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Evolving Digital Skills of first-year students: A Pre- and Post-Covid Analysis

Abstract

Digital skills are necessary for first-year students at Austrian universities. This paper unveils results from two surveys among first-year students at Graz University of Technology (TU Graz): Pre-Covid-19 data (n=921) is derived from a larger study on digital literacy among first-year students in Styria (Janschitz et al., 2021, N=4,676). The same questions were posed in the 2021 'Welcome Days' survey after the Covid-19 distance learning phases (n=1,207). Surprisingly, the only significant change is a noticeable increase of skills concerning the digital signature. This article additionally presents the development of a lecture on digital skills that was implemented at TU Graz as a massive open online course (MOOC).

Keywords

Digital Skills, Austria, first-year students, survey, Massive Open Online Course

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Digitale Skills von Studienanfänger:innen: Eine Vor- und Nach-Covid-Analyse der Entwicklungen von Fertigkeiten

Zusammenfassung

Der Beitrag präsentiert Befragungsergebnisse von Studienanfänger:innen an der Technischen Universität Graz (TU Graz) zu ihren digitalen Skills aus zwei Umfragen: Vor-Covid-19-Daten (n=921) stammen aus einer großen Studie zur digitalen Kompetenz von Studienanfänger:innen in der Steiermark (Janschitz et al., 2021, n=4.676). Dieselben Fragen wurden in der „Welcome Days"-Umfrage 2021 nach den durch Covid-19 bedingten Distanzunterrichtsphasen gestellt (n=1.207). Die einzige deutliche Veränderung sind Fertigkeiten in Bezug auf die digitale Signatur. Der Artikel beschreibt ergänzend die Entwicklung eines Massive Open Online Course (MOOC) zur Förderung der digitalen Skills der Studierenden.

Schlüsselwörter

Digital Skills, digitale Kompetenzen, Österreich, Studienanfänger, Umfrage, Massive Open Online Course

1 Introduction

Digital skills have become a new kind of basic knowledge and competence for the 21st century, much like writing, reading and maths. Digital skills are necessary for participation in many areas of everyday life and work. Students are also expected to possess digital skills – for example, online registration is a prerequisite for the enrolment process at many universities. However, digital skills are not being systematically promoted everywhere. An exception is the new school subject "Digital Basic Education" for all fifth-grade classes in Austria in the 2022/2023 school year. There is also a need to create appropriate offers for higher education students and to monitor changes. At Graz University of Technology (TU Graz), the Educational Technology team is responsible for providing e-learning infrastructure and offers for students and teachers. Therefore, every year since 2007 the team has surveyed first-year students about usage of IT and IT-related communication tools, such as social media applications or gadgets. Our team was able to acknowledge the decreasing use of emails (Nagler, Ebner & Schön, 2016) and rising importance of learning videos (Nagler et al., 2019), and has recorded a decreasing use of portable power packs among first-year students after the first Covid-19 related distance learning phases in Austria (Nagler et al., 2021). In this contribution, we aim to answer the question how digital skills among first-year students at TU Graz can be described and if there are differences between the cohort of first-year students before any Covid-19 restrictions compared with the cohort that started after them. Based on the development during the Covid-19 pandemic and its school closures and transition to distance education using online tools in Austria (e.g. Weber, Ebner & Schön, 2021), it seems reasonable to assume that the digital competencies of first-year students at TU Graz have also evolved. Our research question is therefore: How have digital competences of first-year students at TU Graz changed when comparing first-year students in 2019 (before Covid-19 restrictions) to first-year students in 2021 (after school closures and distance learning)? After a presentation of the results and their discussion, we will highlight one of the measures aimed at fostering digital skills of students at TU Graz and beyond: a MOOC dedicated to this topic.

2 Potential effects of the Covid-19 pandemic on students' digital competences and approaches for assessing them

Reviewing the literature, we were unable to find any contributions on how and whether the skills of Austrian high-school graduates or first-year students have changed because of the pandemic. Of course, there are contributions available about the changes concerning digital learning and its challenges during the Covid-19 pandemic, such as for TU Graz (Ebner et al., 2020), for single university courses (Ebner & Schön, 2020), for higher education in Austria in general (Pausits et al., 2021) or in Austrian schools (Weber, Ebner & Schön, 2021).

There are some articles that deal with the development of students' digital skills during the pandemic. For example, Rodríguez-Moreno et al. (2021) examine the effects of Spanish teacher students using digital tools on digital skills. The analysis of data from nearly 600 students revealed that the use of virtual tools for collaborative work online and the use of YouTube explain the level of digital skills. Sales et al. (2020) chose a qualitative approach, interviewing faculty members from Spanish universities in discussion groups about the development of students' digital skills during online-supported distance learning. The study concludes that there were no improvements during the initial university closures. Studies conducting surveys of students' digital skills before and after Covid-19 are considerably rarer. The contribution by Salem et al. (2022) surveyed the self-perception of one group of students before Covid and another group in 2021, following the reopening of universities in Saudi Arabia. It was found that perceived digital skills were rated lower.

These insights also indicate that the assessment of digital skills varies considerably. Several competence models have already been published to describe students' digital competences. For example, Vishnu et al. (2022) used the European competence framework DigComp as a basis to assess digital skills for online learning among Indian students. Krempkow (2022) published a questionnaire to assess digital com-

petences according to the German version of the DigComp. A current literature review of digital competences in higher education by Zhao, Lorente & Gómez (2021) shows that the European DigComp dimensions are the most referred to. Additionally, this literature review shows that most studies measure competences through a self-assessment by participants.

In our context, Austria, there exists the DigComp 2.1 AT framework, a slightly expanded version of the European framework: 25 individual competences are assigned to six areas, namely 0. basics and access, 1. managing information and data, 2. communication and collaboration, 3. creation of digital content, 4. safety and 5. problem solving and further learning. The Austrian competence framework DigComp 2.2 AT is also the basis for the DiKoS project, which sought to assess students' digital competences (Janschitz et al., 2021, p. 10). The DiKoS study measures digital competences through student self-assessment (see Janschitz et al., 2021, p. 18). The DiKoS study team constructed a multidimensional index reflecting the level of digitalisation among students instead of directly measuring digital competences through performance assessment. The DigComp 2.2 AT competence framework was the basis for a "14-page questionnaire with 113 question items" (ibid.). The items are described by Janschitz et al. (2021, p. 18) as attitude questions (33), behavioural questions (31), knowledge questions (21), self-assessment (17) and socio-demographic questions (11). Our first data set, which predates Covid-19, comes from this larger research project on digital literacy among first-year students (Janschitz et al., 2021). Among other things, in the DiKoS project, almost 80 % of all people who began studying at a Styrian university in the winter semester 2019/2020 (n=4,676) were surveyed in a paper-and-pencil format between September 2019 and November 2019 (ibid., p. 23). In other words, the data collection took place before universities were closed due to the Covid-19 pandemic. The data of first-year students at TU Graz are presented separately for the first time in this article (n=921).

As a second data set, 12 of the questionnaire items on digital skills from the study by Janschitz et al. (2021) were included in an annual paper-and-pencil survey at the "Welcome Days" at TU Graz in October 2021 (n=1,207; Nagler et al., 2022). One

additional item on open licences was added to this questionnaire as well. The answers to these questions are also presented in this form for the first time here. The data from before and after Covid-19 is compared with the help of simple descriptive analysis.

Figure 1 gives an overview of the competence frameworks and questionnaires used and adaptations that were made to them, as well as about the survey and data in general. Details such as the specific items which are used to highlight differences between the TU Graz first-year student cohort from 2019 (using data from DiKoS) and 2021 (using data from our Welcome Days study) are presented in the following chapter along with the results.

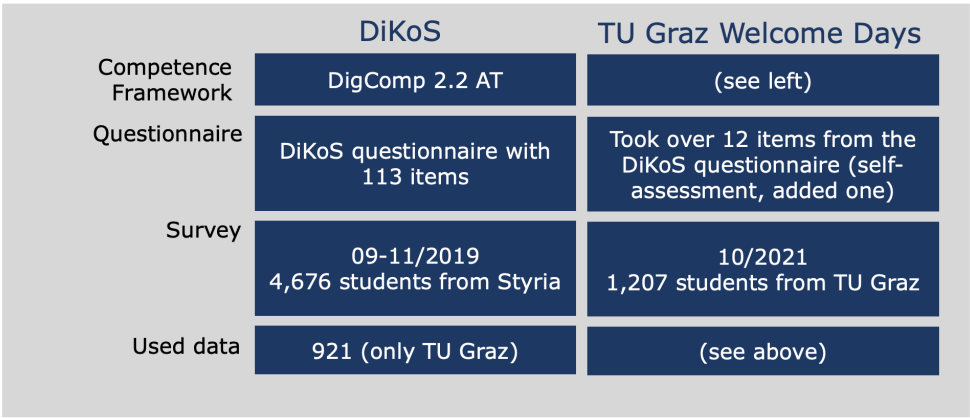

Figure 1: Overview of the data used and its background.

3 Comparison of socio-demographics of the two data sets

Both data sets use data of first-year students at TU Graz (from the years 2019 and 2021). Although the groups are generally similar, a comparison of their socio-demographics shows some small differences. As shown in Figure 2, about two thirds of the students are male and about four of five are younger than 20 years, which is to say that many of the participants, i.e. study beginners, start university directly after school or after their service in the Austrian armed forces. As is typical for a technical university in Austria, more than one third of the participants graduated from an upper-secondary technical school (Höhere Technische Lehranstalt, abbreviated as HTL), about two thirds from a general upper-secondary school (Allgemeinbildende Höhere Schule, abbreviated as AHS). Both surveys reached mostly students who are new to university, but to a lesser extent also students who had already started another degree program.

Overall, the socio-demographic data of the two surveys of first-year students at TU Graz are very similar, which should ensure good comparability between the two survey groups.

Figure 2: Comparison of socio-demographic characteristics of TU Graz students in DiKoS 2019 (n=921) and the Welcome Days 2021 (n=1,207)

4 Digital skills of first-years students before and after Covid-19 distance learning phases

Figure 3 shows the questionnaire items on digital skills and the answers of first-year students at TU Graz in winter term 2019/2020 collected by the digital competences study (DiKoS), in comparison with the corresponding data of first-year students at the Welcome Days (WD) in the winter term 2021/2022. First-year students two years later typically had experience with distance learning in Austria at the start of their university career. As the figure shows, most of the first-year students in 2019 reported that they can work with a learning management system: 31 % chose the option "I know my way around and can also solve any problems that arise", another 51 % chose "I can do it myself". All others, 18 %, chose one of the other options starting with "I can't do it …".

Figure 3 shows that overall, there are no major differences between 2019 and 2021 data. In both surveys, almost all respondents indicated that they could exchange data between different devices, quickly find information via search engines, customise profile settings on social networks to protect personal data and prepare and create written work using digital media. On the other hand, in both surveys, respondents most frequently stated that they cannot design web applications and that they cannot set up a VPN connection (between two thirds and three quarters of respondents in each case). Similarly, just under 30 % of first-year students in 2021 indicated that they can search and correctly use resources with open licences (this item was not included in the 2019 survey).

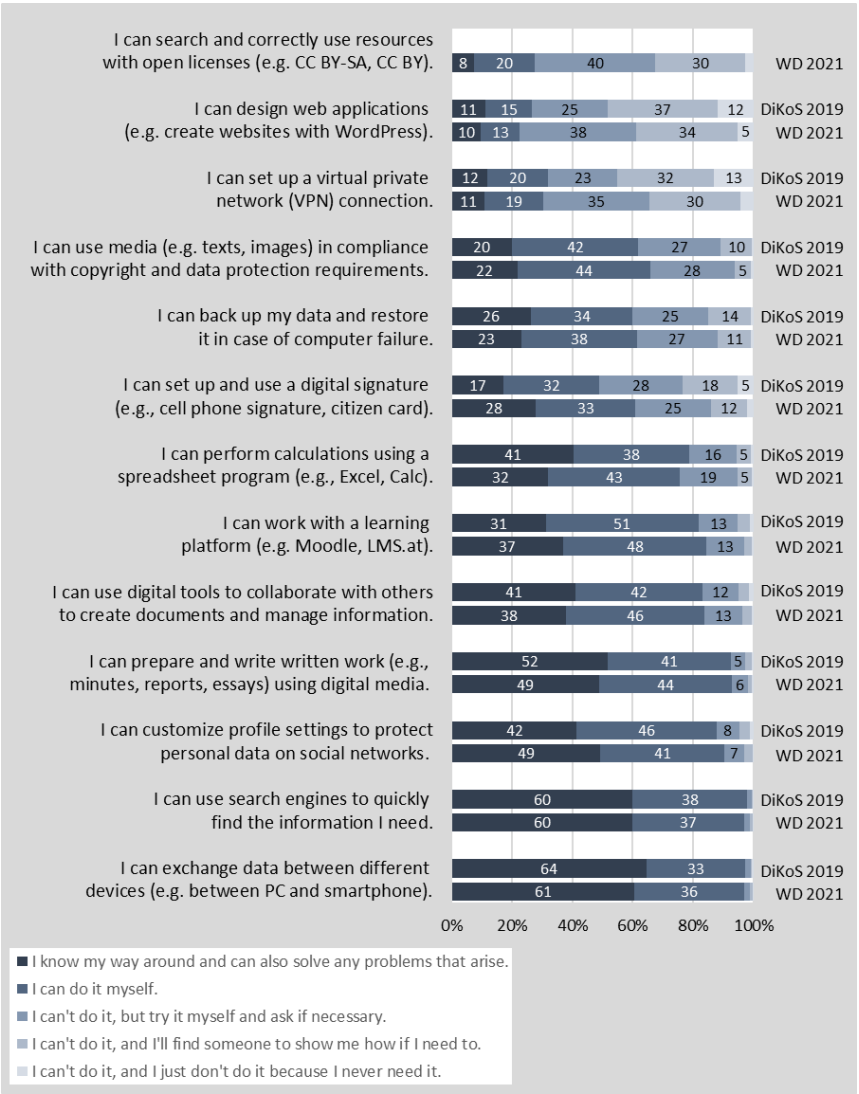

Figure 3: Skills in working with digital applications and content (DiKoS 2019 n=855, WD 2021 n=1,111)

Overall, there is only one item with a noteworthy difference of 12 % between the "I can" and "I cannot" responses between the 2019 and 2021 data: "I can set up and use a digital signature". We can therefore assume that this kind of digital application has become more common among first-years students of TU Graz between autumn 2019 and 2021. If we sum up the two "I can" responses and the three "I cannot" responses for all other items, we can see that there are 3 items which show a slight increase of between 2 and 4 % in those who have indicated that they can do it, as well as three items for which the opposite (a slight decrease) is the case (see Table 1). Five of the items show (almost) no change (+/- 1 %).

Table 1: Change of distribution of those "who can" from 2019 to 2021

increase (12 %)	I can set up and use a digital signature
slight increase (2–4%)	I can use media in compliance with copyright and data protection requirements.
	I can work with a learning platform.
	I can customise profile settings to protect personal data on social networks.
no change (max. +/-1%)	I can back up my data and restore it in case of computer failure.
	I can use digital tools to collaborate with others to create documents and manage information.
	I can prepare and write written work using digital media.
	I can use search engines to quickly find the information I need.
	I can exchange data between different devices.
slight decrease (2–4%)	I can design web applications.
	I can set up a virtual private network connection.
	I can perform calculations using a spreadsheet program.

A Mann-Whitney-U-Test was carried out to check whether there is a statistically significant difference between the respondents from 2019 and those from 2021 for individual items. Table 2 lists the items for which there is a statistically significant difference (p<.050) between the two survey groups.

Table 2: Survey items with significant difference between DiKos 2019 and WD 2021

Item	Mann-Whitney-U-Test	N	Z	Asymp. Sig	r
I can set up and use a digital signature.	413,315.0	2,012	-6.913	0.000	-0.154
I can set up a virtual private network connection.	457,377.5	2,018	-3.627	0.000	-0.081
I can customise profile settings to protect personal data on social networks.	464,879.5	2,026	-3.597	0.000	-0.080
I can perform calculations using a spreadsheet program.	467,358.5	2,029	-3.412	0.001	-0.076
I can design web applications.	468,821.5	2,020	-2.843	0.004	-0.063
I can work with a learning platform.	445,605.5	1,972	-2.778	0.005	-0.063
I can use media in compliance with copyright and data protection requirements.	469,653.5	2,008	-2.261	0.024	-0.050

A look at the correlation values r in the table shows that although there are statistically significant differences between the groups surveyed, the respective effect sizes are only weak. As already shown in Table 2, it is also confirmed here that the only noticeable change between the surveys in 2019 and 2021 regards digital signatures.

5 Expectations regarding university teaching of first-year students before and after Covid-19 distance learning phases

In addition to their own digital skills, the participants were asked in several items about their expectations for university teaching (see Figure 4). Here, too, we see that three items have hardly changed even after the Covid-19 pandemic. In each case, over 80 % of first-year students agree that lecturers should frequently try something new with digital media. The participants think it is good when lecturers use traditional teaching aids, but just as many think that it is good when some courses are offered in the form of online courses. The item "I would like my studies to be conducted entirely in the form of virtual teaching", which was only included in the 2021 survey, shows by far the lowest approval. Nevertheless, about 12 % (rather) agreed to this statement. What is noteworthy is that the 2021 data shows significantly less agreement to the statement that it does not matter what media lecturers use if they keep their focus on the subject matter (75 % agreement in 2019, compared with 61 % in 2021). A similar picture emerges for the item "My studies are supposed to provide me with programming skills". While in 2019 about 82 % (rather) agreed to this statement, in 2021 only 68 % did so.

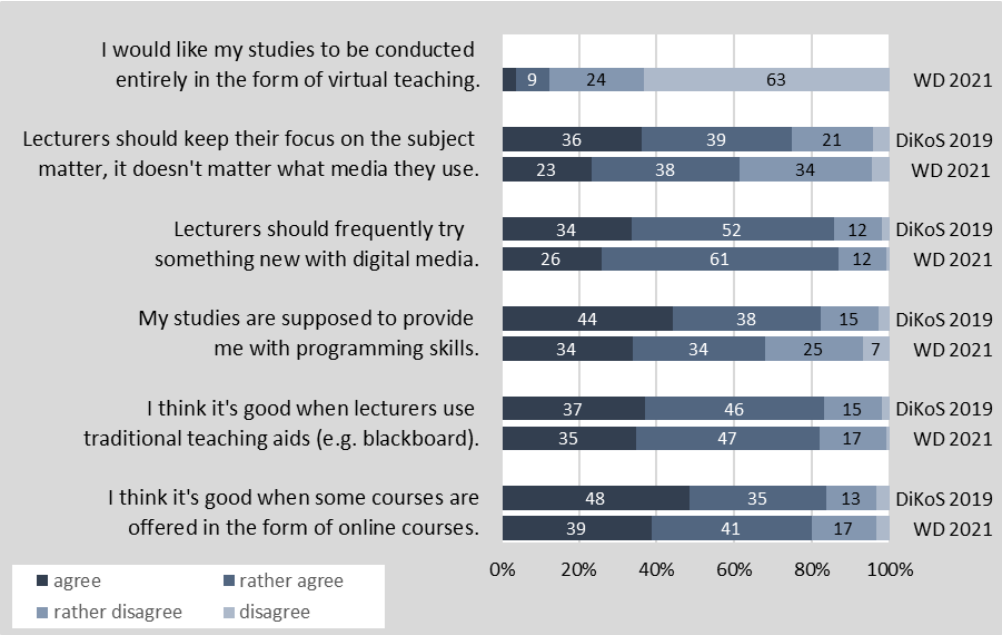

Figure 4: Expectations regarding university teaching (DiKoS 2019 n=875, WD 2021 n=1,133)

6 Discussion of the results concerning digital skills of first-year students

Conceptually, there are always limitations when surveying digital skills using only a self-assessment (see Zhao, Lorente & Gómez, 2021). Studies have reported that students, due to their experiences with digital learning, may have assessed their digital skills as worse – and potentially more realistically (Salem et al., 2022). In any case, it would be important to have objective measurement data available here as well.

In general, we do not know from the comparison of the data from 2019 and 2021 which of the supposed developments are due to changes in schools and universities during distance learning in Austria or whether they are due to other reasons, such as changes in the digital infrastructure.

To sum up, the most noticeable change is the increase of skills concerning the digital signature, which has been available in Austria for several years, but seems to have become more relevant in times of distance communication. Interestingly, to our knowledge and research with the help of Google Scholar, there is no data or literature that supports this interpretation of our data concerning the digital signature in Austria, which is not yet known and implemented at the same level in many other countries such as Germany.

We have already pointed out one interesting development: The 2021 data shows significantly less agreement to the statement “it does not matter what media lecturers use if they keep their focus on the subject matter” (75 % agreement in 2019 compared with 61 % in 2021). This could be interpreted to mean that the type of media selected is of big relevance and that certain forms of media are appreciated less. Looking at the media-related statements, we see decreased support for online courses (3 % decrease for “(rather) agree” in 2021), compared with virtually no difference concerning traditional media such as using the blackboard (1 % decrease for “(rather) agree” in 2021). Without a clear tendency of change in these statements, it is difficult to interpret what first-year students’ favourite media for learning settings

are in 2021: Is it a traditional media use (blackboard), a digitally enhanced in-person lesson, or a virtual setting? Our guess is that a digitally enhanced course with additional recordings for later training or repetition is preferred, as this was implied by another student survey at TU Graz (Schön et al., 2021). Nevertheless, there is still room for further investigations.

The second surprise was the difference between 2019 and 2021 in the item "My studies are supposed to provide me with programming skills". While in 2019 about 82 % (rather) agreed to this statement, in 2021 only 68 % (rather) agreed. We were surprised about this result and are left to wonder why the students' impression of what they need to learn at university has changed.

Finally, we would like to point out that there is a small difference in the way the two surveys were conducted, which might (also) be responsible for these developments that are difficult to interpret: The 2021 survey took place on the very first two days students spend at the university in the third week of September, as part of the "Welcome Days". The DiKoS data, in comparison, was collected during a longer period from September to November. Students' answers might already be influenced by their experiences of teachers and the e-learning setting. Another difference is the fact that the 2019 DiKoS study reached n=921 students, which is about 100 students more than were reached in the Welcome Days survey in the same year (n= 824, see Nagler et al., 2021). Potentially, any differences in the results might also be due to differences in the sample of students reached at different times and through different means.

In addition to these methodological considerations relating to the survey, the differences and possible interpretations of the results, TU Graz is also faced with the practical question of how different skill levels of first-year students can be mitigated as best as possible before the start of their studies and which measures are effective in this regard. In the case of TU Graz, a MOOC on digital skills aimed at first-year students was developed for this purpose.

7 Fostering digital skills of first-year students at TU Graz

At TU Graz, the digital skills of students are of course a very important factor in their studies but also for their subsequent professional life. Since first-year students have different skill levels due to their previous school careers, it was necessary to devise a way of allowing students to catch up on missing skills easily and quickly at the beginning of their studies. In this section, we would like to present one of the measures taken by TU Graz to increase first-year students' digital skills.

For this purpose, a lecture was designed that can be taken as a free elective in any study programme and whose core content is an online course. Students can work through the online content independently, check their knowledge through a self-assessment and receive a course certificate (and ECTS credits) after a final exam. In winter semester 2021/2022, the online course "Digital Skills for Students" was offered for the first time (https://imoox.at/course/DigiStudiWS21). The course was designed as a 'massive open online course' or MOOC (McAuley et al., 2010). This means that while it is aimed at (future) students of TU Graz, it is open to anyone on the national Austrian MOOC platform iMooX.at (Ebner, 2021). Like all other MOOCs on the platform, this MOOC is available as an open educational resource (OER) and can therefore also be integrated into other educational settings (cf. Ebner, Schön & Braun, 2020).

The project team developed a project plan for the content design, which was accompanied by research in the form of a master thesis (Obermayr, 2021). The MOOC was systematically developed by following the European Competence Framework (Carretero et al., 2017, p. 1–48) and the Austrian Competence Framework (BMDW, 2021, p. 1–36). A workshop design was developed with the aim of ensuring that the individual competencies can be backed up with realistic examples from everyday life at university. In two workshops with students of teacher education in the field of computer science, the individual points of the framework were filled in, discussed, and finally prioritised in an open world café setting. This resulted in a matrix that

represents the rough content of the MOOC by forming five units with the corresponding sub-items. Subsequently, the learning goals of the units were defined, and the content was researched, elaborated, and summarised. In parallel, the team developed the video concept: a dialogue between two people in a café. Afterwards, the video scripts were written, and the videos were produced in the video studio of TU Graz. The finished videos, additional materials (links, documents, etc.) as well as self-assessment quizzes were implemented in the platform iMooX.at to form a MOOC. In addition to the MOOC, an accompanying course was created at TU Graz and new students were informed about it at the Welcome Days. The course was held for the first time in winter semester 2021/2022 (see Figure 5).

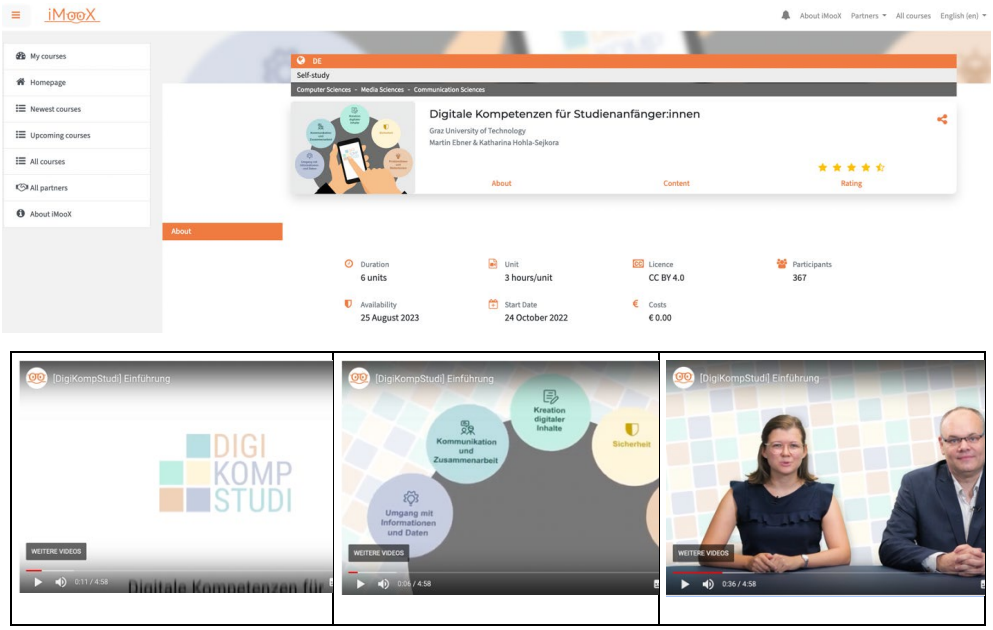

Figure 5: Impressions from the MOOC “DigiKompStudi”, implementation at iMooX: Screenshot of the MOOC website (from the second implementation in 2023) and from the MOOC trailer.

When the MOOC on digital skills for first-year students was first offered in winter semester 2021/2022, 436 registrations to the online course were counted. Almost half of the registered participants successfully completed the MOOC with a certificate. Around 44 % of people who had registered for the MOOC did not interact with the course in the end. The second implementation of the MOOC one year later (winter semester 2022/2023) shows similar figures. It counted 445 registered participants and again about half of those registered completed the MOOC successfully and received a certificate. We hope that this offer will continue to systematically support the digital skills of our first-year students.

8 Acknowledgement

We would like to thank our partners of the DiKoS study as they allowed us to use and present the data related to TU Graz in this report (see Janschitz et al., 2021).

9 References

Bundesministerium für Digitalisierung und Wirtschaftsstandort (2021). *Digitales Kompetenzmodell für Österreich. DigComp 2.2* AT. Bundesministerium für Digitalisierung und Wirtschaftsstandort.

Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with Eight Proficiency Levels and Examples of Use.* Publications Office of the European Union. https://data.europa.eu/doi/10.2760/38842

Ebner, M. (2021) *iMooX – a MOOC platform for all (universities),* 2021 7th International Conference on Electrical, Electronics and Information Engineering (ICEEIE) (pp. 1–5). https://doi.org/10.1109/ICEEIE52663.2021.9616685

Ebner, M., & Schön, S. (2020). Future Teacher Training of Several Universities with MOOCs as OER. In R. E. Ferdig, E. Baumgartner, R. Hartshorne, E. Kaplan-Rakowski & C. Mouza (Eds.), *Teaching, Technology, and Teacher Education during the COVID-19*

Pandemic: Stories from the Field. Association for the Advancement of Computing in Education (AACE) (pp. 493–497). Book is available under CC BY NC ND: https://www.learntechlib.org/p/216903/

Ebner, M., Schön, S., & Braun, C. (2020). More Than a MOOC. Seven Learning and Teaching Scenarios to Use MOOCs in Higher Education and Beyond. In S. Yu, M. Ally & A. Tsinakos (Eds.), *Emerging Technologies and Pedagogies in the Curriculum. Bridging Human and Machine: Future Education with Intelligence* (pp. 75–87). Springer.

Janschitz, G., Monitzer, S., Archan, D., Dreisiebner, G., Ebner, M., Hye, F., Kopp, M., Mossböck, C., Nagler, W., Orthaber, M., Rechberger, M., Rehatschek, H., Slepcevic-Zach, P., Stock, M., Swoboda, B. & Teufel, M. (2021) *Alle(s) digital im Studium?! Projektbericht der Steirischen Hochschulkonferenz zur Analyse digitaler Kompetenzen von Studienanfänger*inne*n*. Graz University Library Publishing. https://doi.org/10.25364/978-3-903374-00-3

Krempkow, R. (2022). DigKomp2.2.de. Erhebung digitaler Kompetenzen gemäß DigComp2.1-Referenzrahmen der EU [Verfahrensdokumentation und Fragebogen]. In Leibniz-Institut für Psychologie (ZPID) (Hrsg.), *Open Test Archive*. ZPID. https://doi.org/10.23668/psycharchives.6599

McAuley, A., Stewart, B., Siemens, G., & Cormier, D. (2010). *Massive Open Online Courses Digital ways of knowing and learning, The MOOC model For Digital Practice.* http://davecormier.com/edblog/wp-content/uploads/MOOC_Final.pdf (accessed on 26 May 2020).

Nagler, W., Ebner, M., & Schön, M. (2016). R.I.P. E-Mail * 1965–2015. In *World Conference on Educational Media and Technology 2016* (pp. 464–473). AACE.

Nagler, W., Haas, M., Schön, M., & Ebner, M. (2019). Professor YouTube and Their Interactive Colleagues How Enhanced Videos and Online Courses Change the Way of Learning. In J. Theo Bastiaens (Ed.), *Proceedings of EdMedia + Innovate Learning* (pp. 641–650). Association for the Advancement of Computing in Education (AACE).

Nagler, W., Schön, S., Mair, B., Ebner, M., & Edelsbrunner, S. (2022). A decade of first-semester students surveys concerning IT equipment and communication applications and effect of Covid-19 related experiences for first-year students in 2021. In T. Bastiaens (Ed.), *Proceedings of EdMedia + Innovate Learning* (pp. 1060–1067). Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/221412/ (accessed on July 12, 2022).

Obermayr, D. (2021). *Digital competencies for first-year students*. Master's thesis at the Graz University of Technology (not available for public).

Pausits, A., Oppl, S., Schön, S., Fellner, M., Campbell, D. F. J., & Dobiasch, M. (2021). *Distance Learning an österreichischen Universitäten und Hochschulen im Sommersemester 2020 und Wintersemester 2020/21.* Bundesministerium für Bildung, Wissenschaft und Forschung. https://pubshop.bmbwf.gv.at/index.php?article_id=9&type=neuerscheinungen&pub=926

Rodríguez-Moreno, J., Ortiz-Colón, A. M., Cordón-Pozo, E., & Agreda-Montoro, M. (2021). The influence of digital tools and social networks on the digital competence of university students during COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *18*(6), 2835.

Salem, M. A., Alsyed, W. H., & Elshaer, I. A. (2022). Before and amid COVID-19 pandemic, self-perception of digital skills in Saudi Arabia Higher Education: A longitudinal study. *International Journal of Environmental Research and Public Health, 19*(16), 9886.

Sales, D., Cuevas-Cerveró, A., & Gómez-Hernández, J. A. (2020). Perspectives on the information and digital competence of Social Sciences students and faculty before and during lockdown due to Covid-19. *Profesional De La información Information Professional, 29*(4). https://doi.org/10.3145/epi.2020.jul

Schön, S., Wieser, V., Dennerlein, S., & Ebner, M. (2021). Gute Online-Lehrpraxis aus Studierendensicht in den ersten Wochen der CoViD-19-Krise: Der studentische Blick auf‹ gute Lehre› an der TU Graz im Mai 2020. *MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung, 40*, 411–429.

Weber, H., Schön, S., & Ebner, M. (2021). Distance Learning an steirischen Mittelschulen in Zeiten der COVID-19-Pandemie. *Online Journal for Research & Education*, *16*, 1–15. https://doi.org/10.53349/resource.2021.i16.a988

Vishnu, S., Sathyan, A. R., Sam, A. S., Radhakrishnan, A., Ragavan, S. O., Kandathil, J. V., & Funk, C. (2022). Digital competence of higher education learners in the context of COVID-19 triggered online learning. *Social Sciences & Humanities Open, 6*(1), 100320.

Zhao, Y., Llorente, A. M. P., & Gómez, M. C. S. (2021). Digital competence in higher education research: A systematic literature review. *Computers & Education*, *168*, 104212.