



# COVID-19 Accelerating Academic Teachers' Digital Competence in Distance Teaching

Liisa Myyry\*, Veera Kallunki, Nina Katajavuori, Saara Repo, Tarja Tuononen, Henrika Anttila, Päivi Kinnunen, Anne Haarala-Muhonen and Eeva Pyörälä

Faculty of Educational Sciences, Centre for University Teaching and Learning, University of Helsinki, Helsinki, Finland

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### \*Correspondence:

Liisa Myyry  
liisa.myyry@helsinki.fi

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This study examines, using a cross-sectional approach, the digital competence of academic teachers at a time when teaching shifted to digital distance learning at the start of the COVID-19 pandemic. Teachers from different academic fields at a large multidisciplinary Finnish university (N = 265) responded to a questionnaire about the purposes for which they use digital tools in teaching, how they evaluated their competence at distance teaching during the lockdown of March-May 2020 and their beliefs about distance teaching. The respondents used digital tools in teaching mostly for delivering information. According to their evaluations, their competence in distance teaching increased during the early stages of COVID-19 pandemic in 2020, but their beliefs about distance teaching did not relate to the feelings of competence. Respondents with no experience in distance teaching before the lockdown evaluated their competence as having increased more than did respondents with previous experience. The implications of the findings for understanding competence development are then discussed.

**Keywords:** digital teaching, digital competence, teacher beliefs, higher education, COVID 19 pandemic

## INTRODUCTION

In 2020, higher education was rapidly converted globally into distance learning due to the COVID-19 pandemic and closures of schools and businesses in societies throughout the world. At the time, academic teachers found themselves in a challenging situation where they had to transform overnight all of their teaching plans to fit the needs of online distance learning. This required teachers to rapidly develop their level of digital competence. Digitalisation not only complemented contact teaching, but learning was based on a digital environment and previous forms of contact teaching now took place at a distance. Studies on the transition to distance learning due to the pandemic revealed notable variation between higher education teachers in how they perceived their readiness to implement remote teaching, with some teachers finding it very challenging (Watermeyer et al., 2021). There were also significant differences between the units in terms of how much online teaching was delivered before the pandemic (Nuere and de Miguel, 2021). During the pandemic, concerns about the quality of online student learning have been raised, especially related to the students' practical skills training (Torda, 2020; Farrokhi et al., 2021). A majority of COVID-19 related studies in higher education have focused on students' experiences of online teaching following the lockdown (Dost et al., 2020; Almendingen et al., 2021; Karadag et al., 2021). In this study, we focus on the transition to remote teaching from the teachers' perspective. We look at the digital competence of teachers, the use of digital

tools in teaching and the development of their digital competence in the early stages of the COVID-19 pandemic.

Technology-enhanced learning environments can be used for many purposes, such as supporting collaborative learning and knowledge building (Häkkinen and Hämäläinen, 2012; Deng and Tavares, 2013), facilitating students' understanding of the topic, for example through visualisation tools (e.g., Sorva et al., 2013; Guillén-Gámez et al., 2021), giving students feedback and monitoring their learning progress (Jääskelä et al., 2017), and implementing online exams and assessments for learning (Myrri and Joutsenvirta, 2015; Marcelo and Yot-Dominiguez, 2019). In general, educational technology is believed to enhance the design of student-centred learning environments (Hannafin and Land, 1997; Ottenbreit-Leftwich et al., 2010; Reilugh, 2014). Recent studies have shown that, despite universities' efforts to increase and improve digital teaching and learning, both teachers and students only use a limited number of digital tools, and teachers use them mainly to organise teaching, not to promote student-centred learning or for pedagogical purposes (Tømte et al., 2015; Bond et al., 2018; Amhag et al., 2019). Thus, both technical and pedagogical support is needed to enhance digital teaching (Amhag et al., 2019; Fernández-Batanero et al., 2020).

The limited use of digital tools may be due to teachers' low competence in educational technology, but on the other hand the increased use of digital tools may improve their sense of competence (Marcelo and Yot-Dominiguez, 2019). For instance, Muños Carril et al. (2013) observed that the competence of higher education teachers' was high in developing course contents and organizing teaching, but low in assessment activities, the latter of which can be considered as more advanced competence in the use of digital tools.

Competence consists of integrated knowledge, skills and attitudes that can be used to perform professional tasks successfully (Baartman and Ruijs, 2011; Janssen et al., 2013). As early as 2005, the concept of digital competence was proposed by the European Commission (European Union, 2005) as one of the eight key competences for learning, referring to the use of computers to store and process information and for participating in collaborative networks. Research on teachers' digital competence has often sought to understand what knowledge and skills teachers should acquire and what kind of professional development support should be provided to them to incorporate the use of new technologies into their teaching in a meaningful way (Koehler and Mishra, 2009). Research reviews have revealed variation in definitions (Voogt et al., 2013; Janssen et al., 2013; Zhao et al., 2021), although the framework presented by DigiComp project of European Commission is often used. Besides information and collaboration, it emphasizes content creation, safety and problem-solving (Ferrari, 2013). Koehler et al. (2013) found that teachers' digital competence continued to consist of teachers updating the use of different digital devices and technology in educational settings, and Janssen et al. (2013) emphasised that digital competence should be understood as a pluralistic concept with complicated links between its aspects.

Building on (Shulman, 1987) Shulman's work on pedagogical content knowledge (1987), Mishra and Koehler (2006) presented a Technological Pedagogical Content Knowledge (TPACK)

framework that integrated digital technology knowledge with pedagogical content knowledge. TPACK makes it possible to utilise the three different types of knowledge, content knowledge, pedagogical knowledge and technological knowledge, as well as their interaction with each other. The more the three areas overlap, and the more aware teachers are of the complex interactions between them, the more effective teaching becomes when using digital tools, which means that pedagogical methods that make use of technologies can be used constructively to teach content (Koehler and Mishra, 2009).

This article focuses on the technological knowledge of teachers as it is presented in the TPACK model and solidly integrated with pedagogical content knowledge. We refer to this form of knowledge as teachers' digital competence. We acknowledge that TPACK describes only a fraction of the many competences and skills teachers need to be successful in their profession. Pedagogical content knowledge and technological pedagogical content knowledge form only one part of teachers' cognitive skills (e.g., Metsäpelto et al., 2020).

Together with the TPACK model, Esteve-Mon et al. (2020) identified four areas or dimensions of digital teaching competence among university teachers: technical skills related to digitalisation, pedagogical application of digitalisation in teaching and learning processes, pedagogical knowledge and digitalisation in teachers' professional development. The fourth dimension includes the ability to develop students' digital competence. Teachers' technological competence seems to exceed their theoretical or didactical skills in using technology (Tømte et al., 2015). Esteve-Mon and colleagues (2020) found that teachers' basic technical skills in using digital technology were clearly superior to their pedagogical skills in using it. While most university teachers in their study had mastered basic technology in their daily work, the pedagogical use of technology ranged from excellent to poor command. Typically, higher education teachers seem to evaluate their digital competence to be at basic or at medium level (Jwaifell et al., 2019; Zhao et al., 2021).

Teachers' persistent beliefs in their educational practices constitute a key barrier that delays or hinders the integration of new technology into courses (Ertmer, 2005; Vongkulluksn et al., 2018; Sánchez-Gómez et al., 2020; Vongkulluksn et al., 2020). Teacher beliefs can be defined as tacit assumptions about effective teaching methods and student learning that are influenced by ideologies, values and attitudes about teacher education strategies. They refer to subjective theories on how students learn, what a teacher should or should not do, and what instructional strategies are effective (Jääskelä et al., 2017). Teacher beliefs are often supported by subjective experience rather than empirical data or evidence-based knowledge (Pajares, 1992). In terms of digital teaching, teacher beliefs refer to teachers' perceptions of how technology can enhance fulfilment of the instructional goals (Kopcha, 2012).

As disadvantages of using technology in teaching previous studies have recognized lack of interaction and difficulty to teach skills online (Beltran-Sanchez et al., 2020; Torda 2020; Farrokhi et al., 2021) as well as that use of technology is time-consuming and unsuitable technology (Adov and Mäeots, 2021). Positive

beliefs, in turn, support the adoption of digital tools in teaching (Ertmer et al., 2012; Jwaifell et al., 2019; Adov and Mäeots, 2021). Therefore, the mere acquisition of new technology and knowledge does not necessarily lead to the effective use of digital learning environments in teaching (Polly et al., 2010; Vongkulluksn et al., 2020). Teachers' positive attitudes and willingness to use new tools and technologies support the uptake of digital skills and the successful integration of online practices into their teaching (Chen, 2010). Positive attitudes can refer to usefulness of using technology in teaching, better time management and attendance (Beltran-Sanchez et al., 2020). Kim et al. (2013) found that teachers used the same digital technology in different ways based on their beliefs about effective teaching methods and practices.

Previous research shows that the teaching experience is related to teachers' beliefs about teaching (Ertmer, 2005), to higher feelings of efficacy in the use of technology in teaching (Al-Awidi and Alghazo, 2012; Han et al., 2017) and to variation in use of digital tools in teaching (Guillén-Gámez et al., 2021). Moreover, prior experience in online teaching seems to increase willingness to continue teaching online (Shea, 2007). Han and colleagues (2017) observed that pre-service teachers who participated in technology-centred teaching practice received higher scores on technology-related self-efficacy at the end of the practice, despite their teacher beliefs. Thus, their confidence in the use of technology in teaching increased. Even a brief period of pedagogical training can have a positive effect on teacher beliefs (Vilppu et al., 2019), and novice teachers seemingly change their beliefs and concepts faster than experienced ones (Englund et al., 2017).

As previous studies show, teachers' pedagogical training has a positive impact on their pedagogical skills and confidence as teachers (Postareff et al., 2007; Ödalen et al., 2019). In addition, with pedagogical training teachers' thinking can become more learning- and student-centred (Gibbs and Coffey, 2004; Postareff et al., 2007; Light and Calkins, 2008; Vilppu et al., 2019). Technology training is not enough, though, to develop teachers' digital competences, pedagogical training is also needed (Fernández-Batanero et al., 2020). Ideally, technology training and pedagogy training proceed hand in hand.

Besides the intrinsic factors influencing the use of technology, such as competence and beliefs about effective teaching strategies, extrinsic factors play a role in how much and for what purposes teachers use digital tools in their teaching. These factors may include such resources as time, training opportunities and support from institutions, colleagues or students (Marcelo and Yot-Dominiguez, 2019; Guillén-Gámez et al., 2021). In addition, disciplinary differences may exist in the application of digital teaching tools and the digital resources teachers use. Marcelo and Yot-Dominiguez (2019) found that social science teachers used technology for assimilation purposes, such as delivering information and assessment, whereas health science teachers use it for communication purposes, such as interactive digital tools to check how students had understood the material. Guillén-Gámez et al. (2021) study showed that across different academic fields (arts and humanities, science, health sciences, engineering and architecture, social and legal sciences) watching

videos and multimedia were the most commonly used resources, except in arts and humanities. Overall, the amount of research on differences between academic fields in the use of digital tools is rather limited.

In March 2020, the COVID-19 pandemic and the consequent closure of societies were external and sudden factors that forced universities worldwide to immediately transfer their education to online distance learning (Aristonvnik et al., 2020; Cleland et al., 2020; Rose, 2020; Torda, 2020; Shin and Hickey, 2021). University campuses, libraries and learning centres were forced to put a stop to all face-to-face activities, and both teachers and students began working online at home (Marioni et al., 2020). Face-to-face instruction and traditional exams at campus lecture halls were replaced with independent study, webinars, instructional videos and online exams.

Thus, teachers had to quickly adapt their lectures and small-group teaching to better suit online meeting platforms, such as Zoom and Teams. Few teachers had used these platforms for teaching purposes, so for most of them the transition to distance teaching meant learning new practices and using online technology in their daily work. During the pandemic, teachers have learned new online teaching methods, made changes to assignments and exams, and sought to make the amount of work expected of students reasonable (Johnson et al., 2020). At the same time, teachers have expressed a need for more support for their own work to facilitate distance learning and more knowledge about best distance learning practices when working from home (Johnson et al., 2020). Even if teachers were prepared for online teaching and had high confidence in their ability to deliver it, they faced many difficulties in their pedagogical role and in integrating work and personal life (Watermeyer et al., 2021). Teachers should be supported in such disruptive events to ensure that students continue their studies (Ayebe-Arthur, 2017; Kebritchi et al., 2017; Rapanta et al., 2020). Therefore, the transition from face-to-face learning to online distance learning requires that the diverse needs of staff, administrators, students and teachers be identified and that higher education institutions adequately support the transition to high-quality distance learning (Johnson et al., 2020; Inglesias-Pradas et al., 2021; Kovacs et al., 2021).

Drawing from previous research on digital competence and the present state of teachers' digital teaching practices, we define in this study academic teachers' digital competence as a set of skills, knowledge and attitudes regarding the use of information and communication technology (ICT) to facilitate student learning in a pedagogically meaningful way. We recognise that digital competence may also cover teachers' professional development as well as the development of students' digital competence, but they remain outside the scope of this study.

The aim of this study was to examine, using a cross-sectional approach, the digital competence of academic teachers at a time when teaching shifted to digital distance learning at the start of the COVID-19 pandemic. Prior studies have shown that digital tools can be used for several purposes (Häkkinen and Hämäläinen, 2012; Sorva et al., 2013; Myry and Joutsenvirta, 2015; Bond et al., 2018; Marcelo and Yot-Dominiguez, 2019; Guillén-Gámez et al., 2021), albeit teachers may not use digital

tools primarily for pedagogical purposes to improve student learning (Tømte et al., 2015; Bond et al., 2018; Amhag et al., 2019). It has also acknowledged that digital competence is a key factor in the use of digital tools in teaching (Mishra and Koehler, 2006; Janssen et al., 2013; Koehler et al., 2013; Metsäpelto et al., 2020; Zhao et al., 2021). Feelings of competence increase the use of digital tools, but likewise increased use also affects feelings of competence (Marcelo and Yot-Dominiguez, 2019). Thus, we explored the pedagogical purposes for using digital tools and teachers' self-assessed ability to adapt their teaching to fit the needs of distance learning in a situation of sudden and rapid changes in their working environment. In addition, since teachers' beliefs (Ertmer et al., 2012; Kim et al., 2013; Jääskelä et al., 2017), experience (Al-Awidi and Alghazo, 2012; Han et al., 2017) and academic field (Marcelo and Yot-Dominiguez, 2019; Guillén-Gámez et al., 2021) influence their use of educational technology, we investigated how academic field, teachers' pedagogical training, teacher beliefs and experiences with distance learning affected their self-assessed digital competence. Hence, our study sheds new light on the interaction of different variables in explaining teachers' use of digital tools.

Our specific research questions were as follows:

1. For what pedagogical purposes did teachers in different academic fields use digital tools in their teaching?
2. How did the digital competence of academic teachers in different academic fields develop during the early months of the COVID-19 pandemic lockdown?
3. How did changes in teachers' digital competences relate to their pedagogical training, teacher beliefs and experiences with distance learning?

## MATERIALS AND METHODS

Our study examines teachers' digital teaching at a large multidisciplinary university in Finland. The university has eleven faculties on four campuses, and the academic community consists of approximately 4,000 teachers and researchers and 35,000 students. To support high-quality university education, the university has offered its teachers voluntary university pedagogy courses, and a large proportion of teachers have completed at least the basic courses in university pedagogy. In addition, teachers are offered a wide range of e-learning courses and receive personal support in how to implement online teaching and assessments.

In recent years, digitalisation at all levels of education has received significant public support in Finland. In 2017, the university made digital learning one of its most important strategic goals. The aim was to support students as active learners and to increase the versatile use of digital learning environments to replace teaching in traditional classrooms. By 2020, digitalisation had progressed in many faculties and degree programmes. In most courses, teachers used the Moodle online learning environment, but the extent to which it was used to support student learning varied considerably from simply

distributing digital learning materials to implementing most course activities on an e-learning platform. Yet almost all university courses were still conducted as face-to-face courses and only open university courses were mostly designed and implemented as distance learning courses.

## Data and Procedure

The data consist of a convenient sample of 273 higher education teachers from the large multi-disciplinary university in Finland. The respondents filled in an online questionnaire in May/June 2020, to which a link was sent via email. One follow-up reminder was sent. The questionnaire was sent to teaching and research staff in seven faculties, divided into three groups of academic fields: humanities and social sciences (teachers in the faculties of arts, education, theology and law: 47%), health sciences (teachers in the faculties of medicine and pharmacy: 26%) and natural sciences (teachers in the faculty of science: 27%).

The faculties were chosen because they represent different academic fields, both humanistic and natural sciences, and versatile teaching methods (lectures, seminars, exercises, laboratory work, field courses, workshops and practical training). Recipients of the electronic survey were informed that the study would gather information on how teachers had experienced the transition to distance learning and use of educational technology during the lockdown. In addition, we emphasised that besides research purposes, the findings would be used to develop support for the use of educational technology. Participation was voluntary and no compensation was provided. Consent to use the answers for research purposes was requested separately in the questionnaire. Eight of the respondents did not give their consent to use the answers in the study, so the final sample size was 265. The exact response rate was difficult to estimate because the link to the questionnaire was sent to all teaching and research staff members in the target faculties. According to university statistics on teaching and research staff, the invitation to participate was sent to approximately 1920 staff members, and the approximate response rate was 14%.

The questionnaire consisted of demographic questions, questions about what digital tools teachers used in teaching and for what purposes, their beliefs about the use of digital tools in teaching and how respondents assessed their own development in the use of digital tools in teaching during the lockdown in spring of 2020. The questionnaire also included other questions not addressed in this paper. It took about 20 min to complete the survey. See the scales used in this study in the **Supplementary Appendix A1**. The descriptive data on the demographic variables are reported in **Table 1**.

## Measures

Use of digital tools for teaching. We designed a scale for measuring the use of digital tools for teaching based on teachers' experiences with educational technology at the university and earlier research on the purposes for which they use digital tools in teaching (Häkkinen and Hämäläinen, 2012; Deng and Tavares, 2013; Sorva et al., 2013; Myyry and Joutsenvirta, 2015). Respondents were asked to think about their teaching during the past two academic years and answer

**TABLE 1 |** Descriptive information on demographic variables according to the academic field.

		Humanities and social sciences	Health science	Science	Total
		n (%)	n (%)	n (%)	n (%)
Gender	Female	76 (60%)	39 (57%)	22 (31%)	137 (52%)
	Male	40 (32%)	26 (38%)	47 (66%)	113 (43%)
	Other/missing	10 (6%)	3 (3%)	2 (1%)	15 (6%)
Age	20–30 years	2 (2%)	3 (4%)	4 (6%)	9 (3%)
	31–40 years	20 (16%)	15 (22%)	30 (42%)	65 (25%)
	41–50 years	43 (34%)	18 (26.5%)	20 (28%)	81 (31%)
	51–60 years	42 (33%)	18 (26.5%)	11 (16%)	71 (27%)
	over 61 years	17 (13%)	14 (21%)	5 (7%)	36 (14%)
Teaching experience	3 years or under	6 (5%)	8 (12%)	7 (10%)	21 (8%)
	4–10 years	26 (21%)	22 (32%)	27 (38%)	75 (28%)
	11–20 years	37 (29%)	20 (29%)	19 (27%)	76 (29%)
	over 20 years	55 (44%)	17 (25%)	17 (24%)	89 (34%)
Pedagogical training	Not at all	21 (17%)	10 (15%)	23 (32%)	54 (20%)
	1–10 credits	24 (19%)	19 (28%)	20 (28%)	63 (24%)
	11–25 credits	32 (25%)	27 (40%)	15 (21%)	74 (28%)
	26–59 credits	13 (10%)	5 (7%)	8 (11%)	26 (10%)
	60 credits study module	11 (9%)	4 (6%)	5 (7%)	20 (8%)
	more than 60 credits	23 (18%)	3 (4%)	–	26 (10%)

nine questions about how they had used or instructed students to use digital tools in their learning. They were asked to respond using a five-point Likert scale (1 = never; 5 = all the time). For example, “I inform students about the course/studying”, “My students produce collaborative learning outcomes” and “I give feedback and assess students” assignments or use digital tools for peer feedback and assessment.

Using Generalised Least Squares factoring with a Promax rotation, three factors were extracted with eigenvalues greater than one, which accounted for 46% of the total variance. The goodness of fit was  $\chi^2(18) = 27.40$ ,  $p > 0.05$ . The factors were as follows: using digital tools to share/deliver information (three items,  $\alpha = 0.81$ ), using digital tools to activate students (four items,  $\alpha = 0.62$ ) and using digital tools to assess or follow progress (two items,  $\alpha = 0.77$ ). The item ‘I use automatically assessed assignments’ was not loaded on either of the factors.

Competence in distance teaching was measured by asking the respondents to evaluate their distance learning competency at the beginning of the lockdown, on March 16, 2020. Twelve items were selected to represent various distance teaching methods used in the target faculties, such as online lecture streaming, recording video lectures, holding seminars and conducting examinations remotely. Teachers were asked to self-assess their competence on a seven-point scale (0 = no competence; 1 = weak; 2 = passable; 3 = satisfactory; 4 = good; 5 = excellent; 6 = does not concern me). Respondents were then asked to rate their competence in distance teaching for the same items at the moment of responding to the questionnaire (end of May 2020). All “does not concern me” responses were coded as missing values.

Beliefs about distance teaching scale was designed to represent both intrinsic (beliefs about effective teaching strategies and student learning) and extrinsic beliefs (resources). The measure included 13 items representing different aspects of technology use, such as “My students did equally well in distance exams as they did in classroom exams” (reversed),

“Distance teaching weakens teacher-student interaction” and “Distance teaching frees up a teacher’s resources because it is not place-bound”. The responses were measured on a six-point scale (1 = fully disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = fully agree; 6 = does not concern me). Using General Least Squares factoring with a Varimax rotation, four factors were extracted with eigenvalues greater than one, which accounted for 45% of the total variance. The goodness of fit was  $\chi^2(32) = 40.266$ ,  $p > 0.05$ . The factors were as follows: learning suffers with distance teaching (four items,  $\alpha = 0.62$ ), interaction suffers with distance teaching (two items,  $\alpha = 0.69$ ), positive opinions about distance teaching (five items,  $\alpha = 0.61$ ) and distance teaching affects resources (two items,  $\alpha = 0.54$ ).

Pedagogical training was measured with the item “I have taken pedagogical training” using a five-point scale: 0 = not at all; 1 = 1–10 credits; 2 = 11–20 credits; 3 = 26–59 credits; 4 = 60 credits; 5 = over 60 study credits. Credits were calculated according to the European Credit Transfer and Accumulation System (ECTS), where the estimated workload for one credit corresponds to 27 h of study.

Experience with distance teaching was measured with the item “I have given online/distance courses without any face-to-face contact” using a five-point-scale: 1 = never; 2 = for the first time during the lockdown; 3 = sometimes before the lockdown; 4 = often before the lockdown; 5 = regularly before the lockdown.

## RESULTS

The means and standard deviations of the main variables are reported in **Table 2**. The table shows that respondents reported having used digital tools during the previous two academic years mostly for delivering information, followed by assessment and activating students. Since the variances in the use of digital tools

**TABLE 2 |** Means and standard deviations of major variables as a function of academic field.

	Humanities and social sciences (n = 126)	Health science (n = 68)	Science (n = 71)	Total (N = 265)
Delivering information	3.63 <sup>a,b</sup> (0.75)	3.18 <sup>a</sup> (0.80)	3.36 <sup>b</sup> (0.91)	3.44 (0.83)
Activating students	2.07 <sup>a,b</sup> (1.01)	1.53 <sup>a</sup> (0.86)	1.34 <sup>b</sup> (0.82)	1.74 (0.98)
Assessment	2.34 <sup>a</sup> (1.26)	1.72 <sup>a</sup> (1.18)	2.22 (1.27)	2.15 (1.67)
Learning suffers	2.75 (0.72)	2.63 (0.72)	2.72 (0.73)	2.71 (0.72)
Interaction suffers	4.04 <sup>a</sup> (0.92)	3.56 <sup>a</sup> (0.87)	3.96 (0.77)	3.89 (0.69)
Usefulness of distance teaching	3.16 (0.73)	3.00 <sup>a</sup> (0.68)	3.41 <sup>a</sup> (0.69)	3.18 (0.72)
Resources	3.41 (0.93)	3.24 (0.93)	3.43 (0.88)	3.37 (0.92)

Note: For each variable, means that share a superscript are significantly different at the  $p < 0.05$  level or less.

**TABLE 3 |** Competence in remote teaching at the beginning of the lockdown and at the end of May based on academic field and a summary of the Chi-Square tests.

		At the beginning of the lockdown			At the end of May			$\chi^2(4)$
		No competence n (%)	Low n (%)	High n (%)	No competence n (%)	Low n (%)	High n (%)	
Streaming lectures	Hum and Soc Sciences	20 (16%)	35 (28%)	41 (32%)	4 (3%)	23 (18%)	83 (66%)	29.95***
	Health science	10 (25%)	22 (32%)	29 (43%)	2 (3%)	9 (13%)	51 (75%)	16.95**
	Science	12 (18%)	19 (27%)	27 (38%)	4 (6%)	15 (21%)	42 (59%)	29.01***
Recording lectures	Hum and Soc sciences	23 (18%)	37 (29%)	31 (25%)	8 (6%)	31 (25%)	63 (50%)	42.90***
	Health science	12 (18%)	25 (37%)	19 (28%)	3 (4%)	15 (22%)	42 (62%)	22.17***
	Science	12 (17%)	17 (24%)	26 (37%)	6 (8.5%)	18 (25.5%)	34 (48%)	38.74***
Remote seminars	Hum and Soc sciences	12 (9.5%)	35 (28%)	43 (34%)	3 (2%)	14 (11%)	80 (63%)	24.52***
	Health science	9 (13%)	18 (26%)	57 (84%)	1 (1%)	10 (15%)	49 (72%)	14.86*
	Science	12 (17%)	13 (18%)	30 (42%)	3 (4%)	10 (14%)	47 (66%)	16.51**
Remote supervision	Hum and Soc sciences	4 (3%)	26 (21%)	66 (52%)	1 (1%)	7 (6%)	91 (72%)	35.00***
	Health science	4 (6%)	18 (27%)	32 (47%)	3 (4%)	7 (10%)	39 (57%)	19.96***
	Science	3 (4%)	14 (20%)	42 (59%)	2 (3%)	8 (11%)	59 (70%)	65.60***
Remote examinations	Hum and Soc sciences	15 (12%)	32 (25%)	41 (32%)	7 (6%)	27 (21%)	56 (44%)	64.06***
	Health science	10 (15%)	24 (35%)	21 (31%)	3 (4%)	18 (26%)	31 (46%)	18.73**
	Science	11 (15%)	21 (30%)	13 (18%)	7 (10%)	17 (24%)	26 (37%)	33.54***

Note: N varies between 147 and 265 due to the missing variables: \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

variables were not homogenous, we conducted a non-parametric Kruskal-Wallis test to examine whether the use of digital tools differed between academic fields. The tests revealed that the ways in which teachers reportedly use digital tools in teaching varied across the samples: delivery of information  $\chi^2(2) = 27.86$ ,  $p < 0.000$ ; activating students  $\chi^2(2) = 26.96$ ,  $p < 0.000$ ; and assessment  $\chi^2(2) = 10.73$ ,  $p < 0.01$ . The multiple comparisons using a Mann-Whitney test with Bonferroni adjustment showed that respondents in the humanities and social sciences had higher scores in all the variables than respondents in health science (all  $p_s < 0.01$ ) and higher scores in delivering information and activating students than respondents in science (both  $p_s < 0.01$ ). The scores for respondents from the health sciences and science did not differ from each other.

To test whether teachers' beliefs about distance teaching differed across the samples, a multivariate analysis of variance was computed using four attitude factors as dependent variables. The multivariate F (Pillai's Trace) was significant:  $F(8, 462) = 4.04$ ,  $p < 0.000$ ,  $\eta^2 = 0.06$ . The univariate analyses revealed that the belief that interaction suffers and regarding the usefulness of distance teaching were related to academic field: ( $F(2, 233) = 6.47$ ,  $p < 0.01$ ,  $\eta^2 = 0.05$ ) and ( $F(2, 233) = 3.79$ ,  $p < 0.05$ ,  $\eta^2 = 0.03$ ), respectively. The multiple

comparisons showed that respondents from the health sciences thought that interaction suffers less in distance teaching than did respondents from the humanities and social sciences and science ( $p < 0.01$  and  $p < 0.05$ , respectively). The respondents from science perceived distance teaching as more useful than respondents from health sciences ( $p < 0.05$ ).

Based on comments by more than 70% of the respondents, we selected the competence items streaming lectures, recording lectures, remote seminars, remote supervision of dissertations and distance examinations for further analysis. To assess the differences between academic fields, we recoded the competence variables into three categories: 0 = no competence; 1 = low competence (weak, passable or satisfactory) and high competence (good or excellent). Competences in remote teaching at the beginning of the lockdown and at the end of May based on academic field and a summary of the Chi-Square tests are reported in **Table 3**. To prevent chance results due to the large number of analyses, we controlled the alpha level via the Bonferroni adjustment. The table shows that respondents from every field rated their competence in each item more highly at the end of May 2020 than at the beginning of lockdown.

**TABLE 4** | Means and standard deviations of the changes in competence variables.

	Experiences with distance teaching			Total		
	Never M (Sd)	First time during the lockdown M (Sd)	Sometimes/regularly before the lockdown M (Sd)	M (Sd)	Range	n
Change in streaming lectures	0.92 (1.25)	1.37 <sup>a</sup> (1.58)	0.59 <sup>a</sup> (0.89)	1.09 (1.40)	-2-5	214
Change in recording lectures	0.72 (1.28)	1.26 <sup>b</sup> (1.58)	0.53 <sup>b</sup> (0.91)	0.99 (1.41)	-2-5	200
Change in remote seminars	0.56 (1.25)	1.42 <sup>c</sup> (1.64)	0.67 <sup>c</sup> (1.05)	1.08 (1.46)	-2-5	199
Change in remote supervision	0.39 (0.96)	0.58 (1.08)	0.25 (0.86)	0.45 (1.00)	-2-5	198
Change in remote examinations	0.35 (0.74)	0.99 <sup>d</sup> (1.35)	0.38 <sup>d</sup> (0.78)	0.73 (1.17)	-2-5	178
Total change in competences	0.49 (0.72)	1.09 (1.19)	0.47 (0.73)	0.82 (1.07)	-1.4.5	241

Note: Means that share a superscript are significantly different at the  $p < 0.05$  level.

More than half of the respondents reported giving distance teaching without any face-to-face contact for the first time during the lockdown. Sixteen per cent of the respondents reported never having done distance teaching before, while 27% had done it at least once before the lockdown. The item included 11 missing responses. Teachers in the humanities and social sciences reported having the most experience with distance teaching before the lockdown (38%), followed by science teachers (24%) and health science teachers (17%). On the other hand, 23% of science teachers reported having never before done distance teaching, compared to 18% of teachers in the health sciences and 13% in the humanities and social sciences:  $\chi^2(4) = 11.86$ ,  $p = 0.02$ .

The teachers' previous digital competence at the beginning of lockdown affected the competence variables for distance teaching, which varied with experiences in streaming lectures ( $\chi^2(4) = 17.90$ ,  $p < 0.01$ ) and recording lecturers ( $\chi^2(4) = 11.40$ ,  $p < 0.05$ ), showing that more experienced teachers rated their competence as high at the beginning of the lockdown more often than teachers using distance teaching for the first time during the lockdown (38.5 vs. 63% and 32.5 vs. 53%, respectively).

To assess how the change in remote teaching competences related to the other main variables, we calculated a change variable for each competence indicating that the competence score increased or decreased from the beginning of lockdown to the end of May by subtracting one from a competence score of two. The mean change values for distance teaching experiences and the range of change are reported in **Table 4**. We recoded the distance teaching experience variable into three categories: 1 = never, 2 = first time during the lockdown and 3 = sometimes/regularly before the lockdown. Since variances in the competence change variables were not homogenous and the group size differed, we conducted to a non-parametric Kruskal-Wallis test to examine whether the competence change differed based on experiences with distance teaching. The tests revealed that all competences varied in relation to experiences with distance teaching: streaming videos  $\chi^2(2) = 8.97$ ,  $p = 0.01$ ; recoding videos  $\chi^2(2) = 10.50$ ,  $p = 0.005$ ; remote seminars  $\chi^2(2) = 10.97$ ,  $p = 0.004$ ; remote supervision  $\chi^2(2) = 6.23$ ,  $p = 0.04$ ; and remote exams  $\chi^2(2) = 12.37$ ,  $p = 0.002$ . The multiple comparisons using a Mann-Whitney test with a Bonferroni adjustment showed that respondents engaging in distance teaching for the first time

during the lockdown reported a significant increase in their competence more with regards to streaming, recording, holding remote seminars and conducting remote exams than did respondents who had engaged in distance teaching sometimes/regularly before the lockdown (all  $p_s < 0.05$ ).

The Pearson correlations of the change variables and main variables are presented in **Table 5**. Pedagogical training related positively to the use of digital tools, and delivering information was positively associated with changes in competence at streaming and recording videos, holding remote seminars and providing remote supervision, although the relationships were only moderate. Respondents with more positive conceptions of remote teaching reported using digital tools more often in their teaching.

## DISCUSSION

This study has explored the purposes for which university teachers from different academic fields and with different experiences use digital tools for distance teaching, their beliefs about distance teaching and how they evaluate their competence at distance teaching during the COVID-19 lockdown of March-May 2020. Based on previous research on digital literacy, we defined the digital competence of academic teachers as skills, knowledge and attitudes regarding the use of information and communication technology (ICT) in such a way that students learn in a pedagogically meaningful manner.

Most respondents had used digital tools during the previous two academic years mostly for delivering information, followed by assessment and activating students. This result was in line with previous findings that teachers use digital tools mostly for organising their teaching and not for promoting student-centred learning or for pedagogical purposes (Tømte et al., 2015; Bond et al., 2018; Amhag et al., 2019). According to the TPACK model, teachers may possess different levels of content knowledge, pedagogical knowledge and technological knowledge (Mishra and Koehler, 2006). An emphasis on delivering information may indicate that our respondents possess robust content knowledge. The results also reflect the conclusions of previous research (Tømte et al., 2015; Esteve-Mon et al., 2020)

**TABLE 5** | Pearson correlations between the main variables and changes in competence.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Pedagogical training	–												
2. Delivering information	0.19**	–											
3. Activating students	0.23**	0.47**	–										
4. Assessment	0.16**	0.46**	0.45**	–									
5. C1_change	0.08	0.14*	–0.05	–0.02	–								
6. C2_change	0.12	0.15*	–0.05	–0.00	0.74**	–							
7. C3_change	0.17*	0.21**	0.02	–0.00	0.73**	0.64**	–						
8. C4_change	0.04	0.17*	0.02	–0.04	0.43**	0.27**	0.48**	–					
9. C5_change	0.05	0.10	–0.14	0.10	0.45**	0.34**	0.43**	0.38**	–				
10. Learning suffers	0.08	–0.06	–0.11	–0.09	–0.05	–0.14	–0.00	–0.00	–0.08	–			
11. Interaction suffers	–0.02	–0.02	–0.06	–0.06	0.05	0.00	0.03	0.00	–0.02	0.15*	–		
12. Usefulness of distance teaching	0.03	0.27**	0.23**	0.24**	–0.05	0.03	0.04	0.04	0.09	–0.15*	–0.32**	–	
13. Resources	–0.03	–0.17*	–0.17*	–0.07	0.03	0.01	0.03	–0.02	–0.09	0.15*	0.20**	–0.23**	–
14. Experience with distance teaching	0.29**	0.22**	0.31**	0.26**	–0.15*	–0.15*	–0.09	–0.07	–0.09	0.00	–0.02	0.31**	–0.10

Note: *N* varies between 147 and 265 due to the missing variables. C1\_change = change in streaming lectures; C2\_change = change in recording lectures; C3\_change = change in remote seminars; C4\_change = change in remote supervision; C5\_change = change in remote examinations. \*  $p < 0.05$ ; \*\*  $p < 0.01$ .

that teachers' technical skills in using digital technology are generally higher than their pedagogical skills.

Teachers from the humanities and social sciences reported using digital tools more often in teaching than did their counterparts from the other academic fields. They did not differ from science teachers only with respect to the use of assessment in distance teaching. Even though some studies have not observed differences between academic fields (Muñoz Carril et al., 2013), this result corresponds with Marcelo and Yot-Dominiguez's (2019) finding that social science teachers use digital tools for assimilative purposes, but not for assessment. We also identified some differences in teacher beliefs about distance teaching based on academic field: teachers from the humanities and social sciences reported believing that interaction suffers more in distance teaching than did teachers from health science. This finding is somewhat surprising when taking into account the fact that they use digital tools for student activation more than do teachers from the other fields. However, the finding is in line with Marcelo and Yot-Dominiguez (2019) observation that health science teachers used digital tools for communicative purposes, i.e., for interacting with students. Science teachers perceive distance teaching as being more useful than do health science teachers, albeit this belief was not reflected in their use of digital tools.

All our respondents rated their distance teaching competences more highly at the end of May than at the beginning of the lockdown in March 2020, without any differences between academic fields. For the respondents, pedagogical training relates to the use of digital tools and to the change in competence at managing remote seminars, but not to their beliefs about distance teaching. This indicates that stronger pedagogical knowledge (Koehler and Mishra, 2009) is linked to more frequent use of digital tools. However, our findings show that pedagogical training is not associated with the kinds of beliefs teachers hold about distance teaching. Using digital tools for delivering information showed positive, but only moderate, correlation with competencies. Belief that distance teaching is useful likewise showed a relation to all the

purposes of using digital tools for teaching, indicating that positive belief is linked to more frequent use, which corresponds to previous results about teacher beliefs and technology use (Chen, 2010; Ertmer et al., 2012; Kim et al., 2013; Vongkulluksn et al., 2018; Jwaifell et al., 2019; Sánchez-Gómez et al., 2020; Beltran-Sanchez et al., 2020; Vongkulluksn et al., 2020; Adov and Mäeots, 2021).

Lack of experience in distance teaching emerged as a crucial factor for competence change, whereas respondents with previous experience in distance teaching showed no improvement. This result supports earlier findings that experience increases feelings of competence (Al-Awidi and Alghazo, 2012; Englund et al., 2017; Han et al., 2017). However, changes in feelings of competence were not related to teacher beliefs about distance teaching, as earlier studies suggest (Chen, 2010; Kim et al., 2013; Jwaifell et al., 2019). Neither did beliefs that learning or interaction suffer from distance teaching nor beliefs that distance teaching affects teachers' recourses (positively or negatively) correlate with change variables regarding competences, and likewise a positive belief about the effects of distance teaching (i.e., it was perceived to be useful) did not correlate with change variables regarding competences either. Thus, we can conclude that in the kind of external and sudden situation that forces universities to immediately shift their education to online distance learning (Aristovnik et al., 2020; Cleland et al., 2020; Rose, 2020; Torda, 2020; Shin and Hickey, 2021; Watermeyer et al., 2021), teachers' confidence and basic skills at conducting distance teaching increase even if they maintain doubts about the advantages of providing distance teaching, especially for purposes of interaction and learning.

The teachers' experiences with distance teaching were positively related to the purpose of using digital tools. Their experiences also correlated positively with the belief that distance teaching is useful. These results correspond the previous findings (Shea, 2007; Guillén-Gámes et al., 2021) and Pajares (1992) claim that teacher beliefs are often reinforced by subjective experience is at least partly supported by our data.



## Strengths and Limitations

This study faces some limitations regarding the reliability and generalisability of the results. The response rate was difficult to estimate exactly, and the response rate for the questionnaire used in this study remained low. A low response rate is a common problem in research, and it may have affected our results, especially because we do not have information about the teachers who did not respond. However, a low response rate in e-mail surveys is a common phenomenon, and e-mail surveys on average have a 20% lower response rate than do mail surveys (Shih and Fan, 2009). Furthermore, the sample represented the teachers at the target university sufficiently with respect to gender. The representativeness of the sample is a more important criterion for evaluating the validity of a study than the response rate (Cook et al., 2000). The participants included teachers from seven different faculties at a large university. Thus, we were able to gather rich data from different academic fields to obtain a more comprehensive understanding of teachers' competences, beliefs and experiences regarding digital tools. However, the number of respondents varied between faculties, and thus, it was not balanced. This research was based only on teachers' self-evaluation of their competence. Although self-evaluation questionnaires are widely used and have previously proven to be a valid way to assess competences, they are also criticised and cannot be used as objective measurements of skill levels (e.g., Schaeper, 2009; Kyndt et al., 2014; Clements and Kamau, 2017). Self-evaluations might also help us reflect on own strengths and weaknesses (Kyndt et al., 2014). We also used only one measurement time in our study, without a pre-post design. This was due to the sudden changes resulting from COVID-19, and thus, this setting could not be predicted. On the other hand, the situation provided us with a unique possibility to collect data on distance teaching at a comprehensive level. In terms of generalising the results to other context and settings, we can argue that even though generalisations must be made carefully, the COVID-19 situation and the sudden change to remote teaching has challenged teachers and their digital skills all around the world. Furthermore, this study included teachers from various academic fields, implying that the results can be somewhat generalised to the teacher population at the target university. Despite these limitations, our study gives valuable information on teachers' use of and experiences with digital tools, and further, their beliefs about their competences. Further validation of the instrument is still needed.

## Conclusions and Implications for Theory and Practice

In sum, our results indicate that changes in the operational environment have forced a change in teaching practices, which in turn has induced changes in the technical competences of those engaged in distance teaching. The other main finding is that teacher beliefs may not be such a crucial factor in digital teaching practices as previous research indicates, at least in the kind of sudden and rapid situation created by the COVID-19 pandemic.

Our study suggests that pedagogical training should be timely and aligned with changes in the operational environment, and it must provide support for teachers coping with changing situations. For future research, a pre-post design should be used that measures teachers' experiences in more detail. Attitudes should be measured both in pre- and post-tests to explore their predictive power. Moreover, some measure of computer self-efficacy and compute anxiety (e.g., Bellini et al., 2016) could be used. Differences across academic fields imply that the organisational culture and teaching culture also play a role in developing and supporting teachers' digital competence, which should be examined in more detail. For instance, we should examine where teachers receive support for their work and for developing digital knowledge and competence.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

LM: conceptualization, methodology, formal analysis, investigation, writing—original draft.; VK: conceptualization, investigation, writing—original draft.; NK: methodology, investigation, writing—original draft.; SR: conceptualization, investigation, writing—original draft.; TT: investigation, writing—original draft.; HA: investigation, writing—original draft.; PK: investigation, writing—original draft.; AH-M: methodology, investigation, writing—original draft.; EP: conceptualization, investigation, writing—original draft.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2022.770094/full#supplementary-material>

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