}$	$.47^{***}$					
t2									
(6) Video test: PV of classroom management	$.42^{**}$	.11	−.04	−.05	−.11				
(7) Video test: PV of instructional support	.12	$.51^{***}$	.04	−.07	−.16	$.36^{**}$			
(8) Written analyses: PV of classroom management	.10	.25	−.08	−.03	−.08	−.02	$.35^{*}$		
(9) Written analyses: PV of instructional support	.20	−.12	.02	.24	.12	$.33^{*}$	−.02	−.05	
(10) Alternatives of action	−.10	−.11	−.07	.22	.08	−.05	−.02	$.36^{**}$	$.38^{**}$

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A1b

Correlations Between the Dependent Variables for Student Teachers in the Example-concept Sequence

Scale	1	2	3	4	5	6	7	8	9
t1									
(1) Video test: PV of classroom management									
(2) Video test: PV of instructional support	.44***								
(3) Written analyses: PV of classroom management	.03	.06							
(4) Written analyses: PV of instructional support	.04	−.07	−.11						
(5) Alternatives of action	.04	.13	.52***	.14					
t2									
(6) Video test: PV of classroom management	.39**	.19	.17	.04	.14				
(7) Video test: PV of instructional support	.36**	.60***	.06	.01	.29*	.39**			
(8) Written analyses: PV of classroom management	.06	−.15	.17	−.19	−.06	.09	−.06		
(9) Written analyses: PV of instructional support	−.01	−.01	−.13	−.11	−.13	.08	−.04	−.17	
(10) Alternatives of action	.10	−.06	.03	−.19	−.14	.08	−.04	.46***	.22

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A1c

Correlations Between the Dependent Variables for Pre-service Teachers in the Concept-example Sequence

Scale	1	2	3	4	5	6	7	8	9
t1									
(1) Video test: PV of classroom management									
(2) Video test: PV of instructional support	.54								
(3) Written analyses: PV of classroom management	.33	.09							
(4) Written analyses: PV of instructional support	.16	.23	.08						
(5) Alternatives of action	.39	.32	.30	.71**					
t2									
(6) Video test: PV of classroom management	–.39	–.31	.13	–.20	–.67*				
(7) Video test: PV of instructional support	.46	.71*	<.01	–.03	–.05	.07			
(8) Written analyses: PV of classroom management	–.04	–.23	–.42	.04	.34	–.48	–.76**		
(9) Written analyses: PV of instructional support	–.06	–.10	.33	–.09	.02	.05	–.39	.31	
(10) Alternatives of action	–.33	.04	–.40	.09	.33	–.42	–.63	.87***	.27

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A1d

Correlations Between the Dependent Variables for Pre-service Teachers in the Example-concept Sequence

Scale	1	2	3	4	5	6	7	8	9
t1									
(1) Video test: PV of classroom management									
(2) Video test: PV of instructional support	.31								
(3) Written analyses: PV of classroom management	$.54^{**}$	.20							
(4) Written analyses: PV of instructional support	.16	.04	.24						
(5) Alternatives of action	.32	−.07	.31	.31					
t2									
(6) Video test: PV of classroom management	$.45^{*}$	.11	.31	.11	.31				
(7) Video test: PV of instructional support	.21	$.61^{***}$	−.04	−.08	.01	$.48^{*}$			
(8) Written analyses: PV of classroom management	$.42^{*}$	.05	.31	.04	−.17	.26	.10		
(9) Written analyses: PV of instructional support	−.01	−.02	.12	.05	−.07	.12	.30	.32	
(10) Alternatives of action	.40	−.02	.19	−.09	.03	.09	−.03	$.50^{**}$	$.48^{*}$

Note. PV = professional vision; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

References

Anderson, J. R., Reder, L. M., & Simon, H. A. (1997). Situative versus cognitive perspectives: Form versus substance. *Educational Researcher*, *26*(1), 18–21. https://doi.org/10.3102/0013189X026001018

Ball, D. L. (2000). Bridging practices. *Journal of Teacher Education*, *51*(3), 241–247. https://doi.org/10.1177/0022487100051003013

Barenthien, J., Fiebranz, A., Todorova, M., Möller, K., & Steffensky, M. (2023). Development of professional vision and pedagogical content knowledge during initial teacher education. *International Journal of Educational Research*, *119*, 102186. https://doi.org/10.1016/j.ijer.2023.102186

Barth, V. L., Piwowar, V., Kumschick, I. R., Ophardt, D., & Thiel, F. (2019). The impact of direct instruction in a problem-based learning setting. Effects of a video-based training program to foster preservice teachers' professional vision of critical incidents in the classroom. *International Journal of Educational Research*, *95*, 1–12. https://doi.org/10.1016/j.ijer.2019.03.002

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B. (2025a). *Exploratory insights on the standardized assessment of professional vision of multiple foci of teaching quality using a classroom video of an elementary mathematics classroom* [under review].

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B. (2025b). *Isolated or integrated? – Instructional approaches to foster professional vision of teaching quality* [under review].

Bauersfeld, J. L., Gold, B., & Holodynski, M. (2025). Development of classroom management competencies throughout teacher education: A longitudinal study. *Teacher Development*, 1–21. https://doi.org/10.1080/13664530.2025.2455113

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y.-M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal*, *47*(1), 133–180. https://doi.org/10.3102/0002831209345157

Blomberg, G., Renkl, A., Gamoran Sherin, M., Borko, H., & Seidel, T. (2013). Five research-based heuristics for using video in pre-service teacher education. *Journal for Educational Research Online*, *5*(1), 90–114. https://doi.org/10.25656/01:8021

Blomberg, G., Sherin, M. G., Renkl, A., Glogger, I., & Seidel, T. (2014). Understanding video as a tool for teacher education: investigating instructional strategies to promote reflection. *Instructional Science*, *42*(3), 443–463. https://doi.org/10.1007/s11251-013-9281-6

Blomberg, G., Stürmer, K., & Seidel, T. (2011). How pre-service teachers observe teaching on video: Effects of viewers' teaching subjects and the subject of the video. *Teaching and Teacher Education*, *27*(7), 1131–1140. https://doi.org/10.1016/j.tate.2011.04.008

Blömeke, S., Gustafsson, J.-E., & Shavelson, R. J. (2015). Beyond dichotomies. *Zeitschrift Für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Blömeke, S., Jentsch, A., Ross, N., Kaiser, G., & König, J. (2022). Opening up the black box: Teacher competence, instructional quality, and students' learning progress. *Learning and Instruction*, *79*, 101600. https://doi.org/10.1016/j.learninstruc.2022.101600

Brophy, J. E. (2000). *Teaching. Educational Practices Series: Vol. 1*. International Academy of Education/International Bureau of Education. https://mldbulletin.wordpress.com/wp-content/uploads/2015/03/teaching-by-jere-brophy.pdf

Brophy, J. E. (2004). *Motivating students to learn*. Routledge. https://doi.org/10.4324/9781410610218

Brunmair, M., & Richter, T. (2019). Similarity matters: A meta-analysis of interleaved learning and its moderators. *Psychological Bulletin*, *145*(11), 1029–1052. https://doi.org/10.1037/bul0000209

Carter, K., Sabers, D., Cushing, K., Pinnegar, S., & Berliner, D. C. (1987). Processing and using information about students: A study of expert, novice, and postulant teachers. *Teaching and Teacher Education*, *3*(2), 147–157. https://doi.org/10.1016/0742-051x(87)90015-1

Champagne, A. B., Klopfer, L. E., & Gunstone, R. F. (1982). Cognitive research and the design of science instruction. *Educational Psychologist*, *17*(1), 31–53. https://doi.org/10.1080/00461528209529242

Charles, C. M. (2013). *Building classroom discipline* (11th ed.). Pearson Education UK.

Chitpin, S., Simon, M., & Galipeau, J. (2008). Pre-service teachers' use of the objective knowledge framework for reflection during practicum. *Teaching and Teacher Education*, *24*(8), 2049–2058. https://doi.org/10.1016/j.tate.2008.04.001

Cortina, K. S., & Thames, M. H. (2013). Teacher education in Germany. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 49–62). Springer. https://doi.org/10.1007/978-1-4614-5149-5_3

Davis, E. A. (2006). Characterizing productive reflection among preservice elementary teachers: Seeing what matters. *Teaching and Teacher Education*, *22*(3), 281–301. https://doi.org/10.1016/j.tate.2005.11.005

Doyle, W. (2006). Ecological approaches to classroom management. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook of classroom management* (pp. 107–136). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203874783-11

Dückers, C., Hörter, P., Junker, R., & Holodynski, M. (2022). Professional vision of teaching as a focus-specific or focus-integrated skill – Conceptual considerations and video-based assessment. *Teaching and Teacher Education*, *117*, 103797. https://doi.org/10.1016/j.tate.2022.103797

Emmer, E. T., & Stough, L. M. (2001). Classroom management: A critical part of educational psychology, with implications for teacher education. *Educational Psychologist*, *36*(2), 103–112. https://doi.org/10.1207/S15326985EP3602_5

Evertson, C. M., & Emmer, E. T. (2012). *Classroom management for elementary teachers* (9th ed.). Addison Wesley.

Evertson, C. M., & Weinstein, C. S. (2006). Classroom management as a field of inquiry. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook of classroom management* (pp. 3–15). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203874783-6

Fajet, W., Bello, M., Leftwich, S. A., Mesler, J. L., & Shaver, A. N. (2005). Pre-service teachers' perceptions in beginning education classes. *Teaching and Teacher Education*, *21*(6), 717–727. https://doi.org/10.1016/j.tate.2005.05.002

Fauth, B., Decristan, J., Rieser, S., Klieme, E., & Büttner, G. (2014). Student ratings of teaching quality in primary school: Dimensions and prediction of student outcomes. *Learning and Instruction*, *29*, 1–9. https://doi.org/10.1016/j.learninstruc.2013.07.001

Glaser, R. (2021). General discussion: Relationships between aptitude, learning, and instruction. In R. E. Snow, P.-A. Federico, & W. E. Montague (Eds.), *Aptitude, learning, and instruction: Vol. 2. Cognitive process analyses of learning and problem solving* (pp. 309–326). Routledge. https://doi.org/10.4324/9781003163145-26

Gold, B., & Holodynski, M. (2017). Using digital video to measure the professional vision of elementary classroom management: Test validation and methodological challenges. *Computers & Education*, *107*, 13–30. https://doi.org/10.1016/j.compedu.2016.12.012

Gold, B., Pfirrmann, C., & Holodynski, M. (2021). Promoting professional vision of classroom management through different analytic perspectives in video-based learning environments. *Journal of Teacher Education*, *72*(4), 431–447. https://doi.org/10.1177/0022487120963681

Greeno, J. G. (1997). Theories and practices of thinking and learning to think. *American Journal of Education*, *106*(1), 85–126. https://doi.org/10.1086/444177

He, Y., & Cooper, J. (2011). Struggles and strategies in teaching: Voices of five novice secondary teachers. *Teacher Education Quarterly*, *38*(2), 97–116. https://www.jstor.org/stable/23479695

Kaiser, G., Blömeke, S., König, J., Busse, A., Döhrmann, M., & Hoth, J. (2017). Professional competencies of (prospective) mathematics teachers – Cognitive versus situated approaches. *Educational Studies in Mathematics*, *94*(2), 161–182. https://doi.org/10.1007/s10649-016-9713-8

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review*, *19*(4), 509–539. https://doi.org/10.1007/s10648-007-9054-3

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Klieme, E., Pauli, C., & Reusser, K. (2009). The Pythagoras study: Investigating effects of teaching and learning in Swiss and German mathematics classrooms. In J. Tomáš & T. Seidel (Eds.), *The power of video studies in investigating teaching and learning in the classroom* (pp. 137–160). Waxmann.

König, J., Blömeke, S., Klein, P., Suhl, U., Busse, A., & Kaiser, G. (2014). Is teachers‘ general pedagogical knowledge a premise for noticing and interpreting classroom situations? A video-based assessment approach. *Teaching and Teacher Education*, *38*, 76–88. https://doi.org/10.1016/j.tate.2013.11.004

König, J., & Kramer, C. (2016). Teacher professional knowledge and classroom management: On the relation of general pedagogical knowledge (GPK) and classroom management expertise (CME). *ZDM*, *48*(1-2), 139–151. https://doi.org/10.1007/s11858-015-0705-4

Korthagen, F. A. J., & Kessels, J. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher*, *28*(4), 4–17. https://doi.org/10.3102/0013189X028004004

Kounin, J. S. (1970). *Discipline and group management in classrooms*. Holt, Rinehart & Winston.

Krauss, S., Bruckmaier, G., Lindl, A., Hilbert, S., Binder, K., Steib, N., & Blum, W. (2020). Competence as a continuum in the COACTIV study: The “cascade model”. *ZDM*, *52*(2), 311–327. https://doi.org/10.1007/s11858-020-01151-z

Kumschick, I. R., Piwowar, V., Ophardt, D., Barth, V. L., Krysmanski, K., & Thiel, F. (2017). Optimierung einer videobasierten Lerngelegenheit im Problem Based Learning Format durch Cognitive Tools. Eine Interventionsstudie mit Lehramtsstudierenden [Optimization of a video-based learning opportunity in problem-based learning format through cognitive tools: An intervention study with pre-service teachers]. *Zeitschrift Für Erziehungswissenschaft*, *20*(93), 93–113. https://doi.org/10.1007/s11618-017-0728-4

Leuders, T., & Holzäpfel, L. (2011). Kognitive Aktivierung im Mathematikunterricht [Cognitive activation in mathematics lessons]. *Unterrichtswissenschaft*, *39*, 213–230.

Likourezos, V., & Kalyuga, S. (2017). Instruction-first and problem-solving-first approaches: Alternative pathways to learning complex tasks. *Instructional Science*, *45*(2), 195–219. https://doi.org/10.1007/s11251-016-9399-4

Lipowsky, F., & Hess, M. (2019). Warum es manchmal hilfreich sein kann, das Lernen schwerer zu machen [Why it can sometimes be helpful to make learning harder]. In K. Schöppe & F. Schulz (Eds.), *Kreativität & Bildung – Nachhaltiges Lernen* (pp. 77–132). kopaed.

Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E., & Reusser, K. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and Instruction*, *19*(6), 527–537. https://doi.org/10.1016/j.learninstruc.2008.11.001

Llinares, S., & Valls, J. (2009). The building of pre-service primary teachers' knowledge of mathematics teaching: Interaction and online video case studies. *Instructional Science*, *37*(3), 247–271. https://doi.org/10.1007/s11251-007-9043-4

Lotz, M., Lipowsky, F., & Faust, G. (2013). *Dokumentation der Erhebungsinstrumente des Projekts „Persönlichkeits- und Lernentwicklung von Grundschulkindern" (PERLE)* [Documentation of the data collection instruments of the project „Personality and learning development of primary school children" (PERLE)]. *3. Technischer Bericht zu den PERLE-Videostudien*. GFPF. https://doi.org/10.25656/01:7702

Maier, U., Kleinknecht, M., Metz, K., & Bohl, T. (2010). Ein allgemeindidaktisches Kategoriensystem zur Analyse des kognitiven Potenzials von Aufgaben [A general didactic categorization system for analyzing the cognitive potential of tasks]. *BzL - Beiträge Zur Lehrerinnen- Und Lehrerbildung*, *28*(1), 84–96. https://doi.org/10.36950/bzl.28.1.2010.9798

Marder, J., Thiel, F., & Göllner, R. (2023). Classroom management and students' mathematics achievement: The role of students' disruptive behavior and teacher classroom management. *Learning and Instruction*, *86*, 101746. https://doi.org/10.1016/j.learninstruc.2023.101746

Martin, M., Farrell, M., Seidel, T., Rieß, W., Könings, K. D., van Merriënboer, J. J., & Renkl, A. (2023). Knowing what matters: Short introductory texts support pre-service teachers' professional vision of tutoring interactions. *Teaching and Teacher Education*, *124*, 104014. https://doi.org/10.1016/j.tate.2023.104014

Mayer, R. E. (2002). Multimedia learning. *Psychology of Learning and Motivation*, *41*, 85–139. https://doi.org/10.1016/s0079-7421(02)80005-6

Mayring. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution*. Available at Social Science Open Access Repository (SSOAR). https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173

Meschede, N., Steffensky, M., Wolters, M., & Möller, K. (2015). Professionelle Wahrnehmung der Lernunterstützung im naturwissenschaftlichen Grundschulunterricht [Professional vision of learning support in science education in primary schools]. *Unterrichtswissenschaft*, *43*(4), 317–335.

Müller, M. M., & Gold, B. (2023). Videobasierte Erfassung wissensbasierten Verarbeitens als Teilprozess der professionellen Unterrichtswahrnehmung – Analyse eines geschlossenen und offenen Verfahrens [Video-based assessment of knowledge-based processing as a subprocess of professional vision: Analysis of a closed and open procedure]. *Zeitschrift für Erziehungswissenschaft*, *26*(1), 7–29. https://doi.org/10.1007/s11618-022-01128-6

Oellers, M., Junker, R., & Holodynski, M. (2024). Individual learning paths mastering teachers' professional vision. *Frontiers in Education*, *9*, Article 1305073. https://doi.org/10.3389/feduc.2024.1305073

Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. *Educational Researcher*, *38*(2), 109–119. https://doi.org/10.3102/0013189X09332374

Praetorius, A.-K., Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: The German framework of Three Basic Dimensions. *ZDM*, *50*(3), 407–426. https://doi.org/10.1007/s11858-018-0918-4

Rakoczy, K., Klieme, E., & Pauli, C. (2008). Die Bedeutung der wahrgenommenen Unterstützung motivationsrelevanter Bedürfnisse und des Alltagsbezugs im Mathematikunterricht für die selbstbestimmte Motivation [The importance of perceived support for motivation-relevant needs and the connection to everyday life in mathematics instruction for self-determined motivation]. *Zeitschrift für Pädagogische Psychologie*, *22*(1), 25–35. https://doi.org/10.1024/1010-0652.22.1.25

Renkl, A., Mandl, H., & Gruber, H. (1996). Inert knowledge: Analyses and remedies. *Educational Psychologist*, *31*(2), 115–121. https://doi.org/10.1207/s15326985ep3102_3

Santagata, R., & Angelici, G. (2010). Studying the impact of the Lesson Analysis Framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education*, *61*(4), 339–349. https://doi.org/10.1177/0022487110369555

Santagata, R., & Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *ZDM*, *43*(1), 133–145. https://doi.org/10.1007/s11858-010-0292-3

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A.-K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

Santagata, R., Zannoni, C., & Stigler, J. W. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Mathematics Teacher Education*, *10*(2), 123–140. https://doi.org/10.1007/s10857-007-9029-9

Seidel, T. (2022). Professionelle Unterrichtswahrnehmung als Teil von Expertise im Lehrberuf [Professional vision as a part of expertise in the teaching profession]. In R. Junker, V. Zucker, M. Oellers, T. Rauterberg, S. Konjer, N. Meschede, & M. Holodynski (Eds.), *Lehren und Forschen mit Videos in der Lehrkräftebildung* (17-35). Waxmann Verlag.

Seidel, T., Blomberg, G., & Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, *34*, 56–65. https://doi.org/10.1016/j.tate.2013.03.004

Seidel, T., & Shavelson, R. J. (2007). Teaching effectiveness research in the past decade: The role of theory and research design in disentangling meta-Analysis results. *Review of Educational Research*, *77*(4), 454–499. https://doi.org/10.3102/0034654307310317

Seidel, T., & Stürmer, K. (2014). Modeling and measuring the structure of professional vision in preservice teachers. *American Educational Research Journal*, *51*(4), 739–771. https://doi.org/10.3102/0002831214531321

Sherin, M. G. (2007). The development of teachers‘ professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 383–395). Routledge. https://doi.org/10.4324/9780203877258-27

Shook, A. C. (2012). A study of preservice educators' dispositions to change behavior management strategies. *Preventing School Failure: Alternative Education for Children and Youth*, *56*(2), 129–136. https://doi.org/10.1080/1045988X.2011.606440

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Simonsen, B., Fairbanks, S., Briesch, A., Myers, D., & Sugai, G. (2008). Evidence-based practices in classroom management: Considerations for research to practice. *Education and Treatment of Children*, *31*(1), 351–380. https://doi.org/10.1353/etc.0.0007

Son, L. K., & Simon, D. A. (2012). Distributed learning: Data, metacognition, and educational implications. *Educational Psychology Review*, *24*(3), 379–399. https://doi.org/10.1007/s10648-012-9206-y

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*(2), 107–125. https://doi.org/10.1007/s10857-007-9063-7

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology*, *94*(2), 344–355. https://doi.org/10.1037//0022-0663.94.2.344

Steffensky, M., Gold, B., Holdynski, M., & Möller, K. (2015). Professional vision of classroom management and learning support in science classrooms – Does professional vision differ across general and content-specific classroom interactions? *International Journal of Science and Mathematics Education*, *13*(2), 351–368. https://doi.org/10.1007/s10763-014-9607-0

Stürmer, K., Könings, K. D., & Seidel, T. (2013). Declarative knowledge and professional vision in teacher education: Effect of courses in teaching and learning. *The British Journal of Educational Psychology*, *83*(Pt 3), 467–483. https://doi.org/10.1111/j.2044-8279.2012.02075.x

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Springer.

Syring, M., Bohl, T., Kleinknecht, M., Kuntze, S., Rehm, M., & Schneider, J. (2015). Videos oder Texte in der Lehrerbildung? Effekte unterschiedlicher Medien auf die kognitive Belastung und die motivational-emotionalen Prozesse beim Lernen mit Fällen [Videos or texts in teacher education? Effects of different media on cognitive load and affective-motivational processes when learning with cases]. *Zeitschrift für Erziehungswissenschaft*, *18*(4), 667–685. https://doi.org/10.1007/s11618-015-0631-9

Tatto, M. T., Rodriguez, M. C., & Reckase, M. (2020). Early career mathematics teachers: Concepts, methods, and strategies for comparative international research. *Teaching and Teacher Education*, *96*, 103118. https://doi.org/10.1016/j.tate.2020.103118

Tomlinson, P. D., & Hunt, D. E. (1971). Differential effects of rule-example order as a function of learner conceptual level. *Canadian Journal of Behavioural Science / Revue Canadienne Des Sciences Du Comportement*, *3*(3), 237–245. https://doi.org/10.1037/h0082265

Tucholka, I., & Gold, B. (2025). Analysing classroom videos in teacher education – How different instructional settings promote student teachers' professional vision of classroom management. *Learning and Instruction*, *97*, 102084. https://doi.org/10.1016/j.learninstruc.2025.102084

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571–596.

van Es, E. A., & Sherin, M. G. (2024). Correction: Expanding on prior conceptualizations of teacher noticing. *ZDM*, 1. https://doi.org/10.1007/s11858-024-01570-2

van Tartwijk, J., Brok, P. den, Veldman, I., & Wubbels, T. (2009). Teachers' practical knowledge about classroom management in multicultural classrooms. *Teaching and Teacher Education*, *25*(3), 453–460. https://doi.org/10.1016/j.tate.2008.09.005

Windschitl, M., Thompson, J., Braaten, M., & Stroupe, D. (2012). Proposing a core set of instructional practices and tools for teachers of science. *Science Education*, *96*(5), 878–903. https://doi.org/10.1002/sce.21027

Wubbels, T., Brok, P. den, Veldman, I., & van Tartwijk, J. (2006). Teacher interpersonal competence for Dutch secondary multicultural classrooms. *Teachers and Teaching*, *12*(4), 407–433. https://doi.org/10.1080/13450600600644269

Supplement

Table S1

Overview of the Aspects of Teaching Quality Addressed in the Texts

Session 1	Session 2
Classroom management withitness, group focus, managing transitions, time management, dealing with disruptions, rules and routines	*Instructional support* activating prior knowledge, cognitively activating tasks, students' contributions, demanding an explanation, exploring students' cognitive thought processes, problem-based learning environments

Table S2

Word Count and Readability of the Texts for Each Group

Session 1		Session 2	
word count	readability	word count	readability
2698	51.78	1947	62.95

Table S3

Item Statistics of Means and Standard Deviations (M [SD]) and Standardized Factors Loadings

Item	teaching quality dimension	cognitive process	t1: *M*(*SD*)	t2: *M*(*SD*)	λ
noticecm	CM	noticing	3.06(1.57)	3.89(2.03)	.921[1]
interpretcm	CM	interpreting	0.97(1.06)	0.82(1.12)	.293[1]
explaincm	CM	explaining	0.54(0.86)	1.15(1.4)	.495[1]
noticeis	IS	noticing	0.97(1.09)	1.74(1.5)	.948[2]
interpretis	IS	interpreting	0.38(0.65)	0.29(0.53)	.376[2]
explainis	IS	explaining	0.27(0.61)	0.62(0.93)	.698[2]
alternative		describing	3.65(1.73)	4.18(1.96)	.921[3]
alternativeex		explaining	1.38(1.35)	1.81(1.70)	.612[3]
alternativedis		discussing	1.04(1.12)	0.54(0.91)	.328[3]

Note. Three-dimensional structure based on Bauersfeld et al. (submitted), $\chi^2(21) = 54.31$, $p < .001$; CFI = .960; TLI = .931; RMSEA = .068; SRMR = .058; CM = classroom Management; IS = instructional support; [1]factor 'PV of classroom management'; [2] factor 'PV of instructional support'; [3]factor 'alternatives of action'.

3. General Discussion

The development and enhancement of professional vision is essential in teacher education as this competency plays a crucial role in future teaching practice (Blömeke et al., 2015). Professional vision influences the implementation of teaching quality and contributes to student achievement (Blömeke et al., 2022; Kersting et al., 2012; Roth et al., 2011). The model of teacher expertise development by Berliner (1988) proposes phases of plateau and solidification in teachers' competency development; however, the longitudinal development of future teachers' professional vision, and how learning opportunities influence it throughout teacher education, as described in models on the development of teacher competency (e.g., Kaiser & König, 2019), remain underexplored. This is especially true with regard to the question of how to design learning opportunities that include video-based analyses to effectively enhance professional vision throughout teacher education. Hence, the goals of this dissertation are to examine how future teachers' professional vision develops throughout teacher education and how it can be effectively enhanced through video-based analyses, taking into account findings related to the instructional principles of educational psychology. The differences between the teacher education phases are thereby considered. The following two main questions are the focus of the Articles: How does professional vision develop within the context of teacher education? How can the instructional principles of educational psychology inform the design of instructional settings around video-based analyses to enhance professional vision?

In the next chapter, key findings from the dissertation's Articles are summarized and discussed. The implications for research and teaching practice are subsequently derived, followed by a presentation of the dissertation's limitations and conclusion.

3.1 Key Findings of the Individual Contributions of the Dissertation

Article I (*The Development of Classroom Management Competencies: A Longitudinal Study*) investigated the development of cognitive processes of professional vision with a focus on classroom management throughout teacher education, including the induction program and how learning opportunities affect this development. The overall findings of multilevel analyses showed no development of professional vision in the bachelor's studies, a linear increase in the master's studies, and a decrease in the induction program, and a general increase of knowledge about classroom management strategies from the start of the master's studies. These results indicate that a minimum amount of knowledge about classroom management is necessary before future teachers can develop professional vision. Furthermore, learning opportunities in the induction program did not affect the development of professional vision, but reflecting with mentors or supervisors had a negative effect on future teachers' development in knowledge about classroom management. This finding suggests that future teachers may have difficulties in transferring learned knowledge from university to teaching practice and may struggle with differences in philosophy between the university and the *Studienseminare*. Moreover, the cognitive processes of professional vision were only associated with each other in the induction program, and knowledge about classroom management at the end of the master's studies predicted professional vision at the end of the induction program, indicating a bidirectional relationship between cognitive processes of professional vision.

Article II (*Can Double-content Examples of Video-based Analyses Foster Student Teachers' Professional Vision of Classroom Management?*) investigated whether the instructional principle of worked examples could be transferred to the ill-structured domain of teacher education to enhance future teachers' cognitive processes and expert features of professional vision with a focus on classroom management by implementing complete and faded double-content examples. In sum, complete and faded double-content examples did not have an effect on the expert features but a detrimental effect on future teachers' professional vision and the application of concepts of classroom management. Additionally, future teachers struggled to self-explain expert features from double-content examples and transfer them for the development of professional vision. These findings highlight the need for further explorations into how the instructional principles of educational psychology can be transferred to the ill-structured domain of teacher education to enhance complex competencies such as professional vision.

Article III (*Isolated or Integrated? – Instructional Approaches to Foster Professional Vision of Teaching Quality*) examined how an isolated or integrated instructional approach to video-based analyses can enhance future teachers' professional vision, thereby considering individual prerequisites. In the isolated approach, future teachers separately focused on the teaching quality dimensions of classroom management, instructional support, and emotional support. By contrast, in the integrated approach, future teachers had to simultaneously focus on these teaching quality dimensions in video-based analyses. Bayesian multilevel models showed that future teachers' professional vision of emotional support was enhanced in the isolated approach compared to a control group, indicating a recency effect. In the integrated approach, professional vision of classroom management and simultaneously focusing on the teaching quality dimensions was fostered compared to a control group. However, the isolated and the integrated approach did not differ in professional vision of classroom management. Furthermore, interest or prior learning opportunities did not affect professional vision development. The findings emphasize the need to support future teachers in connecting content with pedagogy by simultaneously focusing on different teaching quality dimensions.

Finally, Article IV (*Before or After? – Sequencing Concepts and Video-based Analyses for Different Teacher Education Phases*) investigated how the introduction of the theoretical concepts of teaching quality and examples of classroom videos have to be sequenced at university and the induction program to effectively enhance future teachers' professional vision. Overall, generalized linear mixed models indicated that the example-concept sequence enhanced the generation of alternatives of action. Moreover, pre-service teachers in an induction program benefited more from the example-concept sequence in professional vision of instructional support, indicating an expertise reversal effect. In addition, student teachers improved more in professional vision of classroom management, whereas pre-service teachers improved more in professional vision of instructional support. The results highlight the need to consider specific learning goals and different teacher education phases when enhancing professional vision.

3.2 Overarching Discussion of the Contributions of the Dissertation

The four studies display several commonalities, especially regarding the consideration of differences in expertise, characteristics, and demands in the teacher education phases as well as the effect of learning opportunities in the development of professional vision and the implementation of the instructional principles of educational psychology for the enhancement of professional vision. The findings are discussed in the next sections.

3.2.1 How Does Professional Vision Develop in the Context of Teacher Education?

In accordance with the model of teacher expertise development (Berliner, 1988) and models related to competency development in teacher education (e.g., Kaiser & König, 2019), the findings of Article I confirm that professional vision development exhibits phases of stagnation, plateau, and solidification and that this development is affected by teacher education. Article I therefore indicates that teacher expertise in professional vision development evolves through different expertise stages These expertise stages are particularly shown by the lack of development of professional vision in bachelor's studies and the decrease in professional vision in the induction program. These findings diverge from previous findings of cross-sectional studies that propose an overall linear development of professional vision (Stahnke et al., 2016; Wolff et al., 2017; Wolff et al., 2016; Wolff et al., 2015) and findings that suggest a longitudinal development of professional vision with a focus on instructional support in bachelor's studies (Eßling et al., 2023). Yet, the decrease in the induction program confirms longitudinal findings that have revealed a decrease of professional vision in the induction program (Barenthien et al., 2023; Bastian et al., 2022). The previous studies concentrated on content-related aspects, primarily focusing on instructional support addressing content and pedagogical content knowledge. By contrast, Article I expanded on this by explicitly focusing on classroom management, thereby mainly addressing teachers' general pedagogical knowledge. Additionally, the differences between the expertise stages are also indicated by the varying degrees of instructional support required: In Article IV, future teachers participating in the induction program – typically characterized by higher degrees of expertise through their knowledge or experience – benefited more from less instructional support than from extensive instructional support. These findings are consistent with evidence from educational psychology that find that different degrees of instructional support are effective for different expertise stages (for an overview see Kalyuga, 2007). In comparison, the innovative approach of Article I and IV was that they included different teacher education phases with differing characteristics and demands on future teachers.

The found developments not only can confirm the existence of different teacher expertise stages but they can also indicate differences in the characteristics of the teacher education phases. As suggested by models on competency development in teacher education (Kaiser & König, 2019; Kunter, Klusmann, et al., 2013; Yang & Kaiser, 2022) the findings of Articles I and IV could also be explained by differences between the characteristics of the teacher education phases. The dissimilarities between the university and the *Studienseminare* are obvious (as described in chapter 1.2); however, a surprising fact is that relatively scarce research exists on how the transition from the one context to the other affects teacher competency development (Tatto et al., 2020). The dissimilarities may be traced back to the different philosophies of the academic environment of the university and the practice-focused environment of the *Studienseminare*. Future teachers are familiar with the university context, which prioritizes an academic and research-based focus. They must later transition to teaching practice, where experience and reflection on teaching practice are valued. This discrepancy is highlighted by the negative impact of reflection with mentors or supervisors on knowledge development discussed in Article I. Existing research underscores this assumption by indicating that future teachers struggle to navigate between different stakeholders of the university and the induction program (Bullough & Draper, 2004; Valencia et al., 2009) and that in the context of practice, future teachers become detached from theoretical concepts imparted by university (Chitpin et al., 2008; Tatto et al., 2020). As outlined in Article IV, reduced instructional guidance may afford greater flexibility in accounting for the specific characteristics of the teacher education phases when future teachers engage in video-based analyses, employing the theoretical concepts primarily as heuristic tools to facilitate reflective practice. Hence, the findings of Article I and IV cannot only be explained by differences in expertise stages, but also by the differing characteristics of the university and the *Studienseminare* and future teachers' struggle to transition from the university to the induction program.

Another explanation for the findings of Article I and IV may lie in the evolving demands placed on future teachers throughout teacher education. As described in Chapter 1.2, the first and second phase place different demands on future teachers. First, in Article I, this is shown by the finding that bachelor student teachers did not increase in professional vision during their bachelor's studies. This finding confirms theoretical models that propose that professional vision is a knowledge-based process (Baumgartner et al., 2020; Blömeke et al., 2015; Kaiser et al., 2017; Krauss et al., 2020), suggesting that minimum knowledge is necessary before professional vision can develop. Second, the finding in Article I that knowledge at the end of the induction program is predicted by professional vision developed in the first teacher education phase indicates that future teachers now have to use their professional vision in actual classroom situations and act upon them; by contrast, they did not have the pressure to act in the first teacher education phase. Therefore, this finding underscores the theoretical assumption by Santagata and Yeh (2014) that knowledge and professional vision share a bidirectional relationship in the context of teaching practice and supports the claim that teaching practice offers future teachers a valuable opportunity to apply professional vision gained at university and make decisions based on their noticing and reasoning.

Hence, possible explanations for the trajectory of professional vision development can be a combination of differences in future teachers' expertise, the characteristics of the teacher education phases, and the demands placed on future teachers throughout teacher education. Therefore, the findings provide initial evidence that, as proposed by Seidel (2022; Seidel et al., 2024), in early teacher education phases, future teachers acquire knowledge about fundamental theoretical concepts before they can analyze and link them to classroom situations, thereby developing professional vision. In later teacher education phases, especially when switching from the passive observer to actual performance in classrooms, reflecting on teaching practice may become more important. By considering the differing expertise stages and the characteristics and demands of the teacher education phases, we may gain more differentiated insights into the development of teacher expertise and competency throughout teacher education.

However, these proposed explanations contrast models of teacher competency development, which identify learning opportunities as the primary drivers of competency development (Kaiser & König, 2019). Learning opportunities implemented throughout teacher education have been commonly considered to play a central role in the development of teacher competency (Klemenz et al., 2019; König, Ligtvoet, et al., 2017) and specifically professional vision development (Bastian, König, et al., 2024; Orschulik, 2021; Stürmer, Könings, & Seidel, 2015; Stürmer et al., 2016). However, the findings of Article I indicate that theoretical and practical learning opportunities in the induction program could not explain the development of professional vision. Research has commonly agreed that aside from the quantity, the quality of learning opportunities is highly relevant for competency development (e.g., Klemenz et al., 2019) and that theoretical (e.g., seminars) and practical (e.g., teaching experience) learning opportunities need to be aligned to effectively enhance competency development (König, Bremerich-Vos, et al., 2017; König et al., 2018; Scholten & Orschulik, 2022; Stürmer, Seidel, & Schäfer, 2013; Westphal et al., 2018). In Article I, future teachers only had to indicate the number of learning opportunities and did not report on their quality or the alignment of theoretical and practical learning opportunities. Although this approach is highly economic, it presents a very shallow picture of the learning opportunities attended. Follow-up research questions could therefore be how the quality of theoretical and practical learning opportunities and their alignment play a role in professional vision development. Specifically, current research on teacher education suggests that the content covered (Klemenz et al., 2019; Stürmer, Könings, & Seidel, 2013), the uptake of the learning opportunities (Helmke, 2009), and the instructional settings (Santagata et al., 2021) may affect professional vision development. The findings of Article I address the content of theoretical concepts of classroom management, however, they do not cover the uptake of learning opportunities. or the specific instructional settings. Given that individual prerequisites of prior cognitive ability and motivation are suggested to influence the uptake of learning opportunities in teacher education (Klusmann, 2013), considering future teachers' individual prerequisites could provide more differentiated insights into the effectiveness of learning opportunities in teacher education. For example, initial studies using distal factors of knowledge (e.g., High School grade point average [GPA]) gave initial evidence for no predictive value of prior ability in the first phase (Stürmer, Könings, & Seidel, 2015) but a positive predictive value in the second phase on competency development (König et al., 2024; Voss et al., 2017). However, the effect of individual prerequisites on professional vision development throughout teacher education has been investigated scarcely and overall remains unclear.

Regarding the instructional settings, research still debates how to design quality learning opportunities to support professional vision development throughout teacher education. Amid ongoing debates about continuity throughout teacher education, the findings highlight not only the need to align the first and second phases of teacher education but also imply the importance of synchronizing theoretical and practical learning opportunities to enhance competency development. To comply with these demands, teacher education has increasingly implemented practice-oriented learning opportunities (Renkl & Nückles, 2006) using classroom videos as representations of practice (Grossman, 2021; Grossman et al., 2009). Notwithstanding, the existence of several general frameworks for implementing these classroom videos in teacher education (Blomberg et al., 2013; Santagata & Angelici, 2010), the specific design of these settings remains unclear. At the same time, the findings of Article I and IV suggest that the differing degrees of expertise and characteristics and demands of the teacher education phases must be considered (see also Seidel, 2022; Seidel et al., 2024). Therefore, in the next section, the Articles II, III, and IV of this dissertation, which relate to the adequate design of learning opportunities to enhance professional vision throughout teacher education, are discussed. Differing instructional approaches to video-based analyses are thus investigated, which may provide information on how the specific instructional design of learning opportunities implemented to enhance professional vision throughout teacher education might look (Blomberg et al., 2013; Santagata et al., 2021). These insights may enhance our understanding of how and under what conditions learning opportunities impact the development of professional vision.

3.2.2 How can Instructional Principles of Educational Psychology Inform Instructional Settings Around Video-based Analyses to Enhance Professional Vision?

Articles II, III, and IV examined how to enhance professional vision through video-based analyses of authentic classroom situations in learning opportunities throughout teacher education. The goal of these studies was to enhance professional vision using instructional settings around video-based analyses, thereby implementing instructional principles from cognitive load theory as a framework. This dissertation also offers valuable insights into how to design learning opportunities implemented in the context of teacher education. Moreover, the findings shed light on broader research frameworks for applying instructional principles to ill-structured domains. Thus, the studies comply with demands formulated by research on teacher education, which call for investigations on transferring instructional principles of educational psychology to teacher education (Nückles, 2021).

Although the instructional principles of educational psychology aim to reduce cognitive load to enhance learning and competency development, the findings of the Articles II, III, and IV revealed inconsistent effects regarding the enhancement of professional vision. The Articles investigated how instructional principles can be transferred to the ill-structured domain of teacher education, how they have to be implemented throughout teacher education, and how they can support future teachers in focusing on multiple teaching quality dimensions.

Transferring Instructional Principles to the Ill-structured Domain of Teacher Education

Articles II, III, and IV support current evidence that the transfer of the instructional principles of educational psychology to ill-structured domains such as teacher education is not that easy (van Merriënboer & Sweller, 2005). This proposition is in line not only with most other findings related to instructional settings to video-based analyses aiming to enhance professional vision (e.g., Gabel et al., 2024; Grub et al., 2022a; Martin et al., 2022) but also with many other findings related to enhancing competencies in ill-structured domains (e.g., J. Meier et al., 2022; Schworm & Renkl, 2007). This assertion is particularly evident in Article II, where the additional instructional support of the double-content example yielded detrimental effects. Explanations for the inconsistent effects and the finding in Article II could lie in the high complexity and the multifaceted nature (Doyle, 1989) of the ill-structured domain of teacher education and in the transience of the classroom videos (Star & Strickland, 2008; Syring et al., 2015). Although intrinsic load was not assessed directly, it is conceivable that the complexity and transience of the classroom videos increased element interactivity, which in turn may have increased intrinsic load that may have overwhelmed future teachers. As a result, future teachers may not have sufficient cognitive resources to adequately process the additional instructional material. An alternative explanation could be the fact that in ill-structured domains such as teacher education, future teachers not only have to develop knowledge about theoretical concepts but also determine the way of implementing them (Renkl et al., 2009; van Gog et al., 2004). For example, in Article II, the double-content example aims to provide information on theoretical concepts and strategic information on how to conduct video-based analyses. Learners may be overwhelmed with both demands, which may result in ineffective self-explanations (Renkl, 1997) and hampering the acquisition of either demand (see also Renkl et al., 2009). Research on educational psychology commonly agrees that ill-structured domains exhibit high intrinsic load, which explains why additional instructional support may overload learners if the intrinsic load of the additional learning material is also high (also found by Kester et al., 2006). Initial studies that included measures of cognitive load revealed inconsistent results (Gabel et al., 2024; Gabel et al., 2023; Martin et al., 2023; Wilkes et al., 2022); however, these studies did not differentiate between the extrinsic and intrinsic cognitive load that future teachers experience. A further research area could therefore be to examine the effect of extrinsic and intrinsic cognitive load within the ill-structured domain of teacher education. Considering these different types of cognitive loads may provide more differentiated insights into how the ill-structured domain and the complexity of the learning material may affect the effectiveness of instructional support.

Building on this proposition, the findings of the Articles also provide indications that prior knowledge or experience influence the effectiveness of the instructional principles in ill-structured domains. The results of Article IV indicate an expertise-reversal effect (Kalyuga, 2007), which suggests that different instructional principles may be effective for different degrees of prior knowledge or experience as indicated by the two teacher education phases. A possible explanation could provide the basic assumption of cognitive load theory, which suggests that learners with higher prior knowledge generally experience lower intrinsic load and possess more capacities for cognitive processing than learners with lower prior knowledge (Sweller, 1988; Sweller et al., 2011). This proposition may also offer another explanation for the ineffectiveness of the double-content example in Article II. The double-content example additionally provided strategic information on how to analyze classroom videos next to theoretical concepts. Studies in the context of other ill-structured domains have shown that such strategic information is only helpful for learners with high prior knowledge (Schwonke et al., 2009; Seufert, 2019) and may be detrimental to low prior knowledge learners when intrinsic load is high. Typically, future teachers possess low prior knowledge (see also Article I), which explains why the additional strategic information may have overloaded them. However, Article III has considered prior learning opportunities as a distal factor of prior knowledge and found no effects. Nevertheless, the effect of learners' prior knowledge on instructional principles has been considered only rudimentarily, and its role in the effectiveness of instructional principles remains unclear. For instance, in the context of video-based analyses in teacher education, only a few studies have considered measures of prior knowledge and found inconsistent effects (Gabel et al., 2023; Grub et al., 2022a, 2022b; Tannert et al., 2023; Wilkes et al., 2022). Accounting for prior knowledge may yield deeper insights into how varying degrees of instructional support align with different stages of teacher expertise.

Nevertheless, Articles III and IV offer some indications that the instructional principles may be functional in ill-structured domains under certain conditions. The findings suggest that instructional tasks (e.g., focusing on specific aspects of teaching quality) in combination with additional instructional material (e.g., texts addressing the theoretical concepts of teaching quality) may be beneficial for learners. This assumption is supported by other initial findings indicating that preparatory texts can help future teachers focus attention on the relevant events (Martin et al., 2023). By acquiring knowledge and then focusing on relevant aspects, learners may learn how to deal with the high complexity of the ill-structured domain. These findings are in line with evidence from other ill-structured domains that show that only studying instructional material did not effectively enhance competency development, but the combination with prompts did (Schworm & Renkl, 2007). One explanation for the findings of the Articles and those of other studies investigating instructional principles in the context of teacher education (Martin et al., 2023) could be that additional instructional material, the instructional task, and the content of the learning materials have to be closely aligned for learners to be able to transfer learned knowledge to the task at hand. For example, the texts in Articles III and IV specifically address theoretical concepts, and the task of future teachers is to focus on these concepts when analyzing classroom videos. In contrast to existing studies that implement preparatory texts to enhance professional vision with complexity-reduced classroom videos (e.g., displaying micro-teaching sessions) (Martin et al., 2023), Articles III and IV implemented authentic classroom videos without simplifying their complexity and demonstrated that these findings remain valid under more complex conditions.

In sum, the question is not whether instructional principles can be effective in ill-structured domains but under what conditions they work best (see also Udvardi-Lakos, 2023; van Merriënboer & Sweller, 2005). The findings underscore the importance of considering the intrinsic load of the ill-structured domain and therefore also learners' prior knowledge when implementing the instructional principles of educational psychology. The findings also highlight that future teachers generally struggle to deal with the intrinsic load evoked by the transient and complex task of analyzing concepts of teaching quality in classroom situations, thereby reducing the effectiveness of the instructional principles.

Implementing Instructional Principles Throughout Teacher Education

Another important conclusion from the findings of the dissertation is that instructional settings around video-based analyses have to be adapted to different teacher education phases. In line with the assumption by Seidel (2022; see also Seidel et al., 2024) and the findings of Article I, the Articles offer evidence that future teachers at university benefit from illustration and analysis of theoretical concepts, whereas future teachers in the induction program benefit more from deliberate practice and reflection. This assumption is most appropriately supported by the findings of Article IV, in which instructional principles were investigated in the context of the first and second phases. The findings in Article IV indicate that future teachers at university, who often lack sufficient prior knowledge and experience, benefit from the strong instructional support of preparatory texts that aid in acquiring knowledge about the theoretical concepts of teaching quality (also shown in Article III). At the same time, future teachers in the induction program, having already acquired knowledge at university and gained some teaching experience, may have benefited from less instructional support as they engaged in analyzing classroom videos and then reflecting on theoretical concepts. A possible explanation could be the expertise-reversal effect (Kalyuga, 2007; Kalyuga et al., 2003), which suggests that instructional support may become redundant or detrimental with increasing expertise; hence, the additional instructional support of the preparatory text may have become redundant or even detrimental to the development of professional vision. The expertise-reversal effect found in Article IV is supported by previous research indicating that future teachers at university benefit most from illustrating and analyzing theoretical concepts prior to video-based analyses (Martin et al., 2023; Seidel et al., 2013) as well as multimedia research, which suggests the positive effects of pre-trainings before learning (Mesmer-Magnus & Viswesvaran, 2010). These findings extend previous research that has merely investigated future teachers at university by including future teachers in the induction program with higher prior knowledge and more teaching experience. Hence, the findings indicate that instructional settings to video-based analyses have to be adapted to future teachers' prior knowledge and expertise stage.

As suggested in Article I, the findings also highlight the differences between the first and second teacher education phases in their demands (Cortina & Thames, 2013) and communities of practice (Bullough & Draper, 2004). The demands of the phases differ in that future teachers at university still need to acquire knowledge without acting in a classroom. By contrast, future teachers in the induction program must switch from being passive observers to actual performers in the classroom. As a result, as suggested by Seidel (2022; see also Seidel et al., 2024), the learning goals of the phases are different. General frameworks for implementing classroom videos in teacher education have suggested that instructional approaches around video-based analyses should be designed with clear learning goals in mind (Blomberg et al., 2013); hence, the instructional settings have to be adapted to each teacher education phase. Furthermore, future teachers may experience discrepancies between teaching experience and the theoretical concepts introduced at university because of differing philosophies and communities of practice (Chitpin et al., 2008), which explains why they struggle to link theoretical concepts to video-based analyses. When introducing the theoretical concepts after video-based analyses, future teachers may be able to use the language and philosophy of the induction program and match them with the theoretical concepts. Hence, the findings suggest that instructional approaches to video-based analyses have to be adapted to the particular characteristics and demands of the teacher education phase to effectively enhance professional vision.

Supporting Future Teachers in Focusing on Multiple Teaching Quality Dimensions Using Instructional Principles

Another central finding of Articles III and IV shows that future teachers generally struggle to simultaneously focus on multiple teaching quality dimensions. This is indicated by findings in both Articles that future teachers increased only in professional vision of one teaching quality dimension, predominantly those that require general pedagogical knowledge, regardless of the implemented instructional principles. In Article III, future teachers overall increased in professional vision of classroom management or emotional support. In Article IV, future teachers overall increased in professional vision of classroom management. These findings are in line with evidence of previous studies that suggest that when instructional settings display the need to combine the different categories of teachers' professional knowledge (i.e., general pedagogical knowledge, content knowledge, and pedagogical content knowledge; Shulman, 1986, 1987), future teachers can more effectively apply general pedagogical knowledge but not content or pedagogical content knowledge (Harr et al., 2014, 2015; Martin et al., 2023). The findings extend the results of these existing studies by including the approximation of practice of analyses of authentic classroom videos instead of text-based information or complexity-reduced classroom situations and therefore address the call for more complex levels of representations of practice (Fischer et al., 2022; Grossman, 2021). One explanation for this strong focus on pedagogical aspects could be that future teachers consider classroom management to be one of the most pressing tasks of teaching (Fajet et al., 2005). This explanation is supported by research on teacher expertise, which suggests that future teachers typically focus on the aspects of classroom management (e.g., Wolff et al., 2015), particularly classroom disruptions, in which general pedagogical knowledge becomes relevant (König & Kramer, 2016; Wolff et al., 2021). By contrast, expert teachers display a strong focus on student learning and engagement (e.g., Stahnke et al., 2016; Wolff et al., 2015), in which not only general pedagogical knowledge but also content and pedagogical content knowledge becomes relevant (Shulman, 1986). This strong focus on pedagogical aspects in the classroom may be explained by the fact that future teachers typically lack content and pedagogical content knowledge and therefore turn to general pedagogical knowledge to analyze classrooms (Harr et al., 2014, 2015; Hashweh, 1987). Another explanation for this finding could be that novice learners typically process different learning contents in separate entities and struggle to draw connections between the learning contents (Kalyuga, 2007). This isolated processing deficit could again be due to the high intrinsic load that classrooms entail and the ensuing cognitive overload future teachers experience (Ayres, 2013; see also Kim & Klassen, 2018). Therefore, evidence suggests that learners usually do not spontaneously draw connections between learning contents but have to be explicitly encouraged to do so (e.g., Martin et al., 2022). This is also highlighted by the results of Article III that indicate overall low degrees of simultaneous focus and a higher simultaneous focus when future teachers were explicitly instructed to draw connections. However, this simultaneous focus compromised the overall development of professional vision of multiple foci. Hence, the issue of how connecting pedagogy and content can be achieved without compromising the overall development of professional vision remains unclear.

Nevertheless, the findings of Article III suggest that prompting future teachers to draw connections between pedagogy and content is possible through the integrated approach, even with short-term interventions. However, this short-term intervention may also explain the lack of professional vision development of multiple foci. These highly demanding tasks typically require time and practice meaning that their effects tend to manifest over the long term. This relates to the idea of *desirable difficulties* (Bjork & Bjork, 2020) and other frameworks that suggest complex whole-task approaches for enhancing the effectiveness of instructional principles in ill-structured domains (Merrill, 2002; van Merriënboer et al., 2002). According to these approaches, learning environments should be designed to create more challenging learning experiences (e.g., by focusing on multiple teaching quality dimensions when analyzing a classroom video); thereby evoking stronger cognitive engagement and facilitating more in-depth cognitive processing, which ultimately enhances long-term retention and the transfer of knowledge (Lipowsky et al., 2015; Schweppe, 2021). For example, Zeitlhofer et al. (2024) found that increased task complexity contributed to task performance, germane cognitive load and meta-awareness. Hence, together with previous research (Harr et al., 2014, 2015), the results of Article III show that the integrated approach could serve as an initial step in prompting learners to draw connections between the three foci of teaching quality. Investigating the follow-up and long-term effects of these *desirable difficulties* could offer valuable insights into how future teachers can effectively draw connections between content and pedagogy.

In sum, the matter of how learning opportunities in teacher education can support future teachers in applying several categories of teachers' professional knowledge remains somewhat unclear. The findings of the Articles suggest that due to the high intrinsic load of the ill-structured domain of teacher education, future teachers struggle to integrate knowledge and apply it for video-based analyses. An initial step could be the implementation of instructional tasks that necessitate future teachers to draw connections between the categories of teachers' professional knowledge. However, further research is necessary to investigate learners' cognitive processes when striving to integrate knowledge categories, as well as the effect of long-term training programs. With the help of such insights, we could better understand how to overcome the isolated processing deficit in novice learning, support future teachers in focusing on student learning and engagement, and promote the acquisition of integrated knowledge that is ready to apply for the implementation of teaching quality in the classroom.

In conclusion, the Articles of this dissertation provide evidence that a combination of teacher expertise and the characteristics and demands of the teacher education phases play a role in professional vision development. To align the first and second teacher education phases, practice-oriented learning opportunities that include classroom videos embedded within adequate instructional settings may enhance professional vision under certain boundary conditions. Before providing clear guidelines for the design of quality learning opportunities in teacher education to enhance professional vision, the findings of the Articles suggest that further attention should be given to the degrees of cognitive load in the ill-structured domain of teacher education, future teachers' prior knowledge and experience, the connection of pedagogy and content when analyzing and observing classroom situations, the follow-up and long-term effects, as well as the demands and characteristics of the different teacher education phases.

3.3 Implications for Research and Teacher Education

In addition to the specific findings of the Articles, broader implications for education science and teacher education can be inferred. The implications for research primarily focus on the consideration of determinants of teacher education when investigating the development and enhancement of professional vision and how to design interventions that aim to enhance the complex competency of professional vision. The implications for teacher education predominantly focus on the establishment of continuity throughout teacher education, supporting future teachers in dealing with the high intrinsic load of classrooms, and linking pedagogy with content.

3.3.1 Implications for Research

Considering the Effects of Teacher Education

The findings of this dissertation suggest that considering differences in the characteristics and demands of the teacher education phases may deepen our understanding on how teacher education affects professional vision development and enhancement. However, these differences have only rarely been considered in research on professional vision. Notwithstanding the emphasis on the crucial role of learning opportunities placed by models on teacher competency development (e.g., Kaiser & König, 2019) and factors influencing professional vision (Stürmer, Könings, & Seidel, 2015; Stürmer, Seidel, & Kunina-Habenicht,

2015) to develop and enhance professional vision, existing research has largely relied on superficial or unspecific measures when examining their effects. Therefore, the next section addresses how a more detailed consideration of the characteristics and demands of the teacher education phases and learning opportunities may broaden our understanding of how teacher education influences professional vision development and draw implications for its enhancement.

First, especially the findings of Articles I and IV indicated that differences between the teacher education phases may play a role in professional vision development and enhancement as the characteristics of the phases and the demands on future teachers vary. However, research has rarely considered these differences when investigating the development and enhancement of professional vision. The different philosophies and practices of the teacher education phases, as well as how they align with or contradict each other, can be considered (Bullough & Draper, 2004). Including detailed measures related to the stakeholders in teacher education may more thoroughly inform the characteristics and the alignment of the first and second teacher education phases. Moreover, the Articles I and IV also support Seidel's (2022) assumption that the demands on future teachers differ between the teacher education phases. In bachelor's studies, future teachers need to acquire knowledge; in master's studies, they need to be able to analyze classrooms based on this acquired knowledge; and in the induction program, they have to switch from passive observation to active performance in the classrooms (see Seidel, 2022; Seidel et al., 2024). To understand professional vision development in more depth, a helpful step could be the integration of different assessment formats (e.g., open-response and closed-response formats) and measurements (e.g., cognitive processes, expert features, and simultaneous focus) to assess different aspects of professional vision. Research indicates that different assessment formats (Blömeke et al., 2016; Gold et al., 2024; Müller & Gold, 2023) and measurements (see also Articles II and III) are lowly correlated and may therefore display different aspects of professional vision. Possibly, future teachers in later teacher education phases may not develop further in the cognitive process of noticing, but may instead more adequately reason on classroom situations or display more expert features when analyzing and observing classroom situations. Hence, information on the different stakeholders and the institutions as well as the combination of different assessment formats and measures may broaden our understanding on how characteristics and demands of the two teacher education phases affect professional vision development and enhancement.

Moreover, learning opportunities are regarded essential in teacher education (e.g., Klemenz et al., 2019; König, Ligtvoet, et al., 2017), but the lack of effects in Article I suggests that more in-depth investigations into the quality of learning opportunities are necessary to profoundly understand their effect on professional vision development. Research primarily implemented superficial data on learning opportunities in teacher education and only rarely profoundly investigated how these factors affect competency development. Incorporating detailed measures related to the content addressed and the quality of learning opportunities may therefore contribute to uncovering the differential effects of learning opportunities on professional vision Insights into the quality of learning opportunities based on information on the addressed content, ratings of, or interviews with future teachers, instructors, supervisors, or mentors could provide a clearer picture of the effect of learning opportunities on professional vision development. For example, Stürmer, Könings, and Seidel (2015) showed that different contents addressed in seminars could influence professional vision in the first phase of teacher education. Furthermore, research has indicated that cognitive and affective-motivational individual prerequisites may predict future teachers' uptake of and engagement with the learning opportunities implemented in teacher education (Klusmann, 2013; Richter, 2013). This proposition is further supported by Article IV, which indicates that differences in prior knowledge, as indicated by the two teacher education phases, may account for the varying effectiveness of different instructional approaches in learning opportunities. Hence, considering the content and quality as well as individual prerequisites when investigating the role of learning opportunities may further our understanding of how teacher education can contribute to competence development. This may provide insights into how teacher education has to be adapted to meet the demands of the different teacher education phases for professional vision enhancement at different expertise stages.

In addition, further detailed considerations into how teacher education affects professional vision development are conceivable. For example, the issue of how the learning opportunities and teacher education phases affect the development of individual and simultaneous foci on teaching quality of professional vision can be investigated. Most studies have investigated the development of professional vision (e.g., Barenthien et al., 2023; Bastian et al., 2022) and the effect of learning opportunities (König et al., 2024) only for one focus of teaching quality or one knowledge category. However, Articles III and IV have indicated that future teachers at university typically focus on classroom management, while future teachers in the induction program rather focus on instructional support. The inclusion of different foci of professional vision may therefore offer closer insights into the effect of teacher education on competency development. Nevertheless, future teachers still have to learn to simultaneously focus on different aspects of the classroom (Dunekacke, 2016). Therefore, investigating how the teacher education phases affect the simultaneous focus of the teaching quality dimension may offer further insights into how future teachers integrate knowledge categories throughout teacher education. Future research should therefore investigate whether the teacher education phases may shift this strong focus on pedagogy to other foci of professional vision and how future teachers interconnect these foci throughout teacher education.

In conclusion, detailed measurements of the quantity and quality of learning opportunities, the characteristics and demands of the teacher education phases, as well as the individual prerequisites of future teachers could be implemented to investigate how teacher education affects professional vision development in closer detail. Furthermore, differentiated measures of professional vision could provide insights into how professional vision changes over time. For example, assessing the effect of teacher education on professional vision of multiple foci and the simultaneous focus of teaching quality, could help understand how the focus of professional vision shifts between the teacher education phases. At the same time, the level of detail regarding the determinants of teacher education and the assessment of professional vision should be carefully adjusted to align with the specific research objectives and the constructs under investigation. These detailed measurements could not only provide more insights into how professional vision develops but may also inform future investigations related to the development of other teaching competencies (e.g., knowledge, self-regulation, or beliefs). At the same time, the implications could provide information on how to design learning opportunities to fit expertise stages and the characteristics and demands of the teacher education phases.

Transferring Instructional Principles to the Ill-structured Domain of Teacher Education

The complex nature of teacher education and the competency of professional vision, combined with classroom videos as representations of practice, present unique characteristics that render this area particularly suitable for investigations into the conditions and limitations of transferring instructional principles to ill-structured domains (see also Martin, 2024). The findings of Articles II, III, and IV reveal inconsistent results and highlight the difficulty of bringing together the positive findings of instructional principles of educational psychology with ill-structured domains such as teacher education. Therefore, before providing guidelines on how to design interventions using instructional principles in combination with video-based analyses to enhance professional vision, more research into how instructional principles can be transferred to highly ill-structured domains is necessary. Hence, the succeeding sections provide some ideas on the aspects to be considered when investigating the transfer of instructional principles to the ill-structured domain of teacher education.

First, contrary to the assumption of cognitive load theory, where instructional principles seek to reduce extraneous load to help learners focus on the most relevant information, teacher education designed to enhance professional vision strongly emphasizes training these selection processes, primarily the ones involving noticing. Classroom videos provide an effective means of training this skill (e.g., Gold et al., 2021) and may display a great amount of intrinsic load because of their complexity (Doyle, 1989) and transience (Syring et al., 2015). In this context, the Articles (especially Article II) suggest that additional instructional materials may overload learners when they are not directly and immediately aligned with the classroom video. Therefore, the findings offer valuable insights by extending the results of classic research on cognitive load theory, which was conducted mainly in experimental laboratory studies, to teacher education settings. The findings highlight certain issues that may be related to generalizability and boundary conditions when transferring instructional principles to an ill-structured domain (see also Martin, 2024). Hence, under certain conditions, instructional principles may not remain effective. Therefore, the findings of this dissertation stress the need for future research to investigate the underlying reasons why the instructional principles did not offer the expected support for future teachers. A valuable next move could be to take a step back and conduct experimental research, including controlled laboratory studies. In contrast to highly ecological and externally valid quasi-experimental designs, laboratory experiments are better suited to uncovering clear cause–effect relationships. These studies could offer valuable insights into the extent to which instructional principles can be generalized and help identify the conditions under which they can be effectively applied in ill-structured domains. Furthermore, initial evidence indicates that instructional principles combined with video-based analyses may take effect during learning (Martin et al., 2022). By contrast, Article II did not find an effect of self-explanations on outcomes of professional vision. Hence, laboratory studies could more closely examine how learners interact with the learning material and investigate cognitive processing during the learning process. Therefore, experimental laboratory research examining the impact of instructional principles and identifying the conditions that support the development of professional vision could provide advancements for the field (König et al., 2022; Santagata et al., 2021).

Second, differentiated measures of individual prerequisites could further explain how the instructional principles may take effect in ill-structured domains. Initial studies (e.g., Farrell et al., 2024; Tannert et al., 2023) and the Articles that investigated the effectiveness of instructional principles implemented very broad measures of individual prerequisites and yielded inconsistent results. Most of these studies only investigated the overall cognitive load on learners but did not differentiate between extrinsic and intrinsic cognitive load. Implementing differentiated measures of extrinsic and intrinsic cognitive load (e.g., Klepsch et al., 2017) could provide further insights into how learners experience the complexity and transience of the classroom videos and the learning materials. In addition, the intrinsic load is based on learners' prior knowledge (Sweller, 1994; Sweller et al., 2011), which has been shown to influence the development of professional vision (Stürmer, Könings, & Seidel, 2015) and some instructional principles, have been suggested to be particularly effective for low prior knowledge learners (Kalyuga, 2007). Therefore, individual differences in prior knowledge may also affect the effectiveness of the instructional principles. Prior knowledge encompasses not only theoretical concepts but also prior classroom and teaching experience, as evidenced by the findings of Article IV, which suggest that teaching experience gained during the induction program may have influenced the effectiveness of instructional principles. By contrast, Article III revealed that distal factors may not have an influence on the effectiveness of instructional principles. Hence, the matter of which knowledge (i.e., declarative, procedural, strategic, or experiential, Shulman, 1986, 1987) influences the effectiveness of instructional principles remains unclear (see also Farrell, 2024). Thus, future research could explore how different types of prior knowledge may influence the effectiveness of instructional principles by measuring participants' prior knowledge more precisely and analyzing its impact during learning and on transfer tasks. As a result, by considering differentiated measures of prior knowledge when implementing instructional principles, future research may offer insights into how to adapt instructional principles to learners' aptitudes (Kalyuga, 2007; Kalyuga et al., 2000). Furthermore, insights into other individual prerequisites such as affective-motivational factors may also explain the reasons for the effectiveness of instructional principles. However, research on these factors is relatively scarce, and initial findings reveal inconsistent results (e.g., Farrell et al., 2024; Wilkes et al., 2022). Examining how these individual prerequisites influence the effectiveness of instructional principles may provide valuable insights into how to design effective interventions for ill-structured domains, as well as understanding how individual learners engage with and benefit from such learning opportunities.

Third, ill-structured domains generally address the different categories of knowledge and necessitate their integration. This integration typically takes time and practice to achieve. The findings of Article III and previous studies (Harr et al., 2014, 2015) yielded initial promising results that instructional tasks and prompts could support learners in integrating different knowledge categories; however, this outcome may have been at the expense of further developing in the respective categories of knowledge. The findings particularly indicate a weak focus on professional vision of instructional support, suggesting low degrees of pedagogical content knowledge. Hence, more learning opportunities that specifically target the enhancement of professional vision of instructional support may be needed. For instance, future teachers could engage in video-based analyses focused on students' ideas and contributions, thereby studying theoretical concepts and discussing them in relation to the classroom video with their peers and instructors (e.g., Barth-Cohen et al., 2018). Nevertheless, future teachers still have to learn to simultaneously analyze the multiple foci of teaching quality in classrooms (Dunekacke, 2016) to understand the complexity of classrooms. The area of teacher education is therefore a promising field for implementing instructional approaches drawn from the idea of *desirable difficulties*, in which learning is initially made harder to evoke in-depth cognitive processing to enhance long-term retention and transfer (Bjork & Bjork, 2020). The demand to integrate multiple foci in Article III already gives an initial approach for the implementation of *desirable difficulties*. Other possible training approaches could draw on evidence from distributed practice (i.e., spreading video-based analyses of several foci repeatedly over time), retrieval practice (i.e., self-testing instead of repeating the video-based analysis of multiple foci), varying conditions (i.e., analyzing different social contexts [e.g., partner work, individual work, plenary discussions]) or subjects [e.g., mathematics, science, language] in classroom videos) (Lipowsky et al., 2015; Schweppe, 2021). However, competency development in these approaches takes time and practice, and the Articles of this dissertation merely implement short-term intervention studies. The short-term interventions conducted in this dissertation are considered to be practical and feasible regarding time and resources and also display high ecological validity (Dunlosky et al., 2009); however, to fully understand how to enhance professional vision of different foci and their simultaneous focus, follow-up and longitudinal studies might offer more comprehensive insights into how instructional principles can strengthen this integration. With sufficient time for deliberate practice, the short-term trainings in the Articles could be expanded and improved. These future studies could also inform broader research on how to achieve knowledge integration in several professional settings.

In sum, transferring instructional principles to ill-structured domains is quite challenging. The inherent high intrinsic load, prior individual prerequisites of knowledge and affective-motivational factors, and the necessity to draw on the different categories of knowledge may impair the effectiveness of instructional principles in ill-structured domains. Future research therefore needs to investigate these boundary conditions, cognitive processing during learning, and long-term effects.

3.3.2 Implications for Teacher Education

Together with existing research findings, the Articles of this dissertation offer some suggestions for teacher education. The main goal throughout teacher education is to equip future teachers with competencies, such as professional vision, which are necessary for competent performance in the classroom (Blömeke et al., 2015). However, the pressing question of how future teachers can be effectively supported to develop professional vision throughout teacher education remains. The increasing research on the development of professional vision throughout teacher education can improve teacher training programs by clarifying the ways of addressing the different levels of expertise and demands in teacher education phases. The inconsistent evidence from research that aims to transfer findings on instructional principles of educational psychology to the ill-structured domain of teacher education may provide first implications for the design of practice-oriented learning opportunities, such as those including video-based analyses, which foster complex competencies such as professional vision.

If the goal is to develop professional vision throughout all teacher education phases, then a first implication for teacher education could be to ensure continuity throughout teacher education. Hence, the findings of Articles I and IV suggest that the demands and characteristics of the teacher education phases have to be considered in the development and enhancement of professional vision. To ensure continuous competency development, future teachers should be supported in transitioning from passive observation to actual performance in the classroom in the induction program. Hence, adequate instructional settings for practice-oriented learning opportunities should be adapted to the demands of the respective teacher education phases (Seidel, 2022; Seidel et al., 2024). In bachelor's studies, future teachers should acquire fundamental knowledge about the theoretical concepts of teaching quality. In master's studies, the concepts should be illustrated, for example, in classroom videos, and future teachers have to be able to analyze them; in the induction program, which includes teaching practice, they can use the theoretical concepts to reflect on teaching practice. Furthermore, as differences between the academic environment of the university and the community of teaching practice at the *Studienseminare* may hamper competency development, more coordination and alignment between the first and second teacher education phases may enhance (perceived) continuity in teacher education (see also König, Bremerich-Vos, et al., 2017). For example, Cramer (2014) seeks to dissolve the suggested theory-practice dualism in favor of a productive interweaving of theory and practice. Therefore, the continuous enhancement of professional vision throughout teacher education may be a means of bridging this dualism by connecting knowledge with teaching practice (Blömeke et al., 2015; Blömeke et al., 2022).

A second implication may relate to the high intrinsic load of the ill-structured domain of teacher education and the transience of classrooms displayed in the video (Star & Strickland, 2008; Syring et al., 2015). Evidence proposing inconsistent findings on the effectiveness of the instructional principles (see Articles II, III, and IV; e.g., Farrell et al., 2024; Gabel et al., 2023; Grub et al., 2022a; Martin et al., 2022) provides indications that learners may be overwhelmed with the multidimensionality, simultaneity, immediacy, unpredictability, and complexity of classrooms displayed in the videos (Doyle, 2006). As a result, the effectiveness of the instructional principles may have become limited. A possible remedy to this issue could include communicative and discursive approaches with peers and instructors. Studies have shown that when collaboratively conducting a task, collective working memory is increased (F. Kirschner et al., 2011), and the high cognitive load of an ill-structured domain is reduced on learners through the division of labor (P. A. Kirschner et al., 2018). For example, instead of merely studying the double-content example individually, future teachers could exchange their self-explanations and discuss them. With the guidance of the instructor, future teachers may delve more deeply into the double-content example and produce more productive self-explanations to transfer to their own video-based analyses. Hence, the implementation of increasingly discursive practices and exchanges between learners may enhance the effectiveness of the instructional principles. As another possible remedy to help learners deal with the intrinsic load, research on example-based learning in well-structured domains has suggested trainings that address elaboration processes when self-explaining examples (Stark et al., 2002) or the implementation of prompts that learners have to answer before they can proceed to the next step (Hummel & Nadolski, 2002; Renkl & Atkinson, 2002) can enhance learning outcomes. These studies suggest that emphasizing self-explanations as a part of the learning task may help learners deal with the intrinsic load of the ill-structured domain. However, the issue of whether these findings can be transferred to ill-structured and highly complex domains such as teacher education remains unclear.

A third implication is that future teachers require more substantial support and more time for linking pedagogy with content throughout teacher education. This implication goes hand in hand with current demands on teacher education to foster a stronger coherence and integration of pedagogy and content throughout teacher education (Hellmann et al., 2019; M. Meier et al., 2018). This may be achieved through the inclusion of practice-oriented learning opportunities, such as video-based analyses, as well as the use of instructional principles over the course of teacher education (Renkl & Nückles, 2006) and the implementation of *desirable difficulties* for long-term retention and transfer (Bjork & Bjork, 2020). In recent years, teacher education research has proposed curricula that aim to connect pedagogy and content (M. Meier et al., 2018). Research on instructional principles has suggested that instructional principles should be combined into more prolonged and extensive training programs when training complex competencies in ill-structured domains (van Merriënboer & Sweller, 2005). The central issue in teacher education however is that pedagogy and content are taught in separate courses, and knowledge connected to these contents remains separate (Ball, 2000; Ball & Bass, 2000). This division leads to the compartmentalization of knowledge, in which different categories of knowledge remain separate with minimum interconnection. To counteract the compartmentalization of knowledge, Hellmann et al. (2021) have proposed an opportunity-usage model of teacher education, in which teacher educators, learning opportunities, future teachers' perception of coherence, and their uptake should form a unison that provides future teachers with a strong link between pedagogy and content throughout teacher education. Several approaches and seminar concepts have been proposed to achieve this link (Hellmann et al., 2019). Specifically, regarding video-based analyses, the findings of Article III, together with other existing approaches (e.g., Hörter et al., 2020; Zucker et al., 2024), provide initial information on how to design learning opportunities that aim at knowledge integration. For example, Hörter et al. (2020) have proposed a seminar concept in which contents from mathematics didactics and pedagogy are addressed and situated through classroom videos. Digital learning tools constitute another option to increase the integration of pedagogy and content (Zucker et al., 2024). In these tools, individualized support can be implemented to analyze multiple teaching quality dimensions. These formats may be an initial step in designing a curriculum that explicitly aims to achieve more integrated and flexible knowledge as an indicator of teaching expertise (derived from J. R. Anderson, 1983; Berliner, 2001). Additionally, to counteract the compartmentalization of knowledge, teacher educators may also use low-stakes and economic means to increase the link between content and pedagogy. Research on learning and instruction has proposed the implementation of prompts and instructional tasks that seek to connect the different categories of knowledge throughout teacher education to support future teachers' knowledge integration (see Article III; see also Harr et al., 2014, 2015). Thereby, future teachers could practice connecting different knowledge categories and gain interconnected and flexible knowledge, which is easily applicable when teaching in a classroom.

Conclusively, initial implications for teacher education drawn from the contributions of this dissertation include a stronger conflation between the first and second teacher education phases, supporting future teachers in dealing with the high intrinsic load of classrooms, and a stronger integration of content and pedagogy throughout teacher education. The first steps towards these goals have already been undertaken, but more research is necessary to draw clear implications for teacher education.

3.4 Limitations of the Dissertation and Outlook

Aside from the previously noted strengths and implications, this dissertation also exhibits conceptual and methodological limitations that provide valuable opportunities for future research. The limitations predominantly address the consideration of various determinants of teacher education, methodological improvements (e.g., investigations of cause–effect relationships and long-term effects), the recognition of different contexts, and the implementation of professional vision in teaching practice when investigating professional vision development and enhancement.

Considering Different Determinants of Teacher Education

In this dissertation, specific determinants of teacher education affecting the development and enhancement of professional vision were considered, and previous findings (Stürmer, Könings, & Seidel, 2015) have identified relevant factors influencing professional vision. However, in the Articles, only a few factors were considered (e.g., learning opportunities and teacher education phases). According to models related to teacher competency development (Kaiser & König, 2019) as well as research on professional vision (Stürmer, Könings, & Seidel, 2015), the development of professional vision is affected by several determinants of teacher education. The question of how other determinants influence professional vision therefore arises.

Chapter 1.2 briefly addresses possible determinants and factors that affect professional vision and could further explain professional vision development. Several projects investigating teacher competency development (e.g., COACTIV or TEDS-M) have proposed that aside from teacher education phases and learning opportunities, other determinants of teacher education play a major role in competency development (Kunter, Klusmann, et al., 2013). Existing research on professional development, however, has predominantly only considered learning opportunities and teacher education phases. Further determinants proposed by models on teacher competency development (Kaiser & König, 2019), such as differing institutional characteristics between universities and schools and dissimilar individual prerequisites, may explain further variance in professional vision development and enhancement. For example, institutional characteristics of the universities, the organization of the induction program, and the communication between *Studienseminare* and schools may affect professional vision development. Initial studies implemented multi-level designs to consider these differences and found that intraindividual differences between institutions affect competency development (e.g., König et al., 2024). However, to this day, research on the differences in institutional characteristics and their effects on competency development remains limited. Moreover, some individual prerequisites could further explain variance in professional vision development. Individual prerequisites, including cognitive prerequisites, such as prior knowledge or prior learning opportunities (e.g., tutoring experience, seminars, internships, etc.), as well as affective-motivational prerequisites (e.g., interest, motivation, self-efficacy), have been suggested to directly influence professional vision (Stürmer, Könings, & Seidel, 2015). For example, a future teacher who is highly interested in how to implement teaching quality may see more value to analyze teaching quality in classroom videos. Although Articles I and III have included some individual prerequisites as predictors for the development of professional vision, more research is necessary to evaluate their effect on professional vision development. Hence, investigating the effect of institutional characteristics and individual prerequisites may provide more insights into professional vision development. Furthermore, by examining profiles that integrate various determinants of teacher education (e.g., characteristics and demands of the teacher education phases, institutional characteristics, learning opportunities, and individual prerequisites), we may uncover common patterns among future teachers' professional vision development and gain more insights into how the factors of teacher education contribute to competency development and teacher education effectiveness.

In existing research on professional vision enhancement, the effects of individual prerequisites were predominantly investigated as predictors, although their interacting and moderating effects could more accurately explain professional vision enhancement. This is particularly true because the aptitude of cognitive or affective-motivational prerequisites has been shown to influence the uptake of learning opportunities (Richter, 2013). Studies have indicated that learners' prior knowledge and interest affect the uptake of learning opportunities. For example, a student that is highly interested in teaching quality may engage more with the instructional principles to acquire knowledge about teaching quality. Initial studies have suggested that individual prerequisites can influence learning with instructional principles in the enhancement of professional vision (e.g., Farrell et al., 2024; Martin et al., 2023). Thus, the inclusion of aptitude–treatment interactions (Snow, 1991) based on learners' prior knowledge and motivation could further explain under which conditions and individual prerequisites instructional principles become effective in ill-structured domains such as teacher education. The inclusion of these moderating effects could also shed light on the effectiveness of training programs (see König et al., 2025) as well as on boundary conditions of instructional principles in ill-structured domains (e.g., Farrell et al., 2024). This is particularly important as cognitive load theory suggests that learners with high prior knowledge experience lower intrinsic load and may be able to process instructional principles more effectively (Sweller, 1988). However, aptitude-treatment interactions remain scarce when investigating instructional principles in ill-structured domains, and research on how individual prerequisites may affect the effectiveness of instructional principles in ill-structured domains is necessary.

Methodological Improvements

As Articles II, III, and IV only included short-term interventions, the long-term and follow-up effects were not considered. However, Article I suggested that professional vision develops throughout teacher education. Based on the assumption that deliberate practice is necessary for competency development (Ericsson et al., 1993), the development of complex competencies such as professional vision takes time and practice. Therefore, the mixed and inconsistent effects of Articles II, III, and IV may result in long-term effects on future teachers' professional vision development. Most intervention studies on instructional design based on cognitive load theory conducted short-term experimental laboratory studies. Similarly, current research on the enhancement of professional vision using video-based analyses has predominantly investigated effects of the instructional principles in short-term interventions (e.g., Gabel et al., 2023; Grub et al., 2022a; Martin et al., 2023). By contrast, studies in the context of teacher education generally conducted interventions throughout entire programs, courses, or internships and were therefore typically quasi-experimental (König et al., 2025). The same holds for studies that specifically examined the enhancement of professional vision within teacher education, leading to the implementation of more extended training programs (e.g., Gold et al., 2021; see Santagata et al., 2021), for instance, across an entire semester. This difference between the two research strands may have resulted from the fact that educational psychology typically focuses on identifying clear cause–effect relationships, whereas teacher education takes a rather practical approach and aims to improve future teachers' competency development over time at university and in the induction program. However, future teachers typically struggle to relate their knowledge to the teaching practice displayed in the videos (Blomberg et al., 2011; Korthagen & Kessels, 1999; see also Article II); hence, with deliberate practice, a stronger link between theory and practice can be established and professional vision can develop. Additionally, the instructional principles outlined in Articles II and III place significant demands (i.e., desirable difficulties) on future teachers (e.g., deriving expert features from the double-content example and applying them to their own video-based analyses), to which they may not be accustomed. Engaging in the long-term deliberate practice of this complex cognitive processing may aid in professional vision development. Thus, investigating long-term and follow-up effects could enhance our understanding of how instructional principles, combined with video-based analyses, may have lasting impacts. By investigating these long-term effects, we may detect individual trajectories in the enhancement of professional vision.

Some evidence suggests differences in individual learning paths when analyzing classroom videos (Oellers et al., 2024). Together with existing research (see Chapter 1.3.2) (e.g., Kumschick et al., 2017; Tannert et al., 2023; Wilkes et al., 2022), the findings of this dissertation cannot not yet confirm this assumption. Hence, an innovative approach that could provide insights into the effectiveness of instructional principles in the enhancement of professional vision through video-based analyses could be the implementation of learning analytics that identify subgroups that may benefit the most or the least from these instructional principles. Initial studies have suggested differences in learning from video-based analyses depending on learners' heightened attention to specific events in the classroom videos as well as on the different approaches that learners adopted to analyze classroom videos (Oellers et al., 2024). This could contribute to research by generating detailed information about learners' uptake of and engagement with the learning opportunity and the instructional principles during learning (e.g., through the assessment of processing time) and its effect on professional vision.

Hence, as König et al. (2025) have argued, intervention studies in the context of teacher education need methodological improvements. For example, they argue for the inclusion of control groups, analysis of long-term effects, and operationalization of the effect chain. Moreover, innovative data analyses such as learning analytics may provide a more thorough basis for investigating how future teachers actually interact with the learning environment provided. Incorporating these elements into intervention studies aimed at enhancing professional vision could yield more insights into how instructional principles can shape instructional settings involving video-based analyses and thus better analyze the effectiveness of these principles in ill-structured domains such as teacher education.

Considering Different Contexts

As professional vision is considered a domain and situation-specific competency (Blömeke et al., 2015), its development, and the effectiveness of learning opportunities may be dependent on the specific subject. The Articles of this dissertation predominantly implemented classroom videos of elementary science (Articles I and II) and mathematics classrooms (Articles III and IV). As professional vision draws on teachers' professional knowledge (Blömeke et al., 2015), differences in future teachers' professional knowledge may yield differential outcomes depending on the subject. For the interpretation of the findings, a necessary step is therefore to consider subject- and situation-specific demands and conditions on future teachers when conducting video-based analyses by taking into account the teachers' and students' actions and contextual factors of the classroom displayed in the classroom videos. This would also meet demands for a domain-specific perspective on teaching and learning (Berliner, 1985).

For one, the question of how the findings are generalizable across different subjects remains open. Certain generalizability may be indicated by the findings of Articles I and IV, which, despite differing subjects, point to notable differences between future teachers at university and in the induction program. Although both samples of Articles I and IV come from the field of natural sciences, initial evidence reveals differences in professional vision between several subjects (Blomberg et al., 2011). For example, effective instructional support, such as the implementation of cognitively activating tasks, manifests itself considerably differently in English classes than in Mathematics classes. Research on professional vision was conducted predominantly related to natural science classrooms (König et al., 2022). Extending the research to other subjects is therefore a necessary next step. Furthermore, research has also indicated that professional vision is a skill that is not only a subject-specific skill but also is dependent on the topic and the content imparted (Todorova et al., 2017). This proposition suggests that professional vision of instructional support may also draw on topic-specific aspects of content and pedagogical content knowledge (see Gess-Newsome, 2015). Therefore, next to general aspects of professional vision, considering these subject- and topic-specific aspects may provide comprehensive insight into which aspects of professional vision develop and can be enhanced.

Professional vision development may vary not only between subjects and topics but also between different classroom situations, for example, between different social settings in the classroom (e.g., plenum, individual, partner, or group work). Depending on the situation in the classroom displayed in the classroom videos, aspects of teaching quality may manifest themselves in different ways in different contexts (Bohl, 2017). This situation-specificity is indicated by research on the assessment of professional vision (e.g., video tests), which shows that the situation specificity of the different classroom videos implemented has to be accounted for when measuring professional vision (e.g., Gold & Holodynski, 2017). Therefore, (future) teachers could analyze classroom videos differently depending on the context. For instance, when individual work phases are viewed in the video professional vision of instructional support may become more important, as the situation largely demands the teacher to support their students' learning. By contrast, in plenum phases professional vision of classroom management may become more relevant, as the situation mainly demands the teacher to manage students' attention and behavior. However, existing research on the development and enhancement of professional vision has not yet fully considered this close connection to specific situations displayed in the classroom video.

Hence, professional vision may depend on subject-, topic-, and situation-specific aspects and may result in differential effects in professional vision development and enhancement. Considering these aspects may serve as an important leverage point for future studies to investigate differential effects on professional vision development and enhancement between subjects, topics, and situations, as well as provide an in-depth understanding of the processes of professional vision.

Implementing Professional Vision in Teaching Practice

Studies indicate that higher degrees of professional vision result in better classroom performance (Blömeke et al., 2022; Kersting et al., 2012; Roth et al., 2011), but this dissertation did not investigate whether the improvements in future teachers' professional vision actually resulted in better classroom performance. However, models related to complex skill acquisition, such as the learning cycle by McDonald et al. (2013) and the ACT-R (Adaptive Control of Thought – Rational; J. R. Anderson, 1982), propose competency acquisition should always entail a phase of enactment. Thus, recent demands on teacher education require a stronger focus on practicing noticing, reasoning, and generating alternatives of action when actually teaching in classrooms (Nückles & Kleinknecht, 2024). However, as of today, the issue of how future teachers can be effectively supported in using professional vision for performance in classrooms remains unclear. Findings propose that although enhancing professional vision through video-based analysis is relatively straightforward (Santagata et al., 2021), future teachers generally struggle to transfer professional vision to teaching practice (Pouta et al., 2021). Preliminary findings suggest that elaborate training programs with strong instructional support through multiple feedback cycles (Descoeudres et al., 2024) or a combination of several instructional principles (Hipp et al., 2024; Nückles & Kleinknecht, 2024) can support future teachers in transferring professional vision into teaching practice. Hence, future research should further investigate how specific instructional approaches and their combination effectively enhance professional vision in different teacher education phases and how they affect teaching performance and its effects on teaching quality (see also König et al., 2025).

3.5 Conclusion

In view of the high relevance of professional vision for effective teaching practice, research on teacher education has investigated the development and enhancement of professional vision. Therefore, the first goal of this dissertation was to investigate how professional vision develops throughout teacher education. However, the main goal was to investigate how professional vision can be enhanced through video-based analyses and how instructional settings can be informed by the instructional principles of education psychology. The findings of this dissertation highlight fundamental differences in future teachers' expertise stages, in the characteristics of the teacher education phases, and in the demands placed on future teachers in each teacher education phase. The findings also suggest that instructional principles of educational psychology cannot easily be transferred to ill-structured domains such as teacher education, which underscores further consideration of intrinsic load inherent in ill-structured domains. In addition, the findings indicate that future teachers need increased instructional support to simultaneously focus on several aspects of teaching quality, indicating their struggle to achieve integrated and flexible knowledge.

The findings of this dissertation represent an important step toward an improved understanding of how professional vision develops and can be enhanced. It highlights the consideration of the characteristics and demands of the teacher education phases when investigating the development and enhancement of professional vision. On a broader level, the dissertation contributes to a better understanding of how the instructional principles of educational psychology can be transferred to ill-structured domains such as teacher education, and more specifically how future research in teacher education and educational psychology can be brought together to inform the design of learning opportunities in teacher education. Moreover, it provides initial insights into how instructional principles of educational psychology inform teacher education on how to connect content with pedagogy. In this dissertation, however, only a small number of research questions are explored, which relate to the development and enhancement of future teachers' professional vision.

Further research on professional vision may consider other determinants of teacher education, such as institutional characteristics and individual prerequisites; the uptake of and engagement with the provided learning opportunities; the subject-, topic-, and situation-specificity of professional vision; and how acquired professional vision can be used in teaching practice. Research on transferring instructional principles to ill-structured domains such as teacher education may consider the inherent intrinsic load of the ill-structured domain and investigate clear cause–effect relationships in laboratory studies and long-term effects. In addition, future teachers should be increasingly supported in connecting content with pedagogy, thereby implying a necessity for further research on the enhancement of highly complex competencies such as professional vision with multiple foci. Conclusively, research that can provide clear guidelines on how to use instructional principles for designing instructional settings around video-based analyses and develops trainings that tailor instructional approaches to different expertise stages, teacher education phases, and individual prerequisites is necessary.

References II

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review*, *89*(4), 369–406. https://doi.org/10.1037//0033-295x.89.4.369

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior*, *22*(3), 261–295. https://doi.org/10.1016/s0022-5371(83)90201-3

Ayres, P. (2013). Can the isolated-elements strategy be improved by targeting points of high cognitive load for additional practice? *Learning and Instruction*, *23*, 115–124. https://doi.org/10.1016/j.learninstruc.2012.08.002

Ball, D. L. (2000). Bridging practices. *Journal of Teacher Education*, *51*(3), 241–247. https://doi.org/10.1177/0022487100051003013

Ball, D. L., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 83–104). Ablex Publishing.

Barenthien, J., Fiebranz, A., Todorova, M., Möller, K., & Steffensky, M. (2023). Development of professional vision and pedagogical content knowledge during initial teacher education. *International Journal of Educational Research*, *119*, 102186. https://doi.org/10.1016/j.ijer.2023.102186

Barth-Cohen, L. A., Little, A. J., & Abrahamson, D. (2018). Building reflective practices in a pre-service math and science teacher education course that focuses on qualitative video analysis. *Journal of Science Teacher Education*, *29*(2), 83–101. https://doi.org/10.1080/1046560X.2018.1423837

Bastian, A., Kaiser, G., Meyer, D., Schwarz, B., & König, J. (2022). Teacher noticing and its growth toward expertise: An expert–novice comparison with pre-service and in-service secondary mathematics teachers. *Educational Studies in Mathematics*, *110*(2), 205–232. https://doi.org/10.1007/s10649-021-10128-y

Bastian, A., König, J., Weyers, J., Siller, H.-S., & Kaiser, G. (2024). Effects of teaching internships on preservice teachers' noticing in secondary mathematics education. *Frontiers in Education*, *9*, 1360315. https://doi.org/10.3389/feduc.2024.1360315

Baumgartner, M., Oesterhelt, V., & Reuker, S. (2020). Konstruktion und Validierung eines multidimensionalen Beobachtungsinstruments zur Erfassung der klassenführungsbezogenen Performanzen von sportunterrichtenden Lehrkräften (KlaPe-Sport) [Construction and validation of a multidimensional observation instrument for assessing the classroom management performances of physical education teachers (KlaPe-Sport).]. *German Journal of Exercise and Sport Research*, *50*(4), 511–522. https://doi.org/10.1007/s12662-020-00675-6

Berliner, D. C. (1985). Chapter 7 – Effective classroom teaching: The necessary but not sufficient condition for developing exemplary schools. In G. R. Austin & H. Garber (Eds.), *Research on exemplary schools* (pp. 127–154). Elsevier. https://doi.org/10.1016/B978-0-12-068590-5.50013-9

Berliner, D. C. (1988). *The development of expertise in pedagogy*. AACTE Publications. https://eric.ed.gov/?id=ed298122

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research*, *35*(5), 463–482. https://doi.org/10.1016/s0883-0355(02)00004-6

Bjork, R. A., & Bjork, E. L. (2020). Desirable difficulties in theory and practice. *Journal of Applied Research in Memory and Cognition*, *9*(4), 475–479. https://doi.org/10.1016/j.jarmac.2020.09.003

Blomberg, G., Renkl, A., Gamoran Sherin, M., Borko, H., & Seidel, T. (2013). Five research-based heuristics for using video in pre-service teacher education. *Journal for Educational Research Online*, *5*(1), 90–114. https://doi.org/10.25656/01:8021

Blomberg, G., Stürmer, K., & Seidel, T. (2011). How pre-service teachers observe teaching on video: Effects of viewers' teaching subjects and the subject of the video. *Teaching and Teacher Education*, *27*(7), 1131–1140. https://doi.org/10.1016/j.tate.2011.04.008

Blömeke, S., Busse, A., Kaiser, G., König, J., & Suhl, U. (2016). The relation between content-specific and general teacher knowledge and skills. *Teaching and Teacher Education*, *56*, 35–46. https://doi.org/10.1016/j.tate.2016.02.003

Blömeke, S., Gustafsson, J.-E., & Shavelson, R. J. (2015). Beyond dichotomies. *Zeitschrift Für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Blömeke, S., Jentsch, A., Ross, N., Kaiser, G., & König, J. (2022). Opening up the black box: Teacher competence, instructional quality, and students' learning progress. *Learning and Instruction*, *79*, 101600. https://doi.org/10.1016/j.learninstruc.2022.101600

Bohl, T. (2017). Umgang mit Heterogenität im Unterricht: Forschungsbefunde und didaktische Implikation [Dealing with heterogeneity in the classroom: Research findings and didactic implications]. In T. Bohl, J. Budde, & M. Rieger-Ladich (Eds.), *Umgang mit Heterogenität in Schule und Unterricht. Grundlagentheoretische Beiträge, empirische Befunde und didaktische Reflexionen* (pp. 257–273). Klinkhardt UTB.

Bullough, R. V., & Draper, R. J. (2004). Making sense of a failed triad. *Journal of Teacher Education*, *55*(5), 407–420. https://doi.org/10.1177/0022487104269804

Chitpin, S., Simon, M., & Galipeau, J. (2008). Pre-service teachers' use of the objective knowledge framework for reflection during practicum. *Teaching and Teacher Education*, *24*(8), 2049–2058. https://doi.org/10.1016/j.tate.2008.04.001

Cortina, K. S., & Thames, M. H. (2013). Teacher education in Germany. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 49–62). Springer. https://doi.org/10.1007/978-1-4614-5149-5_3

Cramer, C. (2014). Theorie und Praxis in der Lehrerbildung: Bestimmung des Verhältnisses durch Synthese von theoretischen Zugängen, empirischen Befunden und Realisierungsformen [Theory and practice in teacher education: Defining the relationship through synthesis of theoretical approaches, empirical findings, and implementation forms]. *DDS - Die Deutsche Schule*, *106*(4), 344–357. https://elibrary.utb.de/doi/pdf/10.31244/dds.2014.04.04

Descoeudres, M., Baumgartner, M., Baumberger, J., & Mathis, R. (August 2024). *Fernsupervision von Praktikanten im Sportunterricht: Möglichst effektive hochschulische Lehre im Sportunterricht* [Remote Supervision of Interns in Physical Education: Maximizing Effective University Teaching in Physical Education]. NFBS-Tagung 2024. Digitale und naturnahe Lernwelten. (Effektive) Hochschulische Lehre im Fachbereich Bewegung und Sport, Rorschach. http://hdl.handle.net/20.500.12162/7759

Doyle, W. (1989). Classroom management techniques. In O. C. Moles (Ed.), *Strategies to reduce student misbehavior* (pp. 11–31). Office of Research, Office of Educational Research and Improvement, U.S. Department of Education.

Doyle, W. (2006). Ecological approaches to classroom management. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook of classroom management* (pp. 107–136). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203874783-11

Dunekacke, S. (2016). *Mathematische Bildung in Alltags- und Spielsituationen begleiten* [Supporting mathematics education in everyday and play situations] [Dissertation]. Humboldt-Universität zu Berlin, Berlin. https://doi.org/10.18452/17580

Dunlosky, J., Bottirole, S., & Hartwig, M. (2009). Sins commited in the name of ecological validity: A call for representative design in education science. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *The educational psychology series. Handbook of metacognition in education* (pp. 430–440). Routledge.

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*(3), 363–406. https://doi.org/10.1037//0033-295x.100.3.363

Eßling, I., Todorova, M., Sunder, C., Steffensky, M., & Meschede, N. (2023). The development of professional vision in pre-service teachers during initial teacher education and its relationship to beliefs about teaching and learning. *Teaching and Teacher Education*, *132*, 104250. https://doi.org/10.1016/j.tate.2023.104250

Fajet, W., Bello, M., Leftwich, S. A., Mesler, J. L., & Shaver, A. N. (2005). Pre-service teachers' perceptions in beginning education classes. *Teaching and Teacher Education*, *21*(6), 717–727. https://doi.org/10.1016/j.tate.2005.05.002

Farrell, M. (2024). *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* [Dissertation]. Technical University of Munich, München. https://mediatum.ub.tum.de/1730637

Farrell, M., Martin, M., Böheim, R., 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*, *52*(6), 879–917. https://doi.org/10.1007/s11251-024-09662-y

Fischer, F., Bauer, E., Seidel, T., Schmidmaier, R., Radkowitsch, A., Neuhaus, B. J., Hofer, S. I., Sommerhoff, D., Ufer, S., Kuhn, J., Küchemann, S., Sailer, M., Koenen, J., Gartmeier, M., Berberat, P., Frenzel, A., Heitzmann, N., Holzberger, D., Pfeffer, J., . . . Fischer, M. R. (2022). Representational scaffolding in digital simulations – Learning professional practices in higher education. *Information and Learning Sciences*, *123*(11/12), 645–665. https://doi.org/10.1108/ILS-06-2022-0076

Gabel, S., Keskin, Ö., & Gegenfurtner, A. (2024). Comparing the effects of a specific task instruction and prompts on pre-service teachers' noticing of classroom management situations. *Zeitschrift Für Erziehungswissenschaft*, 1–19. https://doi.org/10.1007/s11618-024-01276-x

Gabel, S., Keskin, Ö., Kollar, I., Lewalter, D., & Gegenfurtner, A. (2023). Guiding pre-service teachers' visual attention through instructional settings: An eye-tracking study. *Frontiers in Education*, *8*, Article 1282848. https://doi.org/10.3389/feduc.2023.1282848

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK Summit. In A. Berry, P. Friedrichsen, & J. Loughran (Eds.), *Re-examining pedagogical content knowledge in science education* (pp. 38–52). Routledge. https://doi.org/10.4324/9781315735665-8

Gold, B., & Holodynski, M. (2017). Using digital video to measure the professional vision of elementary classroom management: Test validation and methodological challenges. *Computers & Education*, *107*, 13–30. https://doi.org/10.1016/j.compedu.2016.12.012

Gold, B., Müller, M. M., Weber, K. E., & Prilop, C. N. (2024). Characteristics and validation of video-based standardised instruments measuring professional vision: A closer look at the predictive validity of different task formats. In A. Gegenfurtner & R. Stahnke (Eds.), *Teacher professional vision: Theoretical and methodological advances* (pp. 89–108). Routledge. https://doi.org/10.4324/9781003370901-10

Gold, B., Pfirrmann, C., & Holodynski, M. (2021). Promoting professional vision of classroom management through different analytic perspectives in video-based learning environments. *Journal of Teacher Education*, *72*(4), 431–447. https://doi.org/10.1177/0022487120963681

Grossman, P. L. (2021). *Teaching core practices in teacher education*. Harvard Education Press.

Grossman, P. L., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching*, *15*(2), 273–289. https://doi.org/10.1080/13540600902875340

Grub, A.-S., Biermann, A., Lewalter, D., & Brünken, R. (2022a). Professional knowledge and task instruction specificity as influencing factors of prospective teachers' professional vision. *Teaching and Teacher Education*, *109*, 103517. https://doi.org/10.1016/j.tate.2021.103517

Grub, A.-S., Biermann, A., Lewalter, D., & Brünken, R. (2022b). Professional vision and the compensatory effect of a minimal instructional intervention: A quasi-experimental eye-tracking study with novice and expert teachers. *Frontiers in Education*, *7,* Article 890690. https://doi.org/10.3389/feduc.2022.890690

Harr, N., Eichler, A., & Renkl, A. (2014). Integrating pedagogical content knowledge and pedagogical/psychological knowledge in mathematics. *Frontiers in Psychology*, *5*, 924. https://doi.org/10.3389/fpsyg.2014.00924

Harr, N., Eichler, A., & Renkl, A. (2015). Integrated learning: Ways of fostering the applicability of teachers' pedagogical and psychological knowledge. *Frontiers in Psychology*, *6*, 738. https://doi.org/10.3389/fpsyg.2015.00738

Hashweh, M. Z. (1987). Effects of subject-matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education*, *3*(2), 109–120. https://doi.org/10.1016/0742-051x(87)90012-6

Hellmann, K. A., Kreutz, J., Schwichow, M., & Zaki, K. (Eds.). (2019). *Kohärenz in der Lehrerbildung* [Coherence in teacher education]. Springer. https://doi.org/10.1007/978-3-658-23940-4

Hellmann, K. A., Ziepprecht, K., Baum, M., Glowinski, I., Grospietsch, F., Heinz, T., Masanek, N., & Wehner, A. (2021). Kohärenz, Verzahnung und Vernetzung. Ein Angebots-Nutzungs-Modell für die hochschulische Lehrkräftebildung [Coherence, integration, and interconnection: An opportunity-use model for university teacher education]. *Lehrerbildung Auf Dem Prüfstand*, *14*(2), 311–332.

Helmke, A. (2009). *Unterrichtsqualität und Lehrerprofessionalität: Diagnose, Evaluation und Verbesserung des Unterrichts* [Instructional quality and teacher professionality: diagnosis,]. Klett-Kallmeyer.

Hipp, H., Holstein, A., Kleinknecht, M., & Nückles, M. (August 2024). *How can the acquisition of complex teaching skills be optimally fostered?* University of Freiburg; Leuphana University Lüneburg. EARLI SIG 6 & SIG 7, Tübingen.

Hörter, P., Gippert, C., Holodynski, M., & Stein, M. (2020). Klassenführung und Fachdidaktik im (Anfangs-)Unterricht Mathematik erfolgreich integrieren – Konzeption einer videobasierten Lehrveranstaltung zur Förderung der professionellen Unterrichtswahrnehmung [Successfully integrating classroom management and subject didactics in (elementary) mathematics instruction: Conceptualization of a video-based course to promote professional classroom observation]. *Herausforderung Lehrer*innenbildung - Zeitschrift zur Konzeption, Gestaltung und Diskussion (HLZ)*, *3*(1), 256–282. https://doi.org/10.4119/hlz-2551

Hummel, H. G., & Nadolski, R. J. (2002). Cueing for schema construction: Designing problem-solving multimedia practicals. *Contemporary Educational Psychology*, *27*(2), 229–249. https://doi.org/10.1006/ceps.2001.1089

Kaiser, G., Blömeke, S., König, J., Busse, A., Döhrmann, M., & Hoth, J. (2017). Professional competencies of (prospective) mathematics teachers – Cognitive versus situated approaches. *Educational Studies in Mathematics*, *94*(2), 161–182. https://doi.org/10.1007/s10649-016-9713-8

Kaiser, G., & König, J. (2019). Competence measurement in (mathematics) teacher education and beyond: Implications for policy. *Higher Education Policy*, *32*(4), 597–615. https://doi.org/10.1057/s41307-019-00139-z

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review*, *19*(4), 509–539. https://doi.org/10.1007/s10648-007-9054-3

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist*, *38*(1), 23–31. https://doi.org/10.1207/s15326985ep3801_4

Kalyuga, S., Chandler, P., & Sweller, J. (2000). Incorporating learner experience into the design of multimedia instruction. *Journal of Educational Psychology*, *92*(1), 126–136. https://doi.org/10.1037//0022-0663.92.1.126

Kersting, N. B., Givvin, K. B., Thompson, B. J., Santagata, R., & Stigler, J. W. (2012). Measuring usable knowledge: Teachers' analyses of mathematics classroom videos predict teaching quality and student learning. *American Educational Research Journal*, *49*(3), 568–589. https://doi.org/10.3102/0002831212437853

Kester, L., Kirschner, P. A., & van Merriënboer, J. J. (2006). Just-in-time information presentation: Improving learning a troubleshooting skill. *Contemporary Educational Psychology*, *31*(2), 167–185. https://doi.org/10.1016/j.cedpsych.2005.04.002

Kim, L. E., & Klassen, R. M. (2018). Teachers' cognitive processing of complex school-based scenarios: Differences across experience levels. *Teaching and Teacher Education*, *73*, 215–226. https://doi.org/10.1016/j.tate.2018.04.006

Kirschner, F., Paas, F., & Kirschner, P. A. (2011). Task complexity as a driver for collaborative learning efficiency: The collective working-memory effect. *Applied Cognitive Psychology*, *25*(4), 615–624. https://doi.org/10.1002/acp.1730

Kirschner, P. A., Sweller, J., Kirschner, F., & Zambrano R, J. (2018). From cognitive load theory to collaborative cognitive load theory. *International Journal of Computer-Supported Collaborative Learning*, *13*(2), 213–233. https://doi.org/10.1007/s11412-018-9277-y

Klemenz, S., König, J., & Schaper, N. (2019). Learning opportunities in teacher education and proficiency levels in general pedagogical knowledge: New insights into the accountability of teacher education programs. *Educational Assessment, Evaluation and Accountability*, *31*(2), 221–249. https://doi.org/10.1007/s11092-019-09296-6

Klepsch, M., Schmitz, F., & Seufert, T. (2017). Development and validation of two instruments measuring intrinsic, extraneous, and germane cognitive load. *Frontiers in Psychology*, *8*, 1997. https://doi.org/10.3389/fpsyg.2017.01997

Klusmann, U. (2013). Individual characteristics of prospective teachers. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 311–319). Springer. https://doi.org/10.1007/978-1-4614-5149-5_15

König, J., Bremerich-Vos, A., Buchholtz, C., Lammerding, S., Strauß, S., Fladung, I., & Schleiffer, C. (2017). Modelling and validating the learning opportunities of preservice language teachers: On the key components of the curriculum for teacher education. *European Journal of Teacher Education*, *40*(3), 394–412. https://doi.org/10.1080/02619768.2017.1315398

König, J., Darge, K., Kramer, C., Ligtvoet, R., Lünnemann, M., Podlecki, A.-M., & Strauß, S. (2018). Das Praxissemester als Lerngelegenheit: Modellierung lernprozessbezogener Tätigkeiten und ihrer Bedingungsfaktoren im Spannungsfeld zwischen Universität und Schulpraxis [The practical semester as a learning opportunity: Modeling learning process-related activities and their determinants in the tension between university and school practice]. In J. König, M. Rothland, & N. Schaper (Eds.), *Learning to practice, learning to reflect?* (pp. 87–114). Springer. https://doi.org/10.1007/978-3-658-19536-6_3

König, J., Heine, S., Weyers, J., Arntz, C.-G., Kramer, C., Strauß, S., Gerhard, K., Mühle, J., Engartner, T., Großschedl, J., Hanisch, C., Hanke, P., Hennemann, T., Jost, J., Kaspar, K., & Rott, B. (2025). Effectiveness of interventions in teacher education: Synthesis of reviews (2010–2024). Research Square. https://doi.org/10.21203/rs.3.rs-5771808/v1

König, J., & Kramer, C. (2016). Teacher professional knowledge and classroom management: On the relation of general pedagogical knowledge (GPK) and classroom management expertise (CME). *ZDM*, *48*(1-2), 139–151. https://doi.org/10.1007/s11858-015-0705-4

König, J., Ligtvoet, R., Klemenz, S., & Rothland, M. (2017). Effects of opportunities to learn in teacher preparation on future teachers' general pedagogical knowledge: Analyzing program characteristics and outcomes. *Studies in Educational Evaluation*, *53*, 122–133. https://doi.org/10.1016/j.stueduc.2017.03.001

König, J., Ligtvoet, R., Klemenz, S., & Rothland, M. (2024). Discontinued knowledge growth: On the development of teachers' general pedagogical knowledge at the transition from higher education into teaching practice. *Teachers and Teaching*, 1–19. https://doi.org/10.1080/13540602.2024.2308895

König, J., Santagata, R., Scheiner, T., Adleff, A.-K., Yang, X., & Kaiser, G. (2022). Teacher noticing: A systematic literature review of conceptualizations, research designs, and findings on learning to notice. *Educational Research Review*, *36*, 100453. https://doi.org/10.1016/j.edurev.2022.100453

Korthagen, F. A. J., & Kessels, J. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher*, *28*(4), 4–17. https://doi.org/10.3102/0013189X028004004

Krauss, S., Bruckmaier, G., Lindl, A., Hilbert, S., Binder, K., Steib, N., & Blum, W. (2020). Competence as a continuum in the COACTIV study: The "cascade model". *ZDM*, *52*(2), 311–327. https://doi.org/10.1007/s11858-020-01151-z

Kumschick, I. R., Piwowar, V., Ophardt, D., Barth, V. L., Krysmanski, K., & Thiel, F. (2017). Optimierung einer videobasierten Lerngelegenheit im Problem Based Learning Format durch Cognitive Tools. Eine Interventionsstudie mit Lehramtsstudierenden [Optimization of a video-based learning opportunity in problem-based learning format through cognitive tools: An intervention study with pre-service teachers]. *Zeitschrift Für Erziehungswissenschaft*, *20*(93), 93–113. https://doi.org/10.1007/s11618-017-0728-4

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal of Educational Psychology*, *105*(3), 805–820. https://doi.org/10.1037/a0032583

Lipowsky, F., Richter, T., Borromeo-Ferri, R., Ebersbach, M., & Hänze, M. (2015). Wünschenswerte Erschwernisse beim Lernen [Desireable difficulties in learning]. *Außerschulische Lernorte*, *6*(11), 1–10. https://www.uni-kassel.de/go/lipowsky_et_al_2015.pdf

Martin, M. (2024). *Enhancing video-based learning in teacher education: An experimental investigation of principles of example-based learning and multimedia learning in the context of a professional vision training* [Dissertation]. University of Freiburg. https://doi.org/10.6094/UNIFR/260871

Martin, M., Farrell, M., Seidel, T., Rieß, W., Könings, K. D., van Merriënboer, J. J. G., & Renkl, A. (2022). Focused self-explanation prompts and segmenting foster pre-service teachers’ professional vision - but only during training! *International Journal of Educational Technology in Higher Education*, *19*(1), 1–29. https://doi.org/10.1186/s41239-022-00331-z

Martin, M., Farrell, M., Seidel, T., Rieß, W., Könings, K. D., van Merriënboer, J. J., & Renkl, A. (2023). Knowing what matters: Short introductory texts support pre-service teachers' professional vision of tutoring interactions. *Teaching and Teacher Education*, *124*, 104014. https://doi.org/10.1016/j.tate.2023.104014

McDonald, M., Kazemi, E., & Kavanagh, S. S. (2013). Core practices and pedagogies of teacher education. *Journal of Teacher Education*, *64*(5), 378–386. https://doi.org/10.1177/0022487113493807

Meier, J., Spliethoff, L., Hesse, P., Abele, S., Renkl, A., & Glogger-Frey, I. (2022). Promoting car mechatronics apprentices' diagnostic strategy with modeling examples: Development and evaluation of a simulation-based learning environment. *Studies in Educational Evaluation*, *72*, 101117. https://doi.org/10.1016/j.stueduc.2021.101117

Meier, M., Grospietsch, F., & Mayer, J. (2018). Vernetzung von Wissensfacetten professioneller Handlungskompetenz in hochschuldidaktischen Lehr-Lernsettings [Networking knowledge facets of professional action competence in higher education teaching-learning settings]. In Glowinski, A. Borowski, J. & Gillen, S. Schanze & J. von Meien (Eds.), *Kohärenz in der universitären Lehrerbildung: Vernetzung von Kohärenz in der universitären Lehrerbildung: Vernetzung von Fachwissenschaft, Fachdidaktik und Bildungswissenschaften* (pp. 143–178). Universitätsverlag.

Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development*, *50*(3), 43–59. https://doi.org/10.1007/BF02505024

Mesmer-Magnus, J., & Viswesvaran, C. (2010). The role of pre-training interventions in learning: A meta-analysis and integrative review. *Human Resource Management Review*, *20*(4), 261–282. https://doi.org/10.1016/j.hrmr.2010.05.001

Müller, M. M., & Gold, B. (2023). Videobasierte Erfassung wissensbasierten Verarbeitens als Teilprozess der professionellen Unterrichtswahrnehmung – Analyse eines geschlossenen und offenen Verfahrens [Video-based assessment of knowledge-based processing as a subprocess of professional vision: Analysis of closed and open formats]. *Zeitschrift für Erziehungswissenschaft*, *26*(1), 7–29. https://doi.org/10.1007/s11618-022-01128-6

Nückles, M. (2021). Investigating visual perception in teaching and learning with advanced eye-tracking methodologies: Rewards and challenges of an innovative research paradigm. *Educational Psychology Review*, *33*(1), 149–167. https://doi.org/10.1007/s10648-020-09567-5

Nückles, M., & Kleinknecht, M. (2024). Chapter 6: Modelling, explaining, enacting and getting feedback: How can the acquisition of core practices in teacher education be optimally fostered? In P. L. Grossman & U. Fraefel (Eds.), *Core Practices in Education Series. Core practices in teacher education: A global perspective* (pp. 81–100). Harvard Education Press.

Oellers, M., Junker, R., & Holodynski, M. (2024). Individual learning paths mastering teachers’ professional vision. *Frontiers in Education*, *9*, Article 1305073. https://doi.org/10.3389/feduc.2024.1305073

Orschulik, A. B. (2021). *Entwicklung der Professionellen Unterrichtswahrnehmung* [Development of professional vision]. Springer. https://doi.org/10.1007/978-3-658-33931-9

Pouta, M., Lehtinen, E., & Palonen, T. (2021). Student teachers' and experienced teachers' professional vision of students' understanding of the rational number concept. *Educational Psychology Review*, *33*(1), 109–128. https://doi.org/10.1007/s10648-020-09536-y

Renkl, A. (1997). Learning from worked-out examples: A study on individual differences. *Cognitive Science*, *21*(1), 1–29. https://doi.org/10.1016/s0364-0213(99)80017-2

Renkl, A., & Atkinson, R. K. (2002). Learning from examples: Fostering self-explanations in computer-based learning environments. *Interactive Learning Environments*, *10*(2), 105–119. https://doi.org/10.1076/ilee.10.2.105.7441

Renkl, A., Hilbert, T., & Schworm, S. (2009). Example-based learning in heuristic domains: A Cognitive Load Theory account. *Educational Psychology Review*, *21*(1), 67–78. https://doi.org/10.1007/s10648-008-9093-4

Renkl, A., & Nückles, M. (2006). Träge Kompetenzen? - Gründe für die Kontextgebundenheit von beruflichen Handlungskompetenzen [Inert competencies? Reasons for the context dependence of professional action competencies]. *Bildung Und Erziehung*, *59*(2), 179–192. https://doi.org/10.7788/bue.2006.59.2.179

Richter, D. (2013). Professional development across the teaching career. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 333–342). Springer. https://doi.org/10.1007/978-1-4614-5149-5_17

Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal of Research in Science Teaching*, *48*(2), 117–148. https://doi.org/10.1002/tea.20408

Santagata, R., & Angelici, G. (2010). Studying the impact of the Lesson Analysis Framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education*, *61*(4), 339–349. https://doi.org/10.1177/0022487110369555

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A.-K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

Santagata, R., & Yeh, C. (2014). Learning to teach mathematics and to analyze teaching effectiveness: Evidence from a video- and practice-based approach. *Journal of Mathematics Teacher Education*, *17*(6), 491–514. https://doi.org/10.1007/s10857-013-9263-2

Scholten, N., & Orschulik, A. (2022). Praxisdokumente zur Verknüpfung von Theorie und Praxis auf Basis der Professionellen Unterrichtswahrnehmung [Practice documents for linking theory and practice based on professional vision of teaching]. *Herausforderung Lehrer*innenbildung - Zeitschrift zur Konzeption, Gestaltung und Diskussion*, *5*(1), 179–195. https://doi.org/10.11576/HLZ-5233

Schweppe, J. (2021). Lernen mit digitalen Medien - eine psychologische Perspektive [Learning with digital media – a psychological perspective]. In M. Seifert & S. Jöckel (Eds.), *Bildung, Wissen und Kompetenz(-en) in digitalen Medien: Was können, wollen und sollen wir über digital vernetzte Kommunikation wissen?*. Digital Communication Research. https://doi.org/10.48541/DCR.V8.3

Schwonke, R., Berthold, K., & Renkl, A. (2009). How multiple external representations are used and how they can be made more useful. *Applied Cognitive Psychology*, *23*(9), 1227–1243. https://doi.org/10.1002/acp.1526

Schworm, S., & Renkl, A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology, 99*(2), 285–296. https://doi.org/10.1037/0022-0663.99.2.285

Seidel, T. (2022). Professionelle Unterrichtswahrnehmung als Teil von Expertise im Lehrberuf [Professional vision as a part of expertise in the teaching profession]. In R. Junker, V. Zucker, M. Oellers, T. Rauterberg, S. Konjer, N. Meschede, & M. Holodynski (Eds.), *Lehren und Forschen mit Videos in der Lehrkräftebildung* (17-35). Waxmann.

Seidel, T., Blomberg, G., & Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, *34*, 56–65. https://doi.org/10.1016/j.tate.2013.03.004

Seidel, T., Kosel, C., Böheim, R., Gegenfurtner, A., & Stürmer, K. (2024). The cognitive perspective on teachers' professional vision: How teachers' professional knowledge shapes a professional vision. In A. Gegenfurtner & R. Stahnke (Eds.), *Teacher professional vision: Theoretical and methodological advances* (pp. 43–56). Routledge.

Seufert, T. (2019). Training for coherence formation when learning from text and picture and the interplay with learners' prior knowledge. *Frontiers in Psychology, 10*, 193. https://doi.org/10.3389/fpsyg.2019.00193

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Snow, R. E. (1991). Aptitude-treatment interaction as a framework for research on individual differences in psychotherapy. *Journal of Consulting and Clinical Psychology*, *59*(2), 205–216. https://doi.org/10.1037//0022-006x.59.2.205

Stahnke, R., Schueler, S., & Roesken-Winter, B. (2016). Teachers’ perception, interpretation, and decision-making: A systematic review of empirical mathematics education research. *ZDM*, *48*(1-2), 1–27. https://doi.org/10.1007/s11858-016-0775-y

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice mathematics teachers’ ability to notice. *Journal of Mathematics Teacher Education*, *11*(2), 107–125. https://doi.org/10.1007/s10857-007-9063-7

Stark, R., Mandl, H., Gruber, H., & Renkl, A. (2002). Conditions and effects of example elaboration. *Learning and Instruction*, *12*(1), 39–60. https://doi.org/10.1016/s0959-4752(01)00015-9

Stürmer, K., Könings, K. D., & Seidel, T. (2013). Declarative knowledge and professional vision in teacher education: Effect of courses in teaching and learning. *The British Journal of Educational Psychology*, *83*(Pt 3), 467–483. https://doi.org/10.1111/j.2044-8279.2012.02075.x

Stürmer, K., Könings, K. D., & Seidel, T. (2015). Factors within university-based teacher education relating to preservice teachers’ professional vision. *Vocations and Learning*, *8*(1), 35–54. https://doi.org/10.1007/s12186-014-9122-z

Stürmer, K., Seidel, T., & Holzberger, D. (2016). Intra-individual differences in developing professional vision: Preservice teachers’ changes in the course of an innovative teacher education program. *Instructional Science*, *44*(3), 293–309. https://doi.org/10.1007/s11251-016-9373-1

Stürmer, K., Seidel, T., & Kunina-Habenicht, O. (2015). Unterricht wissensbasiert beobachten. Unterschiede und erklärende Faktoren bei Referendaren zum Berufseinstieg [Knowledge-based observation of classrooms: Differences and explaining factors for pre-service teacher in their early career phase]. Advance online publication. https://doi.org/10.25656/01:15366

Stürmer, K., Seidel, T., & Schäfer, S. (2013). Changes in professional vision in the context of practice. *Gruppendynamik Und Organisationsberatung*, *44*(3), 339–355. https://doi.org/10.1007/s11612-013-0216-0

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction*, *4*(4), 295–312. https://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Springer.

Syring, M., Bohl, T., Kleinknecht, M., Kuntze, S., Rehm, M., & Schneider, J. (2015). Videos oder Texte in der Lehrerbildung? Effekte unterschiedlicher Medien auf die kognitive Belastung und die motivational-emotionalen Prozesse beim Lernen mit Fällen [Videos or texts in teacher education? Effects of different media on cognitive load and affective-motivational processes when learning with cases]. *Zeitschrift für Erziehungswissenschaft*, *18*(4), 667–685. https://doi.org/10.1007/s11618-015-0631-9

Tannert, S., Eitel, A., Marder, J., Seidel, T., Renkl, A., & Glogger-Frey, I. (2023). How can signaling in authentic classroom videos support reasoning on how to induce learning strategies? *Frontiers in Education*, *8*, Article 974696. https://doi.org/10.3389/feduc.2023.974696

Tatto, M. T., Rodriguez, M. C., & Reckase, M. (2020). Early career mathematics teachers: Concepts, methods, and strategies for comparative international research. *Teaching and Teacher Education*, *96*, 103118. https://doi.org/10.1016/j.tate.2020.103118

Todorova, M., Sunder, C., Steffensky, M., & Möller, K. (2017). Pre-service teachers' professional vision of instructional support in primary science classes: How content-specific is this skill and which learning opportunities in initial teacher education are relevant for its acquisition? *Teaching and Teacher Education*, *68*, 275–288. https://doi.org/10.1016/j.tate.2017.08.016

Udvardi-Lakos, N. (2023). *Competences transcending domain boundaries: What field studies tell us about the instructional design of worked examples to foster cross-domain competences* [Dissertation]. University of Freiburg, Freiburg. https://doi.org/10.6094/UNIFR/241670

Valencia, S. W., Martin, S. D., Place, N. A., & Grossman, P. (2009). Complex interactions in student teaching. *Journal of Teacher Education*, *60*(3), 304–322. https://doi.org/10.1177/0022487109336543

van Gog, T., Paas, F., & van Merriënboer, J. J. (2004). Process-oriented worked examples: Improving transfer performance through enhanced understanding. *Instructional Science*, *32*(1/2), 83–98. https://doi.org/10.1023/B:TRUC.0000021810.70784.b0

van Merriënboer, J. J. G., Clark, R. E., & Croock, M. B. M. de (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology Research and Development*, *50*(2), 39–61. https://doi.org/10.1007/BF02504993

van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive Load Theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, *17*(2), 147–177. https://doi.org/10.1007/s10648-005-3951-0

Voss, T., Wagner, W., Klusmann, U., Trautwein, U., & Kunter, M. (2017). Changes in beginning teachers' classroom management knowledge and emotional exhaustion during the induction phase. *Contemporary Educational Psychology*, *51*, 170–184. https://doi.org/10.1016/j.cedpsych.2017.08.002

Westphal, A., Lohse-Bossenz, H., Vock, M., & Lenske, G. (2018). Was wissen Studierende über Klassenführung? Lerngelegenheiten und Lerngewinne in Studium und Praxissemester [What do university students know about classroom management? Learning opportunities and learning achievements in university studies and practical experiences]. In M. Rothland & N. Schaper (Eds.), *Lehrerbildung auf dem Prüfstand: 11 (1). Forschung zum Praxissemester in der Lehrerbildung* (pp. 132–151). Verlag Empirische Pädagogik.

Wilkes, T., Stark, L., Trempler, K., & Stark, R. (2022). Contrastive video examples in teacher education: A matter of sequence and prompts. *Frontiers in Education*, *7*, Article 869664. https://doi.org/10.3389/feduc.2022.869664

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. (2017). See and tell: Differences between expert and novice teachers' interpretations of problematic classroom management events. *Teaching and Teacher Education*, *66*, 295–308. https://doi.org/10.1016/j.tate.2017.04.015

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. A. (2021). Classroom management scripts: A theoretical model contrasting expert and novice teachers' knowledge and awareness of classroom events. *Educational Psychology Review*, *33*(1), 131–148. https://doi.org/10.1007/s10648-020-09542-0

Wolff, C. E., Jarodzka, H., van den Bogert, N., & Boshuizen, H. P. A. (2016). Teacher vision: Expert and novice teachers' perception of problematic classroom management scenes. *Instructional Science*, *44*(3), 243–265. https://doi.org/10.1007/s11251-016-9367-z

Wolff, C. E., van den Bogert, N., Jarodzka, H., & Boshuizen, H. P. A. (2015). Keeping an eye on learning: Differences between expert and novice teachers' representations of classroom management events. *Journal of Teacher Education*, *66*(1), 68–85. https://doi.org/10.1177/0022487114549810

Yang, X., & Kaiser, G. (2022). The impact of mathematics teachers' professional competence on instructional quality and students' mathematics learning outcomes. *Current Opinion in Behavioral Sciences*, *48*, 101225. https://doi.org/10.1016/j.cobeha.2022.101225

Zeitlhofer, I., Zumbach, J., & Schweppe, J. (2024). Complexity affects performance, cognitive load, and awareness. *Learning and Instruction*, *94*, 102001. https://doi.org/10.1016/j.learninstruc.2024.102001

Zucker, V., Lehmkuhl, A., Janeczko, J., Junker, R., Holodynski, M., & Meschede, N. (2024). Förderung der mehrperspektivischen professionellen Wahrnehmung von Klassenführung und Lernunterstützung im naturwissenschaftlichen Sachunterricht [Fostering professional vision of multiple perspectives of classroom management and learning support in science education]. *Herausforderung Lehrer*innenbildung - Zeitschrift zur Konzeption, Gestaltung und Diskussion*, *7*(1), 147–166. https://doi.org/10.11576/hlz-6393

4. Appendix

4.1 Eigenanteile der Doktorandin bei den Beiträgen der Dissertation

Article I

Bauersfeld, J. L., Gold, B., & Holodynski, M. (2025). Development of classroom management competencies throughout teacher education: a longitudinal study. *Teacher Development*, 1–21. https://doi.org/10.1080/13664530.2025.2455113

Datenerhebung: Die Daten wurden von Bernadette Gold und Manfred Holodynski erhoben.

Formulierung der Fragestellung: Die Fragestellung wurde von Jasmin Lilian Bauersfeld und Bernadette Gold gemeinsam entworfen.

Konzeption des Beitrags: Der Beitrag wurde von Jasmin Lilian Bauersfeld und Bernadette Gold gemeinsam konzeptualisiert.

Statistische Auswertungen: Die statistischen Auswertungen wurden hauptverantwortlich von Jasmin Lilian Bauersfeld ausgeführt, wobei Bernadette Gold beratend tätig war.

Schriftliche Abfassung des Beitrags: Jasmin Lilian Bauersfeld verfasste den Text des Beitrags hauptverantwortlich und Bernadette Gold gab Rückmeldungen zu den Textentwürfen, wonach Jasmin Lilian Bauersfeld den Text überarbeitete und finalisierte.

Article II

Bauersfeld, J. L., & Gold, B (2025). *Can double-content examples of video-based analyses foster student teachers' professional vision of classroom management?* [Manuscript under review]. Institute of School Pedagogy and General Didactics, TU Dortmund University.

Datenerhebung: Die Daten wurden von Jasmin Lilian Bauersfeld und Bernadette Gold gemeinsam erhoben.

Formulierung der Fragestellung: Die Fragestellung wurde von Jasmin Lilian Bauersfeld entworfen, wobei Bernadette Gold beratend tätig war.

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Schriftliche Abfassung des Beitrags: Jasmin Lilian Bauersfeld verfasste den Text des Beitrags hauptverantwortlich und Bernadette Gold gab Rückmeldungen zu den Textentwürfen, wonach Jasmin Lilian Bauersfeld den Text überarbeitete und finalisierte.

Article III

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B. (2025). *Isolated or integrated? – Instructional approaches to foster professional vision of teaching quality* [Manuscript under review]. Institute of School Pedagogy and General Didactics, TU Dortmund University; Didactics of Mathematics, University of Erfurt.

Datenerhebung: Die Daten wurden von Jasmin Lilian Bauersfeld, Patricia Bourcevet, Heike Hahn und Bernadette Gold gemeinsam erhoben.

Formulierung der Fragestellung: Die Fragestellung wurde von Jasmin Lilian Bauersfeld entworfen, wobei Bernadette Gold beratend tätig war.

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Article IV

Bauersfeld, J. L., Bourcevet, P., Hahn, H., & Gold, B. (2025). *Before or after? – Sequencing concepts and video-based analyses for different teacher education phases* [Manuscript under review]. Institute of School Pedagogy and General Didactics, TU Dortmund University, Didactics of Mathematics, University of Erfurt.

Datenerhebung: Die Daten wurden von Jasmin Lilian Bauersfeld, Patricia Bourcevet, Heike Hahn und Bernadette Gold gemeinsam erhoben.

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4.2 Eidesstattliche Erklärung

Hiermit versichere ich **schriftlich** und **eidesstattlich** gemäß § 11 Abs. 2 PromO v. 08.02.2011/08.05.2013:

1. Die von mir vorgelegte Dissertation ist selbstständig verfasst und alle in Anspruch genommenen Quellen und Hilfen sind in der Dissertation vermerkt worden.
2. Die von mir eingereichte Dissertation ist weder in der gegenwärtigen noch in einer anderen Fassung an der Technischen Universität Dortmund oder an einer anderen Hochschule im Zusammenhang mit einer staatlichen oder akademischen Prüfung vorgelegt worden.[2]

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3. Weiterhin erkläre ich **schriftlich** und **eidesstattlich**, dass mir der „Ratgeber zur Verhinderung von Plagiaten" und die „Regeln guter wissenschaftlicher Praxis der Technischen Universität Dortmund" bekannt und von mir in der vorgelegten Dissertation befolgt worden sind (der Text ist auf der Homepage der TU Dortmund hinterlegt).

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