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Finally Digital Natives? Changes in Media Use among Science Students during the COVID-19 Pandemic

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Abstract: This study examines the development of pre-experiences with digital media at school and in university, creating and entertainment-oriented media use and attitudes towards digital media in the classroom among students in the first three years of study, particularly those enrolled in science courses, in times of the COVID-19 pandemic. Using a questionnaire adapted from Vogelsang et al. scales were calculated and PERMANOVAs, Kruskal-Wallis tests and post-hoc Dunn tests done shedding light on the influence of graduation year and semester of study as well as the difference between the current cohort and a pre-pandemic one. Results revealed significant shifts in digital experiences, particularly among students who were still attending school during the pandemic. Compared to colleagues without school experience during the pandemic, they showed a more frequent use of digital media for communication and collaboration. Moreover, a discernible trend of increasing digital experiences with academic progression at the university level was observed. A semester-by-semester comparison between a pre-pandemic cohort and the current study also showed an increase in the use of digital media at university. However, attitudes towards digital media in teaching exhibited a slight decrease between pre-pandemic and current cohorts. These findings underscore the imperative of integrating digital tools in educational settings to bolster digital literacy and foster effective digital learning experiences, thereby equipping students with the necessary skills to navigate an increasingly digitalized world.

Keywords: digital natives; digital competencies; teacher training; learning science; DiKoLAN; theory of planned behavior; chemistry education; physics education; science education; DPACK

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1. Introduction

Advancing digitalization and ubiquitous access to the Internet require all citizens to have basic skills in dealing with digital media [1,2]. This concerns not only the ability to use digital technologies [1–4], but also media skills in the sense of digital literacy [3–6] and skills in the area of digitality [7,8]. These are needed to enable responsible participation in a society that is constantly changing as a result of the digital transformation [1,2]. Globally networked systems such as the Internet of Things, the widespread and everyday use of sensors and technical assistance systems, automation, and the use of cyber-physical systems, as well as artificial intelligence, big data and machine learning require new skills from future employees (today's students) that go beyond the expectations of previous generations [9–11]. Hence, digital education is essential. Digital literacy creates new or expanded access to information and thus—not only through formal learning in the classroom—to education and culture.

1.1. Evolution of Digital Competencies: From Digital Natives to Pandemic-Induced Changes

The foundations for the lifelong acquisition of digital skills are laid in school education. The strategy "Education in the digital world" of the Standing Conference of the Minis-

ters of Education and Cultural Affairs [12] made media education for pupils an explicit and emphasized educational goal of schools. The basic digital skills of learners based on The European Framework for the Digital Competence of Educators (DigCompEdu) [13] are to be promoted in all subjects (and not in a subject specifically set up for this purpose) [12]. In addition, teachers are ascribed a central role in anchoring digitalization processes in society [14]. Accordingly, all prospective teachers must themselves have suitable digitalization-related skills in order to be able to use digital media for designing their own subject in a didactically sound and subject-specific manner and to contribute to the media education of pupils [15]. Since teachers should have at least the skills they are supposed to promote in their students, the aforementioned competency frameworks must be taken into account.

For a long time, it has been assumed that children growing up with digital technologies and, in particular, access to the Internet, i.e., who are born directly into a digitized world, would acquire all the necessary skills and cultural techniques required for a life in the digital world virtually from birth as so-called *digital natives* [16,17]. However, this assumption has turned out to be wrong and the concept of digital natives has been exposed as a myth [18–20]. Digital technologies are not available to all young people at all times [21], nor do they use digital technologies and the Internet in everyday life to the extent assumed [21,22]. Also, in terms of the teaching-learning process, the hoped-for effectiveness is not apparent [22]. Hence, children do not learn the skills and abilities needed to deal with digital technologies and media simply through their ubiquitous presence. Furthermore, they certainly do not learn digitalization-related skills (in the sense of digital literacy) in the first place [18,21–24].

However, during the COVID-19 pandemic a new situation has evolved. Schools and teaching had to be digitalized within a very short time [25–27] and both teachers and students had to establish new forms of communication, collaboration, presentation [28–30] and, in the natural sciences, implement supplementary requirements such as remote experimentation in teaching situations [31]. It would be legitimate to acknowledge the possibility that the efforts of society as a whole and the digital transformation of schools and teaching, which was very explicitly driven forward then, could have led to a special cohort of first-year university students who have now practically grown into a form of digital natives after all—albeit not by birth, but triggered by the general transformations during the pandemic.

For the future design and orientation of basic science courses, but also of teaching in general, and especially of university teacher training, such a changed starting position would have to be taken into account to equip teacher (students) with the aforementioned 21st century skills.

1.2. Potential Factors Influencing the Use of Digital Tools in Science Teaching

A direct measurement of the competencies required for a scientific course of study and subsequent occupational and research fields would be very costly, time consuming, and would be difficult to administer for a cross-sectional study at the beginning of the course. Following the COACTIV model [32] assessment should include more action-related skills [32,33], as well as affective dispositions which are crucial in addition to cognitive dispositions [34,35], so that latent competencies can actually be applied in concrete problem-solving situations [32,36,37]. In particular, the academic self-concept [38] and self-efficacy expectations [39] can have a significant impact on a person's motivation, commitment, and performance [40,41] and thus can serve as predictors of underlying competencies [32,42].

Students aiming to enter the teaching profession after graduation generally have few opportunities to apply their digital skills in the classroom during their studies. For the evaluation of courses to promote digitalization-related teaching skills, this means that the acquisition of skills cannot be observed directly [35]. It is therefore just as useful to refer to the intention to use digital media later in teaching as it is to analyze the determinants of behavioral intention [35]. One model that describes the influences of affective constructs on behavioral intention is the Theory of Planned Behavior (TPB) [43]. As relevant influencing

factors for behavioral intention, this primarily focuses on attitudes towards the behavior, the subjective norm, and the perceived behavioral control (Figure 1).

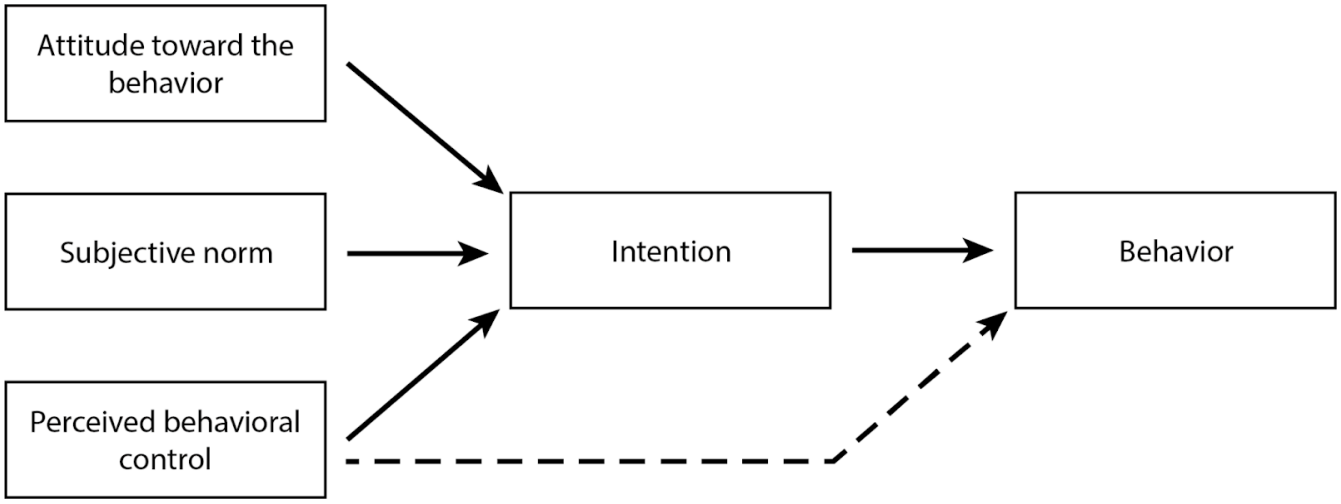

Figure 1. Theory of Planned Behavior, figure adapted from [44].

The TPB can be specifically sharpened to relevant influencing factors on the intention of students to later use digital media themselves in lessons as a learning tool or teaching aid, so that the following constructs are relevant accordingly [35]:

- Attitudes towards learning with digital media,
- Social norm expectations regarding the use of digital media in the classroom,
- Self-efficacy expectations with regard to different forms of media use in science lessons,
- Motivation to use digital media in the classroom, and
- Subjectively perceived constraints on the use of media.

Moreover, four specific aspects were mentioned as factors that influence the self-efficacy expectations with regard to using digital technologies, which are worth considering separately [35]:

- Personal use of digital technologies,
- Previous experience of the students in school,
- Previous experience of digital media use during studies, and
- Beliefs about teaching and learning with digital technologies.

These play an important role in planning courses at university, as the structure and design of courses can specifically influence previous experiences at university. According to [35], these four aspects are described as follows: Personal use of digital technologies (current at the time of the survey) refers to a subjectively perceived frequency of use ("I use digital media to ..."). A distinction is made between leisure or entertainment-oriented forms of use (e.g., social media, watching films) and more creating forms of use (e.g., creating your own website/blog). The learning-related previous experiences for different forms of media use are asked separately for school-related ("During my school days I used ...") and university-related ("During my teacher training course I used ...") experiences. This includes both more interdisciplinary usage scenarios (e.g., creating presentations) and science-specific ones (e.g., smartphone experiments). The beliefs about teaching and learning with digital media in the classroom include convictions about the benefits of integrating digital media for pupils' learning (e.g., through the potential for activation) and for preparing for professional life.

The survey of pre-service teacher students in the study by Vogelsang et al. [35] showed that students had very little learning-related experience with digital tools during their own time at school. However, younger students rated their previous experience higher than older students, which indicated a higher degree of digitization in school. Nevertheless,

student teachers who began their studies between 2012 and 2014 appear to have little prior learning-related experience or media usage habits from their school days. Further, it was shown that prior experience at university increases with the number of semesters completed, as expected [35,45–47]. Additionally, it could be shown that experience gained in university has an effect on self-efficacy expectations and attitudes towards the successful use of media [35,48,49], much stronger than the experiences from school [35]. Experience from school, although rarely reported, could help that fewer difficulties were expected for using digital media in school [35]. Moreover, it is very striking that the majority of the students surveyed stated that they rarely use digital media creatively (e.g., for video editing or when creating websites) [20,35,50,51]. However, all those factors could only explain very little of the variance observed. This may have changed since schools used much more digital tools during the corona pandemic [52].

1.3. Current Study: Aims and Hypotheses

With the study presented here, we contribute to the elucidation of the possibly changing digital pre-experiences of first-year students in science courses. The aim of the study is to find out whether there are changes in students' previous experiences at school or university, creative or entertainment-oriented media use and attitudes towards digital media that make it necessary to adapt study conditions or content. The following hypotheses were investigated. Prior experience in the use of digital media at school is more pronounced, than in times before the pandemic (H1). Significantly higher scores are expected for the area of communication and collaboration than for the other areas in relation to prior experience at school (H2). Previous experience in the use of digital media at the university increases with the number of semesters (H3). In comparison between the two survey periods, there is an increase in the use of digital media at the university from the Vogelsang et al. data set to the current study (H4). In the comparison between the area communication and collaboration and other areas of digital media use at the university, higher scores are achieved for the use of media for collaboration and cooperation than for the other areas (H5). Students in semesters 3 and 5 should have similar scores for communication and collaboration media because they have both completed two semesters under pandemic conditions. However, students in the first semester have only completed one semester under pandemic conditions and should therefore have lower scores (H6). In comparison of the two survey periods, there is an increase of the part that concerns entertainment-oriented media use from the Vogelsang et al. data set to the current study (H7). For the creative media use no significant increase is expected comparing the two survey periods (H8). In comparison between the two survey periods, there is an increase of the scores for attitudes towards digital media in teaching from the Vogelsang et al. data set to the current study (H9).

2. Materials and Methods

2.1. Sample

At the University of Konstanz, 150 students took part in the online survey. Of these, 96 reported studying a subject in the chemical context: 48 chemistry, 39 lifescience and 9 nanoscience. Further, 18 physics students and 43 biology students took part (multiple subjects per student are possible). In addition, the following (in Germany mandatory for pre-service teacher students) second or third subjects were indicated (multiple answers possible): 2 English, 2 German, 1 history, 9 mathematics, 1 philosophy/ethics, 1 political science, 2 sports. 28 were studying a subject leading to a Bachelor of Education (BEd) degree, and 121 were aiming for a Bachelor of Science (BSc) degree.

Their mean study time was 2.63 (1.72) semesters while the median was 3 and the IQR 4. In more detail, the following number of students were found in the first, third and fifth semester of study: 1st Bachelor of Education (BEd) or Bachelor of Science (BSc) (72; 48%), 3rd BEd or BSc (34; 23%), 5th BEd or BSc (44; 29%). Further, seventeen students with college-readiness certificates from 2020 took part.

2.2. Materials

The questionnaire used mainly contained items from the questionnaire of Vogelsang et al. [35]. This questionnaire was developed primarily for the evaluation of a special course program. Accordingly, on the one hand, it includes all applications of digital tools that were addressed as part of the courses offered by the research group. On the other hand, it refers to potential factors influencing the use of digital tools in teaching according to the Theory of Planned Behavior (TPB) as a research heuristic. All items are realized as four-point Likert scales in which only the endpoints are named (for the items on media use and previous experience 1 = never, 4 = very often; for the other constructs: 1 = do not agree at all, 4 = agree completely). The entirety of all items is designed for a survey time of approximate 10 min. The questionnaires cover the following areas:

1. Use of digital media
2. Prior learning-related experience with digital media at school and university
3. Attitudes towards learning with digital media in the classroom
4. Motivational orientation for the use of digital media in the classroom
5. Perceived constraints on the use of digital media
6. Subjective norm expectations regarding the use of digital media
7. Self-efficacy expectations for the use of digital media in (science) lessons

The scales of the questionnaire were formed according to explorative factor analyses and have good to acceptable internal consistencies. Some of the scales correspond to the upper areas, but some of the areas were subdivided again, for example for use of digital media. There are two scales, one for creating media use and one for consuming and entertainment-oriented media use.

In this study, all elements of the first three areas are selected to investigate the impact of the pandemic on teaching and learning of science with the aim of adapting future teaching programs for student teachers and science students to the possibly changed conditions. The items of area two were adopted without changes. In a next step, the items of area two were checked for they coverage of all aspects of teaching and learning with digital media described in the DiKoLAN framework [15]. In particular, no similarities could be found with the area of communication and collaboration, which is why the area was extended by the following 5 self-designed items on the basis of DiKoLAN:

During my time at school/during my studies I . . .

. . . used digital media to collaboratively edit a document (e.g., GoogleDocs, Nextcloud).

. . . used digital media are to share documents (e.g., Moodle, ILIAS, Dropbox, Nextcloud).

. . . used learning platforms to support my learning process (e.g., Moodle, ILIAS, Mahara).

. . . used digital media for asynchronous exchange with schoolteachers/university lecturers (e.g., chats, forums, learning platforms).

. . . used digital media for synchronous exchange in lessons/courses (e.g., video conferencing tools).

Further, the first item of the area 3, attitudes towards learning with digital media, ("Digital media should generally be a strong position in school curricula") was split into two new items to emphasize the difference between learning with digital media and via digital media. Finally, an antagonist to the item "The use of digital media in schools leads to a lowering of the standards of teaching" was added in order to investigate whether students expect a lowering, an increase or no influence.

All items used can be found in the Appendix A in Tables A1–A3.

The scales proposed by Vogelsang et al. and tested by factor analyses were calculated in the evaluation part. The data set from the original publication was kindly made available to us by the authors, so that comparisons between the currently surveyed cohorts and earlier cohorts (before the pandemic) are possible.

2.3. Study Design and Context

An invitation to participate was sent through mailing lists of the university to students in the first three years of study in chemistry ($N = 326$), physics ($N = 173$), and biology

($N = 440$). The approx. 10-min online questionnaire was then provided via soscisurvey (Version 3.2.12, https://www.soscisurvey.de/, accessed on 16 December 2020). Participation was voluntary and no further incentive to participate was offered. Students in the first three years of study were addressed as this provided a sample with experience in school or university contexts of regular and pandemic teaching and learning. Of all students invited, 166 took part. After reviewing the data set, 156 cases remained in which not exclusively demographic questions were answered. Further six datasets were discarded because they were completed by students in higher semesters. This led to the final number of 150 valid data sets. Seventeen students with college-readiness certificates from 2020 were still experiencing school at COVID-19 times. They knew only study conditions in pandemic times, whereas third-semester students had few and fifth-semester students had mostly experiences from regular teaching times. At the University of Konstanz, the introductory lectures are only offered annually, and an academic year includes two semesters, one starting in October and the other in April. This is why only students in odd semesters participated during the survey period in the winter term 2020/2021. The timelines in Figures 2 and 3 show the times at which the study groups (differentiated by *graduation year* or *year of study*) experienced the pandemic-related school and university closures in which phases during their education.

2.4. Statistical Analysis

Statistical analysis was conducted using the R statistical software [53]. Several methods were employed to analyze the data, including scale calculation, PERMANOVA (Permutational Multivariate Analysis of Variance), Kruskal-Wallis tests [54], and post-hoc tests using Dunn's test [55]. The significance level was set at $p < 0.05$ for all analyses.

For descriptive scale statistics mean, standard deviation, median, interquartile range, skewness, kurtosis, and Cronbach's alpha coefficient were computed.

PERMANOVA was used to analyze the multivariate dispersion among groups. The adonis2 function from the vegan package was employed, with Euclidean distance as the dissimilarity measure. Pairwise PERMANOVA tests were conducted for all groups with p-values from the initial PERMANOVA analysis below 0.05. The false discovery rate (FDR) was controlled using the Benjamini-Hochberg adjustment method [56].

Kruskal-Wallis tests were performed to compare the response behavior of multiple groups for each scale. Again, resulting p-values were adjusted using the Benjamini-Hochberg method to control the FDR.

Post-hoc tests using Dunn's test were conducted for scales where the p-value from the Kruskal-Wallis test was less than 0.05. Dunn's test was employed to identify specific group differences while controlling the FDR using the Benjamini-Hochberg adjustment method.

Finally, the effect sizes Vargha and Delaney's A (VDA), Cliff's delta (CD), and the Glass rank biserial correlation coefficient (rg) were calculated between all pairs of groups [57].

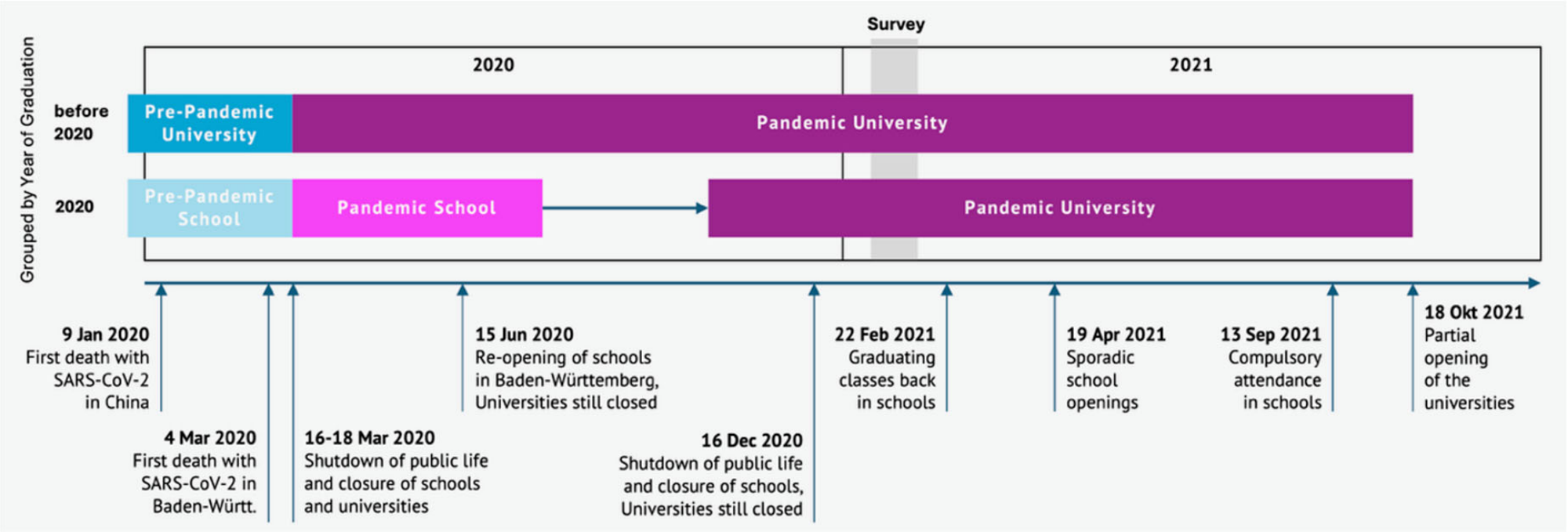

Figure 2. Timeline shows the times at which the study groups differentiated by *graduation year* (graduation in 2020 or before) experienced the pandemic-related school and university closures in which phases during their education.

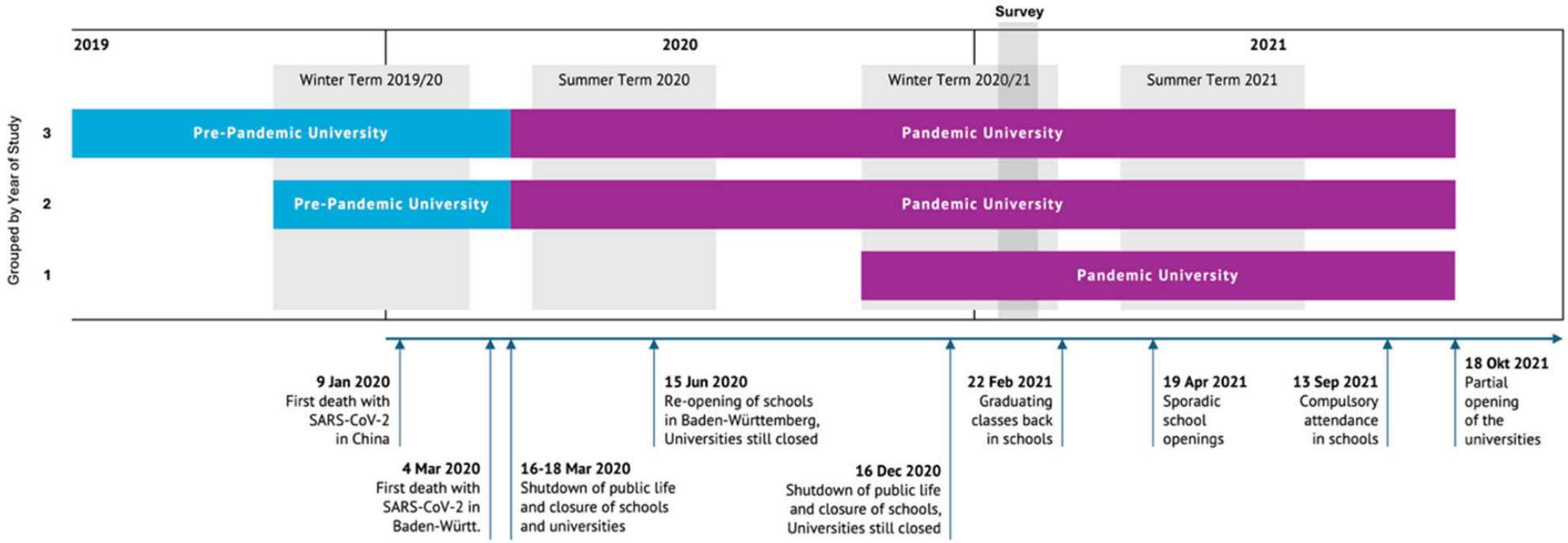

Figure 3. Timeline shows the times at which the study groups differentiated by *year of study* (1 "first", 2 "second" and 3 "third year") experienced the pandemic-related school and university closures in which phases during their education.

3. Results

3.1. Use of Digital Media in School

This section presents the results of the investigation into the differences in the use of digital media within school settings between students who attended school during the COVID-19 pandemic and those having graduated prior to the onset of the pandemic. A PERMANOVA was calculated for this purpose, the results of which can be found in Table 1. For this analysis the year of graduation (DA03) with the two groups "college-readiness certificates in 2020 or before" was chosen as independent variable while the the mean score of the scales *pre-experiences in school* (PES) and *pre-experiences in school communication and collaboration* (PESC) where chosen as dependent variables (see Figure 2 for the relevant events during the pandemic to categorize the sample by graduation year). The results show that the graduation year has a significant ($p < 0.001$) influence on the subset of data with the two subscales of pre-experiences in school.

Table 1. Results of the PERMANOVA for the mean scores of the scales *prior experiences in school* (PES) and *prior experiences in school communication and collaboration* (PESC) as dependent variables and the graduation year (DA03) with the two groups "college-readiness certificates in 2020 or before" of the current study.

	Df	*SumOfSqs*	R^2	*F*	*p*
DA03	1	13.30	0.17	31.12	0.001
Residual	147	62.82	0.83		
Total	148	76.12	1		

Df Degrees of freedom.

Further, Kruskal-Wallis tests were carried out to explore on which scale the two groups college-readiness certified in 2020 or before differ (c.f. Table 2). The results show an influence on both scales *prior experience school* (PES) and *prior experience school communication and collaboration* (PESC). Further, mean and standard deviation were calculated for those scales. It can be seen that the mean value of the PES scale increases from 1.60 (0.29) for students who graduated before 2020 to 1.87 (0.46) for students who graduated in 2020 ($p = 0.002$). There was similarly an increase in the mean value for the Communication and Collaboration scale from 1.39 (0.45) to 2.05 (0.84) ($p < 0.001$). The effect sizes *VDA*, *CD* and *rg* show a medium effect for the PES scale and a large effect for the PESC scale.

Table 2. The results of the Kruskal-Wallis tests and the effect sizes for DA03—Influence of the year of college-readiness certificates, divided in the scales *prior experience school* (PES) and *prior experience school communication collaboration* (PESC).

	Before 2020		2020										
Score	***M***	***SD***	***M***	***SD***	***H***	***Df***	***N***	***p***	η^2	ϵ^2	***VDA***	***CD***	***rg***
PES	1.60	0.29	1.87	0.46	9.39	1	149	0.002	57	63	0.325	−0.350	−0.349
PESC	1.39	0.45	2.05	0.84	23.55	1	149	<0.001	153	159	0.227	−0.546	−0.546

M Median, *SD* Standard deviation, *VDA* Vargha and Delaney's A, *CD* Cliff's delta, *rg* Glass rank biserial coefficient.

In summary, it can be said that the year of graduation has a major influence on the mean value of the *prior experience school* (PES) and *prior experience school communication and collaboration* (PESC) scales (c.f. Figure 4).

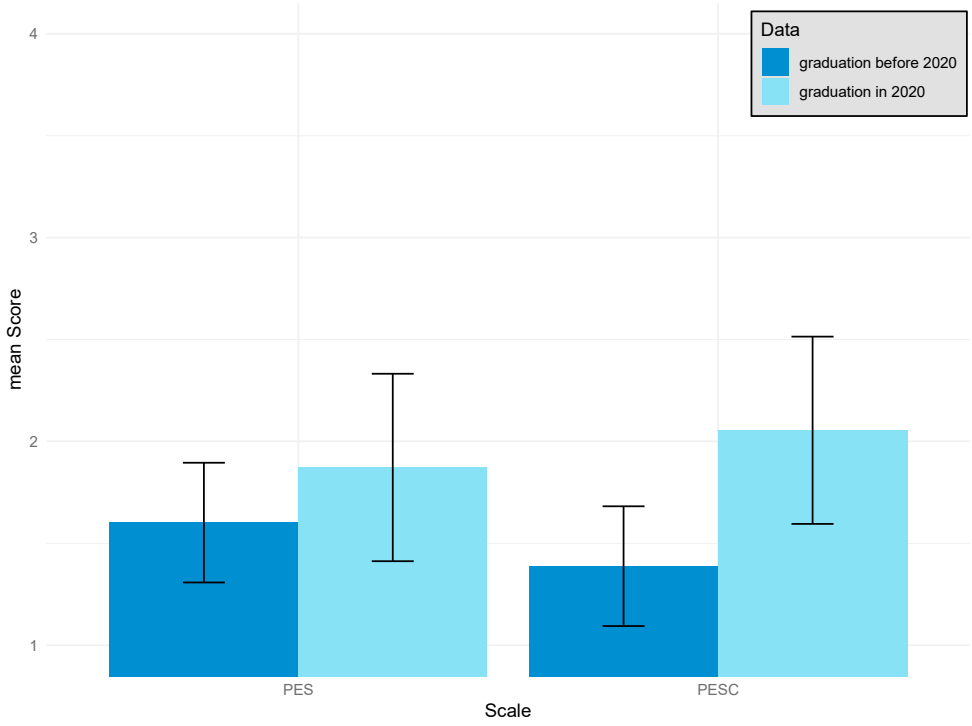

Figure 4. Mean scores and standard deviations for pre-experiences school (PES) and pre-experiences school communication and collaboration (PESC) by the year of graduation.

In addition, results from the pre-pandemic study by Vogelsang et al. and the current study are available for the PES scale. In order to investigate whether this increase is due to a general digital transition in schools or to the pandemic conditions, three subgroups are examined in more detail. Group one includes all data sets from the pre-pandemic study. In group two can be found all data sets from the current study for which college graduation was before 2020. The third group is defined by students with college-readiness certificates from 2020. For the analysis a further PERMANOVA was calculated (c.f. Table 3). It was expected that there would be an influence ($p < 0.003$) as previously shown for two of the groups mentioned above (c.f. Table 2).

Table 3. Results of the PERMANOVA for the mean scores of the scales *prior experiences in school* (PES) as dependent variable and three disjunct groups in DA03 "pre-pandemic study", "college-readiness certificates before 2020" and "college-readiness certificates in 2020" of the current study.

	Df	*SumOfSqs*	R^2	*F*	*p*
DA03	1	1.37	0.03	10.85	0.003
Residual	387	48.87	0.97		
Total	388	50.24	1		

Df Degrees of freedom.

As the dependent variables consist of only one scale, the Kruskal-Wallis test does not provide any new findings and the results are not reported here. A Dunn pairwise post-hoc comparison was conducted to further investigate which factor combinations cause the difference in the PES scale. The results are shown in Table 4. The results show significant *p*-values, adjusted using the Benjamini-Hochberg method, for all factor combinations except for the group of students in the pre-pandemic study and the group of students who graduated from school before 2020 in the current study. While the mean values of the two groups "pre-pandemic" of the Vogelsang dataset and "before 2020" of this study are 1.59 (0.36) and 1.60 (0.29) and do not vary significantly, they each differ significantly from the mean value of 1.87 (0.46) of the "2020" group of this study. A look at the effect sizes

reveals medium effects for the differences between the pre-pandemic study and an earlier school-leaving examination year and those who graduated in 2020 (cf. Table 4).

Table 4. Results of the Dunn's test and the effect sizes for the mean scores of the scale *prior experiences in school* (PES) as dependent variable and combinations of the three disjunct groups in DA03 "pre-pandemic study", "college-readiness certificates before 2020" and "college-readiness certificates in 2020" of the current study.

Comparison	Group 1		Group 2								
	M	*SD*	*M*	*SD*	X^2	*Z*	*p*	p_{adj}	*VDA*	*CD*	*rg*
Pre-pandemic vs. before 2020	1.59	0.36	1.60	0.29	13.59	−0.96	0.1687	0.1687			
Pre-pandemic vs. 2020	1.59	0.36	1.87	0.46	13.59	−3.68	<0.001	<0.001	0.307	−0.386	−0.385
Before 2020 vs. 2020	1.60	0.29	1.87	0.46	13.59	−2.91	0.0018	0.0027	0.325	−0.350	−0.349

M Median, *SD* Standard deviation, *VDA* Vargha and Delaney's A, *CD* Cliff's delta, *rg* Glass rank biserial coefficient.

In summary, it can be said that the previous school experience of those graduating before 2020 is at the same level in the current study and in the study before the pandemic. Furthermore, the mean value of the PES scale for students with graduation year 2020 is significantly different from the others (c.f. Figure 5).

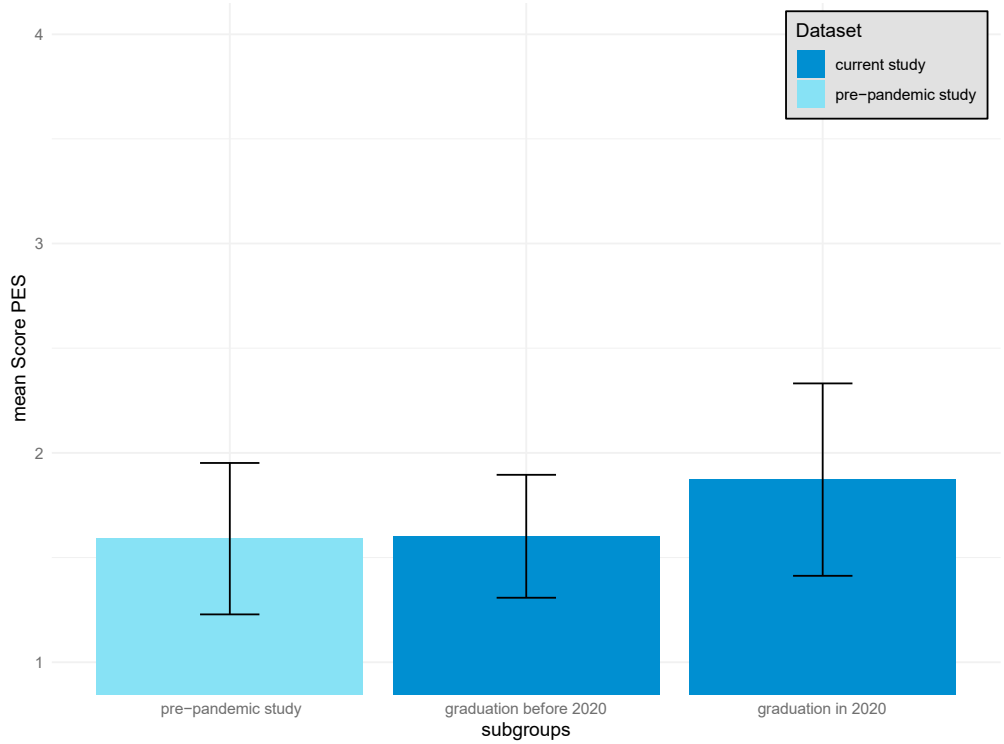

Figure 5. Mean scores and standard deviations for pre-experiences school (PES) between current and pre-pandemic study by number of academic semesters.

3.2. Use of Digital Media at the University

This section breaks down the results of the study on the differences in the use of digital media in the university environment in the pre-experience university (PEU) scale between the current and the pre-pandemic study and by academic semester. Because it is expected that prior experience with digital media increases with the number of semesters completed, the two data sets are compared taking into account the number of semesters (see Figure 3 for the relevant events during the pandemic to categorize the sample by year of study/number of semesters). A PERMANOVA was conducted for this purpose. The resultant insights are tabulated in Table 5. The independent variables examined were the

semester of study ("1", "3" and "5") and the dataset ("current study" or "pre-pandemic study"). The dependent variable was the mean scores of the PEU scale. The results show a significant ($p < 0.001$) influence of both independent variables on the PES scale (c.f. Table 5).

Table 5. Results of the PERMANOVA for the mean scores of the scales *prior experiences in university* (PEU) as dependent variable and the semester number (DA02) with the three groups "first", "third" and "fifth" and the dataset belonging ("current study" or "pre-pandemic study") as independent variable.

	Df	*SumOfSqs*	R^2	*F*	*p*
DA02	1	7.58	0.17	67.79	0.001
DS_ID	1	2.75	0.06	24.57	0.001
Residual	305	34.10	0.77		
Total	307	44.43	1		

Df Degrees of freedom.

Further, two Kruskal-Wallis tests were carried out for the number of semesters (DA02) and the dataset (DS_ID). As the dependent variables consist of only one scale, the Kruskal-Wallis test does not provide any new findings.

In addition, mean and standard deviation were calculated for PEU scale depending on DA02 or DS_ID. It can be seen that the mean value of the PEU scale rises from 1.65 (0.31) for students at the end of the first semester to 1.87 (0.35) at the end of the third semester and to 2.03 (0.37) after the fifth semester. Furthermore, the mean score of the PEU scale increases from 1.79 (0.37) in the pre-pandemic study to 1.91 (0.39) in the current study.

A Dunn pairwise post-hoc comparison was conducted to further investigate which factor combinations of the semester numbers cause the difference in the PEU scale. The results are shown in Table 6, with significant *p*-values for all factor combinations. It can be seen that the effect is small between the third and fifth semester, medium between the first and third and large between the first and fifth. Furthermore, the difference between the current study and the pre-pandemic study is a small effect.

Table 6. Results of the Dunn's test and the effect sizes for the mean scores of the scales *prior experiences in university* (PEU) as dependent variable and combinations of the three semester numbers (DA02) "first", "third" and "fifth" and effect sizes for the independent variable dataset belonging (DS-ID, "current study" or "pre-pandemic study".

	Group 1		Group 2								
Comparison	*M*	*SD*	*M*	*SD*	X^2	*Z*	*p*	p_{adj}	*VDA*	*CD*	*rg*
First vs. third semester	1.65	0.31	1.87	0.35	56.24	−4.24	<0.001	<0.001	0.316	−0.368	−0.369
First vs. fifth semester	1.65	0.31	2.03	0.37	56.24	−7.48	<0.001	<0.001	0.211	−0.578	−0.578
Third vs. fifth semester	1.87	0.35	2.03	0.37	56.24	−2.98	0.0014	0.0014	0.373	−0.254	−0.255
pre-pandemic vs. current study	1.79	0.37	1.91	0.39					0.424	−0.152	−0.153

M Median, *SD* Standard deviation, *VDA* Vargha and Delaney's A, *CD* Cliff's delta, *rg* Glass rank biserial coefficient.

The results of the investigation into the differences in the use of digital media within university settings between the two scales *prior experience university* (PEU) and *prior experience university communication and collaboration* (PEUC) is presented in the following. Because it is expected that prior experience also here increases with the number of semesters completed, the two scales are compared taking into account the number of semesters. (see Figure 3 for the relevant events during the pandemic to categorize the sample by year of study/number of semesters) A PERMANOVA was conducted for this purpose. The resultant insights are tabulated in Table 7. The independent variable scrutinized was the number of semesters completed (DA02), categorized into three groups: "first semester", "third semester", and "fifth semester". Meanwhile, the dependent variables were the average scores of the PEU and PEUC scales. The findings underscore a significant ($p < 0.001$)

impact of the number of semesters completed on the subset of data encompassing the two subscales of university pre-experiences.

Summing up, it can be noted that there is a significant difference on the scale of previous university experience both between the individual semesters and between the current and the pre-pandemic study (c.f. Figure 6).

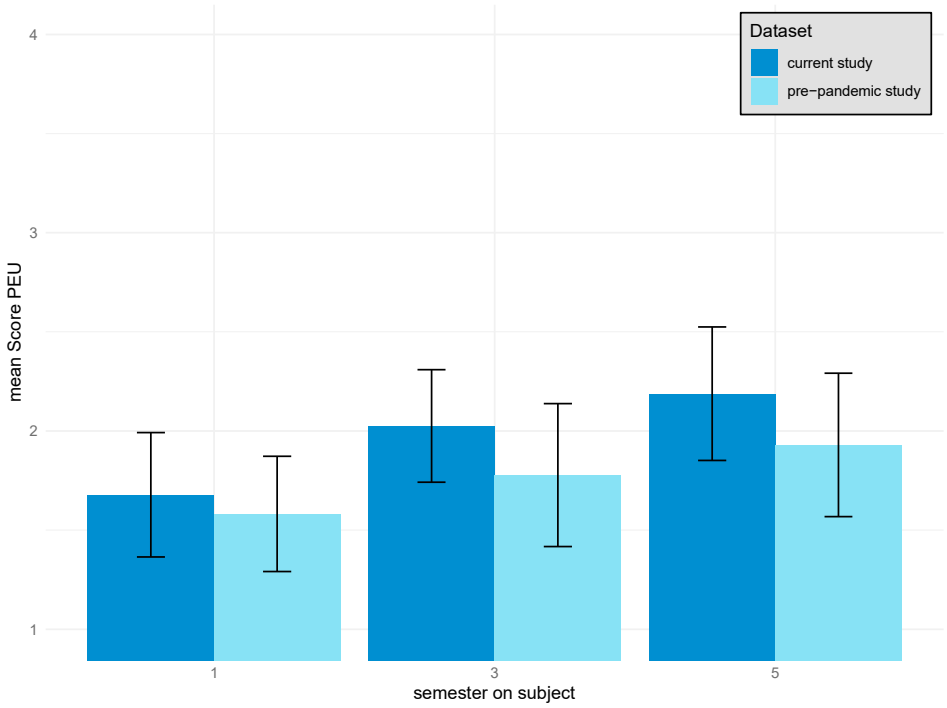

Figure 6. Mean scores and standard deviations for pre-experiences in university (PEU) between current and pre-pandemic study by academic semesters.

Table 7. Results of the PERMANOVA for the mean scores of the scales *prior experiences in university* (PEU) and *prior experiences in university communication and collaboration* (PEUC) as dependent variables and the semester number (DA02) with the three groups "first", "third" and "fifth" as independent variable.

	Df	*SumOfSqs*	R^2	*F*	*p*
DA02	1	8.16	0.12	19.36	0.001
Residual	148	62.41	0.88		
Total	149	70.57	1		

Df Degrees of freedom.

Further, Kruskal-Wallis tests were carried out to explore on which scale the three groups of semester number differ (c.f. Table 8). The results show an influence on the PEU scale ($p < 0.001$), but not on the PEUC scale. Further, mean and standard deviation were calculated for PEU scale. It can be seen that the mean value of the PEU scale rises from 1.68 (0.31) for students at the end of the first semester to 2.03 (0.28) at the end of the third semester and to 2.19 (0.34) after the fifth semester.

A Dunn pairwise post-hoc comparison was conducted to further investigate which factor combinations cause the difference in the PEU scale. The results are shown in Table 9, displaying significant *p*-values for all factor combinations with the first semester students. However, there is no significant difference between students in their third and fifth semester. Looking at Vargha and Delaney's A (*VDA*), Cliff's delta (*CD*), and the Glass rank biserial correlation coefficient (*rg*), a large effect for the difference between first-year students and

students from all other semesters and a small effect for the difference between students from the third and fifth semesters can be observed.

Table 8. The results of the Kruskal-Wallis tests for DA02—Influence of the number of semesters absolved, divided in the scales *prior experience university* (PEU) and *prior experience university communication collaboration* (PEUC).

	First Semester		Third Semester		Fifth Semester							
Score	***M***	***SD***	***M***	***SD***	***M***	***SD***	***H***	***Df***	***N***	***p***	η^2	ϵ^2
PEU	1.68	0.31	2.03	0.28	2.19	0.34	55.09	2	150	<0.001	0.361	0.370
PEUC							4.46	2	150	0.11	0.017	0.030

M Median, *SD* Standard deviation.

Table 9. Results of the Dunn's test for the mean scores of the scales *pre-experiences in university* (PEU) as dependent variable and combinations of the three semester numbers (DA02) "first", "third" and "fifth".

	Group 1		Group 2								
Comparison	***M***	***SD***	***M***	***SD***	X^2	***Z***	***p***	p_{adj}	***VDA***	***CD***	***rg***
First vs. third semester	1.68	0.31	2.03	0.28	55.09	−4.73	<0.001	<0.001	0.193	−0.614	−0.614
First vs. fifth semester	1.68	0.31	2.19	0.34	55.09	−7.01	<0.001	<0.001	0.130	−0.740	−0.741
Third vs. fifth semester	2.03	0.28	2.19	0.34	55.09	−1.56	0.059	0.059	0.360	−0.280	−0.280

M Median, *SD* Standard deviation, *VDA* Vargha and Delaney's A, *CD* Cliff's delta, *rg* Glass rank biserial coefficient.

Summarizing, it can be seen that the PEU scale is dependent on the semester of study and that the differences between the first and third or fifth are particularly significant. However, the semester of study has no significant influence on the PEUC scale. The overall scale values for the PEU scale are in the lower range (mean: around 2) for the mean values of the scale broken down by semester, whereas they are in the upper range (around 3) for the PEUC scale (c.f Figure 7).

3.3. Entertainment-Oriented and Creating Media Use

This section presents the results of the investigation of the differences in entertainment-oriented and creating media use between the current and the pre-pandemic study. A further PERMANOVA was calculated for this purpose. The results can be found in Table 10. The independent variable was the data set with the two groups "current study" and "pre-pandemic study" and the dependent variables were the mean score of the scales *entertainment-oriented media use* (MUE) and *creating media use* (MUC). The results show no significant difference between the current and the pre-pandemic study.

Table 10. Results of the PERMANOVA for the mean scores of the scales *entertainment-oriented media use* (MUE) and *creating media use* (MUC) as dependent variables and the data sets (DS_ID) with the two groups "current study" "pre-pandemic study".

	Df	***SumOfSqs***	R^2	***F***	***p***
DS_ID	1	0.54	0.004	1.41	0.229
Residual	388	149.76	0.996		
Total	389	150.30	1		

Df Degrees of freedom.

In summary, there is a major difference between the entertainment-oriented and creating media use scale for both data sets which can be seen in Figure 8. However, the affiliation to a specific data set does not play a role here.

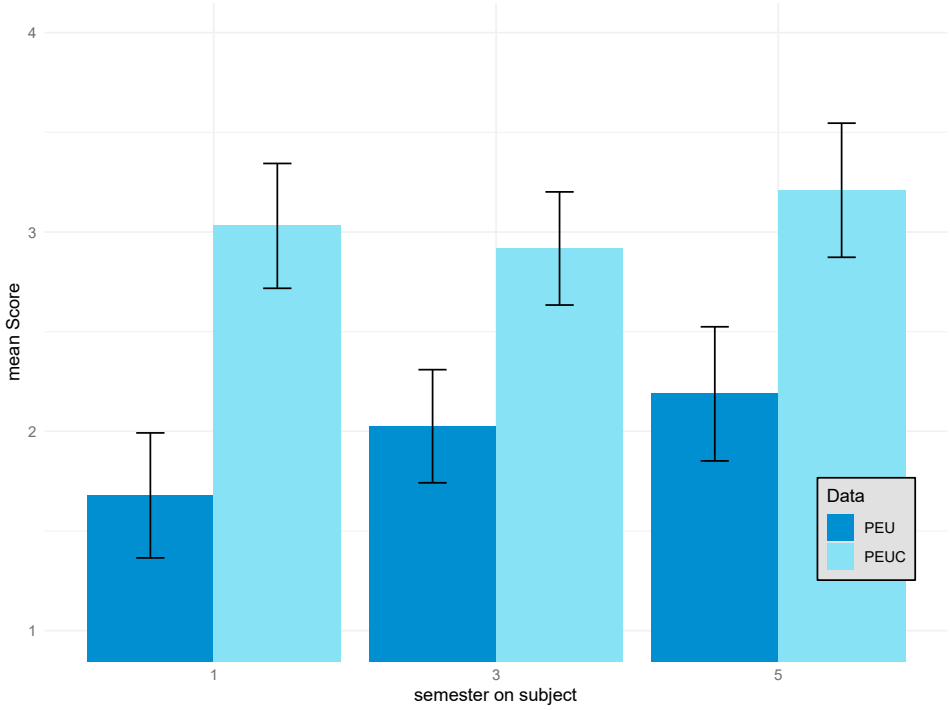

Figure 7. Mean scores and standard deviations for pre-experiences university (PEU) and pre-experiences university communication and collaboration (PEUC) by academic semesters.

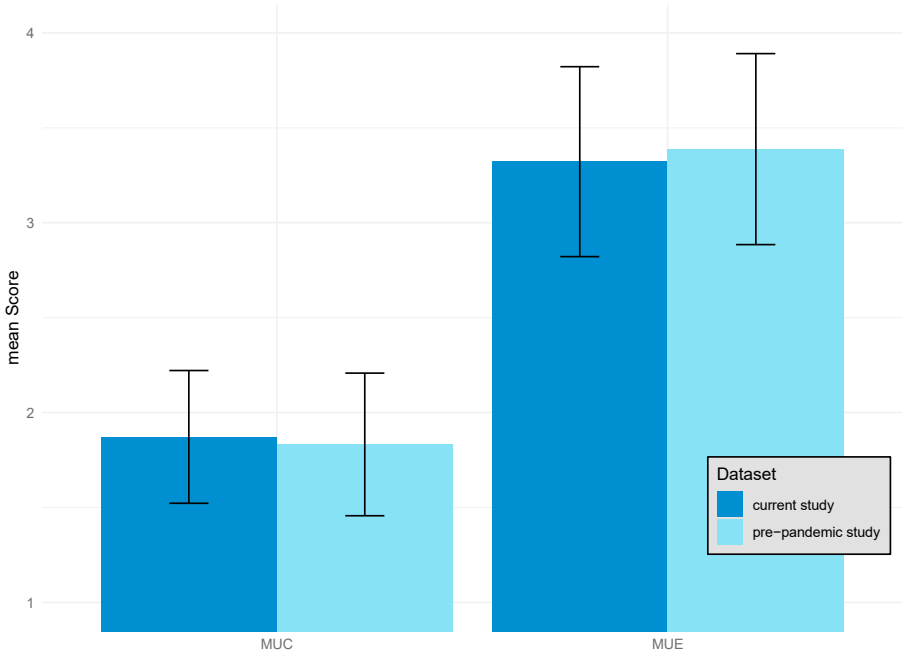

Figure 8. Mean scores and standard deviations for *entertainment-oriented media use* (MUE) and *creating media use* (MUC) between the current and the pre-pandemic study.

3.4. Attitudes towards Digital Media in Teaching

In this section, the findings from comparing attitudes towards digital media in teaching between the datasets of the current study and a pre-pandemic study were presented. To accomplish this, a PERMANOVA analysis was conducted. Details of the analysis are provided in Table 11. The independent variables included the dataset categories "current study" and "pre-pandemic study", as well as the number of semesters completed ("1", "3", and "5") (see Figure 2 for the relevant events during the pandemic to categorize the

sample by graduation year). The dependent variables were the mean scores on the media in teaching (MT) scale. The results indicate that there is no significant difference observed in attitudes based on the number of semesters completed.

Table 11. Results of the PERMANOVA for the mean scores of the scales *media in teaching* (MT) as dependent variables and the data set (DS_ID) with the two groups "current study" and "pre-pandemic study" and the number of semesters absolved ("1", "3" and "5", DA02).

	Df	*SumOfSqs*	R^2	*F*	*p*
DS-ID	1	1.69	0.01	5.50	0.016
DA02	1	0.15	0	0.49	0.468
Residual	387	118.56	0.98		
Total	389	120.40	1		

Df Degrees of freedom.

For the two data sets, however, we find that the mean score of MT differs significantly, but slightly from 2.71 (0.58) in the current study to 2.84 (0.53) in the pre-pandemic study ($p < 0.05$). Summarizing, it can be seen that there is an influence of the data set on the mean of the scale MT (c.f. Figure 9). The effect between the data sets is a small effect with a Vargha and Delaney's A of 0.439 and Cliff's delta and Glass rank coefficient of −0.122.

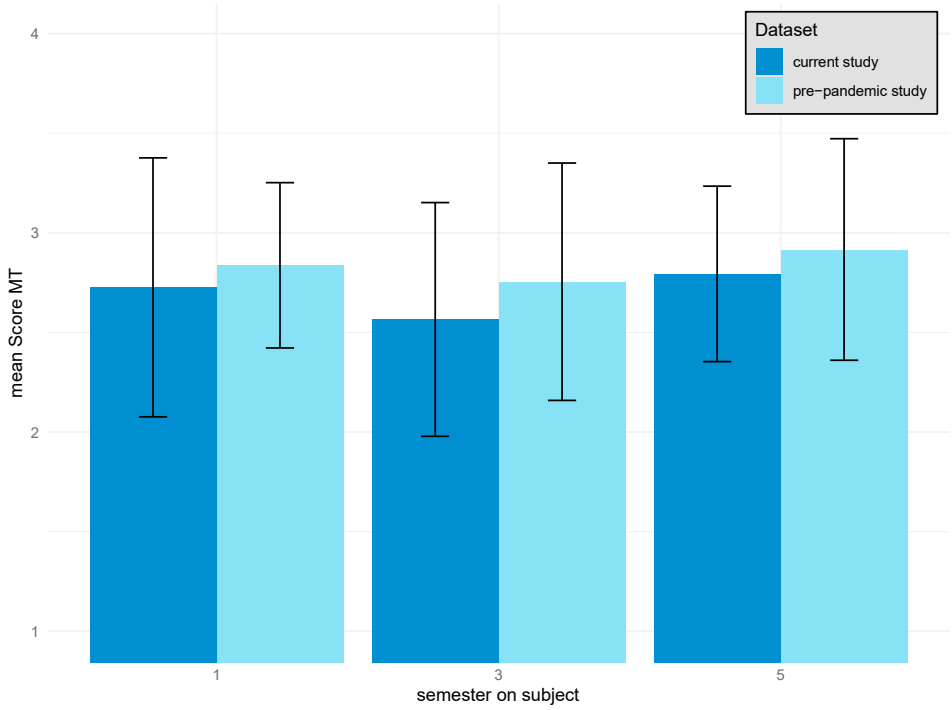

Figure 9. Mean scores and standard deviation for *media in teaching* (MT) between the current and the pre-pandemic study by academic year.

3.5. Scales and Scale Values of the Two Data Sets

Summation scales are formed to match the current sample with the sample from the pre-pandemic study data set. The results of the scale statistics for both data sets are presented in Table 12. In order to obtain a comparable sample, only the students from the first 3 years of study were selected from the second data set. The scales MUC, MUE, PES, PEU, and MT were formed analogously to the scale formation in the data set [35]. Whereas the scales PESC, PEUC and MTN result from the self-designed items. Similar consistency values were achieved, only the scale MUC stands out with a significantly lower Cronbach's alpha of 0.4 to 0.58.

Table 12. Results of building scales. The first line for each scale shows the results for the data set of the current study. The second line in italics shows the results for the data set of the pre-pandemic study (if possible).

Scale Name	Abbreviation	Number of Items	Source	Anchor Item	*N*	*M*	*SD*	*Mdn*	*IQR*	*β*	*κ*	*α*
Creating Media Use	MUC	7	Vogelsang	"I use digital media to design a website or blog".	150 *238*	1.87 *1.84*	1.1 *0.97*	1 *2*	2 *1*	0.87 *0.86*	−0.71 *−0.39*	0.4 *0.58*
Entertainment-oriented Media Use	MUE	4	Vogelsang	"I use digital media to have access to social networks or messenger services (e.g., Facebook, Whatsapp. . .)".	150 *239*	3.32 *3.39*	0.81 *0.81*	4 *4*	1 *1*	−0.93 *−1.2*	−0.03 *0.7*	0.57 *0.55*
Prior Experience School	PES	14	Vogelsang	"During my time at school I used the smartphone to carry out experiments".	148 *240*	1.66 *1.59*	0.97 *0.91*	1 *1*	1 *1*	1.24 *1.36*	0.27 *0.7*	0.71 *0.77*
Prior Experience School Communication Collaboration	PESC	5	newly developed	"During my time at school I used digital media to collaboratively edit a document (e.g., GoogleDocs, Nextcloud)".	148	1.54	0.88	1	1	1.6	1.58	0.77
Prior Experience University	PEU	14	Vogelsang	"During my studies I used the smartphone to carry out experiments".	148 *239*	1.91 *1.79*	1.12 *1.02*	1 *1*	2 *2*	0.78 *0.95*	−0.91 *−0.43*	0.71 *0.76*
Prior Experience University Communication Collaboration	PEUC	5	newly developed	"During my studies I used digital media to collaboratively edit a document (e.g., GoogleDocs, Nextcloud)".	148	3.05	1.03	3	2	−0.72	−0.74	0.63
Media In Teaching	MT	7	Vogelsang	"Pupils can be motivated easier to learn through the use of digital media".	146 239	2.71 2.84	0.89 0.8	3 3	1 1	−0.27 −0.29	−0.65 −0.38	0.81 0.81
Media In Teaching New	MTN	3	newly developed	"Learning with digital media should generally be given a strong position in school curricula".	147	2.8	0.89	3	1	−0.27	−0.68	0.73

N—Total observations, M—Mean, SD—Standard Deviation, Mdn—Median, IQR—Interquartile Range, β Skewness, κ Kurtosis, α Cronbach's alpha.

4. Discussion

In the following, the results for the areas use of digital media in school, use of digital media at the university, entertainment-oriented and creating media use and attitudes towards digital media in teaching are discussed. Limitations and implications for further research and teacher training are highlighted at the end.

4.1. Use of Digital Media in School

It has been shown that, in addition to the *pre-experiences in school communication and collaboration* (PESC) scale, there are differences between the students who attended school during the COVID-19 pandemic and those having graduated prior to the onset of the pandemic in the *pre-experiences in school* (PES) scale, too. The mean value of students with college-readiness certificates from 2020 is always higher than the value of the others. A medium effect was found for the PES and a large effect for the PESC scale. The hypotheses H1 and H2 could therefore not be contradicted. The increase is in line with findings in other studies [27,52,58]. Further, it was shown that the pre-experiences in school (PES) of those graduating before 2020 is at the same level in the current study and in the study before the pandemic and the mean value of the PES scale for students with graduation year 2020 is significantly higher than the other two (c.f. Figure 4). Therefore, the differences in the PES scale can be traced back directly to the time of the COVID-19 pandemic. Despite this, the values are still at a low level with a mean value of less than 2 (1 = never, 4 = very often) as they were before the pandemic [18,21–24]. König et al. [27] obtained similar results, stating that belonging to the generation of digital natives is no guarantee that they have generally developed sophisticated digital skills. So, the efforts in the training and further education of teachers not yet seem to have the desired effect here, with the result that the changes from infrequent use of digital media at school to frequent use are increasing. Adov and Mäeots have shown that there are different types of teachers with different levels of willingness to use technology, change in technology use from pre-COVID to distanced learning, and variety in the use of technology [59]. According to the Technology Acceptance Model (TAM), the use of a technology depends on the intention to use it, which in turn is determined by the subjectively perceived user-friendliness and the perceived benefits of a technology [60,61]. This is why an adaptive further training concept that is adapted to the previous experience of the teachers is still of importance as Schwabl and Vogelsang demand for preservice teachers [62].

4.2. Use of Digital Media at the University

An increase of the prior experiences at university with the number of semesters with a small effect between the third and fifth semester, a medium effect between the first and third semester and a large effect between the first and fifth semester as well as an increase from the pre-pandemic study to the current study was observed. The hypotheses H3 and H4 can therefore be confirmed. Similarly, other studies have shown that during the COVID-19 pandemic in early 2020, the development of ICT skills among student teachers was indeed at least partially driven forward [62–64]. The extent to which students' increased use of digital media can be sustainably consolidated and, at best, transferred to their own lesson design at a later stage remains open at this point [65]. Nevertheless, the metrics remain relatively low, as it was the case with the previous experience from school with an average score falling below 2 on the scale (where 1 indicates "never" and 4 denotes "very often"). This is in line with from the findings reported in other studies where university lecturers were surveyed and an ongoing need for training in digitally supported teaching was identified [25,58]. Another reason for the small increase could be the continuing need to adapt the technical infrastructure to the new ways of learning (e.g., access to the internet or suitable hardware) [59]. This highlights the need for the university administration to improve the existing infrastructure so that the prerequisites for the didactically sound use of digital media are in place.

In the comparison between the two subscales prior experiences in university and prior experience in university with collaboration and cooperation media there were higher scores for the collaboration and cooperation media than for the other areas. The overall scale values for the *prior experiences in university* (PEU) scale are in the lower range (mean: around 2) for the mean values of the scale broken down by semester, whereas they are in the upper range (around 3) for the *prior experience university communication collaboration* (PEUC) scale. This reflects the findings of Baker et al. and Beardsley et al. [28,29], who found that new ways of communicating and collaborating had to be found and promoted. It was demonstrated that for the *prior experiences in university* (PEU) scale the differences between the first and third or fifth semester are particularly significant. However, the semester has no significant influence on the *prior experience university communication collaboration* (PEUC) scale. Hypothesis H5 can therefore be supported, but hypothesis H6 could not be validated. Here, the increase in new learning opportunities in another online semester was probably overestimated for the communication and collaboration items or alternatively a ceiling effect occurred.

4.3. Entertainment-Oriented and Creating Media Use

There was no significant increase of the scores from the pre-pandemic study to the current study for the entertainment-oriented media use (MUE) scales, contrary to the initial assumption (H7). In contrast, other studies have shown an increase in media consumption [66,67]. There may be a ceiling effect at this point, as the students already achieved a mean score of 3.39 in the study before the pandemic (1 "never"–4 "very often") with a median of 4 in both surveys.

Further, it could be confirmed that the scores for the creating scale (MUC) remained at the same level (H8), which is in line with [52]. Furthermore, there is a major difference between the media use entertainment-oriented and the creating scale for both data sets, as Vogelsang et al. have previously shown [35].The differences between the entertainment-oriented and the creating scale are consistent with the findings of Pozo et al. that teachers more often used reproductive than constructive activities and therefore the requirements for student-centered teaching cannot be achieved [52]. Educators should be empowered to integrate digital media into their lessons in order to enable students to use them creatively.

4.4. Attitudes towards Digital Media in Teaching

For the two data sets, the mean score of the scale *media in teaching* differs significantly, but slightly between the two survey periods. The mean value for the current study is lower than for the pre-pandemic study, contrary to the hypothesized higher values for the current study (H9). A deterioration in attitudes to the following items between two points in time in different groups could indicate several possible causes: insufficient training or support for teachers and learners to integrate digital media [29,59,68], technical problems or challenges that hinder smooth implementation [59,68], lack of pedagogical integration of media [68], and negative experiences or expectations regarding their effectiveness in the learning process [68]. Vogelsang and colleagues also found a slightly significant deterioration with a small effect for the development of attitudes during the course of a school internship semester while schools were closed. They attribute this to a possible adjustment of attitudes to real-life conditions in the school context, in the sense that rather naïve positive attitudes are somewhat disappointed at the beginning and possibly changed to more realistic attitudes at the end [69]. Identifying and investigating these causes is crucial for the development of appropriate measures to improve the acceptance and effectiveness of digital media in educational contexts. The findings of [48] indicate that students wish for increased presence of role models and deeper incorporation of digital technologies in their didactic subject courses. Additionally, they expressed, among other aspects, a need for supplementary courses centered around technology, in which the process of creating is discussed from a didactic perspective (e.g., a didactically sound integration). Institutions might address these issues by an enhanced training of educators, revising their curricula

and the improvement of digital infrastructure. Initial laboratory or seminar designs already exist that appear useful for this purpose and could possibly be easily adopted by other faculties [70–74].

4.5. Limitations

When comparing the current study and the pre-pandemic study by Vogelsang et al., differences in the scale scores may also have been caused by other influences in addition to the pandemic, such as the boost in the purchase of digital media through the German government's "digital pact" [75] or general rethinking at school or university. Attempts were made to rule out these influences as much as possible. For the PES scale e.g., no difference was found between the current study and the pre-pandemic study except for those who experienced school during pandemic times. The changes could therefore be attributed to the pandemic time.

Further, data from our study were collected at a single university in Germany in the field of natural sciences. A representative sample for these subjects and the region is assumed because the catchment area of the university is local. Bearing this in mind, one should be careful with generalizations to other regions or subjects.

In addition, the use of digital media is constantly changing due to a constant shift in technological possibilities. The study presented here shows a cross-section of a specific point in time and only compares this with a survey before the pandemic.

4.6. Implication for Further Research

The field of digital media is still very much in flux, with newer technologies emerging and old ones being replaced or simply no longer necessary. Continuous, ongoing surveys are therefore necessary to keep abreast of the current state of prior experience and media use.

In addition, longitudinal studies would be relevant to track the development of digital media use and student attitudes over several semesters. This would provide deeper insights into the long-term effects of digitalization efforts and the sustainability of changes observed during the COVID-19 pandemic.

Further, qualitative research can complement quantitative findings to explore the underlying factors that influence students' digital experiences and attitudes. Qualitative methods such as interviews or focus groups can uncover nuanced perspectives and shed light on contextual factors that shape digital skills.

4.7. Implications for Teacher Education

A necessary step should be to develop appropriate training programs for teachers and evaluate the effectiveness of specific teacher training measures aimed at improving digital literacy and integrating digital media into classroom practice. This would examine the outcomes of tailored training programs in relation to teachers' digital skills and their ability to promote students' digital literacy.

Exploring innovative strategies for technology integration in education and evaluating their impact on students' digital competencies and learning outcomes could provide insights into the effectiveness of blended learning approaches, flipped classroom models or immersive technologies such as AR and VR in improving digital competencies among teachers and students.

5. Conclusions

The study underscores the impact of increased media use during COVID-19 pandemic on shaping digital pre-experiences and attitudes among university students. While there has been an evident increase in digital experiences, particularly in communication and collaboration, challenges persist in facilitating positive attitudes towards digital media in teaching. These findings emphasize the ongoing need for tailored interventions and comprehensive support systems to enhance digital literacy and optimize digital learning

environments. By addressing these challenges and leveraging emerging opportunities, educational institutions can better prepare students to thrive in an increasingly digitalized world.

6. Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used DeepL (www.deepl.com, accessed on 30 March 2024) and Grammarly (www.grammarly.com, accessed on 30 March 2024) in order to improve the readability and language of single sentences. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Author Contributions: Conceptualization, A.H., J.H., L.-J.T. and P.M.; methodology, A.H., J.H., L.-J.T. and P.M.; validation, A.H., J.H., L.-J.T. and P.M.; formal analysis, A.H. and L.-J.T.; investigation, A.H.; data curation, A.H.; writing—original draft preparation, A.H., L.-J.T. and P.M.; writing—review and editing, A.H., J.H., L.-J.T. and P.M.; visualization, A.H. and L.-J.T.; supervision, J.H., L.-J.T. and P.M.; project administration, J.H.; funding acquisition, J.H. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: All participants were students at the University of Konstanz. They took part voluntarily and with informed consent. Pseudonymization of the participants was ensured during the study. Due to all these measures in the conduct of the study, an audit by an ethics committee was waived.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data collected as part of this study are available on request from the corresponding author.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Questionnaire

Table A1. Items that describe media use.

Item ID	Ich Nutze Digitale Medien. . . (German)	I Use Digital Media . . .
MN01 †	. . . um Informationen zu bestimmten Themen zu suchen.	. . . to search for information on specific topics.
MN02 †	. . . um (online und/oder offline) Spiele zu spielen.	. . . to play games (online and/or offline).
MN03 †	. . . um Texte oder Präsentationen zu erstellen.	. . . to create texts or presentations.
MN04 †	. . . um mit Freunden und Bekannten zu kommunizieren.	. . . to communicate with friends and acquaintances.
MN05 †	. . . um im Studium Aufgaben mit Hilfe von Programmen (z.B. Excel. . .) zu erledigen.	. . . to do tasks in my studies with the help of software (e.g., Excel. . .).
MN06 †	. . . damit ich Zugang zu sozialen Netzwerken oder Messenger-Diensten erhalte (z.B. Facebook, Whatsapp. . .).	. . . to have access to social networks or messenger services (e.g., Facebook, Whatsapp. . .).
MN07 †	. . . im Studium durch selbst geschriebene Programme bestimmte Aufgaben zu lösen.	. . . to solve certain tasks in my studies using programs I have written myself.
MN08 †	. . . um mir Filme oder Videos anzusehen.	. . . to watch movies or videos.
MN09 †	. . . zum Schreiben und Lesen von E-Mails für mein Studium.	. . . for writing and reading e-mails for my studies.
MN10 †	. . . wenn ich Fernsehen, Radio oder andere Entertainment-Anwendungen nutzen möchte.	. . . if I want to use television, radio or other entertainment applications.

Table A1. *Cont.*

Item ID	Ich Nutze Digitale Medien... (German)	I Use Digital Media ...
MN11 †	... zur Erstellung von Podcasts (Audio, Video) in meinem Studium.	... for the creation of podcasts (audio, video) in my studies.
MN12 †	... um kreative Texte (z.B. Geschichten) zu verfassen.	... to write creative texts (e.g., stories).
MN13 †	... zum Hören bzw. Schauen von Podcasts (Audio, Video/auch YouTube) für mein Studium.	... for listening to or watching podcasts (audio, video/also YouTube) for my studies.
MN14 †	... zur Fotobearbeitung.	... for editing photos.
MN15 †	... um eine eigene Website oder einen Blog zu gestalten.	... to design a website or blog.
MN16 †	... um Unterricht als Vertretungslehrer, Tutor oder in einer vergleichbaren Tätigkeit zu gestalten.	... to plan lessons as a substitute teacher, tutor or in a comparable position.
MN17 †	... zur Videobearbeitung.	... for editing videos.

† Item from [35], MN: MedienNutzung (German for Media Use).

Table A2. Items that describe pre-experiences from school or university.

Item ID	Während Meiner Schulzeit Bzw. in Meinem Studium Habe Ich... (German)	During My Time at School and during My Studies I...
VE01_01 †	... Tabellenkalkulationsprogramme (z.B. Excel) zur Bearbeitung von Aufgaben genutzt.	... used spreadsheet programs (e.g., Excel) to process tasks.
VE01_02 †	... Experimente oder Beobachtungen mittels Videoanalyse ausgewertet.	... evaluated experiments or observations using video analysis.
VE01_03 †	... bei Experimenten mit Messwerterfassungssystemen gearbeitet.	... worked with data acquisition systems during experiments.
VE01_04 †	... mit Hilfe von digitalen Medien Texte verfasst.	... wrote texts with the help of digital media.
VE01_05 †	... das Smartphone zur Durchführung von Experimenten genutzt.	... used the smartphone to carry out experiments.
VE01_06 †	... das Fach Informatik belegt.	... took the subject computer science.
VE01_07 †	... zur Realisierung von sensor-basierten Experimenten (z.B. Lego Mindstorms, Arduino...) genutzt.	... used [digital media] for the realization of sensor-based experiments (e.g., Lego Mindstorms, Arduino...).
VE01_08 †	... mit Hilfe digitaler Medien Feedback im Unterricht bzw. Lehrveranstaltungen gegeben (z.B. Clicker).	... gave feedback in lessons or courses (e.g., Clicker) using digital media.
VE01_09 †	... mit Augmented-Reality-Anwendungen gearbeitet.	... worked with augmented reality applications.
VE01_10 †	... Prozesse und Phänomene mit Hilfe von Computerprogrammen modelliert (z.B. Simulationen).	... modelled processes and phenomena with the help of computer programs (e.g., simulations).
VE01_11 †	... Lernvideos oder-animationen zum Lernen genutzt (z.B. YouTube...).	... used educational videos or animations for learning (e.g., YouTube...).
VE01_12 †	... Lernvideos oder-animationen selbst erstellt.	... created educational videos or animations myself.
VE01_13 †	... Lehrinhalte mit digitalen Medien für andere aufbereitet (z.B. Quests, Animationen ...)	... prepared course content for others using digital media (e.g., quests, animations ...)
VE01_14 †	... digitale Fachbücher als ebook oder pdf genutzt.	... used digital reference books in ebook or pdf format.
VE01_15 ‡	... digitale Medien genutzt, um kollaborativ ein Dokument zu bearbeiten (z. B. GoogleDocs, Nextcloud).	... used digital media to collaboratively edit a document (e.g., GoogleDocs, Nextcloud).
VE01_16 ‡	... digitale Medien genutzt, um Dokumente auszutauschen (z. B. Moodle, ILIAS, Dropbox, Nextcloud).	... used digital media are to share documents (e.g., Moodle, ILIAS, Dropbox, Nextcloud).
VE01_17 ‡	... Lernplattformen verwendet, um meinen Lernprozess zu begleiten (z. B. Moodle, ILIAS, Mahara).	... used learning platforms to support my learning process (e.g., Moodle, ILIAS, Mahara).
VE01_18 ‡	... digitale Medien für den asynchronen Austausch mit Schullehrkräften/Hochschullehrenden (z. B. Chats, Foren, Lernplattformen) genutzt.	... used digital media for asynchronous exchange with schoolteachers/university lecturers (e.g., chats, forums, learning platforms).
VE01_19 ‡	... digitale Medien für den synchronen Austausch im Unterricht/in der Lehrveranstaltung (z. B. Videokonferenztools) genutzt.	... used digital media for synchronous exchange in lessons/courses (e.g., video conferencing tools).

† Item from [35], ‡ Item self-developed, VE: VorErfahrungen (German for prior experiences).

Table A3. Items that describe attitudes towards digital media and teaching.

Item ID	Digitale Medien und Unterricht (German)	Digital Media and Teaching
DU01 ‡	Das Lernen über digitale Medien sollte generell in den Lehrplänen der Schulen ein starkes Gewicht erhalten.	Learning via digital media should generally be given a strong position in school curricula.
DU02 ‡	Das Lernen mit digitalen Medien sollte generell in den Lehrplänen der Schulen ein starkes Gewicht erhalten.	Learning with digital media should generally be given a strong position in school curricula.
DU03 †	Der Einsatz digitaler Medien in den Schulen führt zu einer Verflachung des Unterrichtsniveaus.	The use of digital media in schools leads to a lowering of the standards of teaching.
DU04 †	Negative Folgen digitaler Medien für das Lernen werden unterschätzt.	Negative consequences of digital media for learning are underestimated.
DU05 †	Der Einsatz digitaler Medien ermöglicht in hohem Maße selbstbestimmtes Lernen.	The use of digital media enables a high degree of self-regulated learning.
DU06 †	Durch den Einsatz digitaler Medien können SchülerInnen besser zum Lernen motiviert werden.	Pupils can be motivated easier to learn through the use of digital media.
DU07 †	Computer und digitale Medien eröffnen Spielräume für Kreativität beim Lernen.	Computers and digital media open up opportunities for creativity in learning.
DU08 †	Der Einsatz von digitalen Medien in der Schule sorgt dafür, dass Kinder gut auf das Berufsleben vorbereitet werden.	The use of digital media at school ensures that children are well prepared for working life.
DU09 †	Das Lernen mit digitalen Medien ist eine effiziente Form des Lernens.	Learning with digital media is an efficient way of learning.
DU10 †	Mit digitalen Medien kann ich Unterricht adressatengerechter planen und anpassen.	With digital media, I can plan and adapt lessons to suit the target group.
DU11 †	Digitale Medien erlauben eine höhere Schüleraktivierung.	Digital media allow for higher student activation.
DU12 ‡	Der Einsatz digitaler Medien in den Schulen hebt das Unterrichtsniveau	The use of digital media in schools raises the standards of teaching.

† Item from [35], ‡ Item self-developed, DU Digitale Medien und Unterricht (German for digital media and teaching).

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