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Decoding the Digital Gap in Teacher Education: Three Perspectives across the Globe

Steinar Thorvaldsen and Siri Sollied Madsen

Abstract

Educational use of technology is regularly assessed, and results often show a gap between educational policies and what is actually practiced. This chapter will help clarify how teacher educators experience the changing educational contexts due to the digital revolution, how their meaning-making shifts, and how outside forces influence those processes. The results are based on comparative international studies. Central for this study is practitioners' professional digital competence, their attitudes towards digital technology and the use of digital technology in education. We found that the influence and contribution of digital practice is carried out quite differently across the globe. Our research questions were: How do practitioners experience teaching in a rapidly changing context? How do attitudes change due to top-down governing of education? and What motivates teacher educators to implement digital technology?

Keywords: professional digital competences, digital attitudes, educators, digital gap, theory of action, political governing

1. Introduction

Societies are gradually becoming a world of digitally rich environments, which includes classroom practice, home equipment and private pocket devices. Digital technologies are deeply transforming what it means to be literate, and digital competence is considered a vital aspect of education that organizations should systematically improve [1]. Educational technologies have brought about many changes in the teaching and learning environment in our schools. While application of appropriate technological processes and the use of ICT facilitates learning, there is an ongoing debate about the usefulness of technology. This chapter attempts to illuminate some of the tensions in this debate.

The global situation within higher education changed drastically in 2020. A public survey in Europe on the impact of the Covid-19 crisis found these results [2]:

- 60% of the respondents had not used online learning before the crisis.

- Over 60% felt that they had improved their digital skills during the crisis and more than 50% of respondents want to do more.

- 95% consider that the Covid-19 crisis marks a point of no return for how technology is used in education and training.

The respondents also said that online learning resources and content need to be more relevant, interactive and easy to use. Preparing teacher students to use ICT is an enduring focus in teacher education, an issue that has been accelerated by the school closures during the Covid-19 crisis and the transfer to remote teaching. The new European Digital Education Action Plan (2021–2027) [2] outlines the European Commission's vision for high-quality, inclusive and accessible digital education in Europe. It is a call for action towards stronger cooperation at the European level to learn from the Covid-19 pandemic, during which technology is being used on an unprecedented scale in education and training, and make education and training systems fit for the digital age. The new action plan has two strategic priorities: (a) fostering the development of a high-performing digital education ecosystem and (b) enhancing digital skills and competences for the digital transformation.

In this situation, it is of great importance to understand academics' perceptions and professional usage of digital technologies in higher education. The digital revolution may be technologically inevitable; however, research shows that access to digital tools are less important for students' learning than how teachers use them across subjects [3, 4]. Krumsvik [5] even argued that one are still in the infancy of understanding how digital technology might contribute to the field of education, and Elstad [6] asserted that educational technology so far has raised several false expectations. Moving to the next phase of implementing education technology (EdTec), the question becomes: How can we improve on what we have learned?

Research has shown that the integration of ICT into academic pedagogic practice is a complex process [7, 8]. Teaching and learning are in themselves complex processes, and ICT integration should not only focus on academics' knowledge of technology, pedagogy and curriculum, but also consider academics' attitudes. Against the multitude of important issues to be considered within EdTec, the research identifies academics' *attitudes* as the most important element [9, 10]. Hence, it is not merely the nature of the technology itself, or the access to technology, that promotes or prevents good use of technology, but academics' beliefs and attitudes are essential and at the heart of the process.

The purpose of this study is to explore how teacher educators make the pedagogical shift in their use of ICT. Teacher education is of special interest because it plays a double role concerning technology. It is a learning organization, and at the same time, the object of study and research is learning itself. Teacher educators are, to a large extent, role models reflecting the practice of EdTec, using technology by design, collaboration with peers, scaffolding authentic experiences and continuous feedback [11, 12]. A teacher educator who uses digital tools for the enhancement of learning also prepares pre-service teachers for how digital tools can be used in their future work [13, 14]. Creating good-quality teacher education in digital arenas embraces the needs of children, schools, technology, and the curriculum.

This chapter describes the situation from countries with quite different educational cultures and presents some recommendations that may contribute to an interactive development of integrating digital technologies within a learning organization.

2. Conceptual framework

The studies in this chapter are based on the 'theory of action' by Argyris and Schön [15, 16], which is widely used in organizational theory to describe the relationship of people in learning organizations [17]. The descriptive framework serves as a methodological instrument for the systematic analysis of learning organizations at the meso level (between macro and micro level). This approach begins

by defining a concept of humans as action makers, and the theory explains the mechanisms by which we connect our thoughts to our actions. Human beings can take action for a stimulus if they have the attitude and the competencies they need. The theoretical framework offers an analytical distinction between espoused theory (attitudes towards digital technology), and theory in use (digital competence). Espoused theory is the theory of action, which is used to explain or justify a particular pattern of activity. In other words, espoused theory can be understood as the attitude of an individual or an organization towards practices. The theory in used is defined as the theory of action implicated in carrying out this pattern of activity, in other words, the practical action of competence. As described by Argyris and Schön [16], the applied organizational theory can be tacit rather than explicit. The tacit theories in use do not necessarily match the organization's espoused theory. The formal documents of an organization, such as such as policy statements or job descriptions, often contain espoused theories of action that are not compatible with the actual pattern of activity of the organization [16]. The mechanisms can occur both consciously and subconsciously; determining the discrepancy between the espoused theory and the theory in use may be challenging.

The study assesses the following three different constructs: the teacher educators' level of professional digital competence (PDC), attitudes towards digital technology in education and the application of digital technology in educational contexts. In the appendix of this chapter, details of the questionnaire are presented. Briefly, the three terms can be described like this:

Professional digital competence (PDC). The concept of PDC is a central element in discourses about teachers' proficiency in using ICT [18–20]. PDC refers to aspects of teachers' work related to the teaching profession that extend beyond subject knowledge. PDC is not limited to classroom teaching, for example school-home communication, online feedback and assessment, classroom management in technology-rich classrooms and how a teacher approaches her/his own continuous professional development in the use of ICT. Subject-related digital competence deals with the particulars of every subject and how each can be taught with and through technology. This may include the use of modeling and simulations. The term is a moving target in the sense that it evolves rapidly in line with the emergence of new technologies.

Espoused theory. Items were prepared based on the OECD report 'Connected Minds: Technology and Today's Learners' [21] and its description of the field's existing attitudes towards technology to understand teacher educators' professional attitudes (their espoused theories). In this chapter, the field is characterized by a continuum from being technology averse to being technology positive. Statements were created to determine respondents' own motivations for using digital tools, their attitudes towards the position of digital tools in the public domain and their attitudes towards the use of digital tools in the classroom. Were prepared to identify the respondents' own motivations for using digital tools, their attitudes towards digital tools' position in the public arena and their attitudes towards the use of digital tools in teaching.

Professional application of tools. This shows the magnitude to which the participants used digital tools and work procedures in their teaching for the past year (i.e., the *digital performance* within the organization). The construct consisted of 16 single items on digital tools/work methods applied in teaching during the past year.

2.1 Single-loop learning (SLL) and double-loop learning (DLL)

A central and comprehensive topic in Argyris and Schön's learning theory is the connection between learning, change and resistance to change. It defines two models, namely single-loop learning processes (SLL, often called Model I) and
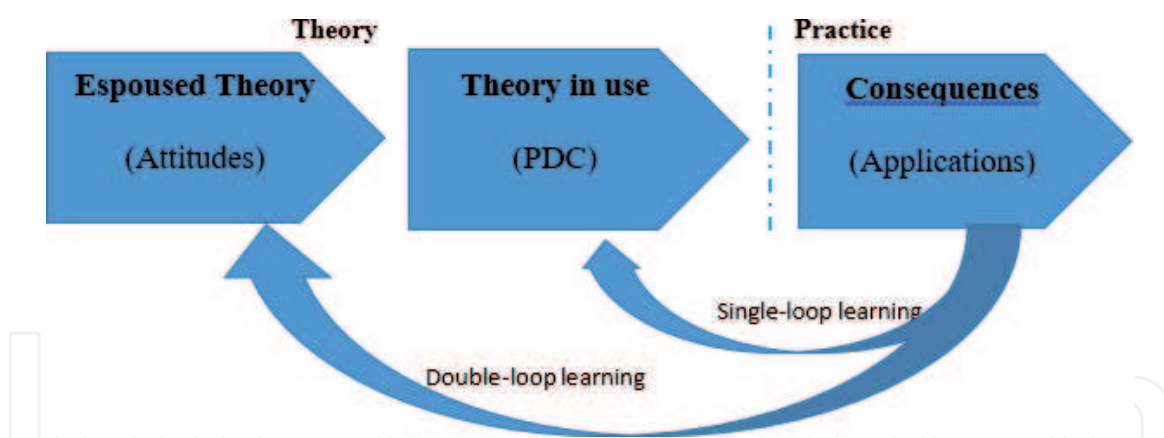
Figure 1.
Single-loop learning (SLL) and double-loop learning (DLL) processes. Adapted from [15]. Organizations that only stress SLL operate within a so-called SLL trap.

double-loop learning processes (DLL or Model II), to highlight organizational learning potential. The models are illustrated in **Figure 1**.

SLL processes involve following the routines and some sort of pre-set plan. This is less risky for the individual and the organization as well as affords greater control. It may also be characterized as a technical way of thinking. SLL seems to be present when aims, values, frameworks and strategies are taken for granted, with only minor updates. The emphasis is on techniques being made more efficient. Any reflection has the same goal. This chapter links SLL with PDC.

DLL processes, by contrast, are more creative and reflexive, as they involve the consideration of notions about what is good. Reflection here is more fundamental. First, the basic assumptions behind ideas or policies are confronted and challenged. Second, hypotheses are publicly tested. Third, the processes are challenging, not self-seeking and have organizational goals. The governing aim includes valid information and internal commitment. DLL involves questioning the role of the framing and learning systems that underlie the actual goals and strategies [15, 16]. Here, DLL is linked with professional attitudes.

The study applies Argyris and Schön's [16] definition of a learning organization to be the 'ability to see things in new ways, gain new understandings, and produce new patterns of behaviours—all on a continuing basis and in a way that engages the organisation as a whole'. Learning within teacher education is a dynamic process, not a prescriptive checklist of best practices [22]. Argyris describes what he calles 'SLL traps' as patterns of values, behaviors and outcomes that 'make it difficult to produce the learning that is required to generate fundamental change' [22]. To be a learning organization means having a culture cantered on DLL processes and staying resilient against the SLL traps that may emerge in the organization [22, 23]. When SLL traps are formed in a DLL organization, there is a growing dissonance. Organizations that focus on innovation learning are more likely to develop a learning culture in SLL and DLL. The motivation in DLL has to be developed in line with the required pedagogy of the organization.

2.2 The study objectives

This chapter seeks to increase the understanding of how the technological revolution and its impact on education can be understood from a practitioner's point of view. It elaborates further the complexity behind the observed mismatch between policies and the use of digital technology in teacher education. Our study addressed the following three research questions:

1. How do teacher educators and teacher students perceive their PDC, professional attitudes and professional use of tools in teaching?

2. Is it possible to predict the extent of digital technologies used in teaching through the degree of PDC and attitudes?

3. What is the relationship of SLL and DLL with digital performance in the organization's learning processes?

We hypothesized that there is no significant positive relationship between SLL and DLL and organizational learning performance among the respondents. The examination of causal relations is based on Argyris and Schön's theory of action.

3. Materials and results

The materials in this chapter are based on information from both quantitative and qualitative studies. Previous quantitative studies [24, 25] examined different strategies to implement digital technology in teacher education based on Argyris and Schön's theory of action. In these studies, the researcher applied samples from academic staff in three countries: Norway (N = 67, response rate 83.8%), New Zealand (N = 47, response rate = 73.4%) and Jordan (N = 107, response rate = 31%). The study from Norway was carried out at the University of Tromsø at the Department of Education, the study from New Zealand from the University of Waikato Department of Education and the Jordanian study was carried out at Al-Hussein Bin Talal University in Ma'an, a poor-environment area of Southern Governorate with lectures from the Faculty of Educational Sciences. All participants answered the questionnaire (Appendix 1) based on Argyris and Schön's theory of action. The items were collapsed into three multi-item constructs, as described in Section 2. All three constructs showed acceptable reliability values, with Cronbach's alpha coefficients between 0.71 and 0.88. The construct describing 'use of tools' had to be modified in Jordan, according to the common types of software available for academics in the university's computer centre.

What is the level of ICT use, PDC and attitudes in teaching and learning among lecturers in the university under study? **Table 1** shows the mean and standard deviation of the multi-item concepts in teaching during the past year. The highest score on PDC was in Norway, while New Zealand scored highest in 'use' (2.99 = occasional use when teaching) and on 'professional attitudes'. The samples from New Zealand and Norway are representative data and may be tested for statistical differences. Both the difference in PCD and in 'use' proves to be statistically significant with p-value = .045 and p-value<0.001, respectively.

	Attitudes Mean (SD)	PDC Mean (SD)	Use Mean (SD)
Jordan	3.25 (.90)	3.55 (1.20)	—
New Zealand	3.37 (.62)	3.71 (.69)	2.99 (.53)
Norway	3.00 (.73)	3.91 (.76)	2.59(.54)

Table 1.
Self-perceived results from Jordan, New Zealand and Norway. The variable describing 'use of tools' had to be modified in Jordan, and the results cannot be compared directly with the other countries.

The regression analysis conducted for each country (**Table 2**) reveals interesting differences and showed that the degree of using digital technology tools can be predicted statistically. In Norway, the best predictor was 'professional attitude' (Beta = .282, p-value = .003), while the best predictor in New Zealand was 'PDC' (Beta = .363, p-value = .002). It appears from this analysis that the influence and contribution of digital practice is carried out quite differently in the two countries. In Norway, the professional use or application of digital tools is dominated by professional and autonomous attitudes, while in New Zealand it is dominated by PDC. At the same time, PDC is somewhat lower in New Zealand than in Norway, but the professional application of digital tools is significantly higher.

The results in **Tables 1** and **2** provide answers to our first two research questions. To address the third research, the study had to go one step deeper in a qualitative analysis of interviews with the academic staff in New Zealand and Norway [26, 27], to explore closer how curriculum and motivation are affected by educational policy and strategies.

One difference between Norway and New Zealand is what educational traditions their curricula for schools are based on, as shown in **Table 3**. In 2006, Norway was the first country in Europe with a curriculum based on digital skills [28]. Norwegian schools operated with a set of five basic skills seen as fundamental to all learning at all levels through school: oral skills, reading, writing, numeracy and digital skills [29]. Such skills are often referred to as the 3Rs – reading, writing and arithmetic, and traditionally, they have been considered the foundations of learning. Nowadays, the 3Rs alone are not enough to provide students with the skills needed to function in the 21st century [30]. The New Zealand curriculum had to a greater extent, integrated the notion of the 4Cs as central to 21st century skills: critical thinking, communication, collaboration and creativity [31]. This is just a small excerpt of the two curricula, and they both include the 3Rs and the 4Cs, but they are not equally in focus when comparing the two sets of formal documents.

Both the Norwegian and New Zealand teacher educators expressed a concern regarding the political pressure they are experiencing. The New Zealand teacher educators fear a potential political movement towards a more skill-based curriculum and

		Attitudes	PDC
Jordan	Use =	0.55[§]	0.27[§]
New Zealand	Use =	0.15	0.36[**]
Norway	Use =	0.28[**]	0.12

[**]*Significant at the 0.01 level (2-tailed).*
[§]*The sample from Jordan has a low response rate and is not reliable for statistical testing.*

Table 2.
Linear regression coefficients to predict use of ICT technology in three countries.

New Zealand key competencies	Norwegian basic skills
Thinking	Oral skills
Using language, symbols, and texts	Reading
Managing self	Writing
Relating to others	Digital skills
Participating and contributing	Numeracy

Table 3.
The New Zealand key competences [32] and the Norwegian basic skills [29].

assess the skill-based perspective as outdated. On the other hand, all of the Norwegian teacher educators expressed critical positions regarding their own skill-based definition of learning, and expressed that a change of definition of what is regarded as fundamental for learning would be a change for the better. When asked to take a stance regarding the skill-based and competency-based perspective on learning, both the Norwegian and New Zealand teacher educators' attitudes towards this difference were surprisingly coherent despite the different affiliations and national curricula.

The Norwegian curriculum consisted of three formal documents and covered both the 3Rs and the 4Cs in different sections. It could therefore be legitimately claimed that merely comparing the two excerpts could paint an unjust picture of the differences between the two educational cultures. To correct for this possibility, the Norwegian participants were also asked about their use of the parts expressing the 4Cs. One of the participants expressed having a somewhat vague knowledge of these frameworks, and the remaining teacher educators claimed to 'know of it'. Of all the participants, not one expressed a close and reflective attitude towards the framework, and only one replied that she/he had used the document explicitly in her/his own teaching. The remainder either did not use it at all or explained that the use is implicit or that it merely exists as a backdrop to their teaching. So, when espousing their views, both the Norwegian and the New Zealand teacher educators were generally critical towards a narrower definition of skills, but when the Norwegian educators were asked about their theory in use, there were discrepancies between their espoused theory and their theory in use [26]. This insight made us question what motivated their practices, and ask whether different motivational factors could explain why such discrepancies occurred.

Motivational theory is central because although Norwegian schools have had a widespread ongoing policy regarding the use of digital technology, national surveys reveal a gap between the established policy and actual practice in Norwegian education. An often-used formula for work performance is: performance = abilities × motivation [33–35] Norwegian and New Zealand teacher educators' abilities (digital competence) and performance (professional application of digital tools) was measured. Our research indicates Norwegian teacher educators have better abilities to teach using digital technology, but are teaching less using digital technology compared to their New Zealand counterparts. Based on Maier's [35] formula, motivation seems to be a key aspect, and Herzberg's [36] two-factor theory was used to categorize the responses. Herzberg's findings suggest that the factors involved in producing motivation are separate and distinct from those that lead to job dissatisfaction. The opposite of job satisfaction is no job satisfaction, and the opposite of job dissatisfaction is no job dissatisfaction [36]. Two different needs are involved—one stems from the built-in drive to avoid pain, and the other from the ability to achieve and experience psychological growth. The stimulus for growth is the job content, and the stimulus inducing pain avoidance behavior is the job environment [36]. He called the two sets of factors: motivation factors (growth) and hygiene factors (dissatisfaction avoidance).

When clarifying their motivation for using digital technology, the Norwegian teacher educators explained their digital practices with nine motivation factors and nine hygiene factors spread across ten informants. The hygiene factors were explained as mandatory curricula and work conditions when teaching online. The New Zealand teacher educators explained their use of digital technology with 14 motivation factors and only four hygiene factors. The explained motivation among the New Zealand teacher educators was generally intrinsic, and its presence created job satisfaction. While the Norwegian teacher educators explained their pedagogical practices with equal occurrences of extrinsic factors, that further was perceived in a way creating dissatisfaction.

4. Discussion

Even though being on opposite sides of the globe, Norway and New Zealand educate teachers in digitally rich environments. For many years, they have been teaching students with high access to technology and educational resources [21]. However, a noticeable difference is that the two countries have different implementation strategies for digital technology in education. Norway has been exposed to a stronger top-down educational implementation of ICT in schools than have other countries [5].

New Zealand teacher educators appear to be more motivated to work with digital technology than Norwegians [27]. This lack of motivation is one reason that could explain why the application of digital tools seemed less in Norway than in New Zealand. The hygiene factors mentioned were also described in a way that indicated that both policy and work conditions are sources of frustration and dissatisfaction. Norwegian teacher educators explained that the main reason they use digital tools is the top-down implementation of government policy. Only 16% of Norwegian staff respondents moderately or strongly disagreed with the statement 'Society's expectations of the impact of digital tools are exaggerated', while 58% of staff moderately or strongly agreed with the affirmation. Thus, most teachers do not agree with the signals that are communicated in public. Therefore, a fundamental question in the use of digital technology in Norway is the policy related to its implementation; as part of the work environment, politics creates job frustration. Teacher educators in both countries highlighted achievements and policies as the main reasons for using digital technology, but Norwegian teacher educators were especially critical of their own country's policy.

What is even more surprising is that the same trend applies when asking whether there are excessive expectations about the effect of digital tools on academic debates at the Norwegian university. On this question, only 13% of staff responded that they somewhat or completely disagree that academic debates at the university have exaggerated expectations about the effects of digital tools. However, 50% agreed that academic debates at the Norwegian university are characterized by too-high expectations about the effect of digital tools. These figures represent a dual culture in which employees have an attitude towards digital tools, indicating that the majority of teacher education staff do not consider digital tools essential for good teaching. This suggests an internal educational culture that does not correspond to public culture and university policies in general. The Norwegian staff expressed loyalty towards the formal curriculum, but struggled with an inconsistent espoused theory when talking about their own practice.

The figures from New Zealand are more in line with the public culture and with the expressed university policies. The Jordanian data are more difficult to interpret, but seems to be somewhere between the two other countries.

Our regression analysis found that the contribution to digital practice occurs somewhat differently between the countries. The digital practice of the Norwegian staff is dominated by the *professional attitude*, whereas in New Zealand, it is dominated by *PDC*.

Argyris and Schön's theory of action may give us a relevant framework to understand this observation on a deeper conceptual level. The theory emphasizes SLL and DLL learning processes. From the analysis above, we infer that the didactical perspective in New Zealand may be characterized as dominated by conventional SLL processes based on PDC. In contrast, the academic staff in Norway are strongly involved in DLL processes in which their professional attitudes are more concerned. The interactions are illustrated in **Figure 1**. SLL is practical and rational at the default and basic didactical level, whereas the DLL mode is more open to discussions and adaptations and provides more opportunities for alternatives. With political pressure experience, the academic staff will look for new methods when

the SLL results in a mismatch between educational goals and the achieved goals. When entering a DLL process and looking critically into the preconditions for the challenges at hand, the Norwegian academics have to enter a systemic double loop. Thus, teachers' independent attitudes and beliefs function as redirectors of the use of ICT in their educational contexts.

According to Elstad [37], political expectations about the modernization of the school system using ICT and the allocation of funds following this policy created agendas which are not compatible with the constraints and operational characteristics within education. If you are presented with an ideology, and this guides the practice, students are more likely to act based on SLL. Experience provides a greater opportunity to evaluate not only policies, but also how policies affect practice. This knowledge is a prerequisite for critical analysis of teaching and for acting based on DLL. Teacher beliefs and attitudes about ICT use and integration challenge institutions to reconceptualize technological infused ways of 'seeing and doing things'.

To be a learning organization means to have a culture that involves DLL processes when needed, and to remain resilient against the SLL traps that may emerge in the organization and create tension and dissonance [22]. Because SLL is prevalent in the dominant culture [38], learning organizations such as those involved in teacher training may be susceptible to SLL traps that develop from the dominant societal culture. We interpret the observed tensions on the use of ICT within teacher education as the occurrence of such SLL traps.

The results of the qualitative interviews [26, 27] revealed that this could be understood as a global concern. It is a concern for deep educational values in many different cultures. Teacher educators were critical to position themselves towards a skills-based learning perspective, and positively towards a competency-oriented perspective. These two perspectives were understood as quite conflicting perspectives, almost mutually exclusive. How can a skills-based and a competency-oriented view be combined in a common understanding of learning? The contradictory elements of this discussion seem to be deeply embedded in the educational culture.

Langset, Jacobsen and Haugsbakken [39] stated that, contrary to top-down initiatives, a more horizontal approach supports pedagogical variation and tailored solutions needed in large heterogeneous organizations. The project carried out by Langset et al. [39] focused on local initiative and participation, as well as the feeling of autonomy experienced by the participants. Participants were free to explore new applications at their own pace and decide what new technologies to implement and how to use them in their courses. Their study findings showed that these were important factors supporting the argument for horizontal approaches rather than top-down implementation.

A recent study from Uganda [40] found that regardless of the resource-constrained context and pedagogical challenges experienced by academics, their attitude demonstrated resilience, flexibility and determination to embrace ICT in their teaching practice. This study challenges the notion of academics being passive, 'making do' with what is at hand [41] and claims that academics are resourceful practitioners, seeking inventive ways to teach more effectively.

5. Concluding remarks

Our aim was to study university departments of education as learning organizations using a self-designed questionnaire involving Argyris and Schön's SLL and DLL (**Figure 1**) tied directly to the pedagogical application of digital tools. The results were used to discuss the influence of skills (PDC) and attitudes (mindsets and opinions) of the respondents on the pedagogical applications (practice) within the

organizations. Many governments have been active in inducing and reforming both the school system and teacher education. This chapter has presented findings regarding how this affects teacher educators' attitudes towards their professional position. The Norwegian implementation plan positions digital technology in teaching in a way that activates resistance and creates contrasts between teacher educators' experiences and work-related requirements.

Multiple linear regressions were used to understand the relationships and contributions of SLL and DLL to organizational learning performance. The investigation empirically identified the potential for the development of an SLL and DLL culture to foster positive contributions to organizational learning performance.

Our study found that Argyris and Schön's separation between SLL and DLL in their theory of action may contribute to a deeper acknowledgement of the fundamental challenges which have to be settled in the domain of educational technology. Both processes exist at the same time and may have different actors. Both actors are important and may make valuable contributions to refining the learning process when technology is involved. However, a policy-induced legitimate system (SLL) is not enough and may create the observed dissonance (SLL trap). Employees are motivated to work within a fixed SLL framework, which does not reflect the complexity of reality. Therefore, there is a risk of developing professional tunnel vision, where employees are forced to abandon what is professionally reasonable. However, teacher education requires flexible and functional team thinking (SSL + DLL) to develop the 'noble art of education'. Technology and high ambitions at the structural macro level are not enough; there is a need for local structures at the meso-level.

The political enthusiasm that has prevailed in the field is now, to a greater extent, faced with critical reflections. The ranking of political goals over pedagogical goals hear is mostly contrary to teachers' understanding of teacher proficiency. The observation that digital tools are not successfully integrated into teacher training may be related to optimistic expectations associated with the use of digital technology in our society [42, 43]. In further studies, this technological optimism must critically examined, which has promoted an unrealistic view of the capacity of digital tools in education.

Teacher educators have developed an awareness of how digital technology can be integrated into curricula and the types of strategies that are best suited to help pre-service teacher students gain this knowledge for their future work. According to Ertmer et al. [44], fundamental change to use ICT in constructive ways may only occur if academics' inherent attitudes about the role of technology is concurrent with their practice. The present study raises such awareness while clarifying the content and complicated processes of integrating technology into teaching and learning. Faster, better, cheaper, applied to education, is not a productive concept. It is a false economy, since it is very difficult to have all three simultaneously. This requires educational institutions to be professional learning organizations, with communities of school professionals engaged in an ongoing dialog to promote cycles of development and reflection in students and teachers.

There are several implications of this study for the field of higher education. First, the idea that technology in itself will transform education if teachers are given access to it has been seriously challenged with empirical data. Second, if society want to meet the high ambitions for digital competence, the repertoire of ICT use in didactically meaningful ways has to grow. Third, the pedagogical landscape is complicated, and the development may preferably be done as an iterative process in its meso-level, between the macro and micro structure. We would suggest that instead of generally focusing on ICT in teacher training, teachers should work systematically at the local level to increase the repertoire—not the use itself—of digital learning technologies.

The implementation of digital technology and the development of digital competence in education require much more than basic digital infrastructure and an ambitious curriculum. Structures at the national level are not enough. There is an urgent need for professional development at the local level to expand the pedagogical repertoire and the didactic motivation of teachers concerning digital technology. This calls for an iterative progress of work in a social context, and requires education institutions as professional learning organizations, engage in an ongoing dialog to promote development and reflection cycles for students and teachers.

Appendix

Our updated questionnaire is based on Argyris and Schön's theory and involves three main constructs: *Professional Digital Competence*, *Professional Attitude* and *Professional Applications of Tools*. To gain insight into the respondents' theories in use, the questionnaire contained questions regarding the extent of use of different digital technologies. Professional digital competence is operationalized using Tømte and Olsen [45] and Lund, Furberg, Bakken and Engelien [46]. In accordance with the definition, three defined aspects of digital competence structured the questionnaire statements: pedagogic and didactic understanding, subject-specific understanding, and technological understanding. This definition of digital competence is generally in agreement with resent literature regarding its categorical understanding of digital competence. To illuminate attitudes (espoused theories), statements were prepared based on the OECD report 'Connected Minds: Technology and Today's Learners' [21] and its description of the field's existing attitudes towards technology. In the report, the field is described as characterized by stretching from being technology averse to technology positive. Statements were prepared to identify the respondents' own motivations for using digital tools, the respondents' attitudes towards digital tools' position in the public arena and attitudes towards the use of digital tools in educational settings.

PDC and professional attitude were measured on a five-point Likert-scaled where 1 = strongly disagree, 2 = moderately disagree, 3 = neutral, 4 = moderately agree and 5 = strongly agree. Professional application of tools was measured based on the reported frequency of use of 16 digital technologies and work methods of the participants in their own teaching in the past year, with 1 = never, 2 = rarely, 3 = occasionally, 4 = often and 5 = extensively. Some items had a reversed scale, denoted by REV (reversal). The main construct of the surveys is illustrated by the version for the teacher educators. However, the survey should be slightly modified for use among teacher students to reflect the differences in their educational context. The constructs were each based on the following questionnaire items:

Professional Digital Competence (PDC).

Decide to what extent you agree or disagree with each of the following statements:

- I am familiar with digital tools that can help diversify teaching.

- 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 that are appropriate for the aspects of the subjects I am teaching.

- It is difficult to use digital tools as an educational resource within my subject. REV.

- When I am using digital tools, it is difficult to adjust the content to the individual student's needs. REV.

- I have no clear idea of the learning outcome when using digital tools in my teaching. REV.

- I use digital tools when giving feedback to students.

Professional Attitude.

Decide to what extent you agree or disagree with the following statement:

- When I use digital tools in my teaching, I find it adds value.

- The use of digital tools is essential for good teaching.

- Society's expectations of the impact of digital tools are exaggerated. REV.

- Expectations related to the use of digital tools in education frustrate me. REV.

- In professional debates at our organization, the expectations of the impact of digital tools are exaggerated. REV.

- The use of digital tools is disruptive for the relationship between student and teacher. REV.

- Digital tools can make the students more interested in the subject I am teaching.

- I like testing new digital tools in my teaching.

Professional Application of Tools.

Which digital tools and work methods have you used in your own teaching in the past year?

- Digital tools for testing with multiple choice questions

- Moodle or Fronter (each university's learning management system)

- Digital tools for presentation (like PowerPoint or Prezi)

- Word processor

- Spreadsheets (like Excel)

- Use of video

- Production of film/video/animation

- Online discussions

- Online meetings (like Lync, Adobe Connect or Skype)

- Production of Wiki (website that allows collaborative modification)

- Screen capture (like Camtasia or Mediasite)

- Programs for scientific analyses

- Student response systems (online questions answered by phone or computers, like Kahoot! or Socrative)

- Tools for collaborative writing (like Google Docs)

- Social media (like Facebook or Twitter)

- The Internet as a source of knowledge

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Conflict of interest

The authors declare no conflict of interest.

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