Article

Preservice Teachers' Online Self-Regulated Learning: Does Digital Readiness Matter?

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Abstract: (1) Background: Teaching in today's schools asks teachers to foster self-regulated learning and digital competences in children and young people. In order to do so, teachers first need to acquire and use these competences themselves. (2) Methods: Based on a mixed-methods approach, the study investigates self-regulated learning in online courses of N = 129 preservice teachers at a German university. (3) Results and conclusions: Perceiving their digital readiness as generally high, preservice teachers appear to not overly self-regulate their learning in the online environment. Finally, preservice teachers' digital readiness was related only weakly to their online self-regulated learning. A discussion is offered which shows teacher education as a broader phenomenon and implies the need for professional development for teacher educators. Additionally, it is argued to link research on self-regulated learning more closely to research on online learning environments in teacher education.

Keywords: self-regulated learning; online learning; preservice teachers; mixed methods

1. Introduction

Around the world, K-12 education faces the need and societal expectation to support children and young people to develop competences to navigate in an increasingly digital life [1]. Teachers are therefore called upon to introduce young learners to these fields and support them in the acquisition and use of these competences [2,3] for digital competences [4]. To foster competences required for navigating in online (learning) environments and to model online self-regulated learning, teachers need to have these two competences themselves.

The current study draws on the well-established body of literature on self-regulated learning (e.g., [5–7]) and that of digital competences and readiness of preservice teachers (e.g., [8,9]). It considers both in order to shed light on their nexus within broadly applied online (distance) learning in the sample of preservice teachers at a German university. Based on a mixed-methods design [10,11], the study seeks to uncover how digitally ready preservice teachers are, how they self-regulate their learning within the online learning context, how contextual and individual factors play into this, and how preservice teachers specifically experience their online self-regulated learning.

1.1. Digital Readiness and Digital Competences of Preservice Teachers

Undoubtedly, today's formal education—including K-12 and higher education—relies on the competent integration of educational technology, both as a means to deliver content (e.g., [12]) and as a result of its teaching and learning efforts (e.g., [13]). In this context, interrelated concepts such as digital competence, digital literacy, or digital skills are of growing importance [14]. They encompass skills related to information retrieval and understanding,

to instrumental use of technology, digital content creation, and communication via digital technology and platforms [14].

Teacher education is not exempt from this development. On the contrary, the "European Framework for the Digital Competence of Educators" addresses educators as a group with the necessity to be digitally competent in order to engage professionally, to teach, assess learning, and navigate increasingly digital learning environments in education institutions [15]. Still, Senkbeil and colleagues [9] indicated in their study in the German context that preservice teachers in their sample lacked sufficient ICT competences. Prestridge [16] states that for inservice teachers, "a relationship between ICT competence, confidence and practice" (p. 457) is emerging. In accordance, it is essential that preservice teachers develop ICT skills in order to support their school students in online learning [17]. However, Cabezas-González, Casillas-Martín, and García-Peñalvo [18] showed, for their Spanish student sample, that personal variables such as gender and age are related to the degree of digital competence as well. Besides, it is not the mere instrumental mastering of digital tools that preservice teacher education is asked to foster. It rather entails also considering the nexus of pedagogy and technology, and in doing so, supporting the notion of how preservice teachers are enabled to professionally develop along this line, e.g., through skills in design thinking [19].

The evaluation of two classes for preservice teachers that made use of the flipped learning approach indicated that authentic situations, in which the preservice teachers could implement educational technology and receive feedback as well, and the integration of technology into the higher education course, is conducive to fostering competences at the junction of content, pedagogy, and technology [17]. Using the example of Korean preservice teachers, Lee and Lee [20] showed that their perceived self-efficacy for technology integration increased after attending a course on educational technology following a blend of theory and practice, aligned with the national school curriculum, and including concrete lesson planning. The latter proved to also be the deciding factor for the increase in perceived self-efficacy. These studies show that pedagogical design is influential in regards to fostering preservice teachers' digital competence and pedagogical views.

Additionally, in a systematic review of qualitative studies on preservice teachers' preparation to use educational technology, Tondeur and colleagues [21] discussed central topics that pertain to teacher education but also to the institution—showing that teacher education is a multilayered field.

1.2. Self-Regulated Learning

Self-regulated learning seems to be particularly important for learning and teaching in online environments, allowing more freedom with regard to time and space and with different types of communication and collaboration [22]. Hence, self-regulated learning plays a central role for successful learning in traditional, but especially in online, learning settings. A student who is able to learn in a self-regulated way "(. . .) is able to set task-related, reasonable goals, take responsibility for his or her learning, and maintain motivation. It is also assumed that self-regulated learners are able to use a variety of cognitive and metacognitive strategies. These students are able to vary their strategies to accomplish academic tasks" [23] (p. 101). Self-regulated learning is described in different models, each focusing on distinct aspects, such as cyclical aspects of processes models [24], different components of self-regulated learning [25], motivational aspects [26,27], or metacognitive aspects (e.g., [28]; for an overview, see [6]).

1.3. (Online) Learning Strategies: Types and Requirements

Learning strategies are a core concept of the theoretical conceptualizations of self-regulated learning [29]. Weinstein and colleagues [29] define learning strategies by "any thoughts, behaviors, beliefs, or emotions that facilitate the acquisition, understanding, or later transfer of new knowledge and skills" (p. 727). The current study focuses on strategies related to behavior and context, i.e., metacognitive strategies and resource strategies [30].

Metacognitive strategies encompass three types of strategies: planning, monitoring, and regulation [31]. Resource management strategies aim to manage and control the learning environment. This includes external resources such as time, study environment, and other people (seeking help from peers or lecturers) but also the regulation of internal resources such as attention or effort [31,32].

The importance of self-regulated learning and learning strategies is given by its relation with performance and learning success (see [22,33,34]). That is, students with higher use of self-regulated learning strategies show higher performance. Vice versa, students' prior knowledge is correlated with their use of learning strategies [35–37].

1.4. Self-Regulated Learning and Digital Readiness

Studying in higher education is characterized by relatively limited degree of external control and structure, requiring students to responsibly steer and regulate their learning processes (e.g., [23]).

Because of the increased use of online and computer-based learning in higher education, self-regulation gains additional importance [22,38], as do questions related to support measures for self-regulated learning [39]. Generally speaking, learning in (online) distance education relies on the prerequisite of certain abilities in self-regulation on behalf of the learner (e.g., [40,41]). However, Foerst and colleagues [42] showed that knowledge about self-regulation strategies does not necessarily translate into respective study behavior.

The case is specific for preservice teachers, who need to be knowledgeable about their self-regulation in order to perceive it as part of their professional identity to be able to subsequently support their students in school [43,44]. For example, in a mixed-method study with high school students, it was found that those who felt more competent to self-regulate their learning procrastinated less and coped better with the specific challenges with regard to online learning [45]. Up to now, preservice teachers have been subject to investigation of their self-regulated learning (e.g., [46]), their self-regulated learning in relation to technological pedagogical content knowledge (e.g., [47]), as well as their behavior and experience when learning with authentic cases or learning with wikis integrated into the instruction of higher education courses [48,49].

In the specific situation of the COVID-19 pandemic, the need for self-regulated learning might even have grown. The possibilities to reach and use external resources (public library spaces) have changed significantly. As stated by Hensley and colleagues [50], "productive study locations and routines students had established were lost and difficult to re-create" (p. 210). In addition, social distancing [51] resulted in fewer opportunities to create one's own learning environment [52] and limited opportunities to interact and seek help from peers and lectures [53,54]. Hensley and colleagues [50] reported that students in their study partly perceived themselves to feel more in charge of their learning, but in general voiced "their inability to access on-campus resources, work in peer study groups, or attend review sessions and office hours" (p. 211), which the students felt as a burden. Thus, due to the pandemic, learning spaces and thereby learning processes have changed, with important consequences for self-regulated learning. Berger and colleagues [55] concluded that competences for self-regulated learning play an essential role in the pandemic situation and found that secondary school students with lower prior knowledge and low motivation had more difficulties coping with the situation.

1.5. Research Questions and Hypotheses

First, regarding a basic competence to navigate in online education (synchronous and asynchronous), we were interested in preservice teachers' digital readiness. Second, as the main aim of the current study, we addressed preservice teachers' online self-regulated learning behavior, that is, how much preservice teachers engage in metacognitive and resource strategies for online self-regulated learning during a term. Third, we investigated whether and how preservice teachers' personal characteristics (age and gender), as well as their skills (digital readiness and prior performance) and resources (quiet learning space)

are associated with their online self-regulated learning (see for example [56]). Fourth, and in order to complement the preceding research questions, we aimed to uncover how preservice teachers describe the possible mechanisms that contribute to their online self-regulated learning. Therefore, the following research questions are addressed:

RQ1. How digitally ready are preservice teachers?

RQ2. How do preservice teachers self-regulate their learning in digital learning?

RQ3. Which individual (gender, age, and digital readiness) and contextual (quiet learning space) factors influence preservice teachers' self-regulated learning in online higher education?

RQ4. How do preservice teachers experience their online learning in terms of challenges and processes?

2. Materials and Methods

In total, 129 preservice teachers, enrolled at a German university, participated in the survey. The participants were between 18 and 48 years old (M_{age} = 23.05 years and SD = 4.08) and were predominantly female (i.e., 70.5%). On average, preservice teachers were in the middle of their fourth semester ($M_{semester}$ = 4.84 and SD = 2.91). Most of the participants were born in Germany (97.7%) and indicated German as their first language (96.1%). When the survey was conducted, all preservice teachers had experienced about two months of online learning in various synchronous and asynchronous courses. Due to the rapid switch to full online learning scenarios, the individual courses did not follow a set standard, but each instructor decided on course structure and organization. This resulted in a range of differently designed courses that preservice teachers needed to adapt to and navigate accordingly.

Seven of those preservice teachers (female: n = 4,) additionally participated voluntary in a semi-structured telephone interview. They were between 19 and 23 years old (M_{age} = 21 years) and, on average, they studied in the sixth semester ($M_{semester}$ = 6.43, $Min_{semester}$ = 2, $Max_{semester}$ = 11). All of them were born in Germany.

This paper reports on the results of a study during the 2020 spring term in Germany. To answer the research questions, the current study focuses on the measurement in June 2020, that is, in the middle of the term when students had already completed seven weeks of online courses. In addition, only preservice teachers who reported being enrolled in a teacher education program were further included in the study. Preservice teachers were informed that participation was voluntary and that the online survey focusing on student learning in the online term takes approximately 20 min. The online survey was administered in the German language and was rolled out via the platform Unipark Questback EFS (unipark.com, accessed on 15 June 2021).

After having completed the online questionnaire, preservice teachers were invited to voluntarily participate in an additional telephone interview (duration approx. 30 min) on various aspects of self-regulated learning during the online semester.

We protected participants' privacy in accordance with the institutional commissioner for data protection. Preservice teachers were not disadvantaged in case of nonparticipation. At the beginning of the questionnaire, the participants gave their informed consent to participate in the study.

The online survey was comprised of socio-economic information and mainly standardized questionnaire scales. First, participants provided information on their individual backgrounds (age and gender) as well as resources (especially quiet learning space). Preservice teachers were asked to indicate whether they had a quiet learning space available and how often they used it: 0 = not available; 1 = yes, but (almost) never used; 2 = yes, used 1–2 times/month; 3 = yes, used 1–2 times/week yes; 4 = used almost every day; and 5 = yes, used daily). Next, participants answered questionnaire scales to assess digital readiness and self-regulated learning strategies during online learning.

To assess preservice teachers' digital readiness, we implemented eight items from the Digital Readiness for Academic Engagement questionnaire DRAE [57] assessing students'

digital tool application and information-sharing behavior. Items had to be answered on a 6-point Likert scale, ranging from 1 "not true at all" to 6 "absolutely true". The scale turned out to be internally consistent (Cronbach's α = 0.79). An example for an item is: "I can interact with classmates using real-time communication tools, for example, video conferencing tools or messengers". All items were translated from the original version and provided in the German language.

The online self-regulated learning questionnaire OSLQ [58] measures self-regulated learning in the online learning environment as active and volitional behavior for successful learning. We focused on two subscales addressing metacognitive strategies (goal setting and self-evaluation) and three subscales regarding resource management strategies (environment structuring, time management, and help-seeking behavior). Participants answered all items of the five subscales on 6-point Likert scales, ranging from 1 "not true at all" to 6 "absolutely true". Overall, internal consistencies were lower in German than in the original English version, and we had to delete one item of the self-evaluation subscale.

The subscale goal setting comprised four items focusing setting standards for one's online learning. An example for an item is: "I set standards for my assignments in online courses." The internal consistency was good (α = 0.83).

The subscale self-evaluation comprised three items focusing on strategies regarding monitoring one's learning and learning progress. An example for an item is: "I ask myself a lot of questions about the course material when studying for an online course." The internal consistency was low but acceptable (α = 0.67).

The subscale environment structuring comprised four items focusing on strategies regarding the organization and choice of preservice teachers' learning environments. An example for an item is: "I know where I can study most efficiently for online courses." The internal consistency was good (α = 0.80).

The time management subscale comprised three items and aimed to assess participants' strategies for organizing their schedules and managing their times of study considering asynchronous and synchronous online courses. One item is: "Although we don't have to attend daily classes, I still try to distribute my studying time evenly across days." The internal consistency was sufficient (α = 0.63).

Finally, the help-seeking scale comprised four items and focused on participants' behavior to ask peers and instructors for help regarding the content of their online courses. An item example is: "I find someone who is knowledgeable in course content so that I can consult with him or her when I need help". The internal consistency was good (α = 0.72).

The semistructured interviews aimed at describing how preservice teachers learn in online courses. In the interview, they were asked to tell which online tools they used, whether they experienced digital barriers, how they learned and planned their learning time, and how they coped with the demands of online learning. The interviews were conducted via telephone and in the German language (all citations from transcripts provided in this paper are translated into English).

To answer RQ1–RQ3, we analyzed data of the online questionnaire. To investigate RQ1 and RQ2, descriptive statistics regarding digital readiness and online self-regulated learning were calculated. To answer RQ3, five separate linear regression analyses were calculated with the scales of online self-regulated learning as criterion, and gender, age, quiet learning space, student achievement, as well as digital readiness as potential predictors.

Finally, to answer RQ4, the interview data were analyzed. The interviews were transcribed according to Wild's [32] classification of learning strategies and analyzed using qualitative content analysis [59]. Next to the described self-regulated learning behavior, the deductively developed category system included two main categories: (1) Use of digital media (cf. DRAE questionnaire [57]), which contains statements about how the student is able to handle digital media in online learning and the specific way of usage. (2) Digital media tools, which includes interview passages providing information about the specific tools used by the interviewed preservice teacher. This category follows Bower's [60] typology of Web 2.0 learning technologies as guidance for which tools to include. The

intercoder reliability was tested and may be considered as sufficient (r = 0.76; cf. Holsti [61]). Table A1 in the Appendix A shows the definition of these two categories as well as the coding rules.

3. Results

3.1. Results of Quantitative Data Analysis

Descriptive statistics are presented in Table 1 (RQ1 and RQ2). On average, preservice teachers felt quite ready to study online. Mean values regarding online self-regulated learning are descriptively lower. They reported knowing where to study and how to arrange their study environment to a relatively high degree (environment structuring). Descriptively lower values were found for time management, goal setting, and help seeking. Finally, preservice teachers provided values below the average scale value regarding self-evaluation.

Table 1. Descriptive Statistics of Digital Readiness and Online Self-Regulated Learning.

	M	**SD**	**Min**	**Max**
Digital Readiness	4.89	0.64	3.00	6.00
Metacognitive strategies:				
Goal setting	4.05	0.96	1.40	6.00
Self-evaluation	3.12	1.10	1.00	6.00
Resource strategies:				
Environment structuring	4.71	0.82	2.00	6.00
Time management	4.32	0.99	1.33	6.00
Help seeking	3.86	1.12	1.00	6.00

All OSRL scales—except self-evaluation—are significantly related to the use of a quiet learning space (Table 2). Preservice teachers with a quiet learning space were more likely to set goals and seek help (small relations) as well as to structure their environment and time (medium correlations). Besides, digital readiness is significantly related to environment structuring but to none of the other OSRL scales.

Table 2. Pearsons' Correlation between Digital Readiness an Online Self-Regulated Learning.

	2	**3**	**4**	**5**	**6**	**7**
1 Quiet learning space	0.12	0.22 *	0.13	0.46 **	0.35 **	0.18 *
2 Digital Readiness		0.06	0.08	0.21 *	0.11	0.11
3 Goal setting			0.38 **	0.42 **	0.65 **	0.24 **
4 Self-evaluation				0.19 **	0.30 **	0.56 **
5 Environment structuring					0.49 **	0.20 *
6 Time management						0.27 **
7 Help seeking						–

** $p < 0.01$ * $p < 0.05$.

Finally, regression analyses to investigate potential factors related to the five OSRL scales (RQ3) are given in Table 3. Overall, we found only small proportions of explained variance for each of the five OSRL scales. While age and gender (the latter with the exception for self-evaluation during online learning) of preservice teachers was not significantly related to OSRL, the use of a quiet learning space showed small relations (except for time management). That is, preservice teachers who use a quiet place to work tend to engage more in metacognitive strategies during online learning (goal setting and self-evaluation) as well as resource strategies to manage their online studies (environment structuring and help seeking).

Table 3. Regression analyses for the five OSRL scales.

Variable	Goal Setting		Self-Evaluation		Environment Structuring		Time Management		Help Seeking	
	B	**β**	**B**	**β**	**B**	**β**	**B**	**β**	**B**	**β**
(constant)	3.17 **		1.45		2.29 **		2.54 **		2.10	
Gender	0.12	0.06	−0.43 *	−0.18 *	0.10	0.06	0.31	0.14	−0.20	−0.08
Age	−0.01	−0.04	0.03	0.12	0.00	0.02	−0.01	−0.04	0.01	0.05
Quiet learning space	0.15 *	0.19 *	0.20 *	0.22 *	0.28 **	0.42 **	0.27 **	0.32 **	0.17	0.18
Prior performance	0.01	0.08	0.02	0.13	0.01	0.05	0.01	0.13	0.02 *	0.19 *
Digital readiness	0.07	0.05	0.07	0.04	0.22 *	0.18 *	0.13	0.08	0.18	0.10
Corr. R^2	0.02		0.05		0.20		0.13		0.20	

* $p < 0.05$; ** $p < 0.01$; gender: 0—male and 1—female.

Interestingly, prior performance was only related to help seeking. Lastly, digital readiness contributed to environment structuring, that is, to one of the resource management strategies but not to the metacognitive strategies. To obtain further insight in preservice teachers' experiences with self-regulated learning, interview data were analyzed by qualitative content analysis.

3.2. Results of Qualitative Data Analysis

As a first step, the number of codings for the two categories "use of digital media" and "digital media tools" was counted. The number of codings per interview for the category "use of digital media" ranges from zero to four. The category "digital media tools" was coded between two and eleven times per interview.

The further analysis of the passages coded for the category "digital media tools" showed that six of the seven interviewed preservice teachers indicated using a variety of different digital tools, as Table 4 shows.

Table 4. Overview of codings of 7 interviews with respect to the category "digital media tools".

Category	Number of Codings
Video meeting software (such as Zoom or Skype)	19
Recorded videos	9
Digital platforms	8
Instant messaging services	6
Online search engines (such as Google)	3
E-mails	2
Office programs (such as MS Word or Power Point)	2

Student C said in the context of the variety of required digital tools:

"In some courses, the lecturers use the platform StudOn [the university's learning management system]; other lecturers only offer live video meetings via Zoom (video conference software). This was difficult for me, especially at the beginning of the semester, and it did not always work quite well because I needed some time to handle all this."

This shows that the variety of tools is a challenge itself during online semesters. In six of the seven interviews, live video conferencing software was the most mentioned digital tool the students used during the digital semester.

Regarding the overall frequency of mentioned digital tools, the most often-described tool was again live video conference software such as Zoom or Skype (19 codings in 7 interviews). One feature of online learning the preservice teachers in our study reported is that they did not only use the digital tools the lecturers had chosen for the courses. The preservice teachers said that they also organized study groups with peers for which they had to find appropriate digital tools on their own. Student A, for example, said:

"Yes, so I have some learning groups that we also conduct via Zoom. We usually prepare exam tasks and then discuss them together."

Regarding the use of instant messaging services for example, student B reported that he and some of his fellow preservice teachers set up an instant-messaging channel specifically to communicate about study content:

"And while I'm doing that, I'm also online in the Discord [instant messaging system] channel that our study group has set up. The idea is that you're in the chat with the topic that you're studying. So, I'm in a chat of educational sciences and if someone from my study group also wants to deal with university content or wants to chat, he can just join."

Despite the use of the tools already mentioned, the preservice teachers also talked about using online search engines (3 mentions in 7 interviews) such as Google as well as e-mails (2 mentions in 7 interviews) and office programs (2 mentions in 7 interviews) such as Microsoft Word or Power Point for their learning processes.

As mentioned above, the variety of different digital tools the preservice teachers have to use during the digital semester is a challenge for them. However, as student C points out, this challenge only occurred at the beginning of the semester, and it was manageable:

"Yes, at the beginning, we had to get used to the procedures. But after a while, we now know how the courses are organized, how the meetings take place. I would say, everything is as usual now."

Student C expected that her poor digital competences would be a central challenge during the digital semester, but she recognized that the challenges during the digital semester were different:

"Yes, especially at the beginning of the semester, it seemed like the lecturers themselves were struggling with the digital challenges. Due to that, many things didn't work or assignments were uploaded quite late which caused a lot of effort and work for me. And this made me feel desperate in the beginning and until I understood, which assignments are obligatory. Every lecturer organizes the online semester in his or her own way."

It was also reported that the lack of personal contact with peers and lecturers makes the orientation in the digital learning environment difficult. In sum, the preservice teachers indicated that the side effects of digital learning, such as a lack of social involvement and insufficient digital competences among lecturers, was a central challenge in the online semester. However, only one of the seven interviewed preservice teachers stated that this affected her use of self-regulation strategies:

"Well, all in all, my self-regulated learning has improved, I began somehow, well I took it serious before, but I take it more seriously now and I realize my responsibility more than before."

4. Discussion

The presented mixed-method study was carried out in order to shed light on preservice teachers' digital readiness and online self-regulated learning.

Overall, our study indicates that preservice teachers felt digitally ready (RQ1) but were not very strongly engaging in self-regulated learning during their online studies (RQ2), which is in line with results from a broader sample [54]. Referring to a current study related to emergency remote teaching [62], this seems to be an alarming learning behavior, as low levels of online self-regulated learning were related to high perceived ineffectiveness of online learning.

As one indicator for online self-regulated learning, the current study investigated preservice teachers' digital readiness. Muilenburg and Berge [63] showed that students "with the highest level of comfort and confidence using online learning technologies

perceived significantly fewer barriers for social interaction, administrative/instructor issues, learner motivation, and time and support for studies" (p. 38) than less technologically comfortable and confident learners. While some of these aspects relate to self-regulated learning, we only found weak correlations of digital readiness and online self-regulated learning (RQ3). More specifically, digital readiness emerged to be related to only two of the OSRL subscales: environment structuring and help seeking behaviors. One reason for the few effects of digital readiness on the OSRL subscales might be that digital competences in tool application and information-sharing behavior do not automatically lead to higher abilities in successfully handling and self-regulating emergency remote teaching. This implies that effective self-regulation in online learning settings requires other competences, which are more relevant for successful learning than digital competences on their own [22]. One potential influence for online self-regulated learning might be the learning environment and support offered by the lecturers [64] (for secondary school context see [45,55]).

From an international perspective, the 2020 summer term saw the use of educational technology that was uncomplicated to use—videoconferencing, multimodal production content such as videos, text files, and functions of institutional learning management systems [65]. Our interview data suggests likewise (RQ4), so we can assume that tasks associated with the use of educational technology were neither overly challenging nor require a high level of digital readiness. The application of videoconferencing software, for example, requires higher competences on the part of the organizers, who are usually the lecturers. For most of the other tools mentioned above, it can be assumed that preservice teachers are very familiar with their use [66]. The mentioned learning management system had been used at the university for many years in almost all courses. The most frequently used instant messaging systems (especially WhatsApp) are also used very frequently by preservice teachers in everyday life [67]. The challenges were not mainly rooted in the application of the tools but rather in the orientation in the digital learning environment, as the course structure varied from course to course. In the specific context of emergency remote teaching [68], it can be hypothesized that instructors opted for individually tailored and quick solutions rather than aiming for standardized courses across the department. Therefore, students needed to adapt to different course formats and structures and navigate in diverse learning contexts—which requires a higher level of self-regulated learning. In this context, it is assumed that a quiet learning space is an important prerequisite for self-regulated learning, which was confirmed by our data (RQ3).

Interestingly, preservice teachers' prior performance was only related to time management but not to the other four online self-regulated learning strategies (RQ3). A probable assumption for the lacking correlations is that prior performance, as measured in our study, referred only to preservice teachers' performance in inperson higher education. Hence, prior performance and online self-regulated learning strategies stem from two different contexts, and consequently prior performance related to inperson learning might not be predictive for students' learning behavior in online learning. Gender and age as further potential predictors, see [56], showed nearly no significant effects on online self-regulated learning (RQ3), which, however, might be attributed to the unequal gender distribution in our sample.

Certain limitations to this study need to be mentioned. First, the sample size used for the quantitative analysis is relatively small compared with the total number of preservice teachers that could have been sourced from the respective university. We drew the entire sample from said university, leaving out other institutions. Second, we did not conduct a longitudinal study but elicited our findings from a cross-sectional one. Therefore, including several measurement points or additionally employing process data from learning diaries to depict developments over time would have been enriching and should be included in further research. Third, information and data on participants' performance were only available for prepandemic semesters with traditional, on-site learning courses rather than exclusive online learning, so that statements on performance for the 2020 summer term are only limitedly possible.

5. Conclusions

The results from this study indicate the need to carry out further research including preservice teachers at numerous universities and using longitudinal research designs. In order to reach beyond self-reported digital competences, it also seems appropriate to integrate performance-based designs, as was conducted by Senkbeil and colleagues [69]. In regard to theories and frameworks, research is needed that reconsiders established frameworks in the field of educational technology research, such as TPACK [70], and link it more strongly with self-regulated learning research, for e.g., along the dual task of a teacher to be himself or herself competent in educational technology applications, a self-regulated learner, and equally foster the same within students.

Furthermore, the study shows that there is a need to adapt the current practice of preservice teacher education at the interface of self-regulation and online learning. As a first field of action in preservice teacher education, a clear need emerges to support preservice teachers to engage in self-regulated learning as a prerequisite to model self-regulated learning behavior at schools [71]. Providing trainings has proven to be an effective means [72,73]. Promisingly, it is possible to support preservice teachers with regard to self-regulated learning in online learning environments (e.g., [74]), as preservice teachers in the present study were not found to be overly self-regulated in their online learning. This can also entail fostering understanding in students on how to use digital technology to support their self-regulation for learning purposes [75].

While the present study indicates that preservice teachers perceived themselves to be digitally ready, this might be different when more complex tools are employed (for example, immersive virtual reality (see Billingsley and colleagues [76]))—and if they are asked to use those actively in their teaching.

Secondly, by revisiting preservice teacher education practice, the study also focusses on the role of educators; Tondeur and colleagues [13] showed that it is also preservice teacher educators who act as "gatekeepers" (p. 1194) and can influence how preservice teachers use educational technology in their teaching practice. The authors conclude that professional development is vital for teacher educators in order to strengthen their respective competences and self-efficacy as well. Furthermore, van Eekelen and colleagues [77] documented that educators in higher education are also not necessarily self-regulated learners but rather learn in a spontaneous and unplanned way. Extrapolating the results of their study, it seems worthwhile to also investigate preservice teacher educators in specific as to how they self-regulate their learning—and later follow up on how they foster self-regulated learning in their students as part of a complex environment [78].

Thirdly, integrating opportunities to develop competence in the use and application of educational technology for teaching purposes is a necessary step forward. Admiraal and colleagues [17] argue that

> "This lack of attention to technology in teacher education means that most learning how to teach with technology in secondary education is done during school practice, after student teachers have graduated and entered the profession. More attention to technology in teacher preparation programmes might make this learning process of teachers in school practice more efficient and effective."

Thus, current teaching practices in preservice teacher education need to be examined in order to focus more closely on competences related to the use of educational technology. Drawing on their research among early career teachers in Germany during the first COVID-19-induced lockdown, König and colleagues [79] state "It (the article, the authors) emphasizes the need to foster the development of teacher competence in ICT-related teaching and learning both in initial teacher education and teacher professional development" (p. 619). In light of Tondeur and colleagues [21], it also seems advisable to conceive this as an institutional development process that also entails revisiting structures and resources as they are.

Appendix A

Table A1. Definition and coding rules for qualitative data analyses.

Category	Definition	Coding Rules	Anchor Example
Use of digital media	This category assesses whether or to what extent students are able to work with digital media in their studies. With reference to the scale for Digital Readiness for Academic Engagement [57] two areas of usage are included: (1) Digital tool application and (2) information sharing behavior.	The coded passages need to refer to at least one of the items of the two DRAE subscales "digital tool application" or "information sharing behavior" [57]. Passages that inform about the subjective readiness as well as passages about the actual usage as well as arising problems and chances are coded.	"Up to now, I didn't have a specific question, I would post into an online forum. Of course, during a live lecture or a live course, I asked questions, which came to my mind quite spontaneously, without thinking quite a lot about them" (Student B)
Digital media tools	This category assesses all quotations of digital media tools (for a list of tools see [60]) applied by the students during their studies.	Descriptions of specific tools used for the studies (example tools) are coded. Only descriptions of digital tools [60] are coded, descriptions of hardware as well as opinions and descriptions of nonusage are not coded. Only passages with information about specific tools are coded, descriptions of unspecified tools, such as the Internet, are not coded.	"Yes, well I'm sometimes in learning groups that we conduct via Zoom." (Student A)

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