

Development of Student Teachers' Professional Digital Competence Beliefs

Insights from the Practical Semester

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Abstract

In a digitalised world, teacher education needs to prepare student teachers to use digital technologies appropriately and in a critically reflective way in school and teaching. Extended school internships, such as the practical semester, offer learning opportunities to facilitate student teachers' professional digital competence beliefs. However, little is known about the development of student teachers' professional digital competence beliefs and technology-related learning opportunities during the practical semester. Addressing this gap, this explorative study investigates the development of student teachers' professional digital competence beliefs during the practical semester and its interaction with learning opportunities provided by schools. Data from N=145 student teachers (53.79% female) from two German universities were analysed using a pretest-posttest control-group design. Results from a repeated-measures mixed MANOVA and repeated measures MANCOVAs show that student teachers' professional digital competence beliefs increase during the practical semester, though only teachers' communication with colleagues interacts with this development. These findings highlight the practical semester's potential as a critical period for facilitating professional digital competence beliefs, suggesting that teacher education programmes should integrate practical technology-based learning opportunities in school settings to better prepare student teachers for their profession. Further research is needed to explore which learning opportunities interact with the development of student teachers' professional digital competence beliefs.

Entwicklung berufsbezogener digitaler Kompetenzüberzeugungen von Lehramtsstudierenden. Einblicke aus dem Schulpraxissemester

Zusammenfassung

*In einer digitalisierten Welt muss die Lehrkräfteausbildung Lehramtsstudierende darauf vorbereiten, digitale Technologien zweckmässig und kritisch reflektiert in Schule und Unterricht einzusetzen. Längere Schulpraktika, wie das Schulpraxissemester, bieten Lerngelegenheiten, um die berufsbezogenen digitalen Kompetenzüberzeugungen von Lehramtsstudierenden zu fördern. Es ist jedoch nur wenig über die Entwicklung der berufsbezogenen digitalen Kompetenzüberzeugungen von Lehramtsstudierenden während des Schulpraxissemesters bekannt. Um diese Lücke zu schliessen, untersucht die vorliegende explorative Studie die Entwicklung berufsbezogener digitaler Kompetenzüberzeugungen von Lehramtsstudierenden während des Schulpraxissemesters und die Interaktion mit den von den Schulen angebotenen Lerngelegenheiten. Daten von N = 145 Lehramtsstudierenden (53.79 % weiblich) aus zwei deutschen Universitäten wurden mit einem Pretest-Posttest-Kontrollgruppen-Design analysiert. Die Ergebnisse einer repeated measures mixed MANOVA und repeated measures MANCOVAs zeigen, dass die berufsbezogenen digitalen Kompetenzüberzeugungen der Lehramtsstudierenden während des Schulpraxissemesters ansteigen, wobei nur die Kommunikation der Lehrkräfte mit ihren Kolleg*innen mit der Entwicklung der Kompetenzüberzeugungen zusammenhängt. Diese Ergebnisse unterstreichen das Potenzial des Schulpraxissemesters als wichtigen Zeitraum für die Förderung berufsbezogener digitaler Kompetenzüberzeugungen und legen nahe, dass Lehramtsstudiengänge praktische, technologiebasierte Lerngelegenheiten im schulischen Umfeld integrieren sollten, um Lehramtsstudierende auf ihren Beruf vorzubereiten. Weitere Forschung ist erforderlich, um zu untersuchen, welche Lerngelegenheiten mit der Entwicklung der berufsbezogenen digitalen Kompetenzüberzeugungen von Lehramtsstudierenden interagieren.*

1. Introduction

The goal of teacher education is to prepare student teachers for their profession. In a digitalised world, this also includes the appropriate and critically reflective use of digital technologies in everyday school life (Eickelmann, Drossel, and Heldt 2022). With the help of digital technologies, learning processes can be optimised and students' digital competencies can be supported (Redecker and Punie 2017). To use digital technologies in their future profession as teachers, student teachers need to be and feel digitally competent, and therefore, they need adequate digital competencies and competence beliefs (I. K. R. Hatlevik and O. E. Hatlevik 2018; Guggemos and Seufert 2021; Kaarakainen and Saikkonen 2021). Student teachers' digital competence

beliefs are «a more general self-evaluation of [...] competence or ability to use digital devices and digital resources [...] in their personal and professional lives» (Rubach and Lazarides 2023, p. 198). In this context, digital competence beliefs can be differentiated into basic (non-job related) and professional (job-related) digital competence beliefs (Krumsvik 2014). Studies have shown that student teachers' professional digital competence beliefs are linked to their use of digital technologies in class (Aslan and Zhu 2016; Vejvoda et al. 2023). However, digital technologies should not simply be used frequently in schools, but for a specific pedagogic purpose and with critical reflection (Lei 2010). To prepare student teachers to use digital technologies appropriately and engage in critical reflection in school and teaching, teacher education should facilitate the development of student teachers' professional digital competencies and related competence beliefs, starting during their university studies. This necessity is also underpinned by national strategy papers on digitalisation in the German school system (KMK 2021, 2017).

In Germany, university studies for a teaching degree involve internships in schools as practical learning opportunities for student teachers to acquire the competencies and relevant competence beliefs needed in the teaching profession. In most federal states, student teachers later in their studies must complete an extended school internship – in most states the so-called practical semester, which, although it is often structured similarly, can differ in its organisation between the federal states or universities. Most commonly, for about five to six months, student teachers are placed at a school four days a week and attend accompanying seminars at university one day a week. The main goals for student teachers are competence development, application of theory in practice, and research-based learning that enables the student teachers to reflect on the specifics of the teaching profession (Ulrich et al. 2020; Porsch and Gollub 2021). In the practical semester, student teachers observe their mentor teachers' lessons, plan and implement their own lesson attempts and participate in school life. This also offers various opportunities to develop student teachers' professional digital competencies and their competence beliefs, depending on whether and how teachers at the practicum school apply digital tools in their work life. So far, only a few studies have examined how student teachers' professional digital competence beliefs develop during the practical semester, indicating a research gap: Results of a study by Vogelsang et al. (2023) show that student teachers' professional digital competence beliefs increase during the practical semester. This development is positively affected by their motivation to use digital technologies in class. Another study on student teachers' technology-related learning opportunities by Hülshoff, Reintjes, and Nonte (2024) shows that practical learning opportunities in school can explain the variance in student teachers' professional digital competence beliefs. The results of these studies indicate that school internships facilitate the development of student teachers' professional digital competence beliefs. However, little is known about

the development of student teachers' professional digital competence beliefs in different competence dimensions during the practical semester and how technology-related learning opportunities offered by schools influence this development. It can be assumed that schools provide student teachers with varying learning opportunities, as the technical conditions at individual schools in Germany can also vary greatly (Schipolowski et al. 2022; Schipolowski et al. 2023). Therefore, this explorative study aims to close this research gap by examining how student teachers' professional digital competence beliefs develop during the practical semester compared to a control group and analysing how the learning opportunities offered are related to this development. More knowledge about the development of student teachers' perceived professional digital competence and learning opportunities in the practical semester may help sensitise internship schools and mentor teachers for their role in facilitating student teachers' professional digital competence beliefs.

2. Theoretical background

2.1 *The development of student teachers' professional digital competence beliefs during a school internship*

The development of student teachers' professional digital competence beliefs during a school internship can be explained by the utilisation of learning opportunities model (Helmke 2017). Learning opportunities can be divided into formal and informal learning opportunities (Desimone 2009). Formal learning opportunities are «structured learning environments with a specified curriculum, such as graduate courses or mandated staff development» (Richter et al. 2014, p. 98). Informal learning opportunities are not mandatory; they «do not follow a specified curriculum and are not restricted to certain environments» (Richter et al. 2014, p. 98). Classroom observations or collaborative activities are examples of informal learning opportunities (Richter et al. 2014). School internships are mandatory in prospective teachers' university programmes, but since there is no specified curriculum for the time spent at the school where the student teachers are placed, we assume that the placement at school offers mostly informal learning opportunities (Reintjes, Thönes, and Winter 2023).

Hascher and Kittinger (2014) adapted the utilization of learning opportunities model developed for explaining students' learning development (Helmke 2017) to describe the learning of student teachers during school internships: the offer and use model of practical training in teacher education (Figure 1). The model assumes that learning is influenced by the learning situation and the resulting learning opportunities, as well as by the learners' approach to the learning situation and their use of the learning opportunities.

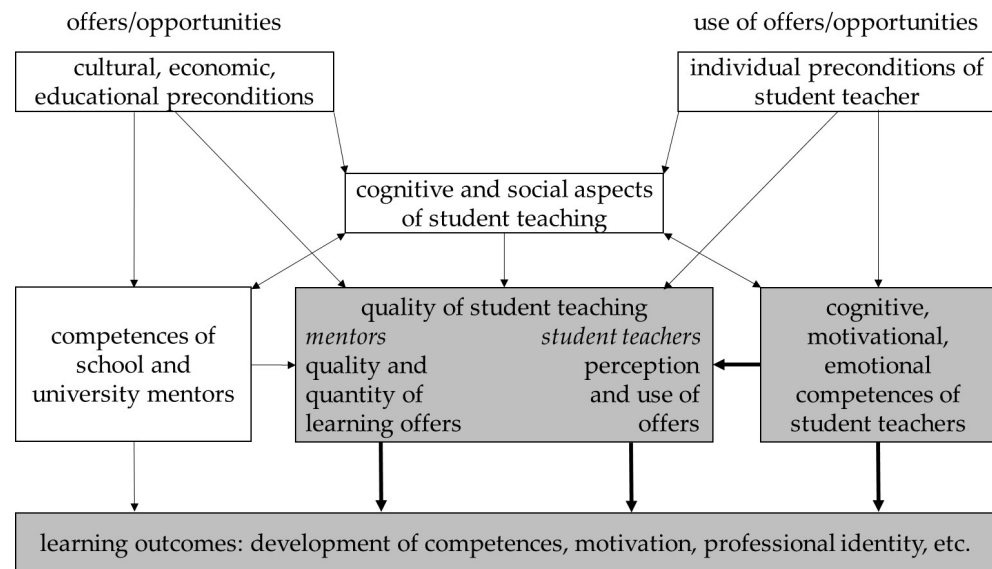


Fig. 1: Offer-and-use Model of Practical Training in Teacher Education. Own representation based on: Hascher and Kittinger (2014), p. 223. Grey fields and bold arrows mark the parts that this study focuses on.

Besides the student teachers, university mentors, the school, (mentor) teachers and students/pupils at school also contribute to the learning situation of student teachers. But it should be noted that the culture of school internships implies an expert-novice relationship between university mentors or (mentor) teachers and student teachers. Hence, the learning situation and learning opportunities depend largely on the practices of university mentors or (mentor) teachers and on the transfer of knowledge from a more experienced educator to a trainee teacher (Hascher and Kittinger 2014). In the following, we will focus on the (mentor) teachers' role in providing learning opportunities to student teachers, as this study analyses the in-school-part of the extended school internship. However, it has to be noted that accompanying university seminars and guided reflection of the practical experience in school may also contribute to the development of student teachers' perceived professional digital competence.

With the (mentor) teachers as role models, student teachers' learning opportunities depend on social learning processes (Hascher and Kittinger 2014). A theory that describes the impact of social learning on the development of student teachers' perceived professional digital competence is Bandura's self-efficacy theory (1997). According to Bandura (1997), self-efficacy is «a belief in one's capabilities to organise and execute the courses of action required to produce given attainments» (p. 3). Therefore, self-efficacy and competence beliefs are related constructs (Rubach and Lazarides 2023). Bandura (1977) describes four sources of self-efficacy: performance accomplishments, vicarious experiences, verbal persuasion and physiological states.

The main part of the extended school internship for student teachers is classroom observation. At the universities where the study took place, the ratio of time allocated in school to classroom observations and student teachers' own lesson attempts is 5:1. The self-efficacy theory assumes that «[s]eeing others perform threatening activities without adverse consequences can generate expectations in observers that they too will improve if they intensify and persist in their efforts» (Bandura 1977, p. 197). Vicarious experiences rely on social learning and social comparison: If student teachers see that their mentor teacher can use digital technologies in school and teaching successfully, they might think they should be able to improve their own use of digital technologies for these purposes. This is also supported by research on preparing student teachers to teach with digital technologies which shows that role models in school and university play an important role for motivating student teachers to use digital technologies in their future profession (Tondeur et al. 2012; Tondeur et al. 2025). Therefore, this explorative study focuses on student teachers' vicarious experiences as learning opportunities.

The quality and quantity of (mentor) teachers' offers of learning opportunities regarding the use of digital technologies in class and student teachers' perception and use of these learning opportunities may result in the development of student teachers' professional digital competence beliefs.

2.2 Student teachers' professional digital competence beliefs and learning opportunities in the practical semester

Different models and approaches can be used to describe (student) teachers' professional digital competence beliefs (Rubach and Lazarides 2023). A suitable framework is the Digital Competence Framework of Educators (DigCompEdu) by Redecker and Punie (2017). Compared to other frameworks, e. g., the Technological Pedagogical Content Knowledge (TPACK) model, it describes detailed tasks teachers face in class and beyond in everyday school life. This study uses an adapted version of the DigCompEdu framework that was validated by Quast, Rubach, and Porsch (2023). It distinguishes 29 professional digital competence beliefs in seven dimensions: Administration and Professional Engagement, Lesson Planning, Teaching and Supporting Students, Assessment, Empowering All Students, Facilitating Students' Digital Competence and Privacy and Copyright Rules (for more information about the adaptations, see Quast, Rubach, and Porsch 2023). To master the various professional tasks of teachers, teacher education should facilitate student teachers' professional digital competencies and related competence beliefs in these seven dimensions. First results by Vogelsang et al. (2023) indicate that during the practical semester, student teachers' professional digital competence beliefs increase in different competence dimensions that overlap with those of the DigCompEdu framework. Importantly, studies have shown that in-service teachers benefit significantly from practical training programmes tailored to their needs regarding specific competence

dimensions (Lucas, Dorotea, and Piedade 2021; Sotáková, Letošníková, and Ganajová 2025). This underlines the relevance of in-field learning opportunities for student teachers targeting various competence dimensions.

First, to professionally use digital technologies, teachers need basic digital competence beliefs or «tool competence» beliefs, e. g., handling technical aspects of digital technologies (Krumsvik 2012). When mentor teachers use a variety of digital devices and tools in their everyday teaching, student teachers are exposed to concrete examples of how these technologies can be integrated into classroom practice. Observing such applications enables student teachers to gain practical insights into the technical handling and pedagogical potential of digital tools. This can support the development of professional digital competence beliefs, as it demonstrates the relevance and feasibility of using digital technologies in authentic educational contexts.

Regarding teachers' professional digital competence beliefs, the DigCompEdu framework (Redecker and Punie 2017) distinguishes three core areas: teachers' professional competencies, teachers' pedagogic competencies and students' competencies.

Teachers' professional competencies are situated in the wider professional environment and can be represented by the competence dimension Administration and Professional Engagement that consists of competencies regarding, e. g., organisational communication and professional collaboration. Digital communication with colleagues and parents is a central aspect of organisational communication and collaboration in schools. Observing and potentially engaging in such digital exchanges provides student teachers with authentic learning opportunities as they participate in the schools' life. This can foster the development of professional digital competence beliefs, as it allows them to experience the practical relevance and application of these competencies within the school context.

The second core area, teachers' pedagogic competencies, contains competencies teachers «need to foster efficient, inclusive and innovative teaching and learning strategies» (Redecker and Punie 2017, p. 16). Teachers' pedagogic competencies can be represented by the competence dimensions: Lesson Planning, Teaching and Supporting Students, Assessment, Empowering All Students and Privacy and Copyright Rules. This includes a wide range of usage scenarios of digital technologies. A tool that can be used for various pedagogical purposes in class is a learning management system (LMS). It «can be used to provide material and tasks for in-person and distant learning, allow to create and customize the system, make announcements and communicate with students, collect and manage data, enable participating and collaborative processes, and share data, files, and information» (Rubach et al. 2024, p. 540). When student teachers observe the use of an LMS in their practicum school, they are exposed to authentic scenarios in which digital technologies are integrated into pedagogical processes. This allows them to experience firsthand how digital tools can support lesson planning, student support, assessment, and inclusive teaching strategies. The demonstration of the relevance and

application of LMS as a versatile digital tool can contribute to the development of student teachers' professional pedagogical digital competence beliefs.

The third core area, students' competencies, aims at specific competencies teachers need to facilitate students' digital competencies and can be represented by the competence dimension Facilitating Students' Digital Competence. When mentor teachers actively integrate digital technologies into their classroom practice to foster students' digital competencies (such as engaging students in information searches) they create authentic scenarios in which student teachers can observe and reflect on pedagogical strategies for digital competence development. Through such practical experiences, student teachers gain insights into how digital tools can be purposefully used to empower learners and support their digital competence development. Observing and, where possible, participating in these digitally enriched teaching activities enables student teachers to understand the relevance, challenges, and opportunities of facilitating students' digital competence in real-world educational settings. This exposure can thus contribute to the development of student teachers' own professional digital competence beliefs, as it demonstrates the practical application and impact of these competencies in everyday classroom contexts.

To sum up, we assume that the vicarious experiences of mentor teachers' use of digital devices and tools, the digital communication between colleagues and with parents, the use of an LMS in school and mentor teachers' use of digital technologies to facilitate students' digital competence may provide learning opportunities for the development of student teachers' perceived professional digital competence during the practical semester. However, according to Hascher and Kittinger (2014), student teachers' perception and use of learning opportunities contribute to the development of professional digital competence beliefs. Since student teachers' classroom observations are an important part of the practical semester, we also assume that student teachers' observation of mentor teachers' use of digital technologies contributes to their development of professional digital competence beliefs.

To our knowledge no study so far examines the relation between different learning opportunities regarding the use of digital technologies in the practical semester and student teachers' development of professional digital competence beliefs. Therefore, our study aims to close this research gap.

2.3 A model for the development of perceived professional digital competence in school internships

This explorative study analyses student teachers' development of their professional digital competence beliefs during the practical semester. Thus, based on the offer and use model of practical training in teacher education by Hascher and Kittinger (2014), we developed an offer-and-use model for the development of perceived professional

digital competence in school internships (Figure 2). We focus on the impact of learning opportunities provided by (mentor) teachers of the practicum school and student teachers' use of learning opportunities on the development of student teachers' professional digital competence beliefs.

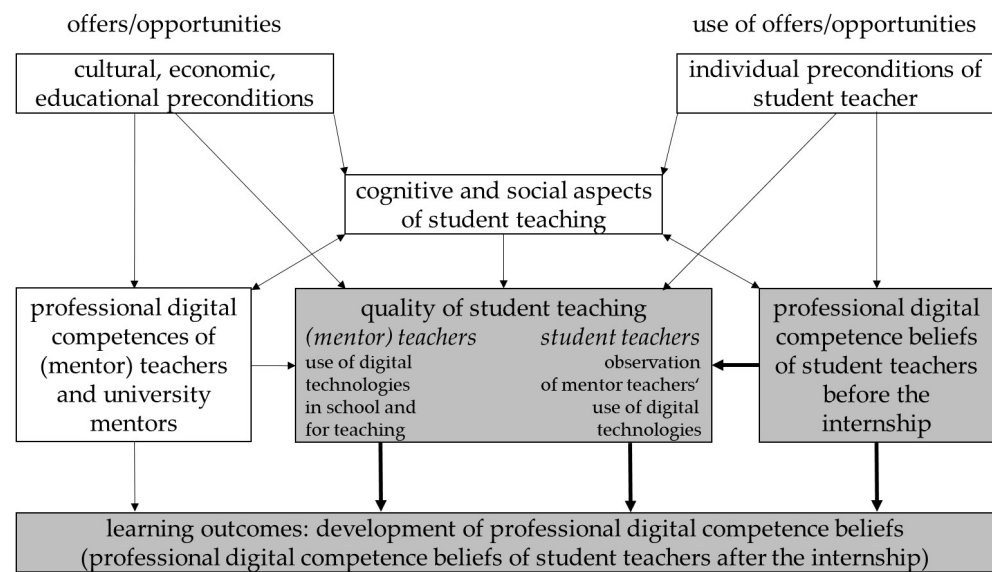


Fig. 2: Adapted Version of the Offer-and-use Model for Professional Digital Competence Belief Development in School Internships. Based on: Hascher and Kittinger (2014), p. 223. Grey fields and bold arrows mark the parts that this study focuses on.

We assume student teachers' professional digital competence beliefs develop during the practical semester. We further assume that the development of perceived professional digital competence is related to (mentor) teachers' use of digital technologies in school and teaching (offer of learning opportunities) and student teachers' observation of mentor teachers' use of digital technologies (use of learning opportunities). To cover a variety of vicarious experiences that student teachers make during their extended school internship, we do not only focus on the mentor teachers but on all teachers working at the internship school.

Based on this model, this study investigates the following research questions:

1. How do student teachers' professional digital competence beliefs develop during an extended school internship compared to a control group?
2. Does the development of student teachers' professional digital competence beliefs during an extended school internship interact with the learning opportunities available to student teachers regarding the use of digital technologies?

3. Materials and Methods

3.1 Design

The study uses data from the MEDAL-II project conducted between January 2022 and December 2024. Between winter semester 2022/23 and winter semester 2023/24, we asked Master's-level student teachers at two German universities to fill out an online questionnaire. The universities are located in Eastern Germany (Magdeburg) and Western Germany (Münster).

Our exploratory study uses a pretest-posttest control group design. The intervention group filled out the questionnaire before (t1) and after (t2) the practical semester, which takes place in the second or third semester of the educational Master's programme at both universities.

For one school half term, student teachers in the intervention group are placed in schools four days a week and attend accompanying seminars (in their subjects and in educational sciences) one day a week. During their stay in school, student teachers observe lessons of their mentor teachers, teach their own lessons, participate in everyday school life (including project days, teacher conferences and work with parents) and carry out a study project as a form of theory-based practical reflection.

The control group filled out the questionnaire at the first (t1) and last (t2) meeting of a compulsory seminar on educational psychology in the first semester of their educational Master's studies. The use of digital technologies in school and teaching was not covered in the seminar. Student teachers in the intervention group have already attended this seminar. Due to the structure of the study programme, we could not survey student teachers in their second or third semester of their educational Master's studies who are not currently doing their extended school internship or have not yet done so. Therefore, we decided to use a control group of student teachers in their first semester of their educational Master's studies, as their completed coursework is almost the same as that of the intervention group.

3.2 Sample

For this study, we used data of $N=145$ student teachers (53.79% female) with a mean age of 24.42 years ($SD=3.89$) who completed the professional digital competence beliefs scale in t1 and t2. Our sample consists of two subsamples of $n=104$ student teachers (71.72% of N) in the intervention group and $n=41$ student teachers (28.28% of N) in the control group. The sub-samples are described in Table 1.

	Intervention group	Control group
Gender	56.73 % female	46.34 % female
Age	M=24.72 (SD=3.94)	M=23.66 (SD=3.67)
University semester	M=7.76 (SD=3.88)	M=6.27 (SD=3.28)

Tab. 1: Description of the sub-samples.

3.3 Instruments

3.3.1 Professional digital competence beliefs

We assessed student teachers' professional digital competence beliefs with an instrument by Quast, Rubach, and Porsch (2023) based on the DigCompEdu framework by Redecker and Punie (2017). The instrument contains 29 items (for all items, see Table A1) in seven dimensions: Administration and Professional Development ($\omega_1 = .87$, $\omega_2 = .79$), Lesson Planning ($\omega_1 = .88$, $\omega_2 = .79$), Teaching and Supporting Students ($\omega_1 = .85$, $\omega_2 = .79$), Assessment ($\omega_1 = .84$, $\omega_2 = .79$), Empowering All Students ($\omega_1 = .85$, $\omega_2 = .80$), Facilitating Students' Digital Competence ($\omega_1 = .85$, $\omega_2 = .69$), and Privacy and Copyright Rules ($\omega_1 = .88$, $\omega_2 = .93$). Answers were rated on a 5-point scale ranging from 1 (not competent at all) to 5 (very competent).

3.3.2 Mentor teachers' use of digital technologies to facilitate students' digital competence

We developed an instrument to assess mentor teachers' use of digital technologies based on the competence dimension «Facilitate Learners' Digital Competence» by Redecker and Punie (2017). Student teachers were asked how often their mentor teacher covered six aspects in class, e.g., using digital media to search for information (for all items, see Table A2). Answers were rated on a five-point scale (1=in none of the lessons, 2=in very few lessons, 3=in some lessons, 4=in most lessons, 5=in every lesson). The reliability of the scale is good ($\omega = .86$).

3.3.3 Variety of mentor teachers' use of digital devices and tools

We assessed the variety of mentors' use of digital devices and tools with an adapted version of the scale by Breiter, Welling, and Stolpmann (2010). Student teachers were asked how often their mentor teacher used up to 15 devices and tools, e.g., projectors (for all items, see Table A3). Only devices or tools available at the specific school were assessed. Answers were rated on a 5-point scale (1=in none of the lessons, 2=in very few lessons, 3=in some lessons, 4=in most lessons, 5=in every lesson). To assess the variety of mentor teachers' use of digital devices and tools, we recoded the answers into a binary format (0=no use, 1=use).

3.3.4 Use of LMS in everyday school life

To assess the use of an LMS in everyday school life, we developed a scale based on Breiter et al. (2021). If an LMS was available at school, student teachers were asked how often 13 functions of that LMS were used in everyday school life, e.g., exams (for all items, see Table A4). Answers were rated on a five-point scale from 1 (never) to 5 (very often). The reliability of the scale is sufficient ($\omega = .78$).

3.3.5 Observation focus on digital technologies

We assessed student teachers' observational focus on digital technologies with a single item. Student teachers were asked how often they focused on the use of digital technologies in class during their classroom observations. Answers were rated on a five-point scale (1=in none of the lessons, 2=in very few lessons, 3=in some lessons, 4=in most lessons, 5=in every lesson).

3.3.6 Digital communication between colleagues and with parents

We developed two scales to assess the digital communication between colleagues at the school and with parents. Student teachers were asked how often teachers at their practicum school use four digital communication channels to communicate with colleagues or with parents: e-mail, private messengers chats (e.g., WhatsApp, Telegram), group chats in messaging apps (e.g., WhatsApp, Telegram) and LMS. Answers were rated on a 6-point scale (1=never, 2=less than once a month, 3=at least once a month, 4=at least once a week, 5=several times a week, 6=daily) with the additional option «I cannot answer that». The reliabilities of both scales are sufficient (digital communication between colleagues: $\omega = .77$, digital communication with parents: $\omega = .71$).

4. Data analysis

To analyse our data, we used IBM SPSS Statistics 29. To answer Research Question 1, we performed a repeated measures mixed MANOVA on the seven dimensions of professional digital competence beliefs for the intervention group and the control group for t1 and t2. A mixed MANOVA can simultaneously analyse the impact of the independent variables (time, group and their interaction) on several dependent variables and can control for the potential correlations among them (Verma 2016). It allows for testing for within-subject effects (changes over time) and between-subject effects (differences between groups). To answer research question 2, we used the data of the intervention group to perform repeated measures MANCOVAs on the seven dimensions of professional digital competence beliefs with the following covariates: mentor teachers' use of digital technologies to facilitate students' digital competence, variety of mentor teachers' use of digital devices and tools, use of LMS in everyday school life, observation focus on digital technologies, digital communication between colleagues and digital communication with parents.

The repeated measures MANCOVA examines how several dependent variables change over time within the same subjects and allows us to control for the effects of covariates (Dimitrov and Rumrill 2003). To examine the influence of the combined covariates and each covariate solely, we performed seven repeated measures MANCOVAs: one with all six covariates combined and six with each only one of the six covariates.

5. Results

5.1 Student teachers' learning opportunities with digital technologies during the practical semester

To contextualise the subsequent analyses, we begin by reporting the frequency distributions for the variables assessing student teachers' learning opportunities with digital technologies during the practical semester.

Student teachers reported that their mentor teachers most frequently used digital technologies with students to create digital content in various formats (21.15% at least in most lessons) and to communicate and collaborate responsibly (16.35% at least in most lessons; Figure 3).

How often did your mentor cover the following aspects with the students in class?

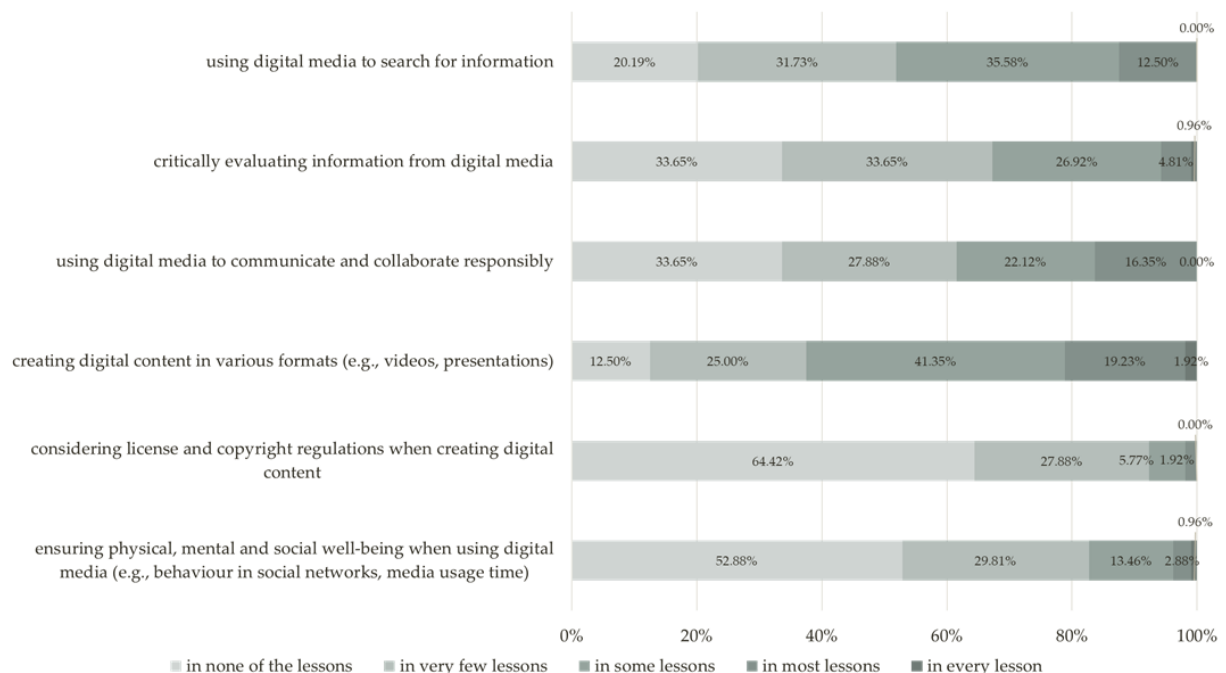


Fig. 3: Mentor Teachers' Use of Digital Technologies to Facilitate Students' Digital Competence. $n=104$.

Regarding mentor teachers' use of digital devices, student teachers reported that mostly Apple TV (79.71 % at least in most lessons) and interactive whiteboards (72.47 % at least in most lessons), if available, were used during lessons (Figure 4). The most used digital tools were digital class books (58.62 % at least in most lessons) and LMS (38.20 % at least in most lessons), if available.

How often were the following digital devices and tools used in the lessons of your mentor?

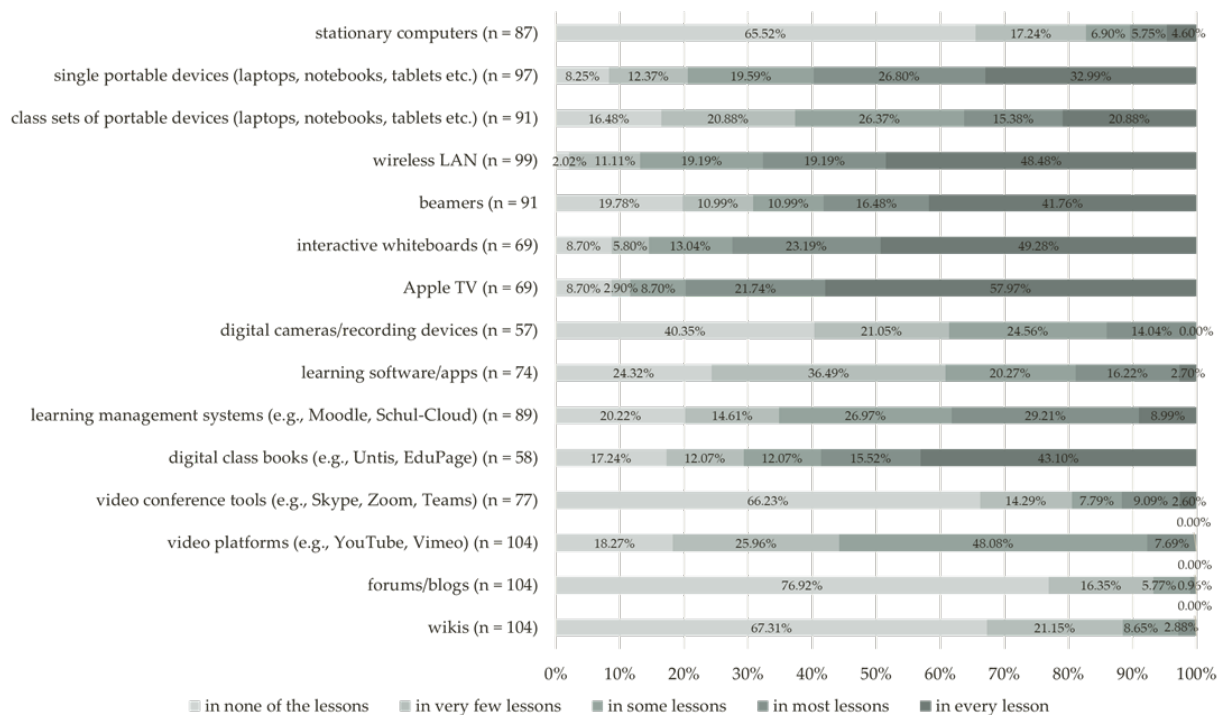


Fig. 4: Mentor Teachers' Use of Digital Devices and Tools.

If an LMS was available at the practicum school, student teachers were asked how often different functions of the LMS were used (Figure 5). They reported that LMSs were most often used as timetables or substitution plans (59.55 % at least often), for data storage (56.18 % at least often) and for e-mails (56.18 % at least often).

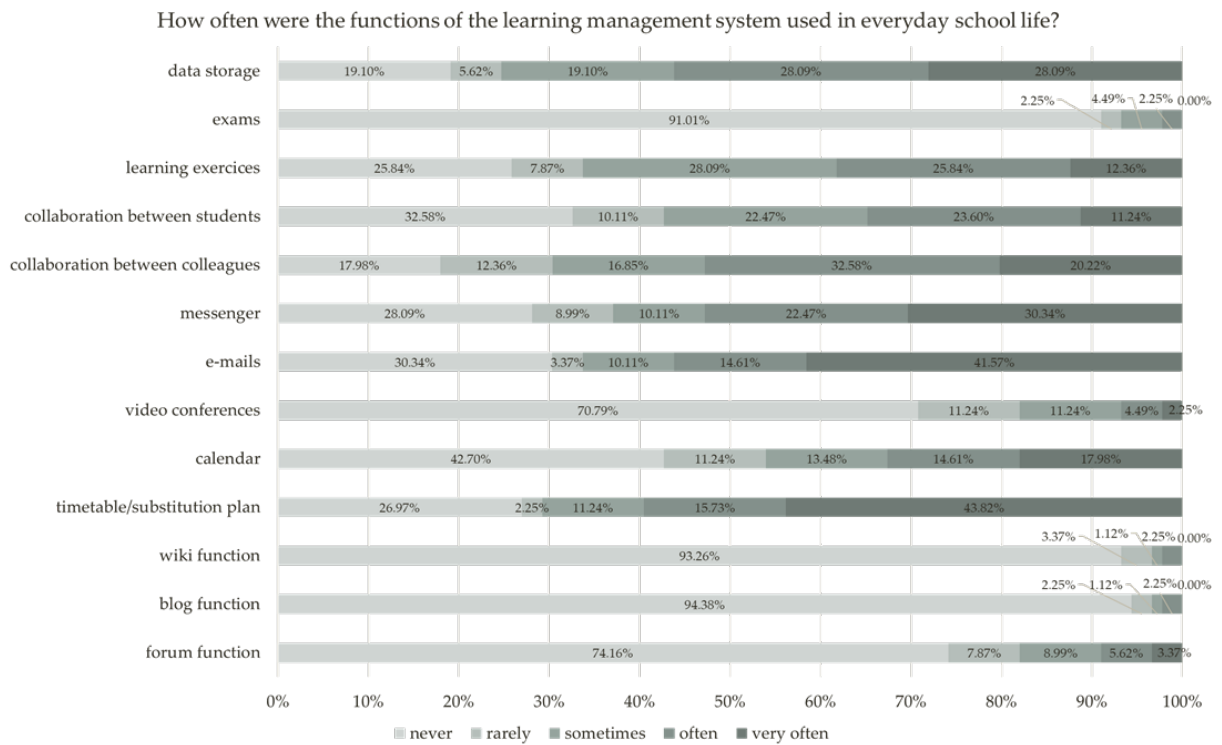


Fig. 5: Use of LMS in Everyday School Life. $n=89$.

If student teachers had a specific focus during their lesson observations, almost a quarter of them (24.73%) reported that they focused on the use of digital technologies in class in at least most lessons (Figure 6).

If you had an observation focus, what did you pay attention to during classroom observations?

Answer: using digital technologies in class

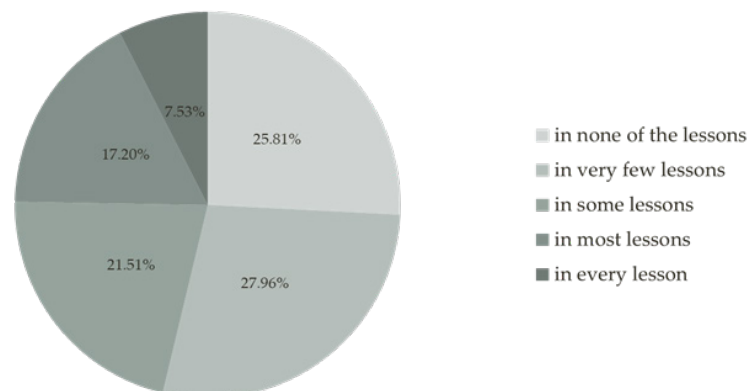


Fig. 6: Observation Focus on Digital Technologies. $n=93$.

Regarding the practicum schools' digital communication, student teachers reported that teachers mostly used e-mails (82.95 % at least several times a week) and private messenger chats (76.19 % at least several times a week) to communicate with each other (Figure 7). To communicate with parents, teachers mostly used e-mails (64.71 % at least several times a week) and the schools' LMSs (46.97 % at least several times a week) (Figure 8).

How often do the teachers at your practicum school use the following communication channels to communicate with each other?

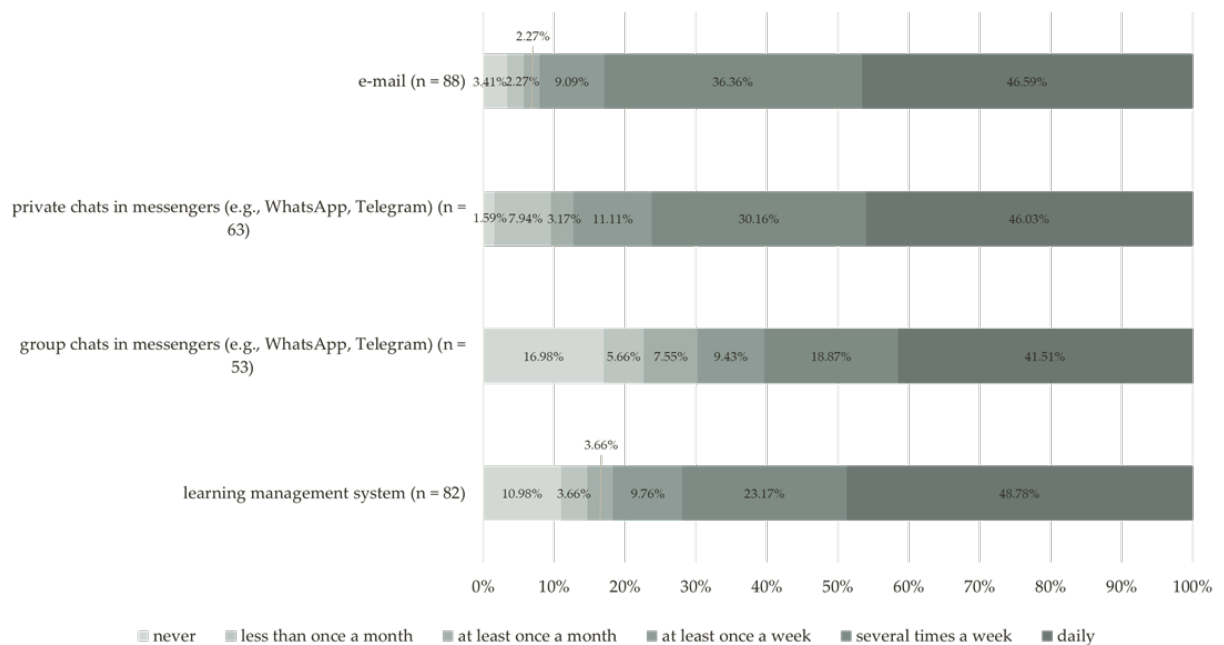


Fig. 7: Digital Communication Between Colleagues.

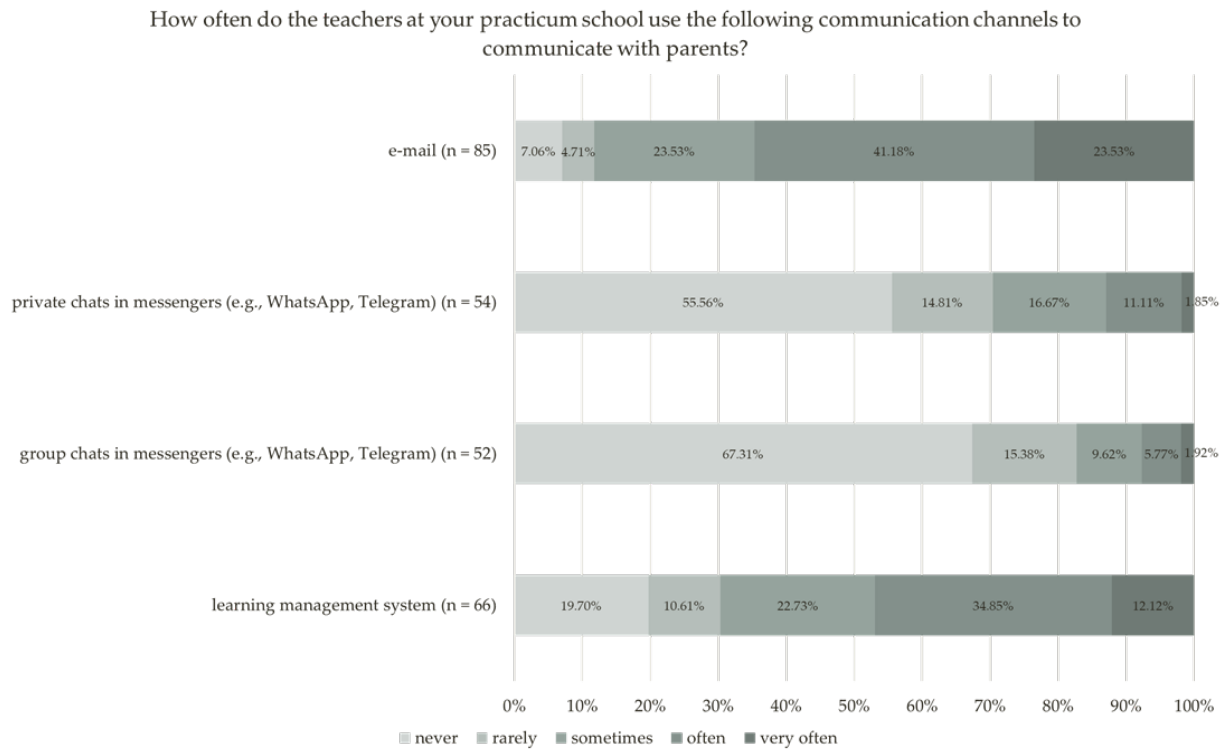


Fig. 8: Digital Communication With Parents.

5.2 Development of student teachers' professional digital competence beliefs during the practical semester (RQ1)

The results of the repeated measures mixed MANOVA showed a significant interaction between the time point of measurement and the group membership for the combined measure of the seven dimensions of professional digital competence beliefs ($F(7, 137) = 3.172, p = .004$, partial $\eta^2 = .136$) suggesting a medium effect size. The results of the follow-up univariate ANOVAs are presented in Table 2. Only for the dimension Assessment, no significant interaction was found. The mean values and standard deviations of the professional digital competence beliefs are displayed in Figure 8 and Table A5 (Appendix).

Competence dimension	dfNum	dfDen	F	p	partial η^2
Administration and Professional Engagement	1	143	9.508	.002	.062
Lesson Planning	1	143	6.624	.011	.044
Teaching and Supporting Students	1	143	18.259	<.001	.113
Assessment	1	143	2.990	.086	.020
Empowering All Students	1	143	2.211	.008	.048
Facilitating Students' Digital Competence	1	143	2.306	.004	.057
Privacy and Copyright Rules	1	143	2.258	.035	.031

Tab. 2: Results of the Interaction Effects Between Time Point of Measurement and Group Membership from the Univariate ANOVAs of Professional Digital Competence Beliefs of Student Teachers.

Notes: dfNum = degrees of freedom numerator. dfDen = degrees of freedom denominator.

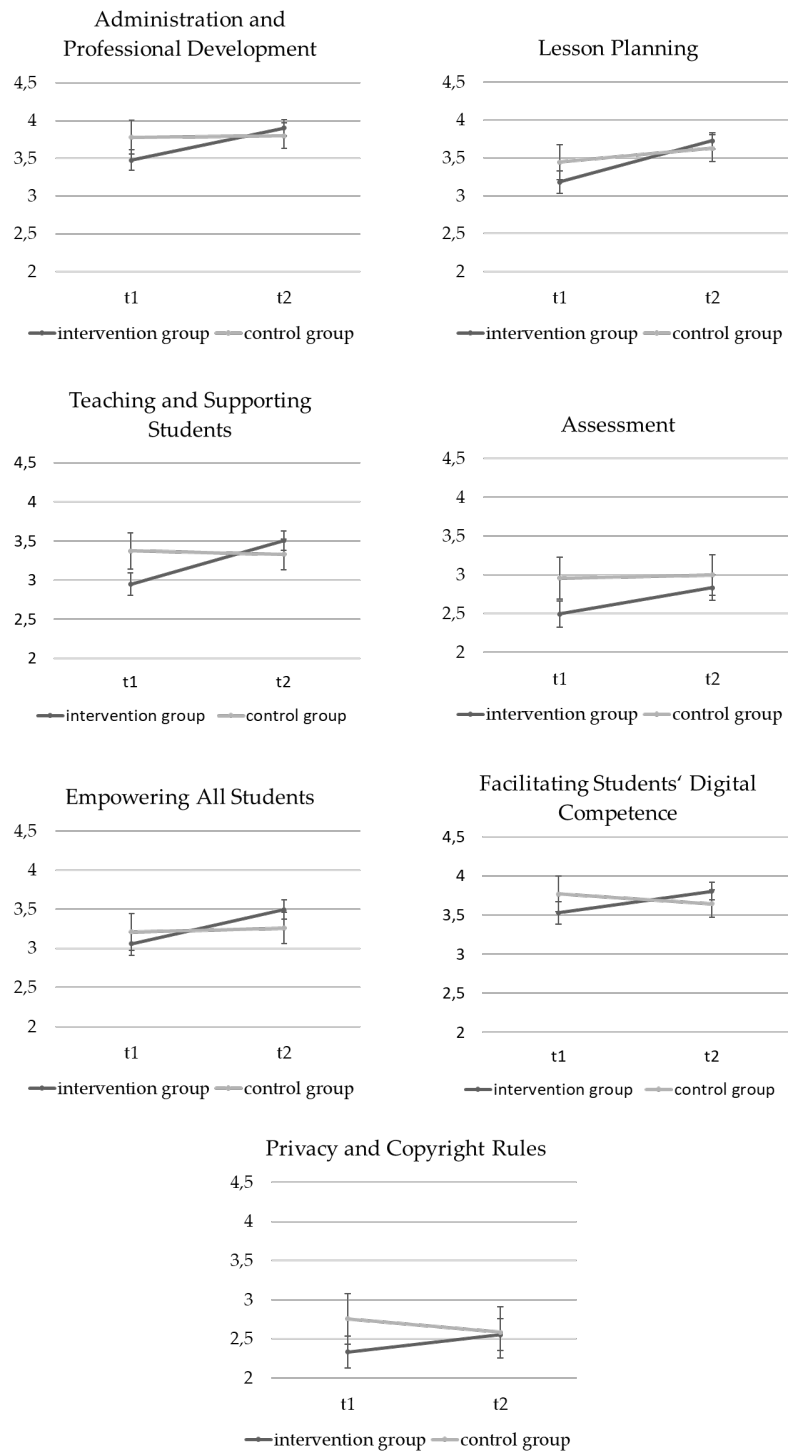


Fig. 9: Professional Digital Competence Beliefs of the Intervention Group and the Control Group for t1 and t2.

The tests of within-subject effects (Table 3) showed significant main effects for the intervention group in all seven professional digital competence belief dimensions and no significant main effects for the control group.

Competence dimension	dfNum	dfDen	F	p	partial η^2
Intervention Group					
Administration and Professional Engagement	1	103	35.277	<.001	.255
Lesson Planning	1	103	53.878	<.001	.343
Teaching and Supporting Students	1	103	55.501	<.001	.350
Assessment	1	103	12.970	<.001	.112
Empowering All Students	1	103	31.434	<.001	.234
Facilitating Students' Digital Competence	1	103	15.870	<.001	.134
Privacy and Copyright Rules	1	103	5.091	.026	.047
Control Group					
Administration and Professional Engagement	1	40	0.041	.840	.001
Lesson Planning	1	40	2.310	.136	.055
Teaching and Supporting Students	1	40	0.130	.720	.003
Assessment	1	40	0.089	.767	.002
Empowering All Students	1	40	0.177	.676	.004
Facilitating Students' Digital Competence	1	40	0.933	.340	.023
Privacy and Copyright Rules	1	40	1.201	.280	.029

Tab. 3: Results of the Within-Subjects Effects from the Univariate ANOVAs of Professional Digital Competence Beliefs of Student Teachers between t1 and t2.

Notes: dfNum = degrees of freedom numerator. dfDen = degrees of freedom denominator.

The tests of the between-subject effects (Table 4) showed significant main effects among both groups for Administration and Professional Development on t1, Teaching and Supporting Students on t1, Assessment on t1 and Privacy and Copyright Rules on t1, suggesting small to medium effect sizes. The results indicate that the control group had higher professional digital competence beliefs on all four measures than the intervention group.

Competence dimension	dfNum	dfDen	F	p	partial η^2
t1					
Administration and Professional Engagement	1	143	5.246	.023	.035
Lesson Planning	1	143	3.602	.060	.025
Teaching and Supporting Students	1	143	9.287	.003	.061
Assessment	1	143	8.243	.005	.055
Empowering All Students	1	143	1.168	.282	.008
Facilitating Students' Digital Competence	1	143	3.123	.079	.021
Privacy and Copyright Rules	1	143	4.859	.029	.033
t2					
Administration and Professional Engagement	1	143	1.044	.309	.007
Lesson Planning	1	143	0.827	.365	.006
Teaching and Supporting Students	1	143	2.232	.137	.015
Assessment	1	143	1.074	.302	.007
Empowering All Students	1	143	3.913	.050	.027
Facilitating Students' Digital Competence	1	143	2.212	.139	.015
Privacy and Copyright Rules	1	143	0.028	.868	.000

Tab. 4: Results of the Between-Subjects Effects from the Univariate ANOVAs of Professional Digital Competence Beliefs of Student Teachers between the Intervention Group and the Control Group.

Notes: dfNum = degrees of freedom numerator. dfDen = degrees of freedom denominator.

5.3 The influence of learning opportunities on student teachers' development of professional digital competence beliefs during the practical semester (RQ2)

The results of the repeated measures MANCOVA showed no significant interaction effect between the time point of measurement and the combined covariates¹ for the combined measure of the seven dimensions of professional digital competence beliefs ($F(7, 58) = 1.099, p = .376, \text{partial } \eta^2 = .117$).

Therefore, we decided to test the covariates' interaction effects separately (Table 5). Only for digital communication between colleagues, there was a significant interaction effect with the time point of measurement for the combined measure of the seven professional digital competence belief dimensions, suggesting a large effect. The results of the follow-up univariate ANOVAs (Table 6) showed significant interactions between

¹ In Appendix B, Figures B1-B7 display the frequency distributions of the covariates.

the time point of measurement and the digital communication between colleagues for four out of seven professional digital competence belief dimensions: Administration and Professional Development, Lesson Planning, Assessment and Empowering All Students, suggesting medium effect sizes.

Covariate	dfNum	dfDen	F	p	partial η^2
Mentor teachers' use of digital technologies to facilitate students' digital competence	7	96	0.690	.680	.048
Variety of mentor teachers' use of digital devices and tools	7	96	0.809	.582	.056
Use of LMS in everyday school life	7	81	1.273	.274	.099
Observation focus on digital technologies	7	85	0.223	.979	.018
Digital communication between colleagues	7	89	2.599	.017	.170
Digital communication with parents	7	86	1.436	.202	.105

Tab. 5: Results of the Separate Repeated Measures MANCOVAs for Each Covariate and the Combined Measure of the Professional Digital Competence Beliefs of Student Teachers.

Notes: dfNum=degrees of freedom numerator. dfDen=degrees of freedom denominator.

Competence dimension	dfNum	dfDen	F	p	partial η^2
Administration and Professional Engagement	1	95	7.039	.009	.069
Lesson Planning	1	95	7.825	.006	.076
Teaching and Supporting Students	1	95	1.739	.190	.018
Assessment	1	95	9.225	.003	.089
Empowering All Students	1	95	7.872	.006	.077
Facilitating Students' Digital Competence	1	95	1.631	.205	.017
Privacy and Copyright Rules	1	95	0.015	.902	.000

Tab. 6: Results of the Interaction Effects Between Time Point of Measurement and Digital Communication with Colleagues from the Univariate ANCOVAs of Professional Digital Competence Beliefs of Student Teachers.

Notes: dfNum=degrees of freedom numerator. dfDen=degrees of freedom denominator.

6. Discussion

The goal of this exploratory study was to examine how student teachers' professional digital competence beliefs develop during the practical semester and how this development interacts with learning opportunities in the practicum school.

The results imply that student teachers' professional digital competence beliefs increase during the practical semester compared to a control group. However the development of student teachers' professional digital competence beliefs only interacted with digital communication between colleagues at school.

6.1 Development of student teachers' professional digital competence beliefs during the practical semester (RQ1)

To get a first indication of the effectiveness of an extended school internship as a place for developing professional digital competence beliefs, we compared two groups of student teachers: one group that took part in the practical semester and the second group that attended a course in educational studies. Student teachers in the intervention group were in the second or third semester of their Master's studies. Student teachers in the control group were in the first semester of their Master's studies, but initially reported higher professional digital competence beliefs. We assume that the student teachers of the control group might have overestimated their professional digital competence beliefs. Rothland (2018) refers to several studies showing that student teachers, even before the practical semester, believe they already possess the necessary competencies for central tasks of the teaching profession. One explanation is that these student teachers possess some competencies but overestimate their abilities, as proposed by the Dunning-Kruger effect (Kruger and Dunning 1999). Another assumption may be that there were changes or differences in the curricula or that there was a cohort effect. Still, these remain assumptions, and it cannot clearly be explained why student teachers of the control group assessed some of their professional digital competencies on t1 higher than those of the intervention group.

In line with our assumption, as the school placement provides several learning opportunities, student teachers of the intervention group increased their professional digital competence beliefs in all competence dimensions. Hence, the extended school internship has an effect on the development of student teachers' perceived professional digital competence. This matches other findings on the increase of student teachers' professional digital competence beliefs during an extended school internship (Vogelsang et al. 2023; Vogelsang and Wiethoff 2022). These findings also support the results of systematic reviews by Tondeur et al. (2025; 2012) who found that role models (modelling) and hands-on experience (exploration) are crucial to familiarise student teachers with the potential of digital technologies in educational settings.

However, we did not observe an interaction effect between the time point of measurement and group membership for the Assessment dimension. That suggests the intervention group had only limited learning opportunities to assess students' learning with digital technologies. This assumption is supported by the fact that although LMS are used at school, they are least used for exams. One explanation could be that the majority of the learning opportunities provided to student teachers during their school placement

are informal (Richter et al. 2014; Reintjes, Thönes, and Winter 2023). Schools provide additional and relevant learning opportunities, but teacher education has to ensure that all professional digital competencies are acquired by all student teachers. In addition, our study points to individual differences between schools, e.g., regarding technical equipment. In other words, some schools might have a strong focus on using digital technology, others not, thus, the learning opportunities for student teachers also differ. Consequently, systematic training at universities is necessary to provide sufficient input for all student teachers.

6.2 *The influence of digital communication between colleagues on student teachers' development of professional digital competence beliefs (RQ2)*

The final research question aims to explain the aforementioned development of professional digital competence beliefs during the extended school internship. Derived from the offer and use model of practical training in teacher education by Hascher and Kittinger (2014), we assumed that development is enhanced by various learning opportunities, in particular those provided by the (mentor) teachers. However, no interaction effect was found between the combined learning opportunities and student teachers' development of professional digital competence beliefs. However, this result must be interpreted in the light of the fact that, e.g., most mentor teachers do not or only rarely use digital technologies with the pedagogical purpose to facilitate students' digital competence. Also, LMS seem to be primarily used for administrative purposes rather than for pedagogical purposes in the practicum schools. Hence, the question remains what influences the development of professional digital competence beliefs during an extended school internship. Vogelsang and Wiethoff (2022) compared the development of professional digital competence beliefs during an extended school internship between typical internships and COVID-19 internships that switched to distance teaching due to the school closures. The study found a difference in the competence belief development between student teachers in a typical internship and student teachers in the COVID-19 internship, whose mentor teachers involved them in teaching. The latter group reported a greater development in their professional digital competence beliefs during the extended school internship. However, there was no difference in the competence belief development between student teachers in the COVID-19 internship, whose mentor teachers involved them in teaching and those whose mentor teachers did not involve them in teaching. This might indicate a limited influence of mentor teachers on student teachers' professional digital competence belief development, as shown in our study. It could be that university mentors and their accompanying seminars, which were not analysed in this study, play an important role in the development of student teachers' competence beliefs. Regarding the question of what contributes to the development of professional digital competence beliefs during an extended school internship, case

studies might reveal an answer. Such studies might also contribute to a deeper theoretical understanding of the relations and effects of formal and informal learning concerning the acquisition of professional digital competencies in teacher training. Finally, a model is needed that explains the development of professional digital competence beliefs during an extended school internship.

Our findings show an interaction effect only for digital communication with colleagues on the development of professional digital competence beliefs. This requires further research, as the communication takes place outside the classroom in the daily school life and is often less visible or not visible to student teachers, compared to the use of digital technology in the classroom. Though, Tondeur et al. (2025) found that collaborations that, e.g., include partnerships and digital communication with mentors, are necessary to prepare student teachers for using digital technologies in school and in class. It seems possible that frequent and diverse digital communication at the practicum school could be a reference to the school's «digital culture» and also involves communication with the student teachers. This would imply that in schools that frequently use different digital communication channels, student teachers have to use these channels themselves, which could be a learning opportunity regarding competence beliefs in the dimension Administration and Professional Development. However, we cannot provide a sufficient explanation for why the individual professional digital competence beliefs of the student teachers are positively affected by frequent and diverse digital communication between teachers at the practicum school in the competence dimensions Lesson Planning, Assessment and Empowering All Students.

7. Limitations

Our study provides insights into student teachers' development of professional digital competence beliefs during an extended school internship. It does, however, have some limitations.

We focused on student teachers' vicarious experiences and did not assess mastery experiences, e.g., how or for what purpose student teachers used digital technologies when teaching independently. The reason for this is that most of the time, student teachers in the practical semester observe their mentor teachers' lessons and the project also examines lesson-observation-only school practicums. A meta-analysis by Täschner et al. (2024) has shown that mastery experience interventions did not produce larger effects than vicarious experience interventions. Also, the results of a study by Vogelsang and Wiethoff (2022) showed no differences in student teachers' professional digital competence belief development depending on how their mentor teacher involved them in teaching in their extended school internship. Future studies should also examine the effects of mastery experiences in extended school internships on the development of student teachers' professional digital competence beliefs.

Another limitation is that this study only focuses on student teachers' stay in school. But they also attend accompanying seminars at the university one day a week. In these seminars, they might learn about the use of digital technologies in teaching and school and critically reflect on (mentor) teachers' use or non-use of digital technologies in school and teaching. Therefore, future studies should check the influence of the learning opportunities in the university during extended school internships and of the guided reflection of the learning opportunities provided by their practicum school on the development of student teachers' professional digital competence beliefs.

Also, we only conducted our research in two universities: one smaller university in Eastern Germany and one larger university in Western Germany. However, an analysis showed no significant interaction effect between the time point of measurement and the membership of either of the two universities. Therefore, the student teachers of both universities did not differ in their development of perceived professional digital competence. During the sampling process, we engaged in various activities to improve the participation rate. Still, the sample size is smaller than intended, which can be explained by the rather comprehensive questionnaire and also a low motivation for participation that the authors experienced in various projects after the COVID-19 pandemic. However, regarding the small sample size, it is a research desideratum to repeat the study in more universities with a larger sample.

8. Conclusions

This explorative study aimed to examine student teachers' development of professional digital competence beliefs during an extended school internship and the interaction with learning opportunities in school. In the extended school internship, student teachers' professional digital competence beliefs increased in all assessed competence dimensions. Therefore, we can assume that student teachers broadly develop their professional digital competence beliefs during these five to six months. Regarding learning opportunities, only teachers' digital communication with colleagues interacted with the development of student teachers' perceived professional digital competence. Future studies should therefore examine which (other) learning opportunities may interact with the development of student teachers' professional digital competence beliefs. With this knowledge, schools and mentor teachers may be better prepared for their important role in the education of student teachers.

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