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Implications of the imposed and extensive use of online education in an early childhood education program

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Abstract

The COVID-19 pandemic forced universities to engage in a transformation regarding how education is provided. The pandemic led to education being pushed in a new direction regarding digital practices. This paper discusses the implications related to this transformation by asking the following research question: After being subjected to the imposed and extensive use of online education due to the pandemic, what implications can be found when we examine pre-service teachers' digital competence and attitudes towards and use of digital technology? This study is based on data from Norwegian pre-service teachers in their third year of an early childhood education program. Data was collected during the spring semester of 2020 and 2021. The data were subjected to regression and correlation analyses to investigate how the pre-service teachers' use of technology, attitudes and digital competence may have been affected 10 months into this educational transformation. The main difference found between the two groups of pre-service teachers is related to their attitudes and how these attitudes relate to the use of digital technology. Our findings indicate the importance of not neglecting attitude as an important component of professional digital competence. Attitude seems to be the component that is most affected by pandemic-related consequences for education, when looking at the dynamics between use of technology, professional digital competence and attitudes.

Keywords: *attitudes; COVID-19; digital competence; early childhood education program; online education; digital technology*

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Introduction

The COVID-19 pandemic has significantly impacted education. Under complex circumstances, the digital transformation has accelerated, and the pandemic has triggered large-scale changes. Developments that could have taken years occurred in just a few weeks (European Commission, 2020a). As a result of physical distancing measures implemented in response to COVID-19, tertiary education institutions shifted to an emergency online learning format in 2020, and distance education became ubiquitous (Grubic et al., 2020; Kim, 2020). Globally, Aristovnik et al. (2020, pp. 7–8) report that for 86.7% of students, onsite classes were cancelled due to COVID-19. Consequently, various forms of online lectures were established. Real-time video conferences were often applied (59.4%), followed by asynchronous forms of lectures, such as sending presentations (15.2%) and video recordings (11.6%) to students, and written communication using forums and chats (9.1%). The European Commission (2020b) conducted an open public consultation on their digital action plan for digital education, which showed that almost 60% of respondents had not used distance or online learning prior to the pandemic. This indicates a lack of preparedness when online education was imposed. Sixty percent of respondents felt they had improved their digital skills during the pandemic, and 95% of the respondents stated that the pandemic marked a point of no return regarding how technology is applied in education (European Commission, 2020a, p. 6–7).

Peimani and Kamalipour (2021) argue that, for many academics across the globe, the forced immersion into technology-enabled forms of learning and teaching has become a disorienting and unusual experience shaped by panic and duress (Watermeyer et al., 2021). Boer (2021) explains that the responses to the pandemic have resulted in an enormous strain on higher education, and that policymakers, educators, and students have experienced these months as a long roller-coaster ride. Naik et al. (2021) describe how the sudden transition of teaching methods to suit online classes left students and faculties confused. The European Commission (2020a) reports that education systems that had previously invested in digital technology were better prepared to adapt their teaching approaches and carry on education on digital platforms.

From a European perspective, Norway is a nation that has previously invested in digital technology, both economically and in terms of policy. Although digital technology in education has been a political priority since 2006, the digital transformation due to the pandemic was challenging for Norwegian education systems. Following the re-opening of higher education, restrictions regarding group sizes were implemented (Office of the Prime Minister, 2020), and online education was conducted throughout the semester. Changes were implemented in a top-down fashion based on external factors. According to a report from Diku (2021), the rapid changes from traditional to online education in Norwegian education systems were, at times, characterised as chaotic changes and revealed several shortcomings and challenges in Norwegian higher education. From our own experience, this was also the

case for early childhood education at UiT The Arctic University of Norway (UiT), where the data for this article were collected. Lecturers, seminars and even practicums were moved to online platforms due to the pandemic, and both synchronous and asynchronous approaches were applied. Government regulations changed on short notice, and during the semester, educators were forced to change their plans with little time to prepare.

After having experienced a pervasive change in how universities organise education, there are conflicting opinions in the literature regarding the quality of online education. Researchers describe how the pandemic enabled educators to evolve in a digital world (Ferdig et al., 2020). Iivari et al. (2020) claim that this transition is overdue and that education must undergo an extensive digital transformation to meet the needs of the young generation and their digitalised future. Within this perspective, the global crisis could, alongside all its negative aspects, also have some positive aspects, as Bubb and Jones (2020) concluded: Changes required during the crisis can accelerate the improvement of education. Popa et al. (2020) are more critical regarding this educational transformation and claim that distance learning of any nature is not to be regarded as an adequate way to deal with the pandemic. The situation is in other words complex, and the field of research somewhat contradictory.

However, the COVID-19 crisis has accelerated the technological transformation of education and provided a learning experience that must be researched. Exploring the capacity of higher education to adapt in a time of uncertainty has, according to Peimani and Kamalipour (2021), become more important than ever. This article is a contribution to this field of research, presenting findings from two groups of pre-service teachers, one group of pre-service teachers in their last year of the early childhood education program in 2020 and the equivalent in 2021. The results are based on two surveys. The first survey was conducted at the start of the lockdown of society in 2020, and the second was conducted 10 months into the lockdown. This article contributes to a deeper understanding of how this transformation of education and the extensive use of online education could be affecting pre-service teachers' digital practises and attitudes toward digital technology in educational contexts.

Research question

After being subjected to the imposed and extensive use of online education due to the pandemic, what implications can be found when considering pre-service teachers' digital competence and attitudes towards and use of digital technology?

Theoretical background

Online education

Distance education occurs when students are physically separated from the instructor and educational institution and these students are provided with learning experiences to access from remote locations (Yilmaz, 2019). Online education is a form of distance education

characterised by the learning content being delivered to students through digital technology, online course materials, and online interactions. Online learning takes place due to online education (Yilmaz, 2019). There are two main forms of distance education: asynchronous and synchronous. When participants cannot be online at the same time, asynchronous learning supports work relationships among learners and between learners and teachers, while synchronous distance education can occur through live video and/or audio conferencing, synchronous online education can make students feel like participants, and instant feedback can be obtained (Hrastinski, 2008). Kim (2020) states that there are several advantages of online learning, regardless of it being synchronous or asynchronous. For instance, students are not dependent on being in the same physical location, which can increase participation rates. Online learning can also be cost-effective because it reduces the travel and other costs required to attend in-person classes.

The European Commission (2020a) claims that the digital transformation in education is driven by advances in connectivity, the increased use of devices and digital applications, the need for individual flexibility, and the increased demand for digital skills. The digital transformation, therefore, comes with the risk of an urban/rural digital divide, in which certain people can benefit more than others (European Commission, 2020a). It has also been argued that the extensive use of technology hinders students' development of critical thinking, and that students in such settings are less likely to participate in creative and collaborative learning activities, discussions with others, and student-faculty interactions as compared to those in face-to-face settings (Dumford & Miller, 2018; Madsen et al., 2021). Kim (2020) claims that the limitations of online teaching are often due to teachers lacking experience or digital skills.

Nevertheless, when deployed skilfully, equitably, and effectively by educators, digital technology can, according to the European Commission (2020a), fully support the agenda of high-quality and inclusive education and training for all learners. Digital technology can, according to the European Commission (2020a), facilitate more personalised, flexible, and student-centred learning and represent a powerful and engaging tool for collaborative and creative learning. When done skilfully, students can develop their own professional digital competence, both through the content and by observing and engaging in the methods chosen by the teacher educators.

Professional digital competence in education

A recent study by Erstad et al. (2021) shows that the term "digital competence" has become an increasingly complex and confusing concept within the context of education and curricula development, and several conceptual frameworks have been developed to grasp different aspects of this complexity. Erstad et al. highlight three theoretical positions with different perspectives on digital competence: (1) new literacy studies, (2) media cultures, and (3) learning science. This study is positioned within learning science, with a focus on learning. Within

learning science, we initially based our understanding of the term "professional digital competence" on a definition by Tømte and Olsen (2013) and Lund et al. (2014). This coincides with the framework for teacher knowledge for technology integration, called TPACK (technological pedagogical content knowledge), which contains three main components of teacher knowledge: (1) pedagogy, (2) content, and (3) technology (Koehler & Mishra, 2009). In fact, TPACK, as a framework, is internationally recognised as central when teaching with technology (Castéra et al., 2020; Tunjera & Chigona, 2020). The understanding of the concept seems somewhat consistent, both across cultures and over time. The more recent European framework for the digital competence of educators aims to support the development of educator-specific digital competences in Europe (DigCompEdu). This framework is also based on a similar understanding, with added complexity, including both the learners' competence and professional engagement (European Commission, 2021). For future teachers in kindergartens, professional digital competence entails a focus on both learning and play, and the current framework plan for kindergartens (Ministry of Education and Research, 2017) has dedicated a section for digital practices under the heading "work methods":

> Digital practices in kindergarten shall encourage the children to play, be creative and learn. The use of digital tools must support the children's learning processes and help implement the principles of the Framework Plan on creating a rich and varied learning environment for all children.
>
> (Ministry of Education and Research, 2017, p. 44)

Furthermore, it states that digital practice in kindergarten must contain digital judgement and staff must support the children in developing an early ethical understanding of digital media. According to the TPACK framework, to use digital tools to support children's learning processes, the early childhood education teacher requires pedagogical knowledge, knowledge of the content, and knowledge of digital technology (Koehler & Mishra, 2009). These aspects are intertwined with and central to ECE teachers' professional digital competence in kindergartens. Developing pre-service teachers' professional digital competence and attitudes towards digital technology is important for their participation in online education and ensuring young children's well-being during pandemics.

Methods

To investigate the implications of the imposed and extensive use of online education in the early childhood education program, a quantitative survey was conducted from April to May of 2020 and again in February 2021. The target group for both surveys consisted of pre-service teachers in their final semesters of the early childhood education program at UiT. "A survey is a system for collecting information from or about people to describe, compare,

or explain their knowledge, attitude, and behaviour" (Fink, 2003, p. 1). Quantitative methods have traditionally been associated with objectivity, but Sandelowski et al. (2009) are critical of the binary logic often seen in discussions regarding research methods. They claim that quantifying involves qualitative judgements and choices, and that numbers are always affected by and related to a context. When we apply the survey as a qualitative method, we work in line with the notion that both qualitative and quantitative methods are based on subjective empirical material. As Maxwell (2010, p. 477) explains, "the distinction between thinking of the world in terms of variables and correlations and in terms of events and processes" is what separates the two methodological traditions. Using the survey as a method enables a broader understanding because it includes a large number of participants, though it is limited to fewer pre-defined variables.

The theory of action as a framework for constructing the survey

The survey tool was developed to gain insight into the dynamics of digital practices (Madsen & Thorvaldsen, 2019), and Argyris and Schön's theory of action (1978) has inspired the structure of the survey applied in this study. The quantitative design contains three central variables comprised of several individual items: (1) pre-service teachers' expectations regarding the application of digital tools in kindergartens as professionals in the future, (2) pre-service teachers' self-perceived level of digital competence, and (3) pre-service teachers' professional attitudes toward digital tools in kindergarten (see Appendix for constructs).

The theory of action defines a distinction between an individual's espoused theory and theory in use. Espoused theory is the meanings created when people espouse their views, while theory in use is related to acting these views out (Argyris, 1992; Argyris & Schön, 1996). By observing individuals' actions and analysing what rules governs these actions, one is gaining insight into individuals' theory in use. There is a paradoxical relationship between theory in use and espoused theory. Argyris (1992) emphasises that the theories guiding our behaviour are rarely the theories we think we are guided by. A person's espoused theory often differs from what one observes. This discrepancy can occur both consciously and subconsciously. It can therefore be challenging to become aware of the discrepancy between one's espoused theory and one's theory in use due to the complex and often subconscious element of this paradox. Argyris (1992) even claims that individuals are programmed to automatically act in ways that are counterproductive to their espoused theories. In other words, people consistently act inconsistently.

Argyris (1999) claims that inconsistencies between an individual's theory in use and his or her espoused theories are often related to defensive reasoning, such as keeping the premises, inferences, and conclusions that shape their behaviour private. When actions are based on defensive reasoning, these are referred to as Model 1 strategies. On the other hand, consistencies between espoused theories and theories in use are often related to a situation where the theory in use are applied when the governing values are based

on valid information, informed choice, and the vigilant monitoring of the implementation of the choice. This is done to detect and correct what Argyris and Schön refer to as errors, or inconsistencies between the two sets of theories. When there is consistency between the two sets of theories, theories in use are espoused theories, and *vice versa*. Such a situation involves Model 2 strategies. According to Argyris (1999), the challenge when inconsistencies are detected is to help individuals transform espoused theories into theories in use by learning a "new" set of values and skills. The survey was developed to grasp some of the dynamics between elements of theory in use and espoused theories. This was done by constructing variables measuring the use of digital tools and digital competence as an indication of theory in use, as well as measuring attitudes as an indication of espoused theory.

The respondents' application of tools and professional digital competence as measures for theory in use

The pre-service teachers' theory in use was established by asking them to agree or disagree, on a five-point scale, with the following statement: "I will often use digital tools in my future pedagogical work in the kindergarten." When constructing the survey, the term "professional digital competence" was initially operationalised with the use of definitions created by Tømte and Olsen (2013) and Lund et al. (2014). In accordance with these definitions, digital competence is understood as containing three intertwined areas: (1) pedagogic and didactic understanding, (2) subject-specific understanding, and (3) technological understanding.

The respondents' attitudes toward the pedagogical use of digital technology as a measure of espoused theory

The pre-service teachers' espoused theories were established by developing statements related to their attitudes toward technology. Attitudes are seen as central to pre-service teachers' digital practices, as Blackwell et al. (2014) found that attitudes toward the value of technology for pedagogical purposes have the strongest effect on ECE teachers' technology use. This was the result of a study of 1,234 ECE teachers using path modelling to investigate the relationship between the extrinsic and intrinsic factors that influence early childhood educators' digital technology use.

The report *Connected Minds: Technology and Today's Learners* (OECD, 2012) presents technology as something people disagree over. Attitudes regarding technology have been characterised by a continuum between extreme positions, from technology aversion to technology enthusiasm. Statements were prepared to include a range of attitudes through identifying (1) the respondents' motivations for using digital tools, (2) their attitudes towards digital tools' positions in the public arena, and (3) their attitudes toward the use of digital tools in pedagogical contexts with children.

Population and sample

The study is based on data from pre-service teachers in the early childhood education program at UiT. The first round of data was collected from April to May 2020, and 61 of 85 pre-service teachers in their last semester of their bachelor's degree replied to the survey, resulting in a response rate of 71.8%. The second round of data was collected in February 2021. 57 of 80 pre-service teachers in their last semester of their bachelor's degree replied to the survey, resulting in a response rate of 70.4%. Data from both groups were collected via an online survey tool called *Nettskjema*. Nettskjema is a tool for the design and implementation of surveys and online data collection, and it is Norway's most secure and most used solution for data collection for research (University of Oslo, 2021). The survey was administered during lectures and made available over the university's learning management system.

Reliability and validity

The survey was first tested in 2015, when conducting a comparative study of teacher educators in New Zealand and Norway (Madsen et al., 2018), and has also been applied internationally (Jwaifell et al., 2019). Prior and following this, several sets of data were collected in Norway, and all sets of data have been tested for internal consistency using Cronbach's alpha, with satisfying results (Thorvaldsen & Madsen, 2018, 2021). The survey tool and its constructs used in this study have, through extensive testing, proven useful and valid for several pedagogical contexts. We have also used reversed items in the survey to correct for agreement bias (see Appendix). Weijters and Baumgartner (2012, p. 737) describe this as follows:

> First, reversed items implicitly correct for acquiescence or agreement bias, particularly if the scale is balanced (…). Second, reversed items may act as cognitive "speed bumps" (Podsakoff et al. 2003) and disrupt nonsubstantive response behavior. Third, reversed items can improve scale validity by broadening the belief sample on which responses are based.

Reversing some of the items has been shown to be related to lower reliability, but removing the reversal would, according to Weijters and Baumgartner (2012), merely create a false sense of security. "While dropping reversed items may improve the reliability of the resulting scale and lead to simpler factor structures, these desirable internal psychometric properties may simply signal mindless and mechanical repetition of responses" (Weijters & Baumgartner, 2012, p. 737).

Cronbach's alpha was calculated to gain insight into the level of internal consistency within the two constructs (see Table 1), and the results were found to be sufficient to conduct further statistical analyses. This is viewed as the most appropriate measure of reliability when applying Likert-scale statements (Taherdoost, 2016).

Table 1. Cronbach's alpha as a measure of internal consistency.

	2020	2021
Professional digital competence	0.676	0.754
Professional attitude	0.721	0.706

Results

Comparing means

When comparing means between the two sets of data, there is a difference between the group of pre-service teachers at the start of the pandemic and the group of pre-service teachers who had attended 10 months of predominantly online education (see Table 2).

Cohen's d is a measure of effect size, which refers to differences in or changes between two groups. He defined effect sizes as small, medium, or large (d = 0.2, d = 0.5, or d = 0.8) (Cohen, 1988; King et al., 2011). Based on Cohen's d, there is a small to medium effect on pre-service teachers' perceived digital competence when comparing the two groups (–0.31). Pre-service teachers' attitudes regarding digital technology in an educational context are almost identical when examining the mean scores of the two groups (d = 0.02). With a mean of 3.53 in 2020 and 3.54 in 2021, the pre-service teachers in the two groups are, in general, positive regarding digital technology in pedagogical contexts. The 10 months of online education have seemingly not affected the pre-service teachers' attitudes when exclusively comparing mean values. When analysing the pre-service teachers' responses to the statement "I will often use digital tools in my future pedagogical work in the kindergarten", pre-service teachers in both groups generally agreed with the statement. When comparing the results, there is hardly any effect (see Table 2).

Correlation between professional application of use, professional digital competence, and professional attitudes

The correlation analyses conducted revealed interesting differences between the two groups (Table 3). The correlation between the application of digital tools and professional digital competence (PDC) is lower within the group who responded 10 months into the pandemic

Table 2. Pre-service teachers' digital competence, professional attitude toward, and professional use of digital technology in the initial phase of COVID and 10 months into the pandemic.

List of constructs and variables	Scale	2020 Mean (SD)	2021 Mean (SD)	Effect size (d)
Professional Digital Competence (c)	1–5	3.72 (.58)	3.53 (.64)	–0.31
Professional Attitude (c)	1–5	3.53 (.59)	3.54 (.53)	0.02
I will often use digital tools in my future pedagogical work in kindergarten	1–5	4.03 (.90)	3.84 (1.09)	–0.19

The table also shows the effect size (Cohen's d)

Table 3. Pre-service teachers' digital competence and professional attitude correlated with the professional use of digital technology.

Pearson correlation	Professional digital competence	Professional attitude
I will often use digital tools in my future pedagogical work in the kindergarten	.574** (2020)	.499** (2020)
	.435** (2021)	.102 (2021)

Correlations are shown for each year separately. *Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).

Table 4. Professional attitude correlated with professional use of digital technology (Item: I will often use digital tools in my future pedagogical work in kindergarten) among Norwegian teacher educators and pre-service teachers over time.

Target group and year	Pearson correlation	P-value (N)
Pre-service teachers (2021)	.102	.450 (57)
Pre-service teachers (2020)	.499**	.000 (74)
Teacher educators (2020)	.316**	.004 (83)
Teacher educators (2015)	.448**	.000 (64)

*Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).

(r = .435**). When we consider pre-service teachers' attitudes, the results are more surprising. The correlation between the application of technology and attitudes is also lower, and the results are, in addition, not statistically significant for the group surveyed in 2021 (r = .102, p = 0.45). Although there is hardly any effect size between pre-service teachers' attitudes in relation to the means, the pre-service teachers' attitudes in 2021 are not statistically significantly correlated with their use of technology.

The non-significant results stand in contrast to prior data collections with the survey tool (Madsen et al., 2018; Thorvaldsen & Madsen, 2018). Collected data have previously shown a strong statistically significant correlation between the application of tools and attitudes when compared with both teacher educators' and pre-service teachers' use of digital technology over time.

There are some limitations regarding the parallels drawn between results from pre-service teachers and teacher educators, but the consistencies in significant correlation over time indicates that the survey contained a solid reliable construct for both target groups until 2021.

Regression analyses: Professional application of use, PDC, and attitudes

When we attempt to predict the professional application of digital tools (Table 5), the best predictor is PDC in both groups, both in the initial phase of COVID (Beta = .43**) and for the group with 10 months of online education experience during the pandemic (Beta = .45***). It appears from these analyses that the influence and contribution of PDC became slightly more dominant during COVID. At the same time, the self-perceived PDC is somewhat lower for this group of pre-service teachers (Table 1).

Table 5. Standardised linear regression coefficients to predict the professional application of ICT technology with the use of the item "I will often use digital tools in my future pedagogical work in kindergarten".

Data collected		Attitudes	PDC
2020	Use =	0.27** (p = 0.012)	0.43*** (p = 0.000)
2021	Use =	–0.05 (p = 0.655)	0.45*** (p = 0.001)

**Significant at the 0.01 level (two-tailed). ***Significant at the 0.001 level (two-tailed).

Table 6. Explanatory power of the predictors of professional attitude and PDC when exploring pre-service teachers' expected use of digital technology as professionals.

	Year	Attitude	PDC
I will often use digital tools in my future pedagogical work in kindergarten.	2020	23.9%***	32.0%***
	2021	0.8%	17.5%***

**Significant at the 0.01 level (two-tailed). ***Significant at the 0.001 level (two-tailed).

The adjusted R-square for the multiple regression model in Table 5 is 0.370 for the initial phase COVID model (2020) and 0.162 for the group with 10 months experience with the COVID situation (2021). This indicates that 37% and 16.2%, respectively, of variation in the output variable ("I will often use digital tools in my future pedagogical work in kindergarten") can be explained by the two predictors in the model. This means that PDC and attitudes have less of an impact on pre-service teachers' predicted use of digital technology in the group that experienced 10 months of online education by over a 20% difference. Furthermore, attitude is not a statistically significant predictor of pre-service teachers' expected use in 2021. This is surprising not only due to previous survey results but because, as mentioned above, research has indicated that attitude is central to early childhood teachers' use of technology (Blackwell et al., 2014).

To understand how attitude and PDC affect one another, separate standardised linear regression analyses were conducted. When analysed individually, the adjusted R-square for PDC is 0.175 (p = .001). This indicates that 17.5% of variation in the output variable (I will often use digital tools in my future pedagogical work in kindergarten) can be explained by the pre-service teachers' PDC. The adjusted R-square for pre-service teachers' professional attitude is –.008 (see Table 6). This indicates that only 0.8% of variation in the output variable can be explained by the pre-service teachers' professional attitudes, but the results are not statistically significant (p = 0.450).

Discussion

One of the obvious differences between the prior survey and the survey conducted in 2021 is that the group of pre-service teachers surveyed in 2021 had experienced 10 months of the educational transformation due to the pandemic. For some of the pre-service teachers

in 2021, their experience has been exclusively online because mandatory attendance was removed during these months, and some even chose to complete their practicums through digital technology to limit the risk of catching and spreading the virus.

The decline in the mean score for professional digital competence (Table 2) is difficult to explain because the teachers gained experience with digital technology during the ten months of extensive online education. It is reasonable to relate this to the change in context rather than an actual decline in competencies. How one assesses one's abilities will always be related to context, and the context changed drastically during those 10 months. Being a pre-service teacher 10 months into the pandemic would require a higher level of digital competence due to the variety of tools and the more extensive use of digital technology.

When considering the pre-service teachers' attitudes, one could expect a decline in the mean score regarding how positive or critical the pre-service teachers perceived the use of digital technology to be. This is based on concerns regarding how students have been coping with the educational transformation, how individuals are often critical toward changes, and resistance to change is often the reason for the failure of organisational change (Darmawan & Azizah, 2019). Both the level of attitude and expected use of digital technology has been quite stable over the ten months, with very low effect size ($d = 0.2$ and $d = -0.19$). What is more interesting is the change of dynamics between the different constructs.

Correlation and regression analyses

The correlation analyses show a statistically significant and positive correlation between the pre-service teachers' application of tools and their professional digital competence and attitudes in 2020. For the group in 2021, there is only a statistically significant, positive correlation when comparing use with professional digital competence. The pre-service teachers' professional attitudes are not significant correlated with use after 10 months of online education (Table 3). The regression analyses lead to similar findings. For the group in 2020, both professional digital competence and attitude are statistically significant predictors of the future application of digital technology. For the group in 2021, only professional digital competence is a statistically significant predictor of use. For this model, the pre-service teachers' attitudes are not a predictor of their future application of digital tools.

The lack of a significant result regarding the dynamics between professional attitudes and the use of tools in pedagogical contexts could indicate that the digital transformation has been a chaotic and frustration time for pre-service teachers, affecting the dynamics of digital practices. A conceptual framework for analysing adaptive capacity presented by Pahl-Wostl (2009) provides an understanding of the structural characteristics of a governance regime, the nature of policy and learning processes, how structure is influencing processes, and how processes lead to a change in structure. The framework is derived from the concept of double-loop learning, created by Argyris and Schön (1978), and has become quite popular in management theory in terms of guiding the conception and practice of

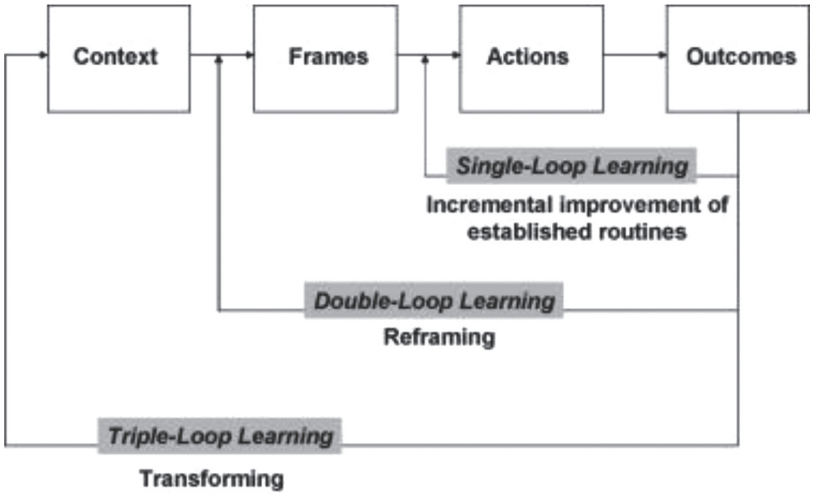

Figure 1. Sequence of learning cycles in the concept of triple-loop learning (derived from Hargrove in Pahl-Wostl, 2009).

managing change in organizations (Hargrove, 2002; Pahl-Wostl, 2009). The addition of the triple-loop concept represents an attempt to refine the influence of governing variables in terms of governing assumptions and governing values (Pahl-Wostl, 2009).

Pahl-Wostl (2009, p. 359) explains how "single-loop learning refers to an incremental improvement of action strategies without questioning the underlying assumptions. Double-loop learning refers to a revisiting of assumptions within a value-normative framework". The added element of triple-loop learning explicitly includes the context, reconsidering underlying values and beliefs if assumptions within a worldview do not hold anymore. These levels of learning can also be associated with theory in use and espoused theory, where double-loop learning is associated with Model 2 strategies, meaning that there is consistency within an individual's theories of action.

During a pandemic, contextually imposed governing variables, such as social distancing, do not necessarily match assumptions related to educational quality. Mandatory requirements and necessities led to behaviour changes, not necessarily changes in pre-service teachers' espoused theory. When individuals' espoused theory and theory in use are aligned, this is often because their theory in use builds on valid information, informed choice, and vigilant monitoring, which means detecting and correcting errors. In these cases, the theories in use are espoused theories. This has not been the case for the technological transformation due to the pandemic, because the transformation did not include elements of choice. Argyris (1999) claimed that learning mainly occurs via individuals changing their espoused theory first and theory in action second. In this case, it seems that pre-service teachers have had to change their theory in use due to external factors, without the change being based on the pre-service teachers' espoused theories. A double-loop learning process, in which espoused theories are more aligned with theory in use, seems to require more time.

Smith et al. (2021) write that society will not return to pre-COVID-19 ways of teaching, but combining digital technology with existing pedagogical visions will be challenging. It seems, to a certain degree, that both pre-service teachers and educators in higher education manage the crisis in what can be regarded as survival mode, adjusting their actions without having time to adapt to the context and establish connection between their pedagogical values and visions.

Pahl-Wostl (2009, p. 359) writes that "the multiple-loop concept for learning is compelling since it takes into account the different levels that provide guidance and stability in a social system at increasing time scales for change". In our study, the multi-loop concept for learning is used as a framework for understanding how contextual variables can also provide a lack of stability and overrule established governing assumptions. The transformation of education has forced pre-service teachers from single-loop learning processes to double-loop processes, in which the underlying premises of online learning are questioned and attitudes do not appear to be coherent because the context has limited educational practices. The dynamics between attitudes, professional digital competence, and the professional application of digital tools are not as predictable and coherent as the established dynamics seemed to be in the group assessed at the start of the pandemic.

The context and how to address it

This unique situation with regard to extensive online education revealed opportunities for teachers to organise their teaching differently and interact with students on a more personalised basis (European Commission, 2020a). At the same time, many experienced shortcomings in the system and a widespread lack of digital readiness. In its digital education action plan for 2021–2027, the European Commission (2020a) states that a key aspect of digital education is the need to equip all learners with digital competences, understood as knowledge, skills, and attitudes. Unfortunately, at the moment, there is no national agenda for research on digital competence in Norway, even though the development of digital competence is becoming an increasingly complex concept (Erstad et al., 2021).

What seems to be central when working with the educational transformation is focusing on attitudes and how pre-service teachers espouse their views regarding digital technology in educational settings. From the perspective of organisational theory, change management has a poor track record (Karp & Helgø, 2009). Failure related to change processes often occurs because leaders do not understand the complexity they are facing. Karp and Helgø (2009) claim that this management challenge is related to the nature of human beings and how we tend to react to change. In Karp and Helgø's view, the solution is not the training of skills but the training of one's mindset, emotions, values, and assumptions. Peimani and Kamalipour (2021) argue that reflecting on the early experiences of managing uncertainty and emergencies can contribute to more nuanced approaches to learning

and teaching. They also emphasise that such changes can help enhance the resilience of higher education in the face of public health crises. Based on our study, we find that, when educating future teachers, it is important to focus on pre-service teachers' attitudes, values, and assumptions, as well as their technological skills, especially in times of educational transformation. If the governing variables are in the process of changing, this may be part of a more extensive digital transformation that is needed in today's education of young children. As we move beyond the unplanned emergency phase imposed on the education system, it is crucial to build on new experiences and define a strategic and long-term approach to digital education and training.

Conclusion

The implications of being subjected to the imposed and extensive use of online education were mainly related to pre-service teachers' professional attitude. What stands out is how pre-service teachers' attitudes, as part of the dynamic of digital practices, seem to have been strongly affected by the digital transformation of education. The experience with online education also seems to have generated a decrease in pre-service teachers' perceived professional digital competence (d-value = −0.31), which could be a result of the contextual differences related to the two groups of pre-service teachers and the insights achieved during the period of digital transformation. It is a reasonable assumption that having to teach and study in these new online settings could make pre-service teachers question their own digital competence without an actual decline. When considering the mean score for pre-service teachers' attitudes, there are hardly any changes during the educational transformation (effect size = 0.02), but the correlation and regression analyses show that pre-service teachers' professional attitudes were once a predictor with high explanatory power. For the group in 2021, this predictor is non-significant. Pre-service teachers' attitudes are almost the same when comparing the means between the two groups, but the correlation and regression analyses support the notion of a mismatch between theory in use and espoused theories for pre-service teachers ten months into the transformation.

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Appendix

Reversed scales denoted as REV

Application of tools

- I will often use digital tools in my future pedagogical work in kindergartens.

Professional digital competence

- I am familiar with digital tools that can help diversify activities when working with children's play, learning, and development.
- I am, in general, confident when using digital tools.
- I find it easy to become familiar with new digital tools.
- I can use digital tools according to premises in early childhood education when working pedagogically with children.
- It is difficult to use digital tools as a pedagogical resource in kindergartens. REV.
- When I am using digital tools, it is difficult to adjust the content to the individual child's needs. REV.
- I have no clear idea of learning outcomes when using digital tools in my pedagogical work with children. REV.
- I use digital tools when assessing the child's development.

Professional attitude

- When I use digital tools in the kindergarten, I find it adds value to the pedagogical work.
- The use of digital tools is essential for good pedagogical programs in kindergartens.
- Society's expectations regarding the impact of digital tools are exaggerated. REV.
- Expectations related to the use of digital tools in kindergartens frustrate me. REV.
- In professional debates at my university, the expectations for the impact of digital tools are exaggerated. REV.
- The use of digital tools disrupts the relationship between the child and the early childhood teacher. REV.
- Digital tools can make children more interested in the planned activity.
- I like testing new digital tools in my pedagogical work in kindergartens.