The European Educational Researcher
http://www.eu-er.com

Self-Assessments of Professional Knowledge in Digital Media Use: Factors Influencing Primary School Teachers in Teacher Training

Cindy Bärnreuther & Marcus Penthin

Friedrich-Alexander University Erlangen-Nuremberg, Germany

Abstract: This study examines motivational orientations, individual prerequisites, and perceived support needs as key factors. It investigates how these factors are associated with prospective primary school teachers' self-assessments of their professional knowledge related to digital media use. The sample consists of $N = 569$ prospective teachers, including participants from both the first phase of teacher education ($n = 216$) and the second phase ($n = 353$). Using structural equation modelling, the study analyses three dimensions: confidence in media use, pedagogical relevance and perceived need for support. The analyses focus on three groups of predictors: motivational orientations (including attitudes and emotional factors), perceived support needs, and individual prerequisites. The analysis highlights emotional-motivational orientations as decisive predictors: anxiety reduces confidence, while enthusiasm fosters perceived relevance and reduces support needs. In addition, socio-demographic and biographical characteristics such as age, sex and prior media experiences contribute to differences in competence self-assessments. Although effect sizes are small, targeted qualification offerings – especially with a media pedagogical focus – prove effective in enhancing knowledge and lowering emotional barriers. These findings add differentiated evidence suggesting that teacher education should go beyond technical training by systematically and reflectively integrating media pedagogy into curricula. Emotion-sensitive, practice-oriented formats that address prior experiences are crucial to prepare future teachers for the challenges of digital transformation.

Keywords: digital media, media pedagogy, primary school, professionalization, teacher training
DOI: https://doi.org/10.31757/euer.922

Introduction

Across many education systems worldwide, teacher education is currently challenged by the question of how digital media, data-driven tools and AI-supported applications can be meaningfully integrated into classroom practice – particularly in primary education, where pedagogical sensitivity and developmental appropriateness are critical. Internationally, studies from Europe, the United States and East Asia indicate that prospective teachers often feel insufficiently prepared for teaching digital education, despite increasing policy expectations (OECD, 2021). Against this background professional societies and policy actors increasingly emphasize the growing relevance of digital education (Redecker, 2017). At the European level, the Digital Education Action Plan (EU, 2020) underscores the need to strengthen digital competencies, improve teaching quality through digital technologies, and ensure adequate infrastructures. The German Society for Educational Science (DGfE, 2022, 2024) calls for prospective teachers to move beyond seeing digital media as mere tools and to develop sound concepts for teaching digital education. Teachers must therefore engage with both opportunities and challenges of digital media in order to foster students' digital competencies (GI, 2023). In its strategy paper Education in the Digital World the German Conference of Ministers of Education (in German: Kultusministerkonferenz, short KMK) stresses the importance of enabling pupils – even in primary school – to use digital media responsibly (KMK, 2017). Achieving this goal requires teachers to acquire solid media pedagogical and didactical competencies (see section 2.2) during their training. In addition to media pedagogy and media didactics, teacher education programs increasingly include digital competencies, such as basic computational thinking and digital technology concepts. These components form part of the broader qualification landscape addressed in the present study. Nevertheless, the integration of digital education into teacher training remains inconsistent. Many universities still lack a compulsory and coherent concept for the

professionalisation of teachers for teaching and learning with and about digital media, rather than isolated or optional courses in media pedagogy (Eickelmann et al., 2016; Kammerl, 2009). Teachers in Germany also participate less in professional development on digital education than colleagues internationally (Kammerl et al., 2016). Deficits are particularly visible in the first and second phases of teacher education (i.e., university-based teacher education and the subsequent practical induction phase in schools) (Breiter et al., 2010; Schuknecht & Schleicher, 2020).

International comparative studies likewise suggest that teachers in Germany participate less frequently in professional development related to digital teaching than their counterparts in other countries (OECD, 2021).
As a distinct professional context, the use of digital media in primary school teaching poses distinct educational challenges with specific pedagogical demands. Teachers in primary education typically act as generalists, integrate digital media across subjects, and are responsible for supporting foundational learning processes such as literacy, numeracy, and socio-emotional development. Consequently, decisions about the use of digital media are strongly shaped by considerations of age-appropriateness, developmental sensitivity, and pedagogical coherence rather than by subject-specific technological expertise.

In contrast to secondary education, digital media in primary school are not only tools for subject-specific learning but also resources for supporting early learning processes, guided exploration, and the development of basic digital literacy. The pedagogical use of digital media therefore requires careful scaffolding, structured guidance, and continuous reflection on developmental appropriateness, as young learners often lack independent learning strategies and require close instructional support. These characteristics highlight that the specificity of media use in primary school lies not merely in its cross-curricular nature but in its strong orientation toward foundational learning, developmental support, and pedagogical responsibility, which in turn shape teachers' professional knowledge and self-assessments in digital education.

Against this background, this study examines which individual and structural factors explain prospective primary teachers' self-assessments of professional knowledge for teaching digital education. Using structural equation modelling (SEM), we analyse the role of attitudes, emotions, socio-demographic and biographical characteristics as well as structural factors (e.g. perceived extent of teaching content, perceived media pedagogical framework conditions) and derive implications for targeted professionalization measures in teacher training (van Ackeren et al., 2019).

Professional development of teachers

Digitalization in education requires targeted professional development of teachers to meet the demands of digital teaching. This chapter presents key theoretical concepts, models, and definitions relevant to teacher professionalization. In addition to general aspects, specific challenges and conditions in German teacher training are discussed. Existing models for describing professional competencies and aspects of media pedagogy and media didactics are considered. A framework for assessing the digital competencies of prospective teachers (Bärnreuther et

al., 2023) including competencies related to media pedagogy and media didactics was adapted with a focus on self-assessed professional knowledge and forms the theoretical basis for the empirical research in this article.

National and European perspectives on teacher professional development

Teacher professionalization is intensively discussed at European and national levels. European comparative studies and policy documents point to common challenges in teacher education, including the rapid pace of technological change, increasing expectations regarding digital competencies, and the need to align digital media use with pedagogical and developmental considerations. At the same time, European developments provide valuable insights into how digital education can be more systematically anchored in teacher training curricula.

In Germany, the federal organization of the education system and differing curricular requirements across the 16 federal states create specific structural conditions that may lead to inconsistent training pathways. Against this background, this chapter outlines international and European standards for teacher education and highlights central features and challenges of teacher training in Germany in order to identify relevant framework conditions for media pedagogy and media didactics competencies.

European and international standards for teacher education

The EU's Digital Education Action Plan (EU, 2020) promotes digital competencies in education through infrastructure improvement, teacher training, and European cooperation. The DigCompEdu Framework (Redecker, 2017) describes six competence areas; for the purposes of the present study, particular attention is given to (1) digital resources and (2) teaching and learning with digital media, as these areas most directly relate to instructional design and classroom practice in primary education. These competencies focus on differentiated, inclusive instruction and supporting learners' digital skills. Compared to other framework for teachers' skills and attitudes with digital media such as the international ISTE (2008) standards, DigCompEdu emphasizes classroom use and promoting students' digital competencies.

Some countries (Finland, Estonia) institutionalize digital teacher training mandatorily, while Germany lags behind (OECD, 2021). These international approaches highlight the need for stronger curricular anchoring of digital education across all training phases.

The role of digital education in teacher training in Germany

The German teacher training system is structured in three phases: (1) university education, (2) practical preparatory service in schools, and (3) continuing professional development. Although, details vary across the 16 federal states, the core elements are comparable.

The first phase takes place at universities or teacher training colleges and leads to either the first state examination or a Bachelor of Education. Students acquire subject-specific, didactic, and educational knowledge over 3.5 to 5 years.

Some states offer compulsory media education courses, but integration into curricula is inconsistent. Systematic teaching of media education, including media pedagogy, media didactics and elements of computer science education, remains inconsistently regulated.

The practical preparatory service forms the second phase and lasts between 12 and 24 months, depending primarily on the federal state and its specific regulations. While the formal structure is comparable across school types, the pedagogical focus and opportunities to engage with digital media differ, particularly in primary education. Prospective teachers gain classroom experience under seminar teachers' guidance and attend seminars to deepen pedagogical knowledge. Although digital media are increasingly used in schools, the systematic teaching of digital literacy and media pedagogy remains inconsistently regulated. While the KMK (2019) sets common requirements, implementation is left to individual states, resulting in uneven training.

After the preparatory service, teachers enter the profession and are largely responsible for their own continuing education. Opportunities to develop digital competencies are often voluntary and organized by states or external providers. Compared internationally, Germany offers few mandatory digital training measures, unlike countries such as Estonia or Finland, where continuing education is more institutionalized and sometimes compulsory.

Professionalization in teacher training in the context of digital education

Teacher professionalization in the context of digital education refers to the development of pedagogically grounded professional knowledge that enables teachers to design, reflect on, and justify the use of digital media in classroom practice. For primary school teachers in particular, this involves evaluating digital media with regard to age-appropriate learning, cross-curricular teaching, and pedagogical relevance rather than technical specialization. Accordingly, professionalization processes in digital education are shaped not only by knowledge and skills, but also by attitudes, emotional-motivational orientations, and perceived structural conditions within teacher training. These dimensions provide the conceptual basis for the models discussed below and for the framework guiding the empirical analysis in this study.

In this study, the term media pedagogy is used as an umbrella concept referring to the pedagogical use of digital media in teaching and learning contexts (Blömeke, 2003; Tulodziecki et al., 2018). In addition to media pedagogical and media didactical competencies, qualifications in computer science education is increasingly considered an essential component of teacher professional development, as it supports teachers' understanding of the functioning of digital technologies and their pedagogical use in classroom contexts (KMK, 2017). Digital education is understood in this study as teaching and learning with and about digital media in pedagogically meaningful ways (Irion & Kammerl, 2018; Tulodziecki et al., 2018). The term digital competencies (Redecker, 2017) refers more specifically to foundational abilities required for responsible and effective participation in a digitally mediated world and includes elements related to computer science education. While closely related to media pedagogy, these concepts serve different analytical purposes in the present study.

Professional development of (primary school) teachers for effective digital teaching: fundamentals and models

Professional development builds on subject knowledge, pedagogical knowledge, and didactic skills (Shulman, 1987). In the context of digital education, these foundations must be complemented by targeted learning opportunities to develop media pedagogy and media didactics competencies enabling teachers to design, justify, and reflect on the pedagogical use of digital media in classroom practice. Blömeke (2003) defines media pedagogy competency as encompassing one's own media skills, the ability to support students, and the capacity to design learning processes with digital media. Her model includes five dimensions: media didactic competency, media educational competency, socialization-related competency, own media competency, and school development competency. This conceptualization highlights the pedagogical and contextual embeddedness of professional competence for digital teaching.

Subsequent models increasingly emphasize the role of individual dispositions in professional development. The M3K model (Herzig et al., 2015) stresses the importance of self-efficacy beliefs and attitudes toward teaching with digital media, while the Will–Skill–Tool model (Knezek & Christensen, 2016) conceptualizes successful media integration as the interplay of motivational orientations (Will), competencies (Skill), and access to appropriate resources (Tool). Together, these approaches underline that professional development in digital education is shaped not only by knowledge and skills, but also by emotional-motivational orientations and perceived opportunities for using digital media in teaching.

More integrative frameworks explicitly address the interaction between individual and structural conditions. The supply–use model (Helmke et al., 2007) describes professional competence as emerging from the interplay of individual abilities, motivational orientations, and contextual learning opportunities. Similarly, Baumert and Kunter (2011) conceptualize professional competence as a combination of knowledge domains and motivational aspects that jointly influence teachers' professional action and development. From a knowledge-integration perspective, the TPACK model (Koehler & Mishra, 2009) illustrates how technological (TK), pedagogical (PK), and content-related knowledge (CK) must be meaningfully connected to inform instructional decision-making in teaching digital education. Comparable perspectives are reflected in the DPACK model (Huwer et al., 2019), which conceptualizes digitally related pedagogical knowledge as an integrated component of teachers' professional knowledge in digitally enriched learning environments.

While these models provide important general insights into teacher professionalization, they should be interpreted in a school-type-specific manner, particularly with regard to emotional-motivational orientations and the perceived pedagogical relevance of digital media. Primary school teachers operate within distinct pedagogical conditions. They are required to balance age-appropriate learning environments, cross-curricular teaching responsibilities, foundational literacy and numeracy goals, and the pedagogical use of digital media without over-instrumentalization. These characteristics shape how digital media are evaluated, appropriated, and integrated into

teaching practices. Empirical studies show that primary teachers tend to report higher uncertainty and lower self-efficacy regarding digital media use compared to secondary teachers (Kindermann & Pohlmann-Rother, 2022; Oetjen et al., 2025). These findings underline the relevance of focusing explicitly on primary teacher education rather than teacher training in general. Primary school teachers typically act as generalists and integrate digital media across subjects rather than within subject-specific instructional traditions. Consequently, self-assessments of professional knowledge in this study reflect cross-curricular pedagogical considerations rather than subject-bound technological expertise.

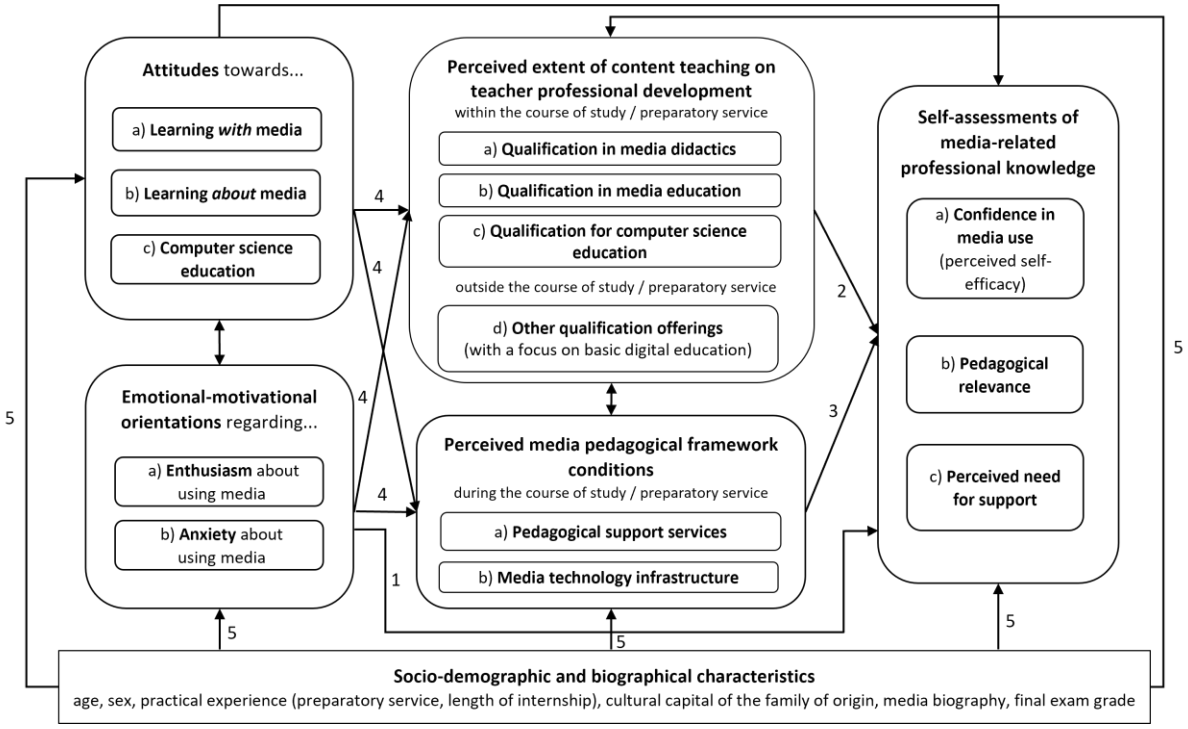
The framework model of profession-related self-assessments by prospective primary school teachers for teaching digital education

Building on the aforementioned models, a framework based on Bärnreuther et al. (2023) systematizes key factors influencing media-related professionalization of primary school teachers (Figure 1). It assumes that self-assessments of media-related professional knowledge are shaped by media-related attitudes, computer science education, emotional-motivational orientations (enthusiasm, anxiety), perceived extent of content teaching on teacher professional development and perceived media pedagogical framework conditions. Qualification for computer science education is considered an important component of understanding the functioning of digital media and is therefore closely related to learning about media within the framework of digital education. Socio-demographic and biographical characteristics of prospective teachers – e.g., age, sex, media biography – play an important role in emotional-motivational orientations, the use of the offering, and the skills of prospective teachers in imparting digital education. The model highlights that media attitudes and emotional-motivational orientations affect professional self-assessment and the effective use of digital media in teaching. For the purpose of transparency, the central constructs and their assumed interrelations are briefly summarized below, while the full theoretical derivation and validation of the model can be found in the referenced publication.

In this study, the term professional knowledge in digital education is used in a competence-oriented sense and refers to teachers' self-assessed pedagogically grounded knowledge for planning, implementing, and reflecting digital education. In line with prevalent competence frameworks in teacher education, professional competence is understood as a multidimensional construct comprising cognitive, motivational, and affective components (Baumert & Kunter, 2011). Accordingly, the focus of this study is not on enacted competence but on teachers' self-assessments of their professional knowledge as an important indicator of professional orientations and perceived readiness for action.

Figure 1

Framework model explaining the professional knowledge of prospective primary school teachers for teaching basic digital literacy, based on Bärnreuther et al. (2023)



Note. The constructs (or their disturbances in the case of endogenous variables) within the outer boxes are assumed to be correlated with each other but are not shown for the sake of clarity. The numbered paths reflect the hypotheses examined (see below).

To ensure terminological clarity, the following distinctions guide the conceptualization of the constructs used in this study: (a) digital education refers to teaching and learning with and about digital media in pedagogically meaningful ways; (b) media pedagogy and media didactics denote pedagogical competencies for designing and reflecting digital learning environments; and (c) digital competencies describe broader abilities related to the responsible and effective use of digital technologies. These concepts are related but not synonymous and are therefore used deliberately throughout the manuscript.

Current state of research on teachers' professional development.

The professional development of teachers in the digital age encompasses individual prerequisites, institutional framework conditions, and perceived support needs. This chapter presents the current state of research on media pedagogy and media didactics as well as elements related to computer science education competencies in teacher training, explicitly focusing on prospective primary school teachers. Due to the limited empirical evidence for primary education, much of the discussion draws on findings from secondary education or international studies, noting where differences to primary teaching may be expected. The structure follows the framework in Figure 1, linking each aspect to the constructs of media-related self-assessment.

Individual prerequisites: attitudes, emotions, socio-demographic and biographical characteristics

Attitudes and emotional-motivational orientations are key factors influencing the use of digital media in the classroom. Numerous studies show that these factors significantly affect the development of media pedagogy competencies (Kindermann & Pohlmann-Rother, 2022; Wijnen et al., 2021). In Figure 1, these factors correspond to media-related attitudes and emotional-motivational orientations, which directly influence self-assessments of professional knowledge and, indirectly, perceptions related to instructional practices. Technological teaching practices are operationalized in the model via perceived qualification offerings, reflecting teachers' perceptions of the availability and scope of formal learning opportunities related to digital media use.

Socio-demographic and biographical characteristics (age, sex, prior media experience) affect emotional-motivational orientations and media-related self-assessments. Age interacts with socialization and prior experience rather than acting as a stable predictor; this nuance is reflected in the model and will be examined further in the results (Oetjen et al., 2025; Rahden, 2025; Vogelsang & Schwabl, 2024). In primary education, media-biographical influences are particularly underexplored, emphasizing the need for school type-sensitive research.

Perceived extent of content teaching on teacher professional development

Teacher training content design is crucial. Systematic teaching of basic digital literacy is heterogeneous: while the Netherlands, for example, has temporary programs to promote media literacy (Boon et al., 2013), the programs in Serbia and Italy are considered inadequate (Calzone & Chellini, 2016). In Austria, despite the availability of technical equipment, there is a lack of binding structural concepts for media education in teacher training programs (Tischler & Wakounig, 2013). This highlights the need for targeted qualification measures, both within and outside of university studies. In Germany, systematic teaching of basic digital literacy in the first phase of teacher training is often lacking (Lachmann et al., 2023), and media pedagogy and media didactics courses are frequently optional (Eickelmann et al., 2014; Kammerl & Mayrberger, 2011; Niesyto, 2012). Similar challenges apply to basic computer science education, where curricular integration and structured learning opportunities are still developing in many teacher education programs. In primary education, courses are often insufficiently tailored; students rate their ability to design digital lessons lower than those in other tracks, highlighting the need for target group-specific strategies considering developmental and didactic characteristics (Irion et al., 2020; Vogelsang & Schwabl, 2024).

Perceived media pedagogical framework conditions

In addition to curricular anchoring, the quality of structural framework conditions is decisive for developing professional media pedagogy competencies. Student teachers often consider media pedagogy programs insufficient and feel inadequately prepared, a problem also noted in Germany regarding the integration of practical elements in university studies (Kammerl & Ostermann, 2010; Sickel, 2019).

Media technology infrastructure is crucial, as inadequate equipment prevents students from acquiring basic skills or gaining teaching experience (Balisane, 2015; Herzig & Grafe, 2007; Honegger & Hielscher, 2017; Tulodziecki,

2012). Effective programs must therefore link media pedagogy content closely with practical phases and available resources. Moreover, technical support alone is insufficient; institutional anchoring, pedagogical frameworks, and clear strategies are needed to promote profession-relevant self-perceptions (Gerick et al., 2023). Teacher training must integrate media-related content with curricular, subject-specific, and practical components to strengthen competencies for digital education.

Self-assessments of digitally media-related professional knowledge

Self-efficacy expectations, i.e., confidence in using digital media in the classroom, are strong predictors of active media use (Bandura, 1997; Herzig et al., 2015). Empirical studies show that primary school teacher training students with positive attitudes and higher self-efficacy are more willing to engage with media didactic opportunities, whereas more sceptical students report higher support needs (Pohlmann-Rother & Kindermann, 2023; Štemberger & Čotar Konrad, 2021).

Although attitudes toward digital media are often positive, teachers may still consider media pedagogy competencies of limited relevance or feel insufficiently prepared (Tulodziecki, 2000), highlighting a gap between attitudes and actual capacity for action. Student teachers increasingly call for targeted support to use digital media meaningfully (Štemberger & Čotar Konrad, 2021), addressing both technical and conceptual-didactic aspects. The emotional dimension is also important: teachers who feel uncertain or overwhelmed report a greater need for support (Wijnen et al., 2021). Positive emotions, such as job satisfaction and work engagement, are linked to active use of digital technologies (Klusmann et al., 2008; Pecher, 2025). Thus, professional development in the digital realm is not only cognitively but also affectively anchored, an aspect often neglected in designing support services.

Despite the growing body of research on teachers' competencies in digital media use, empirical evidence on prospective primary school teachers' self-assessments of their professional knowledge remains limited. Existing studies often focus on single dimensions, such as attitudes, technological skills, or structural conditions, while the combined influence of individual prerequisites, emotional-motivational orientations, qualification opportunities, and institutional framework conditions has rarely been examined within an integrated analytical framework. This fragmentation is particularly problematic in primary education, where professional competence development depends on the interaction of pedagogical, developmental, and contextual factors.

Consequently, there is a need for research that systematically examines how these factors jointly contribute to prospective teachers' self-assessments of professional knowledge in digital education. Addressing this gap requires an integrative model that captures both individual and structural influences on professional learning processes.

Research desiderata and research questions

While international research has examined digital teacher competencies using frameworks such DigCompEdu (Redecker, 2017), comparatively little is known about how emotional-motivational orientations and perceived structural conditions jointly influence self-assessed professional knowledge in primary teacher education. Most

existing studies focus on secondary education, subject-specific digital competencies, or technology acceptance, and often neglect the institutional and pedagogical particularities of primary schools. European research highlights structural disparities across training phases and countries but rarely integrates attitudes, emotions, and socio-demographic factors in comprehensive explanatory models. Empirical evidence specific to primary education remains scarce, limiting the understanding of how prospective primary teachers develop professional knowledge related to digital media and which contextual conditions support or hinder this process.

The present study addresses this gap by explicitly considering the distinctive characteristics of primary teaching, including age-appropriate media selection, cross-curricular integration, and pedagogical responsibility for young learners. It integrates emotional-motivational orientations, perceptions of qualification measures, and structural conditions – including technical equipment, institutional support, and pedagogical guidance – within a single explanatory model. By drawing on international findings where primary school-specific evidence is limited, the study provides a school type-sensitive perspective on the development of media-related professional self-assessments and the conditions that facilitate or constrain digital teacher professionalization. Where the results do not provide conclusive evidence on aspects such as effective course formats (e.g., project-based learning or practical applications), these will be considered further in the discussion section.

The hypotheses derived in this chapter are based on the conceptual framework introduced in Chapter 2 (see Figure 1). The model specifies the relationships between individual prerequisites, motivational orientations, learning opportunities during teacher education, and prospective teachers' self-assessments of their professional knowledge related to digital media use in primary education.

Overall, this paper addresses the following research questions:

(1) *What effects do **media-related attitudes** and **emotional-motivational orientations** have on the self-assessments of media-related professional knowledge?*
Research shows that positive attitudes and high self-efficacy expectations promote engagement with digital media, while uncertainty and fear of technology can have an impeding effect.

(2) *What effect does the **perceived extent of content teaching for teacher' professional development** have on the self-assessments of media-related professional knowledge?*
Research shows that targeted and practice-oriented training content is particularly effective and that subject-specific approaches can have different effects.

(3) *To what extent do the **perceived media pedagogical framework conditions during the course of study** promote or inhibit the self-assessments of media-related professional knowledge among prospective primary school teachers?*

Research findings suggest that practical and curriculum-related measures are particularly effective and that a more precise identification of the most effective offerings is necessary.

(4) *To what extent do the perceived extent of content teaching on teacher professional development and the perceived media pedagogical framework conditions in studies* mediate *the relationship between media-related attitudes or emotional-motivational orientations and self-assessments of professional knowledge?*
Research findings suggest that curricular anchoring, technical equipment, and support services can promote self-assessment in relation to media-related professional knowledge.

(5) *What* ***socio-demographic and biographical characteristics*** *explain the self-assessments of media-related professional knowledge among prospective primary school teachers?*
This question examines the effect of the background variables age, sex, practical experience, cultural capital of the family of origin, media biography, and final exam grade. However, these individual characteristics have only been addressed to a limited extent thus far. A more detailed examination of their significance could therefore contribute to further insights.

(6) *Are there* ***differences*** *between student teachers and prospective teachers in terms of*
   a. *the level of latent means in all constructs?*
   b. *the correlations examined in 1 to 5?*

   Differences in their theoretical and practical training could explain varying assessments and influencing factors.

Methodology[1]

Sample

The cross-sectional survey conducted throughout Germany was carried out digitally via Unipark (Questback EFS, 2020) from April to December 2020 and, in addition to the variables used here, also included items on the six areas of competence in digital education (KMK, 2017), the effects of the COVID-19 pandemic, and related to other needs. A total of 713 people participated (completion rate: 35%, average time taken to complete the questionnaire: 30 minutes and 37 seconds). After cleaning up the data set for cases that only had missing values after the first scale item asked, the sample comprised 569 participants from all subjects taught in primary school education (age: M = 27.12 years, SD = 6.13; min = 18; max = 60), with a very high proportion of women (around 92%), as expected for the primary sector. The low proportion of elderly people are probably career changer. There were 216 in the first phase of training (38%; at the end of their studies) and 353 in the second phase (62%; at the beginning of their preparatory service). We take the different phases of teacher education as a control variable into account to analyse the structural relationships across different training contexts. The distribution of participants across the 16 German federal states varies greatly: Baden-Württemberg with 26%, North Rhine-Westphalia with 22%, Bavaria, Berlin, and

[1] We report all measures in the study, all manipulations, any data exclusions, and the sample size determination rule.

Hamburg with around 8%, Saxony with 7%, Schleswig-Holstein and Hesse with 5%, and all other federal states with less than 5%. This uneven distribution is the result of the sampling strategy: a convenience sample was taken, with the questionnaire link being distributed via various channels. These included internal university networks, mailing lists, and personal contacts. There was no targeted quota allocation by federal state or a-priori power analysis, so participation depended largely on the availability and interest of the target group.

Due to Germany's federal education system, teacher education programs and the level of digital infrastructure vary across the 16 federal states. While some states represented in this sample have introduced mandatory components related to digital education in initial teacher training – most notably Baden-Württemberg, Bavaria and Hamburg – others continue to rely largely on voluntary courses, project-based initiatives or institution-specific implementations, as is the case in North Rhine-Westphalia, Berlin and Saxony at the time of data collection (2020). These differences reflect the federal responsibility for teacher education and result in heterogeneous learning opportunities for prospective teachers with regard to media pedagogy and digital teaching across the training phases. These differences between regional contexts may influence the results and should therefore be considered when interpreting the findings.

Instruments

The measures used in this study are mainly tried-and-tested instruments and were specifically selected and slightly adapted[2] to reflect the professional requirements of primary school teacher education. While some instruments originate from research on teacher education more broadly, all constructs were operationalized with explicit reference to teaching and learning in primary school settings, where pedagogical appropriateness, developmental sensitivity and generalist teaching roles are particularly salient. Since prospective teachers in most German federal states complete internships during their studies, student teachers can also answer questions relating to teaching practice in schools.

Attitudes toward the use of digital media were assessed using the subscales for *learning with media* and *learning about media* (Gerick & Eickelmann, 2017; Richter et al., 2001; Vogelsang et al., 2019), in abbreviated form, and *computer science education in primary schools* (three items based on the results of the group Delphi of Käfer et al. (2020) were adopted).

The e*motional-motivational orientations* were measured on the one hand by *enthusiasm about using media*, following Baumert et al. (2008, p. 98); prompt: "We are now interested in your individual experience with digital media: How do you feel when teaching with and about digital media?"). Item Enth5 ("My attitudes toward digital media in an educational context have changed for the better due to the challenges of the 'coronavirus crisis'.") was

[2] Modifications primarily involved contextual rewording of items to reflect primary school teaching scenarios and the specific professional tasks of prospective primary teachers but did not alter the theoretical core of the constructs. See Table A1 and Table A2 in the online supplements for descriptive statistics, response formats, sample items and adaptions to the original.

excluded due to a low factor loading (λ = .28, see the R-script in the online materials). On the other hand, the research team expanded a scale developed by Venkatesh and Bala (2008, pp. 313–314) on *anxiety about using media* by four items so that the areas of general anxiety about digital media, uncertainty in teaching with media, and uncertainty in teaching about media, including computer science education, could be taken into account. The items included in this scale address emotional and motivational orientations toward both learning with digital media as instructional tools and learning about digital media as subject-related content. This combined perspective reflects the dual role of digital media in primary education, where digital technologies are used both to support learning processes and to develop basic digital literacy.

The scales for the *perceived extent of content teaching on teacher professional development* in the sub-areas of *qualification in media didactics*, *media pedagogy* and *computer science education* were developed in-house as part of the entire P³DiG – Primat des Pädagogischen in der Digitalen Grundbildung (in English: The Primate of Pedagogy in Primary Digital Education). Of the original seven items per sub-area, only the five relating to the first phase of teacher training were included in the analysis. It turned out that the three items with the suffix "...as part of courses/experiences gained outside of university or practical preparatory" could not be empirically assigned to the three sub-areas, but had to be modelled as a separate factor named *other qualification offerings*.

Perceived media pedagogical framework conditions during the course of study were surveyed using ten items based on Bos et al. (2016) and reformulated in relation to "digital media." In the confirmatory factor analyses, two factors could be modelled, namely *pedagogical support services* (five items) and *media technology infrastructure* (two items). One item (ANG_Stud6"I was able to learn how to promote students' informatics competence.") had to be excluded due to content overlap and corresponding double loading with an item from the sub-area q*ualification for computer science education* (λ = .53 and λ = .60, respectively). Item ANG_Stud3 ("There is sufficient pedagogical support for integrating digital media.") was poorly formulated and loaded equally high on both factors with λ = .63, and ANG_Stud10 ("The institution placed emphasis on learning with digital media during the COVID-19 pandemic.") had a low loading (λ = .42) compared to the other items in the factor.

Self-assessments of media-related professional knowledge were collected using twelve items (Endberg, 2019), with prospective teachers asked to rate each item in three areas (self-efficacy expectations in relation to *confidence in media use* (in German: *Zutrauen (Z)*), *pedagogical relevance* (in German: *Wichtigkeit (W)*), *perceived need for support* (in German: *Unterstützungsbedarf (U)*). The items TPCK_Z4/_W4/_U4 ("I can select digital media for my lessons in such a way that they improve what and how I teach and how the students learn.") were excluded from the analyses because they combined three questions into one item each (cf. Table A2).
The *socio-demographic and biographical characteristics* were surveyed and coded as follows: age (open ended response), sex (response format: 0 = male, 1 = female), preparatory service/second phase of teacher training ("I have already started my teacher training (preparatory service).", response format: 0 = no; 1 = yes), practical experiences ("How long is your total practical experience in educational institutions (excluding the time spent in your teaching

internship/preparatory service)?", open ended, in months), cultural capital of the family of origin („How many books were in the household you grew up in?", response format 1 = less than 50 books, 2 = more than 50 to 100 books, 3 = more than 100 to 150 books, 4 = more than 150 to 250 books), media biography (prompt: "Who has taught you about digital media so far?", seven items (teachers/educators during your school days, friends, parents, siblings, university/college, myself, others), 4-point Likert-type scale 1 = nothing at all; 4 = a lot) and the final exam grade (which can be either the grade in the first state examination, an equivalent degree (bachelor's/master's) or another final exam grade, open-ended response format: 1 to 4 with one decimal place).

Methodology

The analyses were performed with R (version 4.5.2) using mainly the packages "lavaan" (v. 0.6-21) (Rosseel, 2012) and "semTools" (v. 0.5-7) (Jorgensen et al., 2025) while applying Maximum Likelihood Estimation with robust standard errors (MLR; Brown, 2015, p. 346) due to slight deviations from normal distribution of the variables used to build the scales (cf. Table A2; skewness range: −1.04, 1.8; excessive kurtosis range: −1.21, 2.23). Missing values for all variables used in the complete CFA (cf. Table A2 and missing data pattern) occurred in 71% of cases (with 132 missing values per variable on average, min = 0; max = 226) and were estimated model-based using Full Information Maximum Likelihood (FIML). The robustness of the results was assessed by inspecting the missing data patterns as well as comparing FIML results with those using listwise deletion (for a detailed description see online appendix and missing data pattern). The inclusion of the federal state as a cluster variable for adjusting the standard errors, as originally planned, was abandoned because these were too unevenly distributed.

Construct validity

We first conducted confirmatory factor analyses using the effect-coding-approach as the scaling method for the latent variables, this yields the optimally weighted average of all indicators per factor (Little et al., 2006).We proceeded step by step, first examining the constructs individually and then all constructs in a complete CFA, removing some items in the process (see chapter 5.2). The constructs were measured generally with good ($\omega \geq .70$) to satisfactory ($\omega \geq .60$) congeneric reliability (Hair et al., 2014, p. 619) whereby the factor "Qualification in media didactics" is not as reliable in the group of students, which is primarily a result of lower factor loadings in this group (cf. Table A2 and Table A4). The factor loadings were all substantial with average variance explained ϵ [.27; .63] by the factors, suggesting convergent validity (Hair et al., 2014). Discriminant validity of the constructs was inspected in two ways. First, the modification indices did not show substantial cross-loadings, except Item ANG_Stud9 ("Overall, the institution places emphasis on teaching with and about digital media.") also had a loading of $\lambda = .37$ on the factor "Media technology infrastructure" but was only assigned to the factor "Pedagogical support services" ($\lambda = .55$). Second, the standardized residuals did not indicate any serious irregularities since 99% of them were below the threshold |4.0| and there were no patterns in the residual correlations (Brown, 2015, 97ff). Third, discriminant validity was evaluated by inspecting the latent correlations of all variables (see Table A2) with the approach suggested by Rönkko & Cho (2022) and their classification system. We found four correlations suggesting marginal problems when testing the upper confidence intervals of the latent correlations against a baseline model.

But the interpretation of the scales as representations of distinct constructs in this case is probably safe (Rönkkö & Cho, 2022, p. 31). Also, check for multicollinearity issues revealed virtually no problems (VIF for all latent constructs < 5, mean VIF = 2.5 (Field, 2018)).

Selecting variables for the analyses

To keep the SEM as compact as possible, we then looked at the effects of the bivariate latent correlations (see Table A2) of our predictor/mediator variables with "Self-assessments of media-related professional knowledge". Variables that showed a non-substantial correlation with one of the three self-assessments of media-related professional knowledge variables with a predefined smallest effect size of interest of $r < |.10|$ were not included in the SEM (Lakens et al., 2018; see the R-Script in the online materials).[3] This only affected background variables, namely sex, age, practical experiences, cultural capital of the family of origin, and four items of media biography (friends, parents, siblings, others).

Considering the complexity of the model, the fit (see Table A1) was within the thresholds according to the criteria by Hu & Bentler (1999), Hair et al. (2014, pp. 576–578) and Brown (2015, p. 74). We estimated direct effects of all variables on the three criteria variables as well as indirect effects (see Table A3). In interpreting the effects in the SEM, we mainly limit ourselves to considering the total effects, as the indirect effects were almost entirely extremely weak (see Table A3). Nevertheless, many effect sizes are mainly rather small. We will therefore only consider findings with effect sizes of at least β = .10 as worth mentioning, which corresponds to a small effect (β can be interpreted similar to Pearson correlations (Acock, 2014; Cohen, 1988, p. 25; Peterson & Brown, 2005), and will not rely on *p*-values for the interpretation (see Wasserstein et al., 2019). Furthermore, contrasts (via difference variables) were computed to test whether the strength of the effects found also differs from one another. The same caution is required here with regard to the interpretation of the *p*-values. Finally, linearity assumptions were checked in the SEM-model via lowess-regressions for all constructs except for the dichotomous variable preparatory service. Assumptions hold for most of the relationships with minor restrictions (for details see online appendix).

Measurement invariance for mean comparisons

For research question 6a, the comparability of the measurements for the latent means (prerequisite: scalar invariance) and the prerequisites for comparing the latent factor covariances[4] (prerequisite: metric invariance + equal factor variances) between the two groups were tested in a multi-group CFA. Since the measurement invariance for the factor "Media technology infrastructure" in the group of student teachers could not be determined, it was tested in separate models that included this factor and the factor "Pedagogical support services", only. According to the thresholds in the literature (Kline, 2023, 182ff) invariance holds in both cases (we

[3] Based on minimum-effect tests for variables where positive or negative relationships would be plausible or where we have not specified any expectations and on non-inferiority-tests for variables for which we had prior assumptions about the direction of the effect.

[4] At this point, reference should be made to the bivariate correlations of the multi-group CFA models in online materials.

did not rely on the (scaled) χ^2-difference test because of its sensitivity on sample size, for details see the R-script in the online materials).

Latent mean differences were determined in the scalar invariance models. Cohen's *d* with Hedge's correction (see Cumming, 2012, p. 294) was calculated from the latent means and factor variances, as well as its 95% confidence intervals (see R-script in Pausch, 2019). At this point, we consider effects of $d > .10$ to be tendency values, even though Cohen (1992) only considers effects with $d > .20$ to be small.

Results

This chapter presents the key findings of the SEM (see Table 1) according to the research questions. The predictor variables explained substantial variance in the self-assessments of media-related professional knowledge, particularly for confidence in media use ($R^2 = .46$) and pedagogical relevance ($R^2 = .37$).

Total effects of media-related attitudes and emotional-motivational orientations (RQ 1)

Only weak effects were observed for *media-related attitudes*. Substantially positive effects were found for learning about media on all three aspects of media-related professional knowledge ($.14 \leq \beta \leq .18$) and for attitudes toward computer science education on the assessment of pedagogical relevance ($\beta = .13$). More convinced teachers of computer science education were less confident in using media ($\beta = -.15$).

Enthusiasm for using media increased perceived relevance ($\beta = .48$), with individual media biography showing an indirect effect of $\beta = .17$. Anxiety had a negative effect on confidence in media use ($\beta = -.46$) and a positive effect on perceived need for support ($\beta = .43$). Indirect effects were relevant for preparatory service, individual media biography, and available educational support (see Table A3).

Overall, effects of the three attitude aspects did not differ significantly in magnitude, but the effects regarding emotional-motivational orientations (enthusiasm and anxiety) did ($-.64 \leq \Delta\beta \leq .32$, see Table A5).

Direct effects of the perceived extent of content teaching (RQ 2)

Qualification in media didactics increased the need for support ($\beta = .35$), while *qualification in media pedagogy* was assessed as pedagogically relevant ($\beta = .26$). Confidence in media use was slightly strengthened *by computer science education* and *other external qualifications* ($\beta \leq .13$).

Differences in overall effects arose between qualification in media didactics and computer science ($\Delta\beta = .32$) or other qualification offerings ($\Delta\beta = .40$), and for pedagogical relevance between media didactics and computer science education ($\Delta\beta = .30$).

Table 1

Direct effects and total effects (standard errors) of the structural equation model explaining self-assessments of media-related professional knowledge

Variable	Self-assessments of media-related professional knowledge					
	Confidence in using media (R^2 = .46)		Pedagogical relevance (R^2 = .37)		Perceived need for support (R^2 = .29)	
	direct	total [a]	direct	total [a]	direct	total [a]
Attitudes towards						
Learning with media (R^2 = .04)	-.06 (.15)	-.08 (.16)	-.02 (.16)	-.02 (.15)	-.04 (.17)	-.07 (.16)
Learning about media (R^2 = .06)	**.15** (.13)	**.14** (.13)	**.13** (.15)	**.18** (.14)	**.15** (.18)	**.15** (.15)
Computer science education (R^2 = .04)	**-.16** (.08)	**-.15** (.08)	**.15** (.08)	**.13** (.08)	-.03 (.10)	.02 (.08)
Emotional-motivational orientations regarding						
Enthusiasm for using media (R^2 = .13)	**.20** (.13)	**.19** (.14)	**.51** (.13)	**.48** (.13)	**.10** (.14)	**.11** (.13)
Anxiety in media use (R^2 = .21)	**-.39** (.09)	**-.46** (.09)	**.19** (.09)	**.15** (.09)	**.41** (.09)	**.43** (.09)
Perceived extent of content teaching for teacher professional development (mediators)						
Qualification in media didactics (R^2 = .25)	.02 (.13)		-.04 (.17)		**.35** (.15)	
Qualification in media pedagogy (R^2 = .25)	.08 (.10)		**.26** (.12)		-.05 (.12)	
Qualification for comp. science educ. (R^2 = .07)	**.11** (.06)		-.05 (.07)		.03 (.08)	
Other qualification offerings (R^2 = .10)	**.13** (.06)		.00 (.06)		-.05 (.07)	
Perceived media pedagogical framework conditions during course of study (mediators)						
Pedagogical support services (R^2 = .22)	.06 (.11)		**-.14** (.15)		**-.39** (.13)	
Media technology infrastructure (R^2 = .13)	.05 (.07)		.09 (.08)		**.18** (.08)	
Socio-demographic and biographical characteristics [b]						
Preparatory service	-.02 (.06)	-.02 (.06)	.05 (.06)	.03 (.07)	**.18** (.06)	**.19** (.07)
Media biography during school years	**-.11** (.05)	**-.11** (.05)	.01 (.05)	.01 (.05)	**.13** (.06)	**.13** (.06)
Media biography during studies	-.03 (.05)	-.03 (.05)	-.09 (.06)	-.09 (.06)	**-.10** (.06)	**-.10** (.06)
Individual media biography	**.10** (.05)	**.11** (.06)	-.03 (.06)	-.06 (.06)	**-.14** (.06)	-.09 (.07)
Final exam grade	-.06 (.07)	-.06 (.07)	-.02 (.06)	-.03 (.06)	**.12** (.06)	**.12** (.06)

Note. N = 569. Fully standardized regression coefficients (standard error) of |.10| and above are in bold. R^2 = explained variance. The latent correlations between the variables (or the disturbance correlations in the case of endogenous variables) as well as the model-fit can be found in the outputs in the online materials (model "sem"). Correlations between social-demographic and biographical characteristics and the two attitude aspects as well as the three aspects of emotional-motivational orientations were set to 0, as these are already related to each other through regression paths.

[a] The total effect corresponds to the sum of the respective direct effect and all corresponding indirect effects (see Table A3 in the online materials). For the mediator variables, the respective direct effect equals the corresponding total effect. [b] The variables listed here are all exogenous, which is why there is no explained variance.

Direct effects of perceived media pedagogical framework conditions (RQ 3)

The use of *educational support services* decreased perceived need for support (β = -.39) and tended to reduce assessment of pedagogical relevance (β = -.14)[5]. Perceived *media technology infrastructure* increased the need for support (β = .18). The two aspects differed significantly regarding perceived need for support (Δβ = -.57).

Mediation effects of perceived extent of content teaching (RQ 4)

Only one mediator-effect was substantial: *anxiety in media use was partially mediated by pedagogical support opportunities* (β = .13, cf. Table A3). All other effects were β < .09.

Effects of socio-demographic and biographical characteristics (RQ 5)

These effects were generally weak. *Preparatory service* and *poorer final exam grades* increased perceived need for support (β = .19 and .12). *Media-related learning in school* slightly decreased confidence in media use (β = -.11) and slightly increased need for support (β = .13). *Media biography during studies* (β = -.10) and *individual media biography* (β = -.14) reduced need for support, while *personal media experience* slightly increased confidence in media use (β = .11). Sex, age, practical experience, cultural capital, media biography regarding friends/parents/siblings/others had no substantial effects. Indirect effects existed for individual media biography on enthusiasm and anxiety (β = .16 and -.17, see Table A3).

Statistically significant differences[6] in the total effects of socio-demographic and biographical characteristics existed between various aspects of media biography and preparatory service (Δβ ranged from -.22 to .29, for details see Table A5).

Group differences between student teachers and prospective teachers (RQ 6)

Latent differences in mean values

Substantial but only very small differences in the self-assessments of media-related professional knowledge were found only for confidence in media use (g = .17), with tendencies for pedagogical relevance and support needs in favour of prospective teachers (see Table A4). Larger, but still weak effects were found in motivational-emotional orientations: students were more anxious (g = .42) and less enthusiastic (g = -.24). Students rated the perceived extent of content teaching within the course of study altogether a little higher ($.15 \leq g \leq .35$) but only tend to learn slightly more from other qualification offerings (g = .14)[7]. Pedagogical support services were more frequently perceived by students (g = .24). All other mean differences were only marginal with mostly tendencies showing that media technology infrastructure was slightly higher for prospective teachers (g = .10), students agreed a little more

[5] The confidence interval for this effect was very wide, which is why the finding should not be interpreted.
[6] Since the variables relating to media biography, final exam grade, and preparatory service were scaled differently, the significance values from the unstandardized contrast effects relied on here.
[7] With comparatively high variance in both groups compared to all other scales.

with learning via digital media and computer science education (g = .19 and .15), but less with general digital media use (g = -.11).

Correlations in SEM

Multi-group SEMs could not be calculated due to small group sizes. Differences in structural relationships between groups can therefore only be determined to a limited extent via the direct effects of the dichotomous variable "preparatory service" in the SEM (see MIMIC model, Brown, 2015). Differences between groups were mainly limited to the path for perceived need for support, indicating higher support needs in preparatory service (see Table 1, but see online materials for details). Other direct paths showed no substantial differences (see Table A5).

Discussion

The present study aimed to explain how prospective primary school teachers assess their professional knowledge for teaching digital education by integrating individual prerequisites (media-related attitudes, emotional-motivational orientations, socio-demographic and biographical characteristics), perceived qualification opportunities and perceived pedagogical framework conditions within a single explanatory model. By doing so, the study directly responds to theoretical approaches that conceptualize professional competence as a multidimensional construct comprising cognitive, motivational, and affective components (Bandura, 1997; Baumert & Kunter, 2011) and to empirical research calling for integrative models of digital teacher professionalization (Tondeur et al., 2017).

Rather than interpreting self-assessments as mere reflections of perceived technical competence, the findings highlight their embeddedness in emotional-motivational and structural contexts. In particular, the strong associations between emotional orientations and perceived pedagogical relevance underline that digital professionalization in primary teacher education is not solely a matter of skill acquisition but also of meaning-making and professional self-concept development.

Importantly, the study addresses a research gap identified in the literature: while digital competencies and technology integration have been widely examined, primary teacher education has rarely been analysed as a distinct professional context with specific pedagogical demands. The findings therefore contribute not only to research on digital professionalization but also to a more differentiated understanding of professional development in primary teacher education.

Synthesis of key findings

Overall, the results indicate that emotional-motivational orientations play a central role in shaping self-assessments of digital professional knowledge, since they have the greatest effects of all variables in the model. Positive orientations, such as enthusiasm and interest in engaging with digital media (reflecting both attitudinal and motivational dimensions), were closely related to higher perceived pedagogical relevance and self-efficacy, whereas uncertainty and anxiety were primarily associated with increased perceived support needs. This pattern is consistent

with research emphasizing the relevance of affective and motivational dimensions for professional competence and engagement in digital contexts (Bandura, 1997; Ertmer, 2005).

Perceived extent of content teaching showed differentiated effects. Learning opportunities related to media pedagogy within teacher education, which included e.g. coursework and structured training activities addressing instructional design and pedagogical use of digital media (see section 5.2), were associated with more favourable professional self-assessments mainly regarding pedagogical relevance. At the same time, participation in media didactics was linked to heightened awareness of one's own support needs. Rather than indicating ineffective training, this finding points to a process of professional sensitization, in which media didactic experiences sharpen participants' awareness of implementation complexities and highlight areas where additional support is required (Blömeke, 2003; Irion et al., 2020). In contrast, qualifications in computer science education and other external offerings showed only weak positive effects on confidence in media use ($\beta \leq .13$), indicating that the current forms of training may provide limited support for strengthening confidence in action. These findings suggest that the design of qualification opportunities in primary teacher education could benefit from a stronger focus on practice-oriented and pedagogically integrated learning experiences that address both cognitive and emotional aspects of professional learning.

Structural framework conditions, such as technical infrastructure and institutional support, contributed to professional self-assessments to a lesser extent. Their influence appeared to be indirect and contingent on individual interpretations and emotional-motivational orientations, which aligns with findings from European research suggesting that structural framework conditions primarily function as enabling contexts rather than direct drivers of professional competence (Eickelmann et al., 2024; Petko et al., 2018). Interestingly, pedagogical support offerings during studies were associated with reduced perceived support needs, whereas better media technology infrastructure sometimes coincided with a higher perceived need for support. This ambivalent pattern suggests that infrastructure alone, while necessary, is insufficient for competence acquisition; without a targeted didactic and pedagogical framework as well as a technical qualification, even well-equipped environments may highlight additional challenges and support requirements. Similar observations have been made in primary schools, where teachers often make limited use of available digital resources, emphasizing the need for integrated professionalization approaches that combine infrastructure, attitudes, and technical, didactical as well as pedagogical qualification offerings (Schwippert et al., 2024).

Socio-demographic and biographical characteristics explained comparatively little variance, underscoring the importance of professional learning processes over static personal characteristics. Notably, media experiences during school years were negatively related to confidence in media use and positively associated with perceived support needs, suggesting that early school-based media exposure often conveys limited practical knowledge and may even hinder professional action. In contrast, personal media biographies, such as everyday media use, strengthened confidence and perceptions of pedagogical relevance, highlighting the value of biographically acquired

experiences as resources for professional learning (Kommer & Biermann, 2012; Pecher, 2025). Furthermore, emotional orientations such as enthusiasm and anxiety mediated the impact of these experiences on self-assessments, illustrating that affective processes are central mechanisms through which biographical experiences shape professional competence and should be explicitly addressed in teacher education.

The largely non-substantial mediation effects indicate that emotional-motivational orientations and media-related attitudes influence self-assessed professional knowledge primarily through direct rather than indirect pathways. The mediation analysis revealed very weak pathways, with only one meaningful mediation observed, namely the partial mitigation of anxiety by pedagogical support offerings during studies. This suggests that such support services do not only convey cognitive knowledge but also provide a conditionally emotional stabilizing effect, helping student teachers manage uncertainties and reduce affective barriers. Particularly in primary school contexts, where deficits in digital competence are more prevalent, these programs can contribute to overcoming emotional barriers and facilitate professional action (Blömeke, 2007; Herzig et al., 2015; Vogelsang & Schwabl, 2024). However, because the remaining mediation pathways are generally weak, the findings underscore that directly addressing emotional-motivational orientations is more crucial than relying on indirect effects through structural or support-related factors. Alternative model specifications, such as reciprocal or longitudinal designs, might better capture these dynamics, explaining why other mediation pathways did not reach significance in the present cross-sectional analysis. Regarding group differences, the latent means of preparatory service were only marginal higher regarding the development of confidence in media use. But, student teachers exhibit higher levels of anxiety and lower enthusiasm compared to prospective teachers, highlighting the need to address affective barriers early in teacher training (Schwippert et al., 2024; Vogelsang & Schwabl, 2024). With respect to qualification offerings, student teachers tend to engage with a broader range of courses during their studies ($.15 \leq g \leq .35$), whereas prospective teachers more frequently rely on external or supplementary offerings ($g = .14$). This pattern may reflect differences in curriculum structure, availability of courses during the preparatory service, or time constraints that limit participation in additional formats. At the same time, other qualification offerings might appear more relevant to prospective teachers, prompting more targeted participation. Overall, these differences underscore that both the stage of training and the structure of available professional development opportunities shape emotional orientations and the perceived scope of qualification, which in turn can influence professional self-assessments and readiness for digital teaching practice.

Interpretation in light of theory and prior research

From a theoretical perspective, these findings align with competence models that emphasize the dynamic interplay between cognitive resources, motivational orientations, and affective processes (Baumert & Kunter, 2011). In this sense, self-assessments of professional knowledge can be understood as indicators of professional orientations rather than direct measures of enacted competence, highlighting the subjective and reflective nature of teacher self-evaluation.

The strong role of emotional-motivational orientations is consistent with self-efficacy theory (Bandura, 1997) and attitude-based models of technology use (Ajzen et al., 2019). Prior research has repeatedly shown that teachers' beliefs and attitudes are decisive for the pedagogical use of digital media (Ertmer, 2005; Ertmer et al., 2012). The present study extends this line of research by demonstrating that emotional orientations are systematically related to differentiated dimensions of professional self-assessment, including perceived support needs and that these effects may interact with structural and qualification-related conditions.

An interesting finding is that teachers who are more convinced of the value of computer science education are less confident in using media. This pattern should not be interpreted as a contradiction between computer science education and the pedagogical use of digital media. Rather, it may reflect that computer science education is valued as a source of foundational technological understanding, while confidence in classroom use depends more strongly on pedagogical experience and context-specific application opportunities. This observation is consistent with studies by Ertmer et al. (2012) on the role of pedagogical beliefs. At the same time, it is clear that there are uncertainties about the added didactic benefit of digital media in primary schools (Vogelsang & Schwabl, 2024), which makes it necessary to specifically address values and beliefs in the context of professional development.

The differentiated effects of qualification opportunities resonate with professionalization research suggesting that learning processes may initially increase awareness of complexity and limitations before confidence and routinization develop. In the context of digital transformation, qualification offerings may therefore function both as resources for competence development and as triggers for reflective uncertainty.

The comparatively limited direct impact of structural framework conditions aligns with findings from European teacher education research indicating that infrastructure alone is insufficient to foster professional competence (Eickelmann et al., 2024; Petko et al., 2018). Structural framework conditions appear to act as enabling contexts whose effects depend on how they are perceived and integrated into professional learning processes. Recent research further suggests that structural conditions act primarily as enabling contexts and are effective only when combined with pedagogically designed opportunities and reflective support mechanisms (Xie et al., 2025). This supports the view that infrastructure, attitudes, and qualification offerings need to be integrated to effectively promote digital professional competence.

Contribution to research on primary teacher professionalization

A central contribution of this study lies in its explicit focus on primary teacher education, a context that has been comparatively underrepresented in international research on digital professionalization (Tondeur et al., 2017). Primary teaching is characterized by cross-curricular integration, developmental sensitivity, and a high degree of pedagogical responsibility, which fundamentally shapes how digital media are evaluated and appropriated.
The findings suggest that emotional-motivational orientations are particularly salient in this context, as prospective primary school teachers must continuously balance pedagogical appropriateness, age-related considerations, and

instructional coherence. By explicitly modelling perceived support needs alongside self-efficacy and pedagogical relevance, the study extends existing models that primarily focus on attitudes or competence beliefs.

Methodologically, the use of an integrative structural equation model allows for a differentiated examination of how individual, institutional, and structural factors jointly contribute to professional self-assessments, thereby responding to calls for more comprehensive explanatory approaches in digital teacher education research.

Implications for teacher education and training

The findings of this study have specific implications for primary school teacher education. In particular, teacher education programs in the primary sector should provide structured opportunities for prospective teachers to develop confidence in using digital media to support foundational learning processes and to promote basic digital literacy in age-appropriate ways.

The study also underscores the importance of addressing emotional-motivational orientations explicitly within primary teacher education. Qualification programs should not focus exclusively on technical competencies but should also create opportunities for reflection on uncertainty, ambivalence, and perceived support needs related to digital media use.

Moreover, the finding that qualification experiences may increase perceived support needs suggests that such needs should be interpreted as a productive component of professional learning rather than as a deficit. This perspective aligns with developmental views of professionalization that emphasize continuous learning and support over time. Sustainable professional development in primary teacher education therefore requires not only initial qualification but also coherent institutional support structures.

Limitations

The study was subject to several methodological limitations. First, the sample was based on voluntary participation, which meant that selection bias cannot be ruled out – for example, through an overrepresentation of digitally savvy individuals. In addition, the distribution of participants across the federal states was uneven and not proportional to the corresponding population. Also, career changers and lateral entrants were not recorded separately. Student teachers were able to base their assessments of teaching practice primarily on internship experiences, which could have limited their validity. The age range of participants included a small number of individuals (n = 8 people over the age of 50) at later stages of their professional careers. These cases reflect alternative career pathways into teacher education and were retained in the analysis to preserve the diversity of the sample. Although, the sample size was sufficient to estimate the specified structural equation model, the ratio of sample size to the number of parameters to be estimated was not ideal, which was reflected in some increased standard errors. Therefore, replication with a larger sample (especially with regard to individuals in the first phase of training) would have been desirable. The data used in this study were collected more than five years ago. While developments in digital media and teacher

education have progressed since then, the data remain relevant for analyzing structural relationships between individual, motivational, and contextual factors influencing prospective teachers' self-assessments of professional knowledge. Nevertheless, the temporal distance should be considered when interpreting the results, particularly with regard to rapidly evolving technological conditions.

Secondly, the data collection was based on self-assessments of professional aspects of media-related professional knowledge. These may have been influenced by subjective biases, such as social desirability or a lack of reflection capability. The exclusive use of the TPACK model (Koehler & Mishra, 2009) without the context dimension also made it difficult to compare with other studies. In the future, supplementary objective competence assessments and external evaluations would have been desirable.

Third, as a cross-sectional study, causal conclusions cannot be drawn, and developmental processes or potential interactions between factors (e.g., infrastructure, qualifications, attitudes) were only partially captured. The study also focused on professional knowledge and not on actual classroom use of digital media; future studies could systematically examine usage contexts.

Despite these limitations, the study provided insights into how emotional-motivational and structural factors influenced prospective teachers' digitally related professional knowledge and offered empirically grounded starting points for profession-sensitive, structurally embedded, and emotion-conscious teacher training in the digital transformation.

Appendix

Online supplements are available at: https://doi.org/10.17605/OSF.IO/JT7R6.

References

Acock, A. C. (2014). *A Gentle Introduction to Stata* (4th ed.). Stata Press.

Ajzen, I., Fishbein, M., Lohmann, S., & Albarracín, D. (2019). The Influence of Attitudes on Behavior. In D. Albarracín & B. T. Johnson (Eds.), *The handbook of attitudes: Volume 1: Basic Principles* (2nd ed., pp. 197–255). Routledge. https://people.umass.edu/aizen/pubs/aonb.pdf

Balisane, H. (2015). Investigation of Teachers' Attitudes towards Computer Use in Primary Education in Kurdistan. *Journal of Education and Practice*, *6*(14), 37-49. https://files.eric.ed.gov/fulltext/EJ1080117.pdf

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. W.H. Freeman and Company. https://de.scribd.com/document/392014248/Self-efficacy-The-Exercise-of-Control-1997

Bärnreuther, C., Kammerl, R., Stephan, M., & Martschinke, S. (2023). Professionalisierung für Digitale Bildung: Ein Rahmenmodell zur Untersuchung der Kompetenzen angehender Lehrpersonen. In T. Irion, T.

Böttinger, & R. Kammerl (Eds.), *Professionalisierung für Digitale Bildung im Grundschulalter* (235-250). Waxmann. https://doi.org/10.25656/01:26208

Baumert, J., Blum, W., Brunner, M., Dubberke, T., Jordan, A., Klusmann, U., Krauß, S., Kunter, M., Löwen, K., Neubrand, M [Miachel], & Tsai, Y.-M. (2008). *Professionswissen von Lehrkräften, kognitiv aktivierender Mathematikunterricht und die Entwicklung von mathematischer Kompetenz (COACTIV): Dokumentation der Erhebungsinstrumente*. *Materialien aus der Bildungsforschung: Nr. 83*. Max-Planck-Inst. für Bildungsforschung. https://pure.mpg.de/rest/items/item_2100057_10/component/file_2197666/content

Baumert, J., & Kunter, M. (2011). Das Kompetenzmodell von COACTIV. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Kraus, & M. Neubrand (Eds.), *Professionelle Kompetenz von Lehrkräften: Ergebnisse des Forschungsprogramms COACTIV* (pp. 29–53). Waxmann.

Blömeke, S. (2003). Medienpädagogische Kompetenz: Theoretische Grundlagen und erste empirische Befunde. *Empirische Pädagogik*, *17*(2), 196–216.

Blömeke, S. (2007). Empirische Forschung zu neuen Medien in Schule und Lehrerausbildung. In W. Sesink, M. Kerres, & H. Moser (Eds.), *Jahrbuch Medien-Pädagogik: Vol. 6. Jahrbuch Medienpädagogik 6: Medienpädagogik - Standortbestimmung einer erziehungswissenschaftlichen Disziplin* (pp. 246–259). VS Verlag für Sozialwissenschaften / GWV Fachverlage GmhH, Wiesbaden. https://doi.org/10.1007/978-3-531-90544-0_12

Boon, D., Kroon, S., & van de Ven, P.-H. (2013). Teacher Education in the Netherlands. In V. Domovic, S. Gehrmann, J. Helmchen, & M. Krüger-Potratz (Eds.), *Lernen für Europa - Berichte und Materialien. Europäische Lehrerbildung. Annäherung an ein neues Leitbild: Berichte aus West- und Südosteuropa* (1st, New ed., pp. 47–71). Waxmann.

Bos, W., Lorenz, R., Endberg, M., Eickelmann, B., Kammerl, R., & Welling, S. (Eds.). (2016). *Schule digital - der Länderindikator 2016: Kompetenzen von Lehrpersonen der Sekundarstufe I im Umgang mit digitalen Medien im Bundesländervergleich*. Waxmann. https://www.waxmann.com/?eID=texte&pdf=3540Volltext.pdf&typ=zusatztext

Breiter, A., Welling, S., & Stolpmann, B. E. (2010). *Medienkompetenz in der Schule: Integration von Medien in den weiterführenden Schulen in Nordrhein-Westfalen*. *Schriftenreihe Medienforschung der LfM: Vol. 64*. Vistas. https://www.medienanstalt-nrw.de/fileadmin/lfm-nrw/Forschung/LfM-Band-64.pdf

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (Second edition). *Methodology in the social sciences*. The Guilford Press.

Calzone, S., & Chellini, C. (2016). Teachers' training: an empirical study on training needs and digital skills. *Open Journal Per La Formazione in Rete*, *2*(16), 33–46. https://doi.org/10.13128/formare-18218

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2. ed., reprint). Erlbaum.

Cohen, J. (1992). A Power Primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Cumming, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis*. *Multivariate applications series*. Routledge. https://doi.org/10.4324/9780203807002

Deutsche Gesellschaft für Erziehungswissenschaft. (2022). *Positionspapier der DGfE-Kommission Grundschulforschung und Pädagogik der Primarstufe*. https://www.dgfe.de/sektionen-kommissionen-ag/sektion-5-schulpaedagogik/kommission-grundschulforschung-undpaedagogik-der-primarstufe

Deutsche Gesellschaft für Erziehungswissenschaft. (2024). *Eine wissenschaftliche Lehrer:innenbildung ist für die Qualifizierung und Professionalisierung von Lehrpersonen als Standard unverzichtbar. Nur so lassen sich die großen Aufgaben und aktuellen Herausforderungen im Bildungssystem langfristig bewältigen.* Deutsche Gesellschaft für Erziehungswissenschaft (DGfE). https://www.dgfe.de/fileadmin/OrdnerRedakteure/Stellungnahmen/2024.02_DGfE-Stellungnahme_Lehrer.innenbildung.pdf

Eickelmann, B., Aufenanger, S., & Herzig, B. (2014). *Medienbildung entlang der Bildungskette: Ein Rahmenkonzept für eine subjektorientierte Förderung von Medienkompetenz im Bildungsverlauf von Kindern und Jugendlichen*. https://www.telekom-stiftung.de/sites/default/files/files/media/publications/buch_medienbildung.bildungskette_end.pdf

Eickelmann, B., Fröhlich, N., Bos, W., Gerick, J., Goldhammer, F., Schaumburg, H., Schwippert, K., Senkbeil, M., & Vahrenhold, J. (Eds.). (2024). *ICILS 2023 #Deutschland. Computer- und informationsbezogene Kompetenzen und Kompetenzen im Bereich Computational Thinking von Schüler*innen im internationalen Vergleich*. Waxmann Verlag GmbH. https://doi.org/10.31244/9783830999492

Eickelmann, B., Lorenz, R., & Endberg, M. (2016). Die Relevanz der Phasen der Lehrerbildung hinsichtlich der Vermittlung didaktischer und methodischer Kompetenzen für den schulischen Einsatz digitaler Medien in Deutschland und im Bundesländervergleich. In W. Bos, R. Lorenz, M. Endberg, B. Eickelmann, R. Kammerl, & S. Welling (Eds.), *Schule digital - der Länderindikator 2016: Kompetenzen von Lehrpersonen der Sekundarstufe I im Umgang mit digitalen Medien im Bundesländervergleich* (pp. 148–179). Waxmann. https://www.waxmann.com/?eID=texte&pdf=3540Volltext.pdf&typ=zusatztext

Endberg, M. (2019). *Professionswissen von Lehrpersonen der Sekundarstufe I zum Einsatz digitaler Medien im Unterricht: Eine Untersuchung auf Basis einer repräsentativen Lehrerbefragung*. *Empirische Erziehungswissenschaft: Vol. 71*. Waxmann.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development*, *53*(4), 25–39. https://doi.org/10.1007/BF02504683

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*(2), 423–435. https://doi.org/10.1016/j.compedu.2012.02.001

European Commission. (2020). *Digital Education Action Plan 2021-2027: Resetting education and training for the digital age.* European Commission. https://education.ec.europa.eu/sites/default/files/document-library-docs/deap-communication-sept2020_en.pdf

Field, A. (2018). *Discovering statistics using IBM SPSS statistics: And sex and drugs and rock'n'roll* (5th ed.). SAGE.

Gerick, J., & Eickelmann, B. (2017). *Abschlussbericht im Rahmen der wissenschaftlichen Begleitung der Evaluation des Projekts "Lernen mit digitalen Medien" in Schleswig-Holstein.* Universität Hamburg; Universität Paderborn. https://leb-gym-sh.de/images/downloads/2017.02.01_Abschlussbericht_wissenschaftliche_Begleitung_Projekt_Lernen_mit_digitalen_Medien.pdf

Gerick, J., Eickelmann, B., Rau, M., Panten B., Rothärmel, A., & Gottschalk, T. (2023). *Digitalisierungsbezogene Schulentwicklungsprozesse erfolgreich gestalten: Handreichung für die schulische Arbeit zu den Ergebnissen des Forschungsprojekts ‚GuTe DigiSchulen NRW'.* Technische Universität Braunschweig. https://www.tu-braunschweig.de/fileadmin/Redaktionsgruppen/Institute_Fakultaet_6/Schulpaedagogik/pdf-Dateien/GuTeDigiSchulenNRW_Praxishandreichung_2023_Gerick_Eickelmann_et_al_final.pdf

Gesellschaft für Informatik e. V. (2023). *Informatikkompetenzen für alle Lehrkräfte: Empfehlungen der Gesellschaft für Informatik e. V. erarbeitet vom Arbeitskreis Lehrkräftebildung.* Gesellschaft für Informatik (GI). https://dl.gi.de/server/api/core/bitstreams/e271f87d-1087-4617-83f5-b0ef98984b04/content

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis* (7. Auflage, Pearson new internat. ed.). *Pearson custom library*. Pearson.

Helmke, A., Helmke, T., Heyne, N., Hosenfeld, A., Kleinbub, I., Schrader, F.-W., & Wagner, W. (2007). Erfassung, Bewertung und Verbesserung des Grundschulunterrichts: Forschungsstand, Probleme und Perspektiven. In K. Möller, P. Hanke, C. Beinbrech, K. A. Hein, T. Kleickmann, & R. Quentmeier (Eds.), *Jahrbuch Grundschulforschung: Vol. 11. Qualität von Grundschulunterricht: Entwickeln, erfassen und bewerten* (pp. 17–34). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-90755-0_2

Herzig, B., & Grafe, S. (Eds.). (2007). *Digitale Medien in der Schule. Standortbestimmung und Handlungsempfehlungen für die Zukunft. Studie zur Nutzung digitaler Medien in allgemein bildendenden Schulen in Deutschland*. https://www.researchgate.net/publication/265092173

Herzig, B., Martin, A., Schaper, N., & Ossenschmidt, D. (2015). Modellierung und Messung medienpädagogischer Kompetenz - Grundlagen und erste Ergebnisse. In B. Koch-Priewe, A. Köker, J. Seifried, & E. Wuttke

(Eds.), *Kompetenzerwerb an Hochschulen: Modellierung und Messung: Zur Professionalisierung angehender Lehrerinnen und Lehrer sowie frühpädagogischer Fachkräfte* (pp. 153–176). Klinkhardt.

Honegger, B. D., & Hielscher (2017). Vom Lehrplan zur LehrerInnenbildung: Erste Erfahrungen mit obligatorischer Informatikdidaktik für angehende Schweizer PrimarlehrerInnen. In I. Diethelm & Gesellschaft für Informatik e. V. (Eds.), *GI-Edition. Proceedings: Vol. 274, GI Edition Proceedings Band 274 "Informatische Bildung zum Verstehen und Gestalten der digitalen Welt": 17. GI-Fachtagung Informatik und Schule vom 13.-15. September 2017 in Oldenburg* (pp. 97–108). Köllen. https://dl.gi.de/server/api/core/bitstreams/333d2e37-d435-4256-a0c1-e72329ed9a5e/content

Hu, L., & Bentler, P. M. (1999). Cutoff Criteria for Fit Indexes in Covariance Structure Analysis Conventional Criteria versus New Alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Huwer, J., Irion, T., Kuntze, S., & Schaal, S. (2019). Von TPACK zu DPACK - Digitalisierung im Unterricht erfordert mehr als technisches Wissen. *MNU Journal*(5), 358–364. https://www.researchgate.net/publication/335748844

International Society for Technology in Education. (2008). *ISTE Standards Teachers*.

Irion, T., & Kammerl, R. (2018). Mit digitalen Medien lernen: Grundlagen, Potenziale und Herausforderungen. *Die Grundschulzeitschrift*, *32*(307), 12–17.

Irion, T., Ruber, C., Taust, K., & Ostertag, J. (2020). Lehrerprofessionalisierung für Medienbildung und Digitale Bildung in der Grundschule. In M. Rothland & S. Herrlinger (Eds.), *Beiträge zur Lehrerbildung und Bildungsforschung: Vol. 5. Digital?! Perspektiven der Digitalisierung für den Lehrerberuf und die Lehrerbildung* (pp. 107–126). Waxmann.

Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., & Rosseel, Y. (2025). *semTools: Useful Tools for Structural Squation Modeling: R package version 0.5-7*. https://CRAN.R-project.org/package=semTools https://doi.org/10.32614/CRAN.package.semTools

Käfer, A.-K., Niederberger, M., & Ruber, C. (2020). Grundsatzfragen zur Digitalen Bildung im mittleren Kindesalter: Ergebnisse eines Gruppendelphi-Prozesses mit Wissenschaftlerinnen und Wissenschaftlern. In M. Thumel, R. Kammerl, & T. Irion (Eds.), *Digitale Bildung im Grundschulalter: Grundsatzfragen zum Primat des Pädagogischen.* kopaed. https://doi.org/10.25593/978-3-86736-543-7

Kammerl, R. (2009). Medienpädagogik in der Lehrerbildung Fehlanzeige? *Tendenz*, *9*(4), 12–14. https://www.blm.de/files/pdf1/2009_Tendenz_4.09.pdf

Kammerl, R., Lorenz, R., & Endberg, M. (2016). Medienbezogene Fortbildungsaktivitäten von Lehrkräften. In W. Bos, R. Lorenz, M. Endberg, B. Eickelmann, R. Kammerl, & S. Welling (Eds.), *Schule digital - der Länderindikator 2016: Kompetenzen von Lehrpersonen der Sekundarstufe I im Umgang mit digitalen Medien im Bundesländervergleich* (pp. 209–235). Waxmann.

Kammerl, R., & Mayrberger, K. (2011). Medienpädagogik in der Lehrerinnen- und Lehrerbildung in Deutschland: Aktuelle Situation und Desiderata. *Beiträge Zur Lehrerinnen- Und Lehrerbildung*, *29*(2), 172–184. https://doi.org/10.25656/01:13776

Kammerl, R., & Ostermann, S. (2010). *Medienbildung - (k)ein Unterrichtsfach? Eine Expertise zum Stellenwert der Medienkompetenzförderung in Schulen*. Medienanstalt Hamburg Schleswig-Holstein. https://www.ma-hsh.de/files/infothek/publikationen/Medienpaedagogik%20in%20der%20Kita%202018/web%20MA%20HSH_Studie%20Medienbildung_180210.pdf

Kindermann, K., & Pohlmann-Rother, S. (2022). Unterricht mit digitalen Medien?! Mit welchen Überzeugungen und motivationalen Orientierungenzum unterrichtlichen Einsatz von Tablets starten Studierende insLehramtsstudium? *Zeitschrift Für Grundschulforschung*, *15*(2), 435–452. https://doi.org/10.1007/s42278-022-00145-y

Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). The Guilford Press.

Klusmann, U., Kunter, M., Trautwein, U., Lüdtke, O., & Baumert, J. (2008). Engagement and Emotional Exhaustion in Teachers: Does the School Context Make a Difference? *Applied Psychology*, *57*, 127–151. https://doi.org/10.1111/j.1464-0597.2008.00358.x

Knezek, G., & Christensen, R. (2016). Extending the will, skill, tool model of technology integration: adding pedagogy as a new model construct. *Journal of Computing in Higher Education*, *28*(3), 307–325. https://doi.org/10.1007/s12528-016-9120-2

Koehler, M. J., & Mishra, P. (2009). What Is Technological Pedagogical Content Knowledge?, *9*(1), 60–70. https://doi.org/10.1177/002205741319300303

Kommer, S., & Biermann, R. (2012). Der mediale Habitus von (angehenden) LehrerInnen. Medienbezogene Dispositionen und Medienhandeln von Lehramtsstudierenden. In R. Schulz-Zander, B. Eickelmann, H. Moser, H. Niesyto, & P. Grell (Eds.), *Jahrbuch Medienpädagogik 9* (pp. 81–108). Springer VS.

Kultusministerkonferenz. (2017). *Bildung in der digitalen Welt: Strategie der Kultusministerkonferenz*. Beschluss der Kultusministerkonferenz vom 08.12.2016 in der Fassung vom 07.12.2017. https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2018/Strategie_Bildung_in_der_digitalen_Welt_idF._vom_07.12.2017.pdf

Kultusministerkonferenz. (2019). *Standards für die Lehrerbildung: Bildungswissenschaften*. Beschluss der Kultusministerkonferenz vom 16.12.2004 i.d.F. vom 16.05.2019. Sekretariat der Kultusministerkonferenz.

Lachmann, C., Ghomi, M., & Pinkwart, N. (2023). Ein Beispielansatz zur Vermittlung von digitaler Kompetenz im MINT-Lehramtsstudium. In J. Roth, M. Baum, K. Eilerts, G. Hornung, & T. Trefzger (Eds.), *Die Zukunft des MINT-Lernens: Perspektiven auf (digitalen) MINT-Unterricht und Lehrkräftebildung* (Vol. 1, pp. 123–138). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-66131-4_7

Lakens, D., Scheel, A. M., & Isager, P. M. (2018). Equivalence Testing for Psychological Research: A Tutorial. *Advances in Methods and Practices in Psychological Science*, *1*(2), 259–269. https://doi.org/10.1177/2515245918770963

Little, T. D., Slegers, D. W., & Card, N. A. (2006). A Non-arbitrary Method of Identifying and Scaling Latent Variables in SEM and MACS Models. *Structural Equation Modeling: A Multidisciplinary Journal*, *13*(1), 59–72. https://doi.org/10.1207/s15328007sem1301_3

Niesyto, H. (2012). Medienpädagogik in der Lehrerbildung in Baden-Württemberg. Konzeptionelle Überlegungen und praktische Schritte zu einer medienpädagogischen Grundbildung. In R. Schulz-Zander, B. Eickelmann, H. Moser, H. Niesyto, & P. Grell (Eds.), *Jahrbuch Medienpädagogik 9* (pp. 333–357). Springer VS. https://doi.org/10.1007/978-3-531-94219-315

OECD. (2021). *Bildung auf einen Blick 2021: OECD-Indikatoren*. wbv Media. https://doi.org/10.3278/6001821ow

Oetjen, B., Widmer, A.-K., Hess, M., Jandl, V., Wiederseiner, V., & Martschinke, S. (2025). Unterrichtsqualität mithilfe digitaler Angebote in der Grundschule: Setzen Grundschullehrkräfte digitale Angebote im Unterricht qualitätsvoll ein? *Zeitschrift Für Grundschulforschung*, *18*(2), 303–321. https://doi.org/10.1007/s42278-025-00229-5

Pausch, V. (2019). Die Berechnung des Konfidenzintervalls für die Effektgröße Cohen's d. *Jahrbuch Musikpsychologie*, *28*, Article e29, 2569–5665. https://doi.org/10.5964/jbdgm.2018v28.29

Pecher, H. (2025). Medienhandeln beim Berufseinstieg von Primarstufenlehrenden zwischen schulischen Normen und ideologiekritischer Medienpraxis. *Medienimpulse*, *63*(2), 1–28. https://doi.org/10.21243/MI-02-25-24

Peterson, R. A., & Brown, S. P. (2005). On the Use of Beta Coefficients in Meta-Analysis. *Journal of Applied Psychology*, *90*(1), 175–181. https://doi.org/10.1037/0021-9010.90.1.175

Petko, D., Honegger, B. D., & Prasse, D. (2018). Digitale Transformation in Bildung und Schule: Facetten, Entwicklungslinien und Herausforderungen für die Lehrerinnen- und Lehrerbildung. *Beiträge Zur Lehrerinnen- Und Lehrerbildung*, *36*(2), 157–174.

Pohlmann-Rother, S., & Kindermann, K. (2023). Wer besucht ein mediendidaktisches Seminar und wer profitiert davon? Ergebnisse einer wissenschaftlichen Begleitstudie zu den mediendidaktischen Überzeugungen von Lehramtsstudierenden. *MedienPädagogik: Zeitschrift Für Theorie Und Praxis Der Medienbildung*, *53*(53), 1–23. https://doi.org/10.21240/mpaed/53/2023.06.10.X

Questback EFS. (2020). *Unipark* (Version Fall 2020) [Computer software]. Tivian XI GmbH. https://www.unipark.com

Rahden, J. (2025). *Digitale Kompetenzüberzeugungen von (angehenden) Lehrkräften*. Otto-von-Guericke Universität Magdeburg. https://opendata.uni-halle.de/bitstream/1981185920/120619/1/Rahden_Jennifer_Dissertation_2025.pdf

Redecker, C. (2017). *European Framework for the Digital Competence of Educators: DigCompEdu* (Europäische Kommission, Ed.) (Vol. 28775). Publications Office of the European Union. https://doi.org/10.2760/159770

Richter, T., Naumann, J., & Groeben, N. (2001). Das Inventar zur Computerbildung (INCOBI): Ein Instrument zur Erfassung von Computer Literacy und computerbezogenen Einstellungen bei Studierenden der Geistes- und Sozialwissenschaften. *Psychologie in Erziehung Und Unterricht*, *48*, 1–13. https://www.researchgate.net/publication/260321346

Rönkkö, M., & Cho, E. (2022). An Updated Guideline for Assessing Discriminant Validity. *Organizational Research Methods*, *25*(1), 6–47. https://doi.org/10.1177/1094428120968614

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2), 1–36.

Schuknecht, L., & Schleicher, A. (2020). Digitale Herausforderungen für Schulen und Bildung. *Ifo Schnelldienst*, *73*(5), 68–70. https://www.ifo.de/DocDL/sd-2020-05-schuknecht-schleicher-digitalisierung-schule-bildung-2020-05-13.pdf

Schwippert, K., Kasper, D., Eickelmann, B., Goldhammer, F., Köller, O., Selter, C., & Steffensky, M. (Eds.). (2024). *TIMSS 2023. Mathematische und naturwissenschaftliche Kompetenzen von Grundschulkindern in Deutschland im internationalen Vergleich*. Waxmann Verlag GmbH. https://doi.org/10.31244/9783830999591

Shulman, L. (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

Sickel, J. L. (2019). The Great Media Debate and TPACK: A Multidisciplinary Examination of the Role of Technology in Teaching and Learning. *Journal of Research on Technology in Education*, *51*(6), 1–14. https://doi.org/10.1080/15391523.2018.1564895

Štemberger, T., & Čotar Konrad, S. (2021). Attitudes Towards using Digital Technologies in Education as an Important Factor in Developing Digital Competence: The Case of Slovenian Student Teachers. *International Journal of Emerging Technologies in Learning (IJET)*, *16*(14), 83. https://doi.org/10.3991/ijet.v16i14.22649

Tischler, K., & Wakounig, V. (2013). Lehrerbildung in Österreich zwischen Tradition und Innovation. In V. Domovic, S. Gehrmann, J. Helmchen, & M. Krüger-Potratz (Eds.), *Lernen für Europa - Berichte und Materialien. Europäische Lehrerbildung. Annäherung an ein neues Leitbild: Berichte aus West- und Südosteuropa* (1st, New ed., pp. 71–101). Waxmann.

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence.

Educational Technology Research and Development, *65*(3), 555–575. https://doi.org/10.1007/s11423-016-9481-2

Tulodziecki, G. (2000). Vergleichende Zusammenfassung und Empfehlung. In G. Tulodziecki & U. Six (Eds.), *Schriftenreihe Medienforschung der Landesanstalt für Medien in NRW: Vol. 36. Medienerziehung in der Grundschule: Grundlagen, empirische Befunde und Empfehlungen zur Situation in Schule und Lehrerbildung* (pp. 459–484). Leske + Budrich.

Tulodziecki, G. (2012). Medienpädagogische Kompetenz und Standards in der Lehrerbildung. In R. Schulz-Zander, B. Eickelmann, H. Moser, H. Niesyto, & P. Grell (Eds.), *Jahrbuch Medienpädagogik 9* (pp. 271–297). Springer VS. https://doi.org/10.1007/978-3-531-94219-3_13

Tulodziecki, G., Herzig, B., & Grafe, S. (2018). *Medienbildung in Schule und Unterricht: Grundlagen und Beispiele* (2. Aufl.). *UTB Erziehungswissenschaft, Schulpädagogik, allgemeine Didaktik: Vol. 3414*. Klinkhardt. http://www.utb-studi-e-book.de/9783838534145

van Ackeren, I., Aufenanger, S., Eickelmann, B., Friedrich, S., Kammerl, R., Knopf, J., Mayrberger, K., Scheika, H., Scheiter, K., & Schiefner-Rohs, M. (2019). Digitalisierung in der Lehrerbildung: Herausforderungen, Entwicklungsfelder und Förderung von Gesamtkonzepten. *DDS – Die Deutsche Schule*, *111*(1), 103–119. https://doi.org/10.31244/dds.2019.01.10

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences*, *39*(2), 273–315. https://doi.org/10.1111/j.1540-5915.2008.00192.x

Vogelsang, C., Finger, A., Laumann, D., & Thyssen, C. (2019). Vorerfahrungen, Einstellungen und motivationale Orientierungen als mögliche Einflussfaktoren auf den Einsatz digitaler Werkzeuge im naturwissenschaftlichen Unterricht. *Zeitschrift Für Didaktik Der Naturwissenschaften*, *25*(1), 115–129. https://doi.org/10.1007/s40573-019-00095-6

Vogelsang, C., & Schwabl, F. (2024). Medienbezogene Vorerfahrungen und Voraussetzungen von Lehramtsstudierenden zu Beginn ihres Studiums: Analysen aus Evaluationsbefragungen an der Universität Paderborn vor und nach der COVID-19-Pandemie. In B. Herzig, B. Eickelmann, F. Schwabl, J. Schulze, & J. Niemann (Eds.), *Paderborner Beiträge zur Bildungsforschung und Lehrkräftebildung: Vol. 1. Lehrkräftebildung in der digitalen Welt: Zukunftsorientierte Forschungs- und Praxisperspektiven* (103-118). Waxmann.

Wasserstein, R. L., Schirm, A. L., & Lazar, N. A. (2019). Moving to a World Beyond "$p < 0.05$". *The American Statistician*, *73*(sup1), 1–19. https://doi.org/10.1080/00031305.2019.1583913

Wijnen, F., van der Walma Molen, J., & Voogt, J. (2021). Primary school teachers' attitudes toward technology use and stimulating higher-order thinking in students: a review of the literature. *Journal of Research on Technology in Education*, 1–23. https://doi.org/10.1080/15391523.2021.1991864

Xie, L., Friedrich, M. C. G., Semmler, L., & Thies, B. (2025). What drives enthusiasm for teaching with digital media? A study of the relative importance of intrinsic value, utility value and self-efficacy using the model averaging approach. *Frontiers in Education*, *10*, Article 1668870, 1–14. https://doi.org/10.3389/feduc.2025.1668870

Corresponding Author Contact Information:

Author name: Cindy Bärnreuther

Department: Department Pedagogy, Chair of Education with a focus on media education

University, Country: Friedrich-Alexander University Erlangen-Nuremberg, Germany

Email: cindy.baernreuther@fau.de

ORCID: ORCID: 0000-0003-2435-384X

Please Cite: Bärnreuther, C., Penthin, M. (2026). Self-Assessments of Professional Knowledge in Digital Media Use: Factors Influencing Primary School Teachers in Teacher Training. *The European Educational Researcher, 9*(2), 5-37. DOI: https://doi.org/10.31757/euer.922

Conflict of Interest: The authors declare that they have no known competing financial or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement: The data that support the findings of this study, the reproducible and annotated R scripts, as well as the output files are openly available at: https://doi.org/10.17605/OSF.IO/JT7R6.

Ethics Statement: Ethical review and approval were not required for this study in accordance with local legislation and institutional requirements. Written informed consent was obtained from all participants prior to data collection. Participation was voluntary, and all data were collected and analysed anonymously.

Author Contributions: Conceptualization: C.B.; Data curation: M.P.; Formal analysis: C.B., M.P; Funding acquisition: Prof. Dr. Rudolf Kammerl; Investigation: C.B., M.P.; Methodology: C.B., M.P; Project administration: Prof. Dr. Rudolf Kammerl; Supervision: Prof. Dr. Rudolf Kammerl; Validation: M.P.; Writing − original draft: C.B., M.P.; Writing – Review & Editing: C.B., M.P.
All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Federal Ministry of Education and Research (short in German: BMBF), Grant Agreement No. 01JD1808A.

Received: February 19, 2026 ▪ Accepted: May 20, 2026