Fostering and assessing pre-service teachers' professional competence with digital reflection and feedback environments

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Content

Abstract

Pre-service teachers need to develop professional competence to be able to provide students with the best possible learning environment. Professional competence manifests itself when teachers combine theory with practice productively. Professional competence encompasses dispositions (i.e., knowledge, beliefs, motivational components, and self-regulatory skills), situation-specific skills (e.g., professional vision), and actual performance.

Professional competence can be fostered productively by authentic, practice-based learning opportunities. Teaching practicums can offer practice-based learning opportunities. Educational research has shown that reflection and feedback are crucial for substantial development of pre-service teachers' professional competence. However, reflection and feedback sessions are not a standard element of teaching practicums due to time- and location-constraints. Digital practicum environments can lift these constraints. Digital reflection and feedback environments have typically applied either textual accounts or video sequences of classroom practice, with varying effects.

Consequently, the studies presented in this cumulative dissertation are focused on how the use of text- or video-based digital reflection and feedback environments during a practicum influence specific components of pre-service teachers' professional competence (i.e., beliefs about teaching and learning, self-efficacy, professional vision of classroom management, feedback competence).

All studies followed a quasi-experimental, pre-test-post-test design. Pre-service teachers at the fourth-semester bachelor level in a German university took part in the studies. Pre-service teachers participated in a four-week teaching practicum at local schools.
During the teaching practicum, pre-service teachers were divided into five different groups. The control group (CG) took part in a traditional practicum with live observations and face-to-face reflection and feedback with peers and experts. Pre-service teachers of the intervention groups (IG 1, IG 2, IG 3, IG 4) reflected and received feedback in highly structured text- or video-based digital environments. Intervention groups 1 (IG 1) and 2 (IG 2) participated in a text-based digital reflection and feedback environment. While IG 1 participants only received feedback from peers, IG 2 pre-service teachers also received expert feedback. Intervention groups 3 (IG 3) and 4 (IG 4) took part in a video-based digital reflection and feedback environment. IG 3 pre-service teachers only received peer feedback, whereas IG 4 participants also received expert feedback.

Mixed methods were applied by generating quantitative and quantitative-qualitative data was with questionnaires, a standardized video-based test and content analysis.

The studies demonstrated that classroom videos and video-based digital reflection and feedback environments can effectively enhance pre-service teachers' professional competence. This finding can be predominantly attributed to two characteristics of the application in the digital reflection and feedback environments: (a) being able to revisit a multitude of authentic teaching situations without time pressure and (b) the degree of decomposition by deliberate, focused practice and scaffolding elements.

Furthermore, expert feedback seemed to be of better quality and entailed more substantial effects than peer feedback. The results of our studies on professional vision of classroom management, beliefs about teaching and learning and feedback competence showed that expert feedback can be seen as a lens reducing and focusing classroom complexity, enabling pre-service teachers to perceive crucial teaching situations that would have otherwise gone unnoticed and to benefit from expert modelling of high-quality feedback.

Consequently, video-based digital reflection and feedback environments with expert feedback can significantly improve pre-service teachers' professional competence during teaching practicums and, thus, better prepare pre-service teachers for future classroom challenges, leading to better learning environments for school students.

Zusammenfassung

Lehramtsstudierende müssen professionelle Kompetenz entwickeln, um SchülerInnen die bestmögliche Lernumgebung bieten zu können. Professionelle Kompetenz zeigt sich, wenn Lehrkräfte Theorie und Praxis produktiv verbinden. Professionelle Kompetenz umfasst Dispositionen (d. H. Wissen, Überzeugungen, Motivationskomponenten und Selbstregulierungsfähigkeiten), situationsspezifische Fähigkeiten (z. B. professionelle Wahrnehmung) und die tatsächliche Performanz.

Professionelle Kompetenz kann durch authentische, praxisorientierte Lernmöglichkeiten produktiv gefördert werden. Schulpraktika bieten praxisorientierte Lernmöglichkeiten. Die Bildungsforschung hat gezeigt, dass Reflexion und Feedback entscheidend für die Entwicklung professioneller Kompetenz von Lehrkräften sind. Reflexions- und Feedbacksitzungen sind jedoch aus zeitlichen und räumlichen Gründen kein Standardelement der Unterrichtspraxis. Digitale Praxisumgebungen können diese Einschränkungen aufheben. In digitalen Reflexions- und Feedbackumgebungen wurden in der Regel Text- oder Videofälle aus der Unterrichtspraxis angewendet. Es zeigten sich differenzielle Effekte.

Infolgedessen konzentrieren sich die in dieser kumulativen Dissertation vorgestellten Studien darauf, wie die Verwendung text- oder videobasierter digitaler Reflexions- und Feedbackumgebungen während eines Praktikums spezifische Komponenten der professionellen Kompetenz von Lehramtsstudierenden (Lehr-Lern-Überzeugungen, Selbstwirksamkeit, professionelle Wahrnehmung der Klassenführung, Feedbackkompetenz) beeinflusst.

Alle Studien folgten einem quasi experimentellen Prä-Test-Post-Test-Design. An den Studien nahmen Lehramtsstudierende im vierten Bachelorsemester teil. Die Lehramtsstudierenden absolvierten ein vierwöchiges Schulpraktikum.

Während des Praktikums wurden die Lehramtsstudierende in fünf verschiedene Gruppen eingeteilt. Die Kontrollgruppe (KG) nahm an einem traditionellen Praktikum mit Live-Beobachtungen und face-to-face Reflexion sowie Feedback von Peers und Experten teil. Lehramtsstudierende der Interventionsgruppen (IG 1, IG 2, IG 3, IG 4) reflektierten und erhielten Feedback in hochstrukturierten text- oder videobasierten digitalen Umgebungen. Die Interventionsgruppen 1 (IG 1) und 2 (IG 2) nahmen an einer textbasierten digitalen Reflexions- und Feedbackumgebung teil. Während die Lehramtsstudierenden der IG 1 nur Feedback von Peers erhielten, erhielten die Lehramtsstudierenden der IG 2 auch Expertenfeedback. Die Interventionsgruppen 3 (IG 3) und 4 (IG 4) nahmen an einer videobasierten digitalen Reflexions- und Feedbackumgebung teil. Lehramtsstudierende der IG 3 erhielten nur Peerfeedback, während Lehramtsstudierende der IG 4 auch Expertenfeedback erhielten.

Die Studien zeigten, dass Unterrichtsvideos und videobasierte digitale Reflexions- und Feedbackumgebungen die professionelle Kompetenz von Lehramtsstudierenden effektiv verbessern können. Dieser Befund ist vor allem auf zwei Charakteristika der Anwendung in der digitalen Reflexions- und Feedbackumgebung zurückzuführen: (a) die Möglichkeit, eine Vielzahl authentischer Unterrichtssituationen ohne Zeitdruck und wiederholt zu betrachten, und (b) den Grad der Dekomposition durch bewusstes, gezieltes Üben und Scaffoldingelemente.

Darüber hinaus schien Expertenfeedback von besserer Qualität zu sein und hatte größere Auswirkungen als Peerfeedback. Die Ergebnisse unserer Studien zur professionellen Wahrnehmung der Klassenführung, zu Lehr-Lern-Überzeugungen und zur Feedbackkompetenz zeigten, dass Expertenfeedback die Komplexität des Unterrichts reduziert und konzentriert und Lehramtsstudierenden ermöglicht, wichtige Unterrichtssituationen wahrzunehmen, die andernfalls unbemerkt bleiben würden. Zudem profitieren Lehramtsstudierende von dem Lernen am Modell qualitativ hochwertigen Expertenfeedbacks.

Folglich können videobasierte digitale Reflexions- und Feedbackumgebungen mit Expertenfeedback die professionelle Kompetenz der Lehramtsstudierenden während des Unterrichtspraktikums signifikant verbessern. Lehramtsstudierende können somit besser auf zukünftige Herausforderungen im Unterricht vorbereitet werden, was folglich zu besseren Lernumgebungen für SchülerInnen führt.

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Christopher Neil Prilop

1   Introduction

Teachers can have a significant impact on students' learning and achievement (Hattie, 2009). Consequently, teachers need to develop professional competence to be able to provide students with the best possible learning environment (Baumert & Kunter, 2006; Blömeke, Gustafsson, & Shavelson, 2015). Professional competence manifests itself when teachers combine theory with practice productively. Professional competence encompasses dispositions (i.e., knowledge, beliefs, motivational components, and self-regulatory skills), situation-specific skills (e.g., professional vision), and actual performance (Blömeke et al., 2015; Kunter, Kleickmann, Klusmann, & Richter, 2011).

Pre-service teachers require authentic learning environments to develop professional competence (Berliner, 1994). Hence, teacher education has recently shifted toward creating practice-based learning opportunities in which the separation between theory and practice, as well as the divide between university and school, are undone (Grossman, Hammerness, & McDonald, 2009). These kinds of learning opportunities are characterised by variants of practice (i.e., the *representation of practice*, *approximation of practice*, and *investigation of practice*; Grossman, Compton et al., 2009), which accounts for teachers needing to practice situation-specific skills, such as perception, interpretation, and decision-making, to utilise professional competence appropriately (Blömeke et al., 2015). Decomposing the complexities of teaching makes it possible for pre-service teachers to deliberately practice individual skills, receive feedback from peers and experts, and develop expertise (Ericsson, Krampe, & Tesch-Römer, 1993; Grossman, Hammerness, & McDonald, 2009).

Teaching practicums can offer such practice-based learning opportunities (Gröschner, 2019). In the setting of teaching practicums, the development of pre-service teachers' professional competence can be supported by reflection and feedback sessions (Grossman, Hammerness, & McDonald, 2009; Ericsson et al., 1993). However, reflection and feedback sessions are not a standard element of teaching practicums (Valencia, Martin, Place, & Grossman, 2009). Digital practicum environments can make reflection and feedback sessions more readily available, as their application can be time- and location-independent (Hixon & So, 2009). Digital reflection and feedback environments have typically applied either textual accounts (e.g., Bonk, Malikowski, Angeli, & East, 1998) or video sequences of classroom practice (e.g., Kleinknecht & Gröschner, 2016), with varying effects.

Consequently, the studies presented in this cumulative dissertation are focused on how the use of text- or video-based digital reflection and feedback environments during a practicum influence specific components of pre-service teachers' professional competence. First, the text- and video-based digital reflection and feedback environments were comprehensively described and discussed in a conceptual and practical paper (Weber, Prilop, Glimm, & Kleinknecht, 2018). Second, the development and validation of a video- and text-based tool to assess pre-service teachers' competence regarding peer feedback were elaborated (Prilop, Weber, & Kleinknecht, 2019a). The following three studies focused on how pre-service teachers' disposition (i.e., self-efficacy and beliefs about teaching and learning; Prilop, Weber, & Kleinknecht, 2019b), situation-specific skills (i.e., professional vision of classroom management; Weber, Gold, Prilop, & Kleinknecht, 2018) and performance (i.e., feedback; Prilop, Weber, & Kleinknecht, 2020) developed due to the text- or video-based digital reflection and feedback environment.

1.1 Teachers' professional competence

Teachers' professional competence can be defined as specific occupational prerequisites that determine how well a teacher meets the challenges of the teaching profession (Kunter, Kleickmann, Klusmann, & Richter, 2011). In general, educational research assumes that differences in teachers' professional competence are based on teaching-related qualifications and personality traits that are non-teaching-specific (e.g., Baumert & Kunter, 2006; Kennedy, Ahn, & Choi, 2008). While the personality traits hypothesis presumes certain personality characteristics exist, such as cognitive ability or affective and motivational tendencies, that enable some teachers to be more successful than others (Kunter et al., 2011; Kennedy et al., 2008), the qualifications hypothesis postulates that teachers' professional competence is dependent on the quality of teacher education courses (e.g., Darling-Hammond, 2006; Kennedy et al., 2008). Kunter et al. (2011) integrated both seemingly exclusive hypotheses into one model of professional competence. In this competence model, personal prerequisites (i.e., cognitive abilities, motivation, and personality) can influence the development of professional competence; however, the components of teachers' professional competence (i.e., knowledge, beliefs, motivational components, and self-regulatory skills) can be fostered by pre-service teacher education and active service (Baumert & Kunter, 2006). Blömeke et al. (2015) extended this conceptualisation of professional competence by adding situation-specific skills connecting disposition (i.e., knowledge, beliefs, motivational components, and self-regulatory skills) to

performance. Mediating processes, such as "the perception and interpretation of a specific job situation together with decision-making" (Blömeke et al., 2015, p. 8), translate the disposition into performance.

Teacher education can foster (pre-service) teachers' professional competence by offering high-quality learning opportunities (see Figure 1; Darling-Hammond, 2006; Kunter et al., 2011). As highlighted by Blömeke et al. (2015), teacher education should focus on not only promoting (pre-service) teachers' content knowledge, pedagogical content knowledge, general pedagogical knowledge and affective-motivational components (Shulman, 1987; Blömeke, 2017) but also providing (pre-service) teachers with learning opportunities that enhance their situation-specific skills (Blömeke et al., 2015; McDonald, Kazemi, & Schneider Kavanagh, 2013).
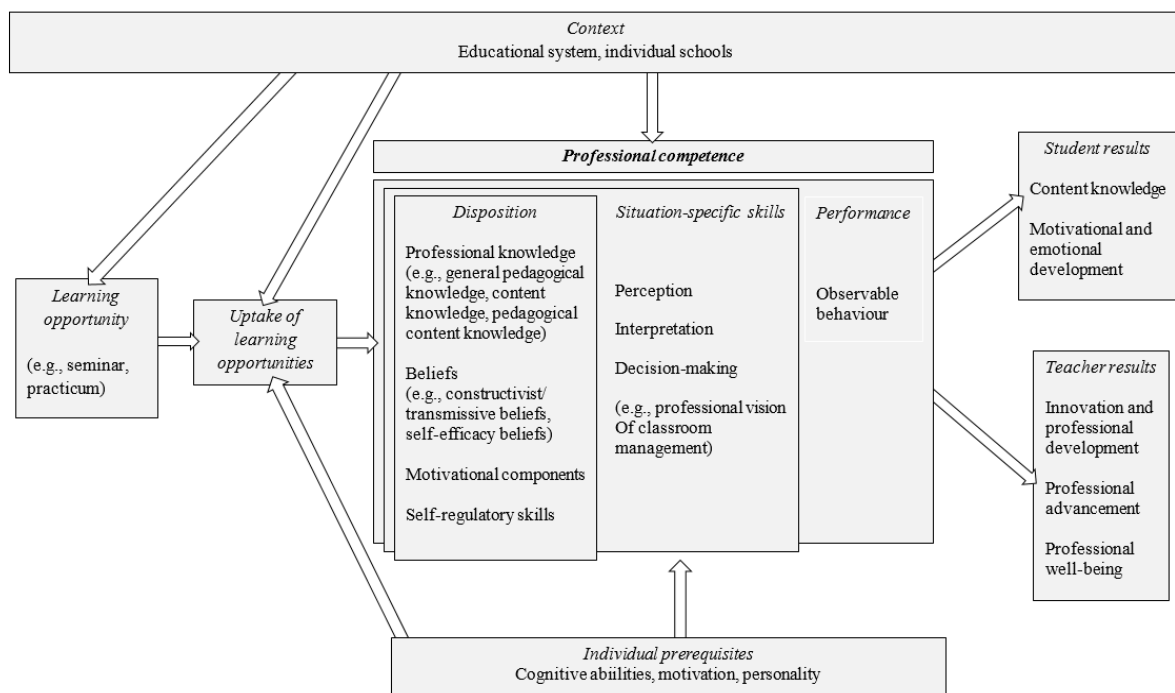
Figure 1: Determinants and consequences of teachers' professional competence, based on Blömeke et al. (2015) and Kunter et al. (2011).

1.2 Practice-based learning opportunities

Practice-based learning opportunities enable pre-service teachers to develop their professional competence (Grossman, Hammerness et al., 2009). Pre-service teachers can connect theory with practice, thus bridging the divide between universities and schools (Grossman, Hammerness, & McDonald, 2009). This entails organising teacher education

programs around a "situated perspective on learning" (McDonald et al., 2013, p. 4) and decomposing the complexities of teaching into *core practices* (Grossman, Hammerness, & McDonald, 2009). Core practices can be defined as complex, research-based high-frequency and high-leverage practices that pre-service teachers can begin to master with training (Grossman, Hammerness, & McDonald, 2009). McDonald et al. (2013) suggested a learning cycle that integrates university courses and classroom teaching. Fostering pre-service teachers' classroom management skills could lead to the following learning cycle. First, classroom management skills are modelled by university instructors. This can take the form of live enactments as well as case or video analysis (*representation of practice*; Grossmann, Compton et al., 2009). Second, pre-service teachers plan and rehearse classroom management skills (*approximation of practice*). Third, classroom management skills are enacted in an authentic classroom setting with school students. Fourth, the enactment of classroom management skills is analysed, for example, on the basis of video recordings or written reflections (*investigation of practice*). McDonald et al. (2013) emphasised that "the reflective and analytic work that novices do together is a key aspect of giving meaning to the practices that are being worked on" (p. 6). Another crucial element of practice-based learning opportunities is that pre-service teachers require specific feedback that helps them to fully comprehend complex practices (Grossman, Hammerness, & McDonald, 2009).

Representations of practice, *approximations of practice,* and *investigations of practice* can be implemented with varying degrees of decomposition and authenticity (Grossman, Compton, & McDonald, 2009). Practicing with a written account of a teaching situation can be considered a less authentic *representation* or *approximation* than with a video recording of the classroom events. However, actual classroom observations would offer the highest degree of authenticity. Furthermore, written accounts, classroom videos, or classroom observations need to be decomposed for pre-service teachers by focusing on core practices.

Research in the field of expertise has also highlighted the importance of feedback (Ericsson, Krampe, & Tesch-Römer, 1993). According to Ericsson et al. (1993), expert performance is a result of deliberate practice. Deliberate practice can be defined as a highly structured practice that is continuously monitored for weaknesses to improve one's performance. Experts purposefully and intensely work on specific skills for extended periods of time. However, without adequate feedback, even highly motivated individuals display only minimal improvement (Ericsson et al., 1993). Ericsson also points out that video recordings can be applied to monitor performances and identify elements for improvement (Ericsson, 2004).

1.3 Teaching practicums as learning opportunities

In teaching practicums, pre-service teachers can connect theory to practice (Allen & Wright, 2014; Gröschner, 2019). In practicums, pre-service teachers can practice teaching skills repeatedly in authentic classroom settings, observe their peers' classroom skills, and focus on specific elements of teaching in subsequent feedback and reflection sessions. Various studies have established that teaching practicums lead to an increase in pre-service teachers' knowledge (e.g., König & Klemenz, 2015), affective-motivational components (e.g., Hascher & Hagenauer, 2016; König, Rothland, Tachtsoglou, Klemenz, & Römer, 2016) and situation-specific skills (e.g., Stürmer, Seidel, & Schäfer, 2013). Furthermore, teaching practicums also foster pre-service teachers' self-assessed professional competence (Hascher, 2006; Gröschner & Müller, 2014). However, research has also shown that teaching practicums can have detrimental effects on pre-service teachers (for a summary, see Hascher, 2012). Teaching practicums can lead to pre-service teachers not connecting theory to practice and vice versa, which Gröschner (2012) termed inert practice. To prevent the negative effects of teaching practicums, preparatory university courses need to be aligned with the practicum's learning goals to connect theory with practice (Hammerness et al., 2005). Consequently, prior modelling in university courses is essential because, otherwise, observing teachers' classroom interactions during the practicum can lead to reflections that are not grounded in theory (Seidel, Blomberg, & Renkl, 2013). Moreover, practicums need to be sufficiently scaffolded, including feedback and reflection sessions with qualified mentors or university supervisors (Kleinknecht & Gröschner, 2016; Valencia et al., 2009). Closely connecting university learning and school practice seems necessary concerning reflection and feedback sessions, as in-school mentors' feedback has been shown to be less constructive and, thus, lead to minimal reflection (Crasborn & Hennissen, 2010; Valencia et al., 2009). However, preparatory courses and university supervision during teaching practicums are not standard components in German universities currently (Gröschner et al., 2015).

1.4 Reflection and feedback

Reflection and feedback play a crucial role in pre-service teachers' competence development (Grossman, Compton et al., 2009; Valencia et al., 2009). A considerable number of studies (e.g., Gregory et al., 2017; Fisher, Frey, & Lapp, 2011; Gröschner, Klaß, & Dehne, 2018; Kleinknecht & Gröschner, 2016; Matsumura, Garnier, & Spybrook, 2013; Sailors & Price, 2015; Tschannen-Moran & McMaster, 2009; Vogt & Rogalla, 2009) have found that

feedback has positive effects on (pre-service) teachers' knowledge, beliefs, situation-specific skills, and practice and, thus, student achievement.

In teaching practicums, pre-service teachers invite their peers or experts to observe their lesson and then discuss the lesson in reflection and feedback sessions (Lu, 2010). When pre-service teachers reflect on their own teaching with peers or experts, internal and external feedback loops interplay (Narciss, 2013). In their self-reflections (i.e., internal feedback), pre-service teachers "consider the effect of their pedagogical decisions on their situated practice with the aim of improving those practices" (Tripp & Rich, 2012b, p. 678), while peers' and experts' reflections (i.e., external feedback) add to pre-service teachers' internal feedback. The external feedback pre-service teachers are provided with stimulates further reflection. External feedback, in this context, can be defined as a criteria-based assessment of teaching practice concerning possible strengths or weaknesses that enables pre-service teachers to reach desired performance goals (Narciss, 2013; Sluijsmans, Brand-Gruwel, Merriënboer, & Bastiaens, 2004).

Research in different domains has shown that the status of the provider of external feedback entails varying effects. Experts' knowledge authority can lead to passiveness and the misinterpretation of feedback (Yang, Badger, & Zhen, 2006). However, expert feedback has been found to be of higher quality than peer feedback (Prins, Sluijsmans, & Kirschner, 2006) and, consequently, foster stronger performance improvements (Yang et al., 2006). Peers' equal status can lead to a relationship of trust and make it easier to discuss shortcomings, resulting in deeper reflection (Topping, 2005). Overall, expert or peer feedback can facilitate reflecting on teaching situations that would otherwise go unnoticed (Wu & Kao, 2008).

However, concerning teaching practicums, reflection and feedback sessions between pre-service teachers are difficult to accomplish, as pre-service teachers are usually assigned to a variety of practicum schools (Wu & Kao, 2008). Hence, a lack of university supervisors supporting pre-service teachers during teaching practicums and reflection and feedback sessions between pre-service teachers can be attributed to time- and location-constraints (Lee & Wu, 2006).

1.5 Digital reflection and feedback environments

As emphasised by Grossman, Compton, et al. (2009), the *investigation of practice* can be a productive element in fostering pre-service teachers' professional competence. Consequently, studies have made use of digital practicum environments for reflection and feedback sessions and investigated their effects (e.g., Bonk, Hansen, Grabner-Hagen, Lazar, & Mirabelli., 1998; Kleinknecht & Gröschner, 2016; So, Pow, & Hung, 2009; Whipp, 2003; Wu & Kao, 2008). Digital practicum environments have either applied less authentic (text; e.g., Bonk, Hansen, et al., 1998) or more authentic (video; e.g., Kleinknecht & Gröschner, 2016) material for reflection and feedback. Digital practicum environments provide pre-service teachers with the opportunity to upload a video recording or written account of their classroom practice, reflect on their teaching, and receive feedback by peers or experts in reflection and feedback sessions (e.g., Bonk, Malikowski, et al., 1998; Kleinknecht & Gröschner, 2016). Incorporating text (i.e., classroom text) or video (i.e., classroom video) enables pre-service teachers to interact asynchronously without being at the same location and discuss their teaching practice with experts or peers more easily (Bonk, Malikowski, et al., 1998; Wu & Kao, 2008). Experts, such as university supervisors or experienced teachers, can be more efficiently involved as they can coach pre-service teachers concerning specific classroom situations (Lee & Wu, 2006).

Classroom text and video can be beneficial on various levels. Text and video reduce classroom complexity to a different extent (Yadav et al., 2011). While videos provide an authentic representation of teaching situations and can capture the multitude of simultaneous processes in a classroom (Borko, Whitcomb, & Liston, 2009), texts are more selective by placing focus on only necessary information and omitting seemingly unimportant details (Syring et al., 2015). Moreover, classroom situations are narrated in sequential order (Clark & Paivio, 1991). Video causes a higher cognitive load than text, whereas video leads to higher motivation and immersion (Syring et al., 2015). Furthermore, classroom videos act as situated stimuli for contextualised or tacit knowledge about teaching and learning (Seidel & Stürmer, 2014; Kersting, 2008). In addition, video situations can be analysed in depth by revisiting specific situations with different foci (Sherin, 2007).

1.6 Designing digital reflection and feedback environments

Since the late 1990s, digital reflection and feedback environments have been applied to a greater extent in pre-service teacher education. In general, digital practicum environments make use of some kind of online platform for synchronous or asynchronous uploading of reflection and feedback of teaching events (e.g., Bonk, Hansen, et al., 1998; Kleinknecht & Gröschner,

2016). Online reflection and feedback sessions either take place between peers (e.g., Bonk, Hansen, et al., 1998; So, 2012) or peer and experts (e.g., Bonk, Malikowski, et al., 1998; Kleinknecht & Gröschner, 2016). Various studies have been able to determine prerequisites for the effective application of text- or video-based digital reflection and feedback environments (e.g., So, 2012; Bonk, Malikowski, et al., 1998).

Bonk, Hansen, et al. (1998) analysed the effects of text-based synchronous and asynchronous digital environments on pre-service teachers' interaction online. Pre-service teachers discussed written cases of other teachers via a web conferencing platform during a designated 50-minute time slot (i.e., synchronous) or within ten days (i.e., asynchronous). Bonk, Hansen, et al. (1998) found that pre-service teachers in the asynchronous group were more engaged and interactions more lengthy, while pre-service teachers of the synchronous group interacted more often, albeit more briefly. However, this might have also been an effect of the material as the synchronous group worked with brief descriptions of classroom events, whereas the asynchronous group received more detailed accounts. Nonetheless, Bonk, Hansen, et al. (1998) concluded that teaching situations require complexity for prolonged investigation and that instructors should scaffold the task and provide feedback. In a follow-up study, Bonk, Malikowski, et al. (1998) contrasted text-based digital practicum environments with heavy scaffolding and weak scaffolding. Additionally, mentors monitored the discussions and provided feedback or new ideas. Bonk, Malikowski, et al. (1998) analysed pre-service teachers' interactions concerning teaching situations from their observational practicum. On the one hand, they found that participants of the heavy scaffolding group generated more cases. On the other hand, feedback by mentors was of higher quality than peer feedback. Whipp (2003) also focused on scaffolding elements in online discussions of pre-service teachers. In Whipp's study, pre-service teachers discussed teaching situations from their practicum on e-mail. Whipp concluded that higher-level reflection could be achieved by providing pre-service teachers with a framework for critical reflection or including experts such as experienced teachers into the discussions to push knowledge boundaries.

Studies in the field of the application of video in teacher education have established general prerequisites that must be met to tap the full potential of classroom video (Kang & van Es, 2018). During live observations of teaching, observers can grasp contextual information, such as the classroom's culture, atmosphere, and environment (Körkkö, Morales Rios, & Kyrö-Ämmälä, 2019). Hence, contextual information needs to be added to classroom videos. Moreover, observational targets need to be specified to prevent attentional biases (Derry, Sherin, & Sherin, 2014). Pre-service teachers also need to be prompted to share critical and

positive teaching events to provide a comprehensive picture of their classroom experiences (Sharpe et al., 2003). Furthermore, determining a well-defined focus can also counteract cognitive overload (Syring et al., 2015; Derry et al., 2014). Finally, studies (e.g., Kleinknecht & Schneider, 2013; Seidel, Stürmer, Blomberg, Kobarg, & Schwindt, 2011) concerning different video types (*own video* = teachers' own classroom practice vs *other video* = peers' or other teachers' classroom practice) showed that own and other video can have different cognitive and motivational effects on (pre-service) teachers. By combining both types, pre-service teachers benefit from being confronted with an inner (*own* video) and outer perspective (*other* video) (Hellermann, Gold, & Holodynski, 2015).

While early approaches to video-based reflection and feedback applied less structured video observations to confront participants with their own behaviour, current video use applies highly structured environments to foster pre-service teachers' professional competence more productively (Fukkink, Trienekens, & Kramer, 2011). Harford and MacRuairc (2008) established that structured peer video analysis could promote pre-service teachers' reflective skills and, consequently, classroom practice. Pre-service teachers filmed and reflected on their teaching following a framework of written prompts. After evaluating positive aspects of their peers' teaching, pre-service teachers were instructed to discuss critical classroom events. Harford and MacRuairc (2008) established that pre-service teachers were reluctant to address critical events; however, they reflected more analytically when reminded of the prompts by the university facilitators present during reflection and feedback sessions. The need for highly structured reflection and feedback environments was also emphasised by So (2012), who analysed the learning outcomes of pre-service teachers in a video-based digital reflection and feedback environment. Although pre-service teachers reported that they benefitted from the possibility of peer interaction and self-reflection, So (2012) found that most online comments and feedback were superficial in nature. Therefore, So (2012) emphasised the need to provide pre-service teachers with standardised guidelines for evaluation to improve peer comments and feedback. Therefore, Kleinknecht and Gröschner (2016) applied a highly structured video-based digital reflection and feedback environment in a recent study. Pre-service teachers' reflections and feedback sessions were structured according to a video feedback cycle. Each session began with self-reflection, followed by peer and expert feedback, and concluded with a reflection on the proposed alternatives. Pre-service teachers' and experts' reflections and feedback were prompted by open-ended questions or rating items and composed following a three-step analysis. By first describing and then evaluating and explaining evaluations, followed by creating alternative teaching approaches for improvement, comprehensive reflections and

feedback were intended to be achieved. Additionally, feedback rules were established before pre-service teachers started filming themselves.

Apart from the inner structure of digital reflection and feedback environments, the outer structure also needs to be considered. Lee and Wu (2006) found that personal face-to-face interaction between pre-service teachers and experts, in addition to the digital reflection and feedback environment, was valued by pre-service teachers. Interacting only in video-based digital reflection and feedback sessions can become impersonal. Therefore, video-based digital reflection and feedback sessions should be accompanied by traditional face-to-face sessions (Malewski, Phillion, & Lehman, 2005).

1.7   Effects of digital practicum environments on reflection and feedback

Digital practicum environments enable pre-service teachers to reflect and receive feedback independent of place and time, thus increasing the opportunity for reflection and feedback sessions (Hixon & So, 2006). However, the different types of digital practicum environments (i.e., text vs video, peer feedback vs peer and expert feedback, synchronous vs asynchronous, and heavy scaffolding vs weak scaffolding) had varying impacts on pre-service teachers' reflection and feedback.

The text-based digital practicum environment used in the study by Bonk, Hansen, et al. (1998) showed that pre-service teachers in the asynchronous group provided their peers with more general feedback or suggestions than the synchronous group. Pre-service teachers in the asynchronous group focused more on their peers' analyses, which led to more in-depth analysis, while the synchronous group acted more 'egocentric' (Bonk, Hansen, et al., 1998, p. 308). In the previously mentioned follow up study, Bonk, Malikowski, et al. (1998) found that in both groups (i.e., heavy scaffolding and weak scaffolding), the mentor provided "individualised feedback and apprenticeship into the teaching profession" (p. 285). Furthermore, peer feedback in both scaffolding groups predominantly consisted of unsupported advice and opinions. Nonetheless, participants reported that they felt they benefited from sharing ideas and perspectives. However, they also indicated that their peers provided too many unreflective comments. Similarly, pre-service teachers in Whipp's (2003) study reported that they saw the biggest advantage in analysing issues from multiple perspectives. Furthermore, some participants indicated that opposing views led them to change their own perspective. In Kleinknecht and Gröschner's (2016) study, the video-based digital reflection and feedback environment was compared to a text-based control group concerning its impact on pre-service teachers' reflection and observation of teaching events. Although the control group did not work

online and did not receive peer feedback, Kleinknecht and Gröschner's study offers some insights into the effects of text-based reflection. The authors found that participants in the text-based control group explained their evaluations of classroom practice more thoroughly than pre-service teachers in the video-based digital practicum environment.

However, in Kleinknecht and Gröschner's (2016) study, pre-service teachers participating in the video-based digital reflection and feedback environment focused on more positive teaching situations in their reflections than the text-based group. Furthermore, participants in the video-based digital practicum environment also provided their peers with more teaching alternatives. In a video-based digital reflection and feedback environment applied by Wu and Kao (2008), pre-service teachers discussed their classroom practice with peers and experienced teachers. Wu and Kao (2008) established that the implementation of video allowed for more specific and in-depth feedback. Lee and Wu (2004) had previously made the same finding. The authors of both studies concluded that feedback specificity was improved because the video-based digital reflection and feedback environment enabled pre-service teachers to mark specific classroom events in the videos when providing feedback. In a similar study, So et al. (2009) found that pre-service teachers benefit from digital reflection and feedback environments by developing a "knowledge base for teaching" (p. 783) from observing a range of effective and ineffective teaching situations. Furthermore, the increased interaction between pre-service teachers in terms of comments and feedback led pre-service teachers to adopt suggested alternatives in future teaching practice (So et al., 2009).

Tripp and Rich (2012a) analysed the impact of face-to-face video reflection and feedback on in-service teacher change. The authors found that teachers trusted their peers' and mentors' recommendations more when they were able to witness the teaching situation "with their own eyes" (p. 738). Furthermore, teachers reported that the application of video helped them monitor their own progress and that they remembered salient video situations in subsequent teaching, which led to changes in practice. Moreover, the dissonance between self-reflections and video sequences prompted questions by participants and elicited deeper discussion. In a review of 63 video-based studies, Tripp and Rich (2012b) emphasised that mentors or supervisors play a significant role in video-based reflection and feedback. The authors found that participants placed more trust in their mentors' or supervisors' opinions than their own. Rich and Hannafin (2008) indicated that the use of video made mentor feedback more structured, specific, and comprehensive in comparison to face-to-face feedback.

2 Research question, research papers, and research design

2.1 Research question

Teaching practicums can effectively combine theory with practice and university with school (Gröschner, 2019; Grossmann, Hammerness, & McDonald, 2009). Teaching practicums enable pre-service teachers to advance their professional competence on all levels (i.e., disposition, situation-specific skills, and performance). Carefully designed digital practicum environments can also enhance pre-service teachers' development of professional competence (Bonk, Malikowksi, et al., 1998; Kleinknecht & Gröschner, 2016). Consequently, this cumulative dissertation focused on determining to what extent text- or video-based digital reflection and feedback environments have added value to pre-service teachers' development of professional competence in comparison to a traditional face-to-face format.

2.2 Research papers

This question was addressed by five research papers. Two of the papers are of a conceptual and methodological nature. They focus on the development and practical implementation of text- and video-based digital reflection and feedback environments, as well as the construction and validation of the text- and video-based tool and coding scheme applied to assess pre-service teachers' peer feedback competence. The papers were published nationally in a peer-reviewed conference anthology (Prilop, Weber, & Kleinknecht, 2019a) and refereed journal (Weber, Prilop, Glimm, & Kleinknecht, 2018). The remaining three research papers present empirical studies focusing on individual levels of professional competence and were published in international peer-reviewed journals (Prilop, Weber, & Kleinknecht, 2019b, 2020; Weber, Gold, Prilop, & Kleinknecht, 2018). In the following sections, the goals, approaches, and findings of the research papers will be outlined and discussed.

2.3 Research design

Pre-service teachers at the fourth-semester bachelor level in a German university took part in the studies. Pre-service teachers participated in a four-week teaching practicum at local schools. During their bachelor's degree program, pre-service teachers are required to take part in two teaching practicums. The first practicum is purely observational, while the second practicum requires pre-service teachers to teach four lessons by themselves. The studies were conducted during the second teaching practicum.

To connect theory to practice productively, teaching practicums need to be aligned to prior coursework (Gröschner et al., 2015; Hammerness et al., 2005). To enrol in the teaching practicum, pre-service teachers had to attend a lecture and a seminar on didactics and methods in the semester prior to the teaching practicum. While the lecture prepared pre-service teachers for the teaching practicum by providing an overview of theoretical concepts and teaching methods, the seminar ensured that pre-service teachers could plan a lesson. Pre-service teachers had to develop a fictitious lesson plan based on the theory and methods from the lecture.
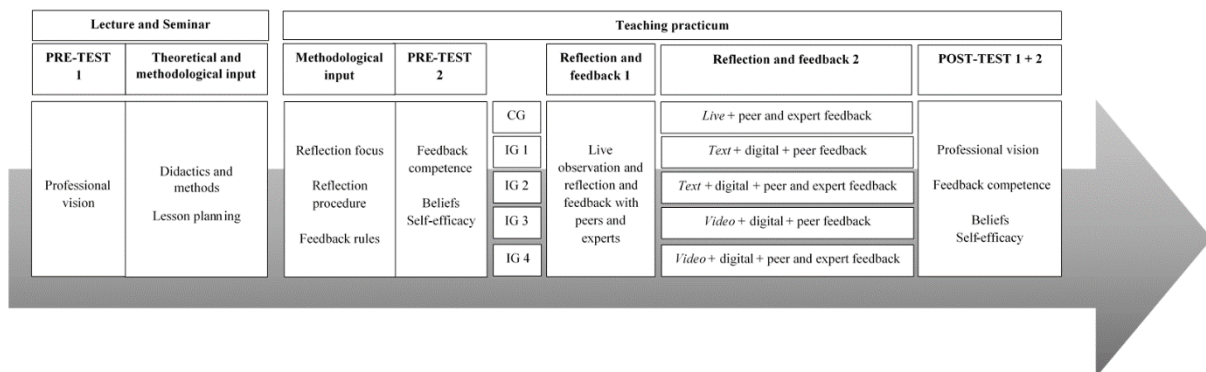

Figure 2: Timetable of intervention and overview of individual components (CG = control group/traditional practicum; IG 1 = intervention group 1/text-based digital reflection and feedback environment; IG 2 = intervention group 2/text-based digital reflection and feedback environment enhanced by expert feedback; IG 3 = intervention group 3/video-based digital reflection and feedback environment; IG 4 = intervention group 4/video-based digital reflection and feedback environment enhanced by expert feedback)

All studies followed a quasi-experimental, pre-test-post-test design (see Figure 2). Pre-service teachers had to complete four tests. One of the pre-tests was administered at the beginning of the semester (Pre-test 1), while the second one was administered at the end of the semester (Pre-test 2), before the teaching practicum. After the teaching practicum, two combined post-tests were administered (Post-test 1 + 2).

All the pre-service teachers participated in identical seminars and the same lecture before the teaching practicum. During the teaching practicum, pre-service teachers were divided into five different groups. The control group (CG) took part in a traditional practicum with live observations and face-to-face reflection and feedback with peers and experts, while the intervention groups 1 (IG 1) and 2 (IG 2) participated in a text-based digital reflection and feedback environment. While IG 1 participants only received feedback from peers, IG 2 pre-service teachers also received expert feedback. Intervention groups 3 (IG 3) and 4 (IG 4) took part in a video-based digital reflection and feedback environment. IG 3 pre-service teachers only received peer feedback, whereas IG 4 participants also received expert feedback. Pre-service teachers in IG 1, IG 2, IG 3, and IG 4 reflected and received feedback on two teaching

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sequences online and participated in one live observation with face-to-face reflection and feedback. CG pre-service teachers participated in two live observations and face-to-face reflection and feedback sessions.

3 Conceptional and methodical research papers

3.1 Development of digital reflection and feedback environments

Highly structured text- and video-based digital reflection and feedback environments (see Figure 3) were developed based on Kleinknecht and Gröschner (2016). Pre-service teachers were asked to upload, describe and reflect on instances of their teaching practice that showed both successful and unsuccessful classroom management (*monitoring*, *managing momentum*, *rules and routines*). They were provided with observation criteria. The sequence of reflection and feedback followed the video feedback cycle, and reflections and feedback were supposed to be composed according to a three-step-analysis (Kleinknecht & Gröschner, 2016). Additionally, pre-service teachers were provided with feedback rules and a worked example that illustrated reflection and feedback in the digital environments.

Figure 3: Interface of the video-based digital reflection and feedback environment with expert feedback (IG 1 = without video and without expert feedback, IG 2 = without video, IG 3 = without expert feedback).

3.2   Text- and video-based tool and coding scheme concerning feedback competence

A text- and video-based tool was developed to assess pre-service teachers' feedback competence. It consisted of a feedback situation that was based on an authentic one-minute classroom video sequence and a fictitious self-reflection of the teacher depicted in the video. Participants were asked to provide the teacher with feedback on classroom management. Written feedback was coded by applying a coding scheme adapted from Prins et al. (2006), which comprises six categories (i.e., focus, specificity, alternatives, activation, valence, and style).

Experts' ratings showed an acceptable degree of content validity concerning the feedback situation and coding scheme. Furthermore, intercoder reliability was found to be high. Comparing feedback written by pre-service teachers at the bachelor level with feedback from experts revealed that the tool and coding scheme were able to show expertise differences. Expert feedback was of a significantly better quality concerning specificity, activation, and style.

4   Empirical research papers

The effect of the different practicum environments (traditional practicum, text-based digital reflection and feedback environments, video-based digital reflection and feedback environments) was analysed on all levels of pre-service teachers' professional competence (see Table 1). Each study focused on a different level (disposition, situation-specific skills, performance). To establish a comprehensive understanding of the effects of the reflection and feedback environments, different independent variables were combined.

Study	Dependent variables	Independent variables
Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2019b). How digital reflection and feedback environments contribute to pre-service teachers' beliefs during a teaching practicum. *Studies in Educational Evaluation, 62*, 158-170.	Beliefs about teaching and learning; self-efficacy (disposition)	Traditional practicum vs text-based digital reflection and feedback environment enhanced by expert feedback vs video-based digital reflection and feedback environment enhanced by expert feedback
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.	Professional vision of classroom management (situation-specific skills)	Traditional practicum vs video-based digital reflection and feedback environment vs video-based digital reflection and feedback environment enhanced by expert feedback
Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2020). Effects of digital video-based feedback environments on pre-service teachers' feedback competence. *Computers in Human Behavior*, *102*, 120–131.	Teachers' feedback competence (performance)	Traditional practicum vs video-based digital reflection and feedback environment vs video-based digital reflection and feedback environment enhanced by expert feedback

Table 1: Dependent and independent variable of individual empirical studies.

4.1 Dispositions

Concerning dispositions, the impact of the different reflection and feedback environments on pre-service teachers' beliefs about teaching and learning (i.e., constructivist and traditional) and self-efficacy beliefs was investigated. These beliefs can have a significant effect on the instruction of teachers (Pajares, 1992). Teachers with traditional beliefs emphasise transmission- and control-based classroom practices, while teachers with constructivist beliefs provide learning environments that stress students' knowledge construction. When teachers possess high self-efficacy beliefs, they feel capable of coping with challenging or unmotivated students (Moulding, Stewart, & Dunmeyer, 2014). Various studies have established that high

teacher self-efficacy (Zee & Koomen, 2016) and constructivist beliefs (e.g., Kunter et al., 2013), in contrast to traditional beliefs, correlate positively with high school student achievement.

The study showed significant differences in the development of pre-service teachers' constructivist beliefs. Constructivist beliefs decreased in the traditional practicum (CG) and text-based digital reflection and feedback environment (IG 2), while constructivist beliefs remained at a high level in the video-based digital environment (IG 4). Additionally, traditional beliefs increased in the text-based digital environment but not in CG and IG 4. Although self-efficacy beliefs increased in all groups, there were no statistically significant differences. Content analysis of pre-service teachers' reflections and feedback in IG 2 and IG 4 revealed that reflections of pre-service teachers in the video-based digital reflection and feedback environment displayed higher level knowledge-based reasoning than pre-service teachers in the text-based digital environment. Furthermore, reflections in IG 4 contained more positive than negative evaluations. Evaluations contained in feedback were significantly more positive in the video-based digital reflection and feedback environment than in the text-based digital environment.

4.2   Situation-specific skills

Regarding situation-specific skills, the effects of the video-based digital reflection and feedback environments (IG 3, IG 4) on pre-service teachers' professional vision of classroom management (PVCM) were compared to the traditional practicum (CG). Classroom management has been found to have substantial effects on school students' cognitive, affective, and motivational outcomes (Hattie, 2009). PVCM is perceived as a necessary mediating skill for effective classroom management (van Es & Sherin, 2002). It enables teachers to notice and interpret crucial teaching situations and determine how to react appropriately (Sherin & van Es, 2009).

Results from a standardised, video-based test (Gold & Holodynski, 2017) indicated that participants of the video-based environment with peer and expert feedback (IG 4) significantly improved their overall PVCM and facets of PVCM (i.e., *monitoring*, *managing momentum*, *rules,* and *routines*) with a large effect. Pre-service teachers of IG 3 (i.e., video + peer feedback) only improved their PVCM concerning *monitoring* significantly. No significant improvements were found for the control group (i.e., a traditional practicum). Furthermore, significant interaction effects of time x group showed that IG 4 outperformed the CG regarding overall PVCM, *monitoring* and *managing momentum,* and IG 3 concerning *managing momentum*.

4.3   Performance

Concerning performance, the impact of the video-based digital reflection and feedback environments (i.e., IG 3 and IG 4) on pre-service teachers' feedback competence was assessed in contrast to the control group (CG). Feedback competence (i.e., providing a fellow teacher with an assessment of her or his teaching) can be considered crucial for developing professional competence in general (Hammerness et al., 2005; Sluijsmans et al., 2003).

Results from the text- and video-based tool applied to assess the development of pre-service teachers' feedback competence showed that participants in the video-based digital reflection and feedback environments (i.e., IG 3 and IG 4) improved their feedback competence regarding *specificity* more than pre-service teachers in the traditional practicum (i.e., CG). Moreover, pre-service teachers in IG 4 increased the quality of their feedback competence regarding *suggestions* significantly more than participants in IG 3.

5   Discussion, limitations, practical implications and future directions

5.1   Discussion

5.1.1   Video as a tool in practicums

The studies demonstrate that classroom videos and video-based digital reflection and feedback environments can effectively enhance pre-service teachers' professional competence. This finding can be predominantly attributed to two characteristics of the application in the digital reflection and feedback environments: (a) being able to revisit a multitude of authentic teaching situations without time pressure and (b) the degree of decomposition by deliberate, focused practice and scaffolding elements.

The content analysis of pre-service teachers' reflections and feedback in the text- and video-based digital reflection and feedback environments (i.e., IG 2 and IG 4) showed that being able to revisit their teaching experience on video provided pre-service teachers with additional reflective time and, thus, enabled participants of the video-based digital practicum environment to engage in more in-depth reflection (Sherin, 2007; Grossman, Compton et al., 2009). This was indicated by the significantly higher number of evaluations and a significantly higher degree of knowledge-based reasoning at the highest level. Furthermore, pre-service teachers also did not need to rely on their peers' self-reflections. The analysis of the peer feedback revealed that pre-service teachers were able to perceive additional information, in contrast to their peers' self-reflections. Their perceptions of the teaching situations were

significantly more positive than in the text-based digital reflection and feedback environment. The interplay and contrast of internal (i.e., self-reflection) and external (i.e., peer and expert) feedback seem to create a more balanced perspective on pre-service teachers' own teaching in the video-based digital practicum environment (Narciss, 2013; Tripp & Rich, 2012a). Consequently, the dissonance between pre-service teachers' classroom videos and their self-reflections and the authenticity of the *representations of practice* sparked a more thorough *investigation of practice* (Grossman, Compton et al., 2009; Tripp & Rich, 2012a). Furthermore, pre-service teachers in the video-based digital reflection and feedback environments benefited from being provided with an inner (*own* video) and outer perspective (*other* video) of teaching practice (Hellermann et al., 2015). Pre-service teachers in the video-based digital practicum environment with expert feedback were able to accumulate a situation-specific knowledge base (So et al., 2009) that fostered their professional vision of classroom management significantly more than the traditional practicum. Moreover, the outer perspective (*other* video) might have also shed a different light on their teaching practice (*own* video) as they were able to compare peers' successful or unsuccessful teaching events (*other* video) to their own. This might have also led to differences in the development of pre-service teachers' beliefs about teaching and learning.

The video-based digital reflection and feedback environments (i.e., IG 3 and IG 4) seem to have also had an advantage regarding decomposition over the traditional practicum setting. Video-based digital reflection and feedback environments can be characterised as *approximations of practice,* as they decompose the reality of actual peer feedback practice by means of asynchronous communication, as well as the use of specific classroom video sequences and a highly structured approach (Grossman, Compton et al., 2009). Contrary to pre-service teachers in the traditional practicum, participants in the video-based digital practicum environments were able to reflect and feedback without real-time pressure. In combination with methodological support (e.g., the reflection and feedback cycle, three-step-analysis, feedback rules, observation criteria, and worked example), pre-service teachers benefited from the reduced complexity of classroom events by video use and, thus, produced more in-depth reflections and higher quality feedback (Lee & Wu, 2006; Wu & Kao, 2008; Tripp & Rich, 2012a, 2012b). Apart from outperforming pre-service teachers' in the control group concerning their professional vision of classroom management (IG 4), this is also indicated by pre-service teachers achieving significantly more feedback competence concerning specificity (i.e., IG 3 and IG 4). The higher degree of decomposition (e.g., video sequence vs entire lesson; synchronous vs asynchronous) in the video-based digital reflection and feedback environment

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led to the deliberate practice of pre-service teachers' professional vision of classroom management and feedback competence (Ericsson et al., 1993; Ericsson, 2004).

5.1.2   Expert feedback in video-based digital reflection and feedback environments

Feedback plays a crucial role in practice-based learning opportunities and deliberate practice (Grossman, Hammerness, & McDonald, 2009; Ericsson et al., 1993). However, expert feedback seems to be of better quality and entails more substantial effects than peer feedback (e.g., Prins et al., 2006; Yang et al., 2006). The results of our studies on professional vision of classroom management, feedback competence, and the development of the text- and video-based tool to assess feedback competence support these findings.

The study on professional vision of classroom management showed that experts seem to draw pre-service teachers' attention to facets of classroom management that would otherwise go unnoticed. Comparing the video-based digital reflection and feedback environments (i.e., IG 3 and IG 4) revealed that pre-service teachers in the intervention group with expert feedback (i.e., IG 4) improved their professional vision concerning *managing momentum* significantly more than participants in the intervention group involving only peer feedback. The expert-novice-comparison conducted for the validation of the text- and video-based tool to assess feedback competence showed that experts provide significantly more specific, more activating, and more first-person feedback, while peers' feedback lacked specificity and displayed hardly any activating questions. It can be assumed that experts in IG 4 enhanced pre-service teachers' professional vision by specifying teaching situations regarding *managing momentum* and activated pre-service teachers with regard to these situations by asking them questions. Consequently, expert feedback can be seen as a lens that reduces classroom complexity and focuses on relevant teaching situations. The difference in the quality of feedback between experts and pre-service teachers might also be an explanation for a higher degree of trust in their mentors' and supervisors' feedback, as shown by Tripp and Rich's (2012b) review of 63 studies in the field of video-based feedback. The comparison of pre-service teachers' development of feedback competence adds to this picture. Pre-service teachers participating in the video-based digital reflection and feedback environment with expert feedback (IG 4) improved their feedback competence significantly more regarding the quality of suggestions than those in IG 3. In this instance, expert feedback can also be perceived as *representations of practice* (Grossman, Compton et al., 2009) and considered more authentic, as it is a competence they routinely put into practice. Pre-service teachers in IG 4 benefitted from expert modelling,

while IG 3 participants did not have the opportunity to observe the contrast between their own or other pre-service teachers' feedback concerning peers' classroom video sequences and feedback by experts.

5.2   Limitations

Some limitations concern all studies to the same degree. These limitations can largely be attributed to the research being conducted in an ecologically valid setting. The ecologically valid teaching practicum setting entailed non-random assignment to intervention groups, a small sample size, and limited controllability.

Due to data privacy laws, pre-service teachers had to actively volunteer and sign up for the video-based practicum groups (i.e., IG 3 and IG 4). Consequently, pre-service teachers could not be assigned randomly to individual groups. As a result, pre-service teachers in IG 3 and IG 4 could have been more motivated than participants in the control (i.e., CG) or text-based practicum (i.e., IG 1 and IG 2) groups.

Data privacy laws also had a limiting effect on the number of schools at which pre-service teachers could film themselves, as school authorities and students' parents had to agree to classroom videos being recorded. This resulted in small sample sizes concerning the video- and text-based practicums. The goal was to have similar sample sizes in the text- and video-based digital reflection and feedback environments. However, in a recent review, Major and Watson (2018) were able to show that research including *own video* rarely involves large samples. Because video application in teacher education is on the rise, classroom video can be expected to become more accepted.

Finally, ecologically valid settings entail a large number of contextual factors that can only be controlled to a limited degree. Although multiple contextual factors that could have impacted pre-service teachers' development of professional competence were assessed, some should be focused on in detail, such as the feedback pre-service teachers received from school mentors (Kraft, Blazar, & Hogan, 2018).

5.3   Practical implications and future directions

Although the limitations constrain broader implications to a certain extent, the findings also give rise to future research and practical implications, such as peer feedback training, the

construction of digital reflection and feedback environments, and the application of *other video* in digital reflection and feedback environments.

Peer feedback between (pre-service) teachers is neglected in teacher education (Hammerness et al., 2005). Generally, expert feedback is of higher quality than feedback by novices (Prins et al., 2006). Therefore, specific peer feedback training should be implemented in teacher education. However, components of peer feedback competence, such as domain knowledge and professional vision, need to be fostered (Alqassab, Strijbos, & Ufer, 2018). Hence, to increase the effect of digital video-based environments with only peer feedback, pre-service teachers should be progressively trained by first establishing domain knowledge (e.g., classroom management), then practising their noticing and knowledge-based reasoning skills by observing live classrooms or classroom video (e.g., professional vision of classroom management) and finally training the provision of peer feedback.

Research concerning (digital) reflection and feedback environments has found that scaffolding elements improve pre-service teachers' reflection and feedback (e.g., Bonk, Malikowski, et al., 1998; Harford & MacRuairc, 2008) and have positive performance effects (e.g., Gan, 2011; M. Gielen & De Wever, 2015). However, a variety of studies have also shown that scaffolding elements can negatively affect participants' disposition (e.g., Alqassab et al., 2018; S. Gielen, Peeters, Dochy, Onghena, & Struyven, 2010). Consequently, future studies should analyse the design of scaffolding elements in digital reflection and feedback environments in detail to produce scaffolds that have a positive impact on participants' disposition and performance.

Although using a combination of *own* and *other video* seems to promote pre-service teachers' professional competence most productively (Hellermann et al., 2015), integrating *own video* can reduce the number of participants or options for participation as indicated in the limitations section. Furthermore, implementing *own video* in digital video-based reflection and feedback environments requires a lot of technical and legal preparation before and assistance during practicums. Hence, incorporating only *other video*, which can be used as a stimulus for reflection, might be a viable alternative for more large-scale implementations of digital video-based reflection and feedback environments. However, additional research on how to make *other video* more productive would need to be conducted.

6   Conclusion

This cumulative dissertation contributes to understanding the effects of text- and video-based digital reflection and feedback environments during teaching practicums on pre-service teachers' professional competence. Text- and video-based digital environments make reflection and feedback time and location independent and, thus, can increase pre-service teachers' opportunities to reflect on their teaching practice and receive feedback from peers or experts (Lee & Wu, 2006). Digital reflection and feedback environments also offer *representations of practice* and *investigations of practice* concerning teaching practice and *approximations of practice* regarding feedback practice (Grossman et al., 2009a). However, the studies showed that authenticity could be considered a crucial element in fostering pre-service teachers' professional competence, making classroom video a superior alternative to live observation and text. Classroom videos can be decomposed into learning objective-specific sequences that can be revisited without time pressure and supported by scaffolding elements. Additionally, video-based digital reflection and feedback require expert feedback for a substantial impact on pre-service teachers' professional competence. Expert feedback can be seen as a lens reducing and focusing classroom complexity, enabling pre-service teachers to perceive crucial teaching situations that would have otherwise gone unnoticed and to benefit from expert modelling of high-quality feedback.

Consequently, video-based digital reflection and feedback environments with expert feedback can significantly improve pre-service teachers' professional competence during teaching practicums and, thus, better prepare pre-service teachers for future classroom challenges, leading to better learning environments for school students.

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Paper 1: Development of digital reflection and feedback environments

Weber, K. E., Prilop, C. N., Glimm, K., & Kleinknecht, M. (2018). Video-, Text- oder Live-Coaching?: Konzeption und Erprobung neuer Formate der Praktikumsbegleitung [Video-, text- or live-coaching?: Concept and field trial of new practicum support formats]. *Herausforderungen Lehrer_innenbildung*, *1*, 90-119. https://doi.org/10.4119/hlz-2384

Paper 2: Text- and video-based tool and coding scheme concerning feedback competence

Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2019a). Entwicklung eines video- und textbasierten Instruments zur Messung kollegialer Feedbackkompetenz von Lehrkräften [Development of a video- and text-based instrument to assess teachers' peer feedback competence]. In: *Lehrer. Bildung. Gestalten: Beiträge zur empirischen Forschung in der Lehrerbildung* [*Teacher. Education. Shape: Contributions to empirical research in teacher education*]. Ehmke, T., Kuhl, P. & Pietsch, M. (Eds.). Weinheim Basel: Beltz Juventa Verlag.
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Paper 3: Dispositions (beliefs about teaching and learning, self-efficacy)

Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2019). How digital reflection and feedback environments contribute to pre-service teachers' beliefs during a teaching practicum. *Studies in Educational Evaluation. 62*, 158-170. https://doi.org/10.1016/j.stueduc.2019.06.005

Paper 4: Situation-specific skills (professional vision of classroom management)

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

Paper 5: Performance (feedback competence)

Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2020). Effects of digital video-based feedback environments on pre-service teachers' feedback competence. *Computers in Human Behavior. 102*, 120–131. https://doi.org/10.1016/j.chb.2019.08.011

Erklärungen und Versicherung

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Hiermit erkläre ich, dass ich mich noch keiner Doktorprüfung unterzogen oder mich um Zulassung zu einer solchen beworben habe.

Ich versichere, dass die Dissertation mit dem Titel „Fostering and assessing pre-service teachers' professional competence with digital reflection and feedback environments" noch keiner Fachvertreterin bzw. Fachvertreter vorgelegen hat, ich die Dissertation nur in diesem und keinem anderen Promotionsverfahren eingereicht habe und, dass diesem Promotionsverfahren keine endgültig gescheiterten Promotionsverfahren vorausgegangen sind.

Ich versichere, dass ich die eingereichte Dissertation „Fostering and assessing pre-service teachers' professional competence with digital reflection and feedback environments" selbstständig und ohne unerlaubte Hilfsmittel verfasst habe. Anderer als der von mir angegebenen Hilfsmittel und Schriften habe ich mich nicht bedient. Alle wörtlich oder sinngemäß anderen Schriften entnommenen Stellen habe ich kenntlich gemacht.

Hamburg, 31.01.2020