

How Well Are Pre-Service Teachers Prepared to Impart Digital Skills in Secondary-Level Education?

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Abstract—This research full paper is concerned with the question, in how far advanced pre-service teachers at the University of Vienna feel ‘fit’ to mediate digital skills as part of their instruction at secondary levels K5–K8. While the digital transformation is progressing rapidly, digital skills have become indispensable for all stakeholders in the educational field. To address this issue, we composed an online questionnaire consisting of closed- and open-ended questions. It was distributed among 4,054 students of the teacher education degree program and generated 322 full responses. In the survey, the students were asked to state their opinion on the integration of digital competencies in their attended teacher education degree program and how to improve it. With the use of qualitative content analysis (QCA), we analyzed which competencies and tools they missed the most in their studies or had to acquire on their own.

The results of this mixed methods study indicate a lack of essential digital skills in the studies of most students, and that they feel a lack of preparation for the challenges to come as a teacher in the modern world. Moreover, most students agree that they had to acquire more than 75% of the required digital competencies on their own and pointed out the skills and tools they required the most throughout their study program or during their work as a teacher. Yet, some students report good practices in use in elective courses and in courses of various subject didactics. The paper provides a short overview of which digital competencies students wish most to be covered in their studies, including a truly professional handling of MS Teams and other tools such as learning apps, response systems, and tools for issuing learning materials and quizzes. As much as we value students’ capacities for self-learning in the digital sphere, we conclude with implications for a thoughtful integration of digital skills in teacher education programs to optimally prepare students for tomorrow’s challenges.

Keywords—digital skills, teacher education, mixed methods, pre-service teachers, basic digital education

I. INTRODUCTION

There is no doubt that the 21st century poses new difficulties to educational institutions and their learners. Hence, teacher candidates of all subjects are expected to possess the respective content-related and pedagogical knowledge as well as technical skills to promote digital competencies. However, several reports revealed a lacking integration of 21st-century skills in general and digital skills in particular in educational practice. Furthermore, a small pre-study at the authors’ university showed that graduates of teacher education programs tend to feel insufficiently prepared to foster students’ digital competencies such as setting up online courses via an e-learning platform, managing student data, or teaching computational thinking. To explore the underlying issues and derive good practices, this paper presents a university-wide survey at a mid-European

university and discusses its implications for further research and action. The paper aims to be of interest to curriculum designers, teacher educators, teachers, (computer-)scientists, and policymakers co-framing the digital transformation in learning.

Methodologically we chose an online survey to reach as many respondents as possible. The questionnaire consisted of 21 closed- and open-ended questions asking students for their opinion about the integration of digital skills in their attended teacher education degree program and their experiences and perceptions of successful and less-successful or lacking practices. The questionnaire’s design (see also Section II) was influenced by national and international digital competencies frameworks as well as a survey carried out by a partner university. Based on the findings of our mixed-methods study, evidence-based strategies and open educational resources should be developed to fill identified gaps. The paper concludes with implications for a sustainable integration of digital competencies in teacher education programs to prepare future generations for tomorrow’s challenges.)

A. Related work

There have been several efforts to define required 21st-century skills and digital competencies for teachers and learners and to develop related meaningful frameworks – some on a national scale, like the Austrian DigiKompP [1], or an international scale. Examples of these frameworks, which aim at defining required skills and competencies for a constructive digital learning and teaching environment, are “ICT Competency Framework for Teachers” by UNESCO [2] and “The Digital Competencies Framework 2.0” or “DigComp 2.0” in short form [3] by the EU Commission. The latter one is the base for national variants, like the DigiComp 2.2 AT for Austria. [4]. To elaborate on the competences met by the students, we decided to use DigComp 2.0, which describes the skills in five areas: 1. information and data literacy, 2. communication and collaboration, 3. Digital content creation, 4. Safety, and 5. Problem-solving. In this paper, the terms digital skills, digital competences and digital competencies are used interchangeably, as they all appear in different frameworks with strongly overlapping meanings.

In addition to the frameworks above, there is also ongoing research on the required competencies from a teacher’s point of view. In a recent paper on digital competencies for teaching and learning [5], Lameris and Moumoutzis revealed six digital competencies and sub-competencies from which parts could be considered as an extension to the DigiComp2.2 framework.

Although there are several definitions of digital competencies, our team agreed on the following one for this study:

‘By digital skills, we mean all the skills and abilities necessary in the digital era to participate responsibly in social and professional life, such as the informed acquisition of

information and the responsible use of digital media, tools, and platforms.’

This definition was used in the introduction of our questionnaire, which we detail in II c.

In a study, Norwegian researchers examined how future teachers are educated to teach with ICT in an English as a Second Language course (ESL) [6]. Based on the chosen definition of digital competencies, “kills, knowledge, creativity, and attitudes required to use digital media for learning and comprehension in a knowledge society”, originally from Erstad et al [7] they found a wide variety in the mastery of teaching ICT amongst young teachers. Moreover, they found various factors that enable or inhibit the development of digital competencies. For instance, students wished for the presentation of tools or a resource bank, but it was also stated that sometimes the teacher educators presented new tools, and because the students weren’t actively using them and only passively listening to the instructions, therefore they didn’t feel comfortable enough to actively use them later on.

Brevik et al. [8] found that pre-service teachers face numerous challenges in developing professional digital competency. They illustrate how a small private online course, which is based on the concept of transformative digital agency, integrates the development of digital competencies with academic seminars and practice.

In Portugal, Lucas et al. [9] studied the effects of three sessions on the development of digital competences of teachers. Based on the DigCompEdu Framework, they encountered improvement in proficiency levels in all competence areas covered in the sessions.

The Master’s Thesis of Lisa Prenner [10] revealed considerable differences in teaching digital skills among Austrian academic institutions. Based on these findings, we conducted our research focusing on the University of Vienna to learn more about pre-service teachers’ qualifications for mediating digital competencies at secondary levels K5–K8. To further investigate this matter, we will first describe the teacher training at the University of Vienna to give an overview:

B. Brief description of teacher education at the University of Vienna

The teacher education program at the University of Vienna is divided into a bachelor’s (8 semesters) and a master’s (4 semesters) program. Usually, students choose two teaching subjects from a total of 27 available [11].

In the bachelor’s program, the students have to “acquire subject-related academic and didactic knowledge” in each subject, which amounts to 100 ECTS (1 ECTS corresponds to an average student workload of 25 hours), and complete 40 ECTS in the General Principles of Educational Sciences. During their studies, students have to complete pedagogical-practical studies” [12].

After the bachelor’s program, students typically apply to work as teachers and start with an introductory and orientation period while continuing their studies in the master’s program. The master’s program amounts to 120 ECTS. After graduation, students typically work at secondary schools (levels K5 – K13).

C. Research interest and research questions

The main goals of this survey were to gain students’ perspectives on the coverage of digital skills in teacher education and to find out what learning opportunities they

encountered as a result of their initial teaching experiences. These led us to the following research questions:

RQ1: How well do advanced pre-service teachers feel prepared by their teacher education programs to mediate elementary digital competencies to their students?

RQ2: To what extent do advanced pre-service teachers indicate to have received training of digital competencies, and to what degree do they report to have acquired these competencies in a self-organized way?

RQ3: In which part of their studies do advanced pre-service teachers receive instruction, promoting their digital competencies, and where do they lack such training?

RQ4: Which digital competencies do advanced pre-service teachers miss in their studies?

Note that – due to the length limitations of a conference paper – the four research questions address just a fraction of the research conducted through the survey.

II. METHODS

To assess the student-perceived coverage of digital competencies of advanced pre-service teachers and to locate areas for improvement, an online survey consisting of closed and open-ended questions was conducted. The closed questions should provide a broad and structured overview. The answer possibilities were fixed and designed based on an ordinal scale, from which the answers were derived and descriptively analyzed. In addition to the broad-level outcomes, the participants had to respond to a few open-ended questions to give more detailed responses. The open-ended questions were analyzed using a qualitative content analysis following Mayring’s procedure [13]. A qualitative content analysis seemed more suitable than a thematic analysis because the topics were decided upon beforehand by posing carefully chosen questions. The students’ perceptions and their number of occurrences were of highest relevance since they can be the foundation for developing new strategies and concrete measures to optimize pre-service teachers’ training. The resulting mixed methods approach is not only intended to reveal the “big picture” regarding pre-service teachers’ digital skills but also to uncover areas needing improvement and good practices.

A. Participants

The target group of the study were advanced pre-service teachers who had already acquired at least 180 ECTS (1 ECTS amounts to 25 hours of student workload) in their bachelor’s program or who were already in their master’s program or even started teaching recently.

Only those demographic categories relevant to the research questions were in the questionnaire, as indicated in Table I. Those were the chosen subjects, the type of study (bachelor/master), and the number of semesters a student had already studied. Keeping the number of demographic categories minimal helped to ensure participants’ anonymity.

TABLE I. SAMPLE CHARACTERISTICS

Characteristic	n (%)
Subject	n total 322
German	116 (36)
History, Social Studies, and Politics	99 (31)
English	69 (21)
Geography and Economics	65 (20)
Mathematic	54 (17)
Biology and Environmental Science	52 (16)
Psychology and Philosophy	39 (12)
Other	206
Student Program	
In bachelor's program	114 (35)
In master's program	209 (65)
Finished the master's program	3 (1)
Other	5 (2)
Survey Response	
Full response	322
Partial response	319

^a since any of the 322 students having provided a full response, can study more than 2 subjects, the n for this question (Q1) is 700. Two students selecting "Other", finished their bachelor's program and didn't start the master's degree yet.

B. Research instruments

The questionnaire consisted of qualitative/open and quantitative/closed questions to provide both descriptive quantitative results and more detailed insights based on the respondents' thoughts, opinions, and perceptions.

Since we wanted to conduct our survey with a field-tested questionnaire, we investigated similar research to base our questionnaire on. In Mandl et al.'s [14] preprint on the use of digital media in teacher education in the subject of mathematics and natural science, they created a survey based on previous studies by Vogelsang et al. [15] and Stinken-Rösner et al. [16]. We added questions that were particularly relevant for our research interest and slightly adapted other questions to fit the questionnaire to our context.

The German form of the questionnaire and its translation into English can be obtained by contacting the first author.

C. Procedure of data collection

Data collection consisted of five steps. First, we developed an initial prototype of the survey in Microsoft Forms [17], which we used to conduct a pilot study with five participants. We did this to identify issues and shortcomings of the survey and to estimate the time needed to answer it.

Second, we incorporated the collected feedback and created the final version of the questionnaire. We did this in a university self-hosted LimeSurvey [18] environment to maximize the students' data privacy.

Third, we consulted with several teams and departments of the university regarding data protection and the conduction of the survey, including our university's quality assurance, the teaching affairs and study services, the coordination of student services, the center for teaching and learning, the employee representatives, as well as the rectorate, which also approved of the conduction of the survey.

Fourth, we added all teacher-education-bachelor students with more than 180 ECTS and all master students to the list of recipients in LimeSurvey, resulting in a total of 4,054 recipients, and generated access tokens, allowing them to save and resume the survey and preventing wrong responses.

Finally, we opened the survey and sent it out to all recipients on 24 February 2022, which was during a holiday period, using a service e-mail address we created for this survey to assist students in need of help. We sent out two

reminders on 9 March 2022 and 18 March 2022 before we closed the survey on 22 March 2022. That implies that the survey was online for 27 days. Overall, we collected 641 responses, out of which 322 were complete. Since most of the remaining 319 incomplete responses were missing a lot of data, we decided only to consider the 322 complete ones for the descriptive statistics. That corresponds to a response rate of 8%.

D. Procedure of mixed methods data analysis

For the closed questions, we applied evaluation procedures provided by LimeSurvey to calculate the frequencies of individual responses and to depict the results in bar charts. We refrained from hypothesis testing since we were primarily interested in getting an overview of advanced pre-service teachers' perceptions and opinions regarding several aspects of their digital competencies and ways to acquire them. In other words, we entered the field of research openly and did not form hypotheses. We rather wanted to inspect the topic area by descriptive statistics to present the results. Those areas were intended to be inspected and better understood by analyzing related open-ended questions via qualitative content analysis (QCA) by Mayring [13]. His eight-step procedure that we followed (see below), provided valuable guidance through the process. We also appreciated the flexibility of Mayring's approach allowing for modifications along the way. For example, we refrained from paraphrasing several short and simple responses, which helped us to work more effectively.

Step 1: Research question, theoretical background:

We had decided on the research questions before any methodological decisions. Nevertheless, step 1 caused us to emphasize the exploratory nature of this study: What matters in mediating digital competencies to pre-service teachers? Moreover, the frequencies of related statements would allow to estimate the weight of any measure taken in terms of its potential effect.

Step 2: Establishment of a selection criterion, category definition, level of abstraction centers:

Due to space limitations in this paper, we chose to select and analyze only responses to one out of twelve qualitative questions in detail. These responses constituted a corpus of 2386 words. The unit of analysis was a meaningful phrase. That could be a part of a longer sentence or a few associated sentences. In sum, 374 meaningful phrases were distinguished and analyzed.

Due to the exploratory nature of this study, the category system was established inductively based on the questions selected from the survey. Categories were derived for each of the questions from the participants' responses. For simplicity, we refrained from multiple-categorization and, thus, decided on the best fit of all potentially relevant categories. To increase reliability, two researchers engaged in category formation and the rating of units. Both are co-authors of this article, one also serving as a teacher and, thus, being expected to reveal any potentially hidden assumptions of the designers of the study.

Steps 3–6: Working through the texts line by line, new category formulation or subsumption; Revision of categories and rules after 10-50% of texts; Final working through the material; Building of main categories if useful:

In our process of establishing categories, each of the two researchers came up independently with a list of categories. These proposals were shared and combined into one list of candidates. After that, the two raters arranged a Zoom™ videoconference and went through about 30 responses to the

selected question. They compared, discussed, and coded their categorizations in a MSWord document. After the initial rating, some splitting-up of categories took place. For example, we split up the category “Other” into two categories: “Hardware-related” and “Other” since we realized that a fair number of students wanted to receive input on how to use or explain various devices such as smartboards or tablets. The remaining responses were categorized independently, whereby each researcher selected a category from the category list. Subsequently, we discussed all discrepancies in the rating until we found an agreement. After careful consultation of each rating, the inter-rater-agreement rose from initially about 90% to 100%. Hand in hand with assigning statements to subcategories, one researcher described the categories while the other one checked them, based on his understanding. Subsequently, one researcher selected statements that appeared to be prototypical examples of the respective category, translated them into English, and associated them with the respective category. The other researcher carefully checked the fit and the translation.

Step 7: Intra-/Inter-coder agreement check:

In our case, the intra- and inter-coder agreement and consistency checks happened iteratively throughout the process. During the final meeting, we resolved any remaining discrepancies and agreed upon the format of the table for presenting the findings of the content analysis. Moreover, we agreed on the presentation of the descriptive statistics contribution to the mixed methods approach.

Step 8: Final results, frequencies, interpretation:

We agreed to consider frequencies of statements falling into the same category since these would reflect the weight of the respective category and point to implications for the teacher education curriculum.

III. RESULTS AND FINDINGS

A. Results from closed questions

We directly asked if students think that digital skills were sufficiently integrated into their studies/course program. The question was formed as a statement with which the students could agree or disagree. The answer possibilities were in accordance with the Likert-Scale from A1 to A4 (disagree, rather disagree, rather agree, agree) and A5 being the option not to answer the question.

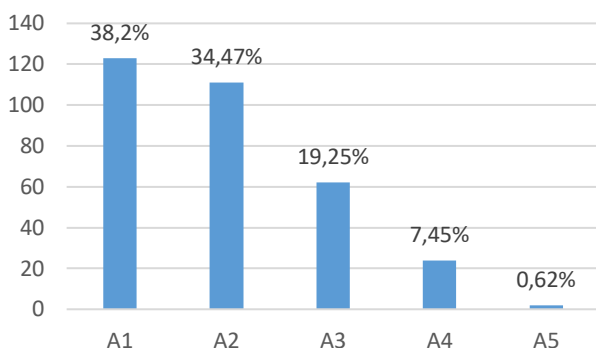


Fig. 1. Students' degree of agreement on the statement "Digital skills are sufficiently integrated into the courses of my teacher training programme" (A1 disagree, A2 rather disagree, A3 rather agree, A4 agree)

Out of the 322 students, 123 (38.2%, A1) completely disagreed with the statement and 111 (34.47%) voted on rather disagree. 62 Students (19.25%, A3) tended to rather agree and 24 (7.45%) fully agreed with the statement. Overall, the vast majority (A1+A2= 72.67%) felt that digital skills were not sufficiently integrated into the courses of their study program. Only about every fourth student considered the integration of digital skills more or less sufficient. In addition to finding out about the integration of digital skills into the study program, we were interested in how far students felt that, overall, their studies equipped them to pass on digital skills to their students.

As shown in Fig. 2, almost half of the students agreed or rather agreed with the statement "I feel well prepared through my studies to support my students with the acquisition of digital skills" and about half of the students disagreed or rather disagreed. More precisely, 116 Students (32.02%, A3) tended to rather agree and 47 (14.6%) fully agreed with the statement, whereas 72 (22.36%, A1) students disagreed and 84 (26.09%) voted to rather disagree with the statement. In brief, almost half of the students (A1 (disagree) + A2 (rather disagree) = 48.45%) felt that they did not gain enough knowhow through their study program in terms of digital skills to pass on these skills to their students.

The high divergence in students' opinions can be explained by the observation of the fact that different subject didactics place different emphasis on imparting digital skills. Hence, depending on the choice of their subjects, students appear to be more or less well prepared for the task to impart digital skills in their teaching at the secondary level. Following up on this perception that was already indicated in Prenner's pre-study [10], we asked the students about their opinion if: "digital competencies should play a bigger role in the general basics of educational science". At the University of Vienna this is part of every teacher candidate's study program, regardless of the student's subject choice.

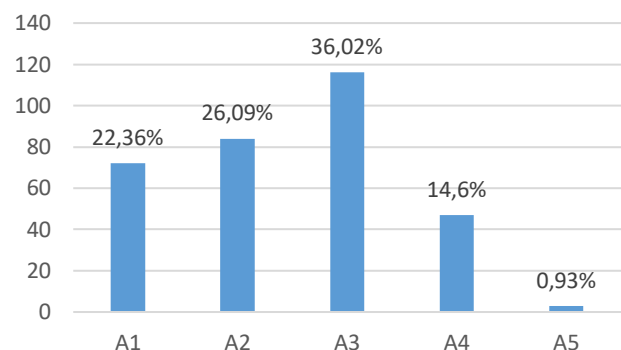


Fig. 2. Students' degree of agreement with the statement "Overall, I feel well prepared through my studies to support my students with the acquisition of digital skills." (A1 disagree, A2 rather disagree, A3 rather agree, A4 agree, A5 no answer)

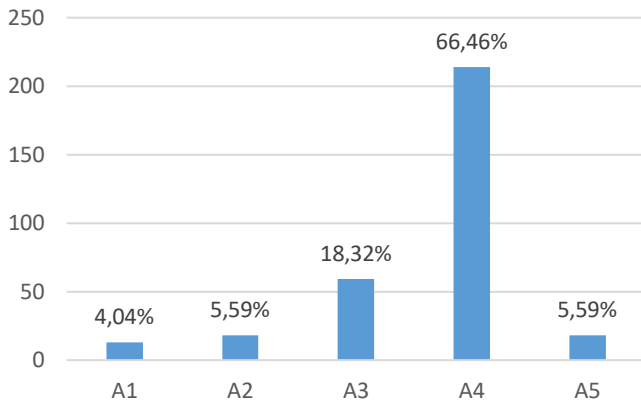


Fig. 3. Students' opinion on "in my opinion, digital competences should play a bigger role in the general basics of educational science" (A1 disagree, A2 rather disagree, A3 rather agree, A4 agree)

Unlike the previous question, this question showed a highly concordant result, as shown in Fig. 3. two-thirds (214 students, 66,46%) fully agreed with the statement and almost 85% (A3+A4= 84,78) of the students were in general agreement. Only 13 students (4,04%) disagreed and 18 (5,59%) rather disagreed with the statement that digital competences should play a bigger role in the 'general basics of educational science' part of their studies. We conjecture that, since the majority of students want to be better prepared for imparting digital skills, a crucial core of these skills needs to be accommodated in the part of the teacher education that deals with the general basics of educational science. This accommodation, however, is challenging and needs innovative approaches since thousands of students have to pass the respective courses.

The final question of the quantitative analysis elaborated in this paper lays the basis for an in-depth open-ended question addressed in Section B. We asked: How many (in percent) of your digital skills did you acquire directly through your study program and how many did you acquire in a self-organized way? Respondents were asked to choose one of five options as depicted in Fig. 4 and described below.

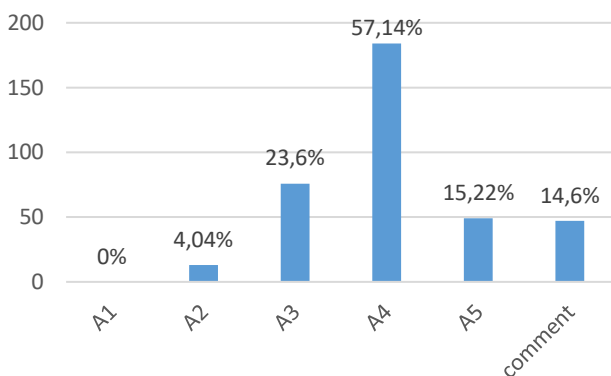


Fig. 4. Students should estimate how many (in percent) of their digital skills they acquired directly through their study programme and how many they acquired in a self-organized way. The options were A1 (acquired 100% of my digital skills as part of my studies, 0% through self-study or through previous training.); A2 (75%/25%); A3 (50%/50%); A4 (25%/75%); A5 (0%/100%) and an optional comment on why students choose their option

Zero students answered that they acquired all the digital skills through their study program and only 13 students (4%) responded they gained at least 75% via their academic study. 76 students (23,6%) stated that half of their digital skills were self-taught, and half of the skills were gained from their study program. 184 (57,14%) stated that they acquired 75% of their digital skills in a self-organized way, and 49 (15,22%) of the 322 students even said that they gained all their digital skills in a self-organized manner.

This result sparks versatile interpretations as well as questions. For example: Is the result shown in Fig. 4 a strength or weakness of the system in place? If students manage to acquire a vast number of digital skills in a self-organized way, should they at all be integrated into the study program? Do students who resort to self-study acquire the respective competencies sufficiently well to be able to pass them on to secondary level students, or do they just learn them to the minimally necessary degree such as "survive" in the digital world? To find out more, we included further open-ended questions in our survey that we are going to analyze in a similar way as we did with the selected open-ended question presented in the subsection below.

B. Findings from open ended questions

To respond to RQ4: "Which digital competencies do advanced-pre-service teachers miss in their studies?", we asked the survey participants the open-ended question: "As a teacher, what digital skills did you have to acquire in a self-organized manner?" The findings from the QCA regarding this question are summarized in Table II and discussed below.

TABLE II. SELF-TAUGHT DIGITAL SKILLS

As a teacher, what digital skills did you have to acquire in a self-organized manner?		
RQ4: Which digital competences do advanced pre-service teachers miss in their studies?		
Category	Prototypical example	Count
MSTeams	How to use MSTeams properly; Handling MSTeams as an exchange platform between teachers and teachers and students	67
General tools	Online platforms used for digital learning, such as Kahoot, online pinboards, surveys, mindmaps, etc.; Usage of learning apps and collections of teaching materials; Learning to use the whole bunch of online tools:	45
All and almost all	All; I had to learn almost everything in a self-organized way	31
Media literacy	Representation of content in a way that appeals to children; How one can teach pupils to recognize fake news and to find legitimate information online; Inclusion of digital media into everyday instruction in class; Support in digital self-organization; Orientation in the Internet;	29
Administrative tools	Handling of tools such as Webuntis and Socrates: Handling of the digital class-register (Edupage): Platforms such as schoolfox	28
Video	Handling of Zoom – not only as a listener as in seminars but the screen	27

Conferencing	sharing, materials, etc had to be managed by myself; Moderation of zoom course-units; Handling of distance learning (Zoom, Collaborate, ...)	
Usage of hardware	Usage of smartphones, tablets, or laptops in class; Working with tablets; Solid knowledge of computers, given students ask questions about that.	25
Description of situation	As a millennial who grew up with digital media, I can't distinguish between learning for life and learning for my job as a teacher; Finding appropriate content that would be suitable and understood by learners at various levels;	21
Moodle, etc.	Working with Moodle; How to use Moodle properly;	20
Other	Knowledge of computing; Programming to some degree; Legal conditions to be able to use digital appliances and teach legal matters.	19
None and almost none	None; Little during internships; Not much; At the University of Vienna exists one elective course I took. If I hadn't selected that course, I wouldn't have learned anything in my master's study; Nothing yet.	18
MSOffice	Skills in creating documents, slides, etc.; Cooperative and collaborative work with Office 365;	14
Content creation	Creating interactive PDFs; creating instruction sheets for tasks; Video design;	14
Subject-specific tools	GeoGebra to some degree; Conducting digital guided tours in museums; Meaningful usage of learning apps for learning German	9
Negative emotion or statement	Since I feel technically and mathematically tortured in my studies, one must elaborate on the social and societal stuff oneself; All we were told was to produce a creative Moodle Course, but the only support we got was a ridiculous 3-pager how to set up a course – this doesn't help with course design;	6
Positive emotion/ statement	[Referring to self-organized learning of digital competencies;] This, so far, didn't cause any problem.	1
Sum: units of analysis		374
Number of responses		239
No response		77
Number of words in corpus		2386

The most frequently mentioned category with 67 mentions was “MSTeams,” specified as: *The category “MSTeams” covers competencies needed for using MSTeams professionally including competencies needed by an administrator.*

This frequent mentioning of MSTeams™ is not surprising since it reflects the situation of the SARS-COV-19-pandemic in the Austrian school system. The government asked schools to choose optimally one digital platform to handle as many tasks as possible. Several schools started to use MSTeams™ so that students doing internships or starting to teach, had to adapt to that situation, often without any previous training. They tended to share that they wished to be properly introduced to the platform so that they are able to exploit its

functionalities professionally and get support on how best to apply MSTeams™ in various situations - in distant and hybrid modes, but also in the class, for communication, and for collaboration.

The second-most frequently mentioned category with 45 mentions was “General tools.” *This category collects statements addressing competencies needed for professional use of tools for digital general-purpose tools in the educational context, such as mind-maps, quizzes, assistive technologies, browsers, etc., except for tools from MSOffice and content creation tools which are devoted to a separate category, respectively.* The frequent mentioning of general-purpose tools reflects the fact that students wish to have competence that allow them to actively participate in digitalization efforts concerning education. This resonates well with the need for competence of the Self-Determination Theory [19].

Already on the third place in terms of the frequency and with 31 mentions is the category “All and almost all”, defined as: *Any statement indicating a substantive demand for self-organized acquisition of digital competences falls into the “All and almost all” category.* The frequency of this category reflects the fact that there exist paths through the teacher education program on which students can bypass any course that imparts digital skills. Moreover, the prominent frequency of statements of the “All or almost all” category rings the bell that several students did not feel sufficiently supported by their teacher education program to acquire those digital competencies needed as teachers. One can speculate that this result would have been less evident before the SARS-COV-19 pandemic, nevertheless, it is a clear call to action toward better supporting pre-service teachers in their need to acquire a broad range of digital competencies.

Since four categories received a very similar number of mentions, we will discuss them at once: These are the categories: “Media literacy” (29 times), “Administrative tools” (28 times), “Videoconferencing” (27 times), and “Usage of hardware” (25 time) defined, respectively as:

The “Media literacy”-category includes all statements addressing respondents' ability to access, analyze, create, reflect, and skillfully handle any media messages in order to work and communicate in a way to make a positive difference.

The category “Administrative tools” covers mentions of any tools supporting school- or class administration.

The category “Videoconferencing” covers competences connected with using the tool Zoom™ and similar tools (except for MSTeams™) including competencies needed by a moderator.

The category “Usage of hardware” collects all aspects associated with the competence to use specific computer hardware or to explain its usage to students.

Competencies addressed by those categories are somewhat more specific such that pre-service teachers might not have experienced situations in which they had felt a lack of those competencies. Plus, the dominance of MSTeams™ in Austrian schools seems to overshadow the need to use other video-conferencing tools such as Zoom™ or others, not coupled with content management facilities. Not surprisingly, professional command of hardware devices is considered relevant in our era of digitalization. The frequent omission of imparting skills needed for the professional usage of tools for school- and class-administration can be explained by the observation that academic educators from various subject didactics often do not have access to such tools. They lack practice in using them because these tools are specific to the

school context. Consequently, the usage of these tools would best be addressed and practiced in courses accompanying school internships that are accompanied by in-service teachers acting as mentors.

Several students (29 mentions) indicated a lack of media literacy and needed to acquire it in a self-organized way. Related to media literacy but focusing on digital content production, the category “Content creation” was specified to encompass *statements that address the competencies needed to produce digital content, including suitable tools to produce videos or learning materials, except for tools by the MSOffice suite*. This category received 14 mentions, meaning that students acquired the more specific content creation competencies less often in a self-organized way than the more general media literacy competencies. Note, however, that summing up the categories “media literacy” and “content creation” amounts to 43 mentions. That would rank a hypothetical category dealing with media production and literacy competences among the first three categories and, hence, needing thorough attention among the digital competencies perceived as essential for school education.

The category ‘Description of the situation’ occurred 21 times. It was specified to include *all statements characterizing some aspect of the respondents’ current situation regarding digital competencies*. Since respondents described their current status quo, statements in this category were helpful for grasping the students’ current perceptions. For example, one student shared: “In some seminars, one gets hints on existing tools, but one has to find out on their own about how they work.” Readers should have a look at Table II for further illustrative statements.

The category “Moodle, etc.”, defined as *covering competencies needed for using the Moodle™ LMS (Learning Management System) including competencies needed by an administrator* attracted 20 mentions. We think that - since Moodle is frequently used in academic courses - several students feel less inclined to mention that they needed to acquire competencies for working with Moodle on their own. Nevertheless, a decent number of respondents needed to elaborate more advanced competences for setting up a designing Moodle courses in a self-organized way, as illustrated by the representative statements given in Table 1.

A decent number of statements (18) fell into the category “None and almost none”, specified as: *Any statement indicating that (almost) no digital competencies had to be learned in a self-organized way – for whatever reason*. Illustrative responses express that there has not yet been any perceived need for acquiring digital competencies or that students had acquired needed competencies in an elective course or elsewhere.

The category “MSOffice”, specified as encompassing any *competencies for professional usage of tools from the MSOffice suite*, was mentioned 14 times. We interpret the relatively low number of statements in the MSOffice category as a result of the fact that several students had former training in the MSOffice suite. However, competencies needed for cooperative and collaborative work with Office 365 were acquired in a self-organized way or not (yet) needed.

The remaining categories addressed competencies for working with subject-specific tools (9 mentions), negative (6) and positive (1) emotions expressed by respondents, and the catch-all category “Others” (19 mentions) holding singular, however, interesting remarks, such as: “Managing the proprietary school platforms;” “Application of portals”, or

“How can I illustrate subject-specific content to students (What are the single steps?)”

C. Integration and learnings from the mixed methods approach

Even though the qualitative content analysis of hundreds of free-text responses is very time-consuming, we are sure that the responses provide valuable insight into the field. We believe that this would not be possible by any statistical analysis of response distributions. This cognition, however, should in no way diminish the value of the quantitative analyses in our context. They illuminated the “topology” of our students’ feelings and opinions and, thus, let us evaluate “where we are” in our teacher education program. In a nutshell, we warmly recommend a mixed-methods approach when analyzing the strengths and weaknesses of degree programs or searching for responses to questions such as those popping up during the digital transformation in education.

IV. DISCUSSION AND FURTHER WORK

A. Limitations and further work

Our study comes with numerous limitations. First, we inquired about the perspectives of pre-service teachers of one university only, which means there might be a strong influence stemming from the particular study program and the lecturers and tutors giving the program’s courses. Nevertheless, we think that the research described in this paper is generally more valuable by presenting the research instruments and procedures on the one hand and illustrating the situation in a large European University, which might serve as a prototypical example for other universities on the other hand.

Another limitation is that we could only analyze the viewpoints of those pre-service teachers who chose to respond to the survey. The opinions of those who stayed silent are not, thus, not represented in our analysis. However, since two of the authors of this paper are also active as teachers at the University of Anonymus and, therefore, in frequent dialogue with our students, we sense that the responses would describe the students’ perception pretty well. Nevertheless, further studies at different universities and triangulation with other research methods, such as conducting focus groups with various pre-service-teacher groups, would increase the reliability of our findings. Yet further insight would be gained by interviewing academic staff teaching within the teacher education program as well as talking to secondary level students about their instruction regarding digital skills in their particular school contexts and subjects. Furthermore, inspection into the practices and learning from other (inter-)national universities are viewed as a must in moving on in a well-informed way.

A very concrete limitation is imposed by the necessary length-limitation of a conference paper. Findings from several questions of our survey did not find space in this paper. They are going to be reported on in the project report of the encompassing project on “Teaching Digital Thinking”, supported by the Anonymized Ministry of Education. Moreover, we intend to write an encompassing journal paper adding further results to the current study.

Further analysis of the survey questions will also be done with regards to the students’ choice of subjects since this is deemed to have discriminatory power regarding students’ perceptions of the integration of digital skills into their study program. A detailed analysis of pre-service teachers’ “wish-

list” on open educational resources will inform our further activities in providing such resources along with didactical support on how to use them in class. Such resources are intended to support both self-organized learning and academic courses of teacher education programs.

B. Findings and impact

Based on the mixed methods research we found the following responses to our research question:

RQ1: How well do advanced pre-service teachers feel prepared by their teacher education programs to impart basic digital competencies to their students?

There is a high divergence in advanced pre-service teachers’ perceptions regarding the question of how well they feel prepared by their teacher education programs to pass on elementary digital competencies. Almost half of the survey respondents indicated to feel rather well or well prepared, whereas approximately the other half stated the opposite. Reasons for this diversity of perceptions are manifold, reaching from differences in the course offerings and didactics across individual subject didactic to variations in the perceived need and intensity of imparting digital skills to secondary level students. This finding indicates that any effort to improve the teacher education program to meet the needs brought about by the digital transformation will have to consider the versatile needs and self-learning capacities of pre-service teachers. A “one size fits all” solution will not suffice.

RQ2: To what degree do advanced-pre-service teachers indicate to have received training of digital competencies, and to what degree do they indicate they acquired these competences in a self-organized way?

There is substantial coherence in the responses to this question. More than two-thirds (72, 36%) of pre-service teachers stated to have acquired 75% or even 100% of their digital skills in a self-organized way and not through their teacher education program. This result raises the important question whether the high degree of self-acquisition of digital skills can be considered as a viable option for teacher education or whether action is required to provide suitable means and strategies to integrate digital skills into teacher education. Considering RQ2 in connection with the responses to RQ4 below provides an orientation pointing to a suitable compromise between self-organized acquisition of specific digital competencies and their coverage in teacher education. Moreover, the responses to RQ1 indicating that almost every second pre-service teacher does not feel adequately prepared to impart digital skill to their students, leads us to the implication that pure self-acquisition of digital skills does not suffice since it would not deliver the required level of depth or professional competence needed for imparting digital skills or at least certain (which?) digital skills.

RQ3: In which part of their studies do advanced pre-service teachers receive instruction promoting their digital competences and in which part do they lack such training?

This research question has a clear response. More than 85% of the respondents agree or rather agree that digital competences should be an issue in the general basics of educational science, the part of teacher education that is common to all teacher candidates. Consequently, didactical approaches for addressing and engaging digital skills in individual small and very large courses as well as at the level of the whole curriculum will need to be developed.

RQ4: Which digital competences do advanced-pre-service teachers miss in their studies?

Although the responses to this question are summarized in Table II, we note that the SARS-COV-19 pandemic had a crucial influence on the results. Pre-service teachers missed most often truly professional handling of MTeams™ as a versatile tool to organize one’s work, communication, and contacts on the one hand and to professionally manage and conduct video conferences on the other hand. Being widespread in Austria’s schools, MTeams™ had helped teachers to engage with students when classical teaching in the classroom had been impossible for several weeks and even months. Several pre-service teachers also had missed being introduced to a professional usage of general-purpose tools supporting learning, such as learning apps, response systems, and tools for issuing quizzes.

V. CONCLUSION

In the mixed-methods study described in this paper, we tried to find out how advanced pre-service teachers perceived the contribution of their academic teacher education program to equip them with the digital competencies needed in their job as teachers in times of digital transformation. For this reason, we designed a survey with closed- and open-ended questions and with the permission of the university distributed the online survey among all advanced pre-service teachers at a large European university.

The survey uncovered that many pre-service teachers had acquired 75% or more of their digital skills in a self-organized way. Yet, almost half of the pre-service teachers felt well or rather well prepared by their teacher education program to impart digital skills to the secondary level students, while the other half felt not or not sufficiently well prepared for their task as a teacher to impart digital skills in their subject. To get an idea about the pre-service students’ view, on which digital skills they were missing most, a qualitative content analysis allowed us to identify and rank those skills missing. The respective findings are intended as an initial, student-centered path to developing and proposing strategies and resources to support pre-service teachers regarding the acquisition of those digital competences they were missing most.

In general, Figures 1, 2, and 4 show that the majority of advanced pre-service teachers - as far as digital skills are concerned - indicate that they do not feel sufficiently prepared by their study program to mediate these skills to their secondary level students.

The paper discusses the implications of our findings as well as further work needed to design strategies and concrete measures to be taken to equip pre-service teachers with the digital and implicitly also other 21st-century skills needed to help secondary level students in dealing with the challenges of the digital as well as the real world, in engaged, mature and reflected ways. Pioneering good practices do exist. The challenge lies in extending their reach and impact on more teacher educators.

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