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Teacher preparation for the digital age: Is it still an instrumental endeavor?

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ABSTRACT

Preparing student teachers for a profession that continuously changes in relation to digitalisation is a global challenge. By analysing survey data about how teacher educators ($N = 389$) report that they prepare their students for this challenge, we find that the focus is still on learning to use digital technologies for instrumental purposes, while relating to more fundamental epistemic challenges emerging in digital learning environments receives less attention. We address risks associated with this finding, and how a more concurrent focus on the instrumental and epistemic dimensions of professional digital competence (PDC) can be supported in teacher education.

Introduction

It is a global challenge to prepare student teachers for a profession that continuously changes in relation to digitalisation. When digital technologies are introduced and infused into schools and teacher education (Starkey, 2020), researchers observe that learning activities, resources, tasks, assessment and roles are challenged (Lund & Aagaard, 2020). Algorithms, artificial intelligence, simulation software, social media and virtual worlds are among the technologies with power to influence how and with what resources individuals acquire and relate to knowledge and learning. An example is Artificial Intelligence (AI) chatbots, e.g., ChatGPT, enabling learners to pass traditional exams with minimal cognitive effort. As a result, institutionalised assessment practices no longer "play by the rules" (Weick, 2002), and schoolteachers and teacher educators are compelled to determine what AI technologies' presence in education entails for teachers and learners' roles, learning activities, task design and assessment criteria. Moreover, teacher educators face the challenge of identifying what types of competencies student teachers need to be prepared for in a profession that constantly is evolving in response to the widespread use of digital technologies as AI bots, but also other digital technologies, within and out of school.

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The present quantitative study aims to examine what teacher educators emphasise when trying to prepare their students for this situation through facilitating their students' professional digital competence (PDC). The following research question guided our study:

What characterises teacher educators' facilitation of student teachers' PDC development?

We approached this research question by analysing survey data revealing how 398 teacher educators from five Norwegian TE-institutions responded to a survey we conducted in 2021. Our aim is to provide contemporary insights of international relevance about how PDC is integrated and conceptualised in Norway and contribute theoretically to how PDC can be understood and analysed independent of our national context. The study paves the way for discussing what teacher education should be aware of in future efforts when promoting student teachers' PDC development and how the conceptual understanding of PDC could be nuanced.

In the following section, we synthesise previous research about efforts to prepare student teachers for a lifelong teacher profession in digitally infused schools. We then present how PDC can be understood and our own conceptual point of departure. Following this we elaborate on the context and methods employed before presenting and discussing results and their implications for further PDC-development in teacher education. We end up with suggesting possible initiatives for teacher education to move forward, drawing on literature about transformative agency, and finally reflect upon the need for further research.

Background

Teacher preparation for the digital age – efforts identified in previous research

Due to Starkey's review (2020), when digital technologies was first introduced to schools, focus was on learning how to operate the new tools, or develop what was called "generic digital competence". Later, as digital technologies were more and more integrated into teaching, "digital teaching competence" was requested. However, in todays' digitally infused schools, PDC is requested. In broad terms, PDC implies knowing how to enact the profession in digitally infused contexts that continuously is changing (Starkey, 2020; Starkey & Yates, 2022).

Not all schools across the world are digitally infused, but Norwegian schools are, with about 90% providing one computer for each pupil (Langseth et al., 2022; NDET, 2022). Nevertheless, some studies indicates that the enacted focus in Norwegian teacher education is instrumental (Lund & Aagaard, 2020), learning how to operate the tools (Tveiterås & Madsen, 2022). This both seems to be the case at campus and when students' have their school practice (Gudmundsdottir & Hatlevik, 2020). More fundamental challenges, such as preventing and dealing with digital bullying or digital non-subject-related activities, receives limited attention (Hjukse et al., 2020), even if student teachers want to learn more about such issues and report that they possess digital skills or easily can acquire it themselves (Almås et al., 2021).

This indicates a need for more critical perspectives on digital technology use, which also is addressed in international studies about teacher education (see e.g., Cattaneo et al., 2022). For instance, Spanish teacher education is found to pay insufficient attention to ethical challenges emerging in digital learning environments (Novella-García & Cloquell-Lozano, 2021), and in Swedish teacher education, there is identified a need to put digital citizenship on the agenda (Örtegren, 2022).

Based on this background, we were curious to find out what characterised teacher educators' facilitation of student teachers' PDC development at five Norwegian teacher education institutions. They were selected because they recently had finalised well-funded R&D projects to prepare student teachers in a five-year MA programme better for digitally infused schools (Arstorp & Røkenes, 2022). With three years of targeted effort, these institutions should have good conditions to be in the forefront of PDC development.

Professional digital competence: a co-created and complex competence area

Many people and communities have been eager naming and making frameworks describing the competence teachers need to relate to the digital context in professional ways. Internationally, Dig-CompEdu (Redecker, 2017) and the ICT Competency Framework for Teachers (UNESCO, 2018) are examples.

In Norway, PDC was introduced as term by scholars already in 2013 (Tømte et al., 2013). The later years it has increasingly been used internationally (e.g., Starkey, 2020; Starkey & Yates, 2022), particularly in Europe (e.g., Heine et al., 2022; Mirete Örtegren, 2022; Ruiz et al., 2020). PDC include learning to operate digital tools for teaching and in learning (Skantz-Åberg et al., 2022, p. 14), but researchers have also suggested that PDC includes cultural awareness (Nagel, 2021); professional orientation (Gudmundsdottir & Hatlevik, 2018, 2020); an open, but critical, attitude towards technology and ethical reflection (McDonagh et al., 2021); knowledge about how to promote digital citizenship (Falloon, 2020); awareness of how digitalisation affects society and knowledge practices (Aagaard & Lund, 2020; Nagel, 2021); and transformative digital agency (Aagaard & Lund, 2020; Brevik et al., 2019) to mention some.

As we see, PDC is becoming a complex competence area that keeps being co-created by researchers, but also policymakers (Ilomäki et al., 2016; Skantz-Åberg et al., 2022). In this study, we have applied the Norwegian national PDC-framework (Kelentrić et al., 2017) developed by the Norwegian Directorate for Education and Training. The framework is made for schoolteachers and teacher education and comprises seven PDC areas: (1) "Subjects and basic skills"; (2) "School in society"; (3) "Ethics"; (4) "Pedagogy and subject didactics"; (5) "Leadership of learning processes"; (6) "Interaction and communication"; and (7) "Change and development". Under each area, seven to ten learning outcomes are listed (Kelentrić et al., 2017), for example about how digitalisation challenges the content of subjects and fundamental skills in learning (reading, writing, numeracy, and orality), but also childhood, child and youth culture, and identity development.

For a brief comparison, DigCompEdu (Redecker, 2017) is targeted towards educators across all levels and programmes, in both formal and non-formal learning contexts. 22 competences are organised in six areas. For example, "Digital resources" is an area, comprising the competencies: "selecting"', "creating and modifying" and "managing, protecting and sharing". The framework has no learning outcomes to be directly applied in teacher education. Our main reason for applying the Norwegian national PDC framework in this study, is that this framework and its learning outcomes played a key role in all the mentioned R&D projects at the included institutions.

A call for empirical and conceptual contributions

Despite the emergence of digitally infused schools and universities and the conceptual development of PDC, we have referred to studies indicating that the enacted focus in teacher education has tended to be on how to use digital technologies - what we in this article call the instrumental PDC dimension. Two Norwegian case studies (Aagaard et al., 2022; Brevik et al., 2019) have documented initiatives to "go beyond" this by engaging student teachers or teacher educators in transformative digital agency. In both cases, such agency involves breaking away from established actions and using digital tools to transform teaching and learning practices in response to challenges (Siddiq et al., 2023). In the first, the students collaborated on solving tasks which prepared them for digitalisation-induced epistemic changes (Brevik et al., 2019). In the second, teacher educators engaged in R&D projects, solving fundamental subject specific or didactical conflicts and challenges by adapting e.g., roles and content-focus, as well as utilising digital technologies in new ways (Aagaard et al., 2022). Also, international studies indicate that PDC can be promoted through supportive, collective, and explorative practices (Pettersson, 2018; Tondeur et al., 2017). Nevertheless, researchers request more studies about how PDC is integrated, scaffolded, and understood in teacher education (Nagel et al., 2023; Starkey, 2020). In the present study, we contribute

empirically by investigating whether the selected TE institutions, who recently had had major R&D grants to promote PDC, still took an instrumental approach or managed to "go beyond" (Lund et al., 2014).

"Going beyond" is not a suitable analytical concept. However, we have found "epistemic" to be useful. Our reason was that "going beyond" the skills of operating digital technologies for teaching or learning purposes, implies reflecting on epistemic questions in a digital context, such as (1) What is the nature of knowledge in this context? (2) How and through what means do people in this context develop knowledge? (3) Where is knowledge located? (4) What are the limits of our knowledge today? While these fundamental questions, raised by for instance Magrini (2010), keep being relevant for teacher education and schools, the answers to them are changing in response to digitalisation (Aagaard & Lund, 2020). For example, when students go into an alliance with AI chatbots (machine learners), their teachers are compelled to consider where the knowledge is located, as well as the limits of the students' and the AI-bots' knowledge. Further, they are required to ensure that AI-bots are utilised optimally for learning and prevent them from disrupting the knowledge work. How teacher educators and student teachers respond to such wicked problems, depends on their epistemic beliefs (Tondeur et al., 2017). While knowing how to operate a robot is an instrumental skill, understanding how it challenges epistemic practices and beliefs – and addressing epistemic conflicts, tensions, and ethical dilemmas (McDonagh et al., 2021) through professional action is linked to what we call the epistemic dimension of PDC.

In summary, we argue that the instrumental dimension relates to knowledge about how digital tools can be used for various purposes in educational contexts. This includes having technical skills, but also knowing regulations or guidelines for digital technology use, e.g., the General Data Protection Regulation. The epistemic dimension calls for considering the mutual relationship between digitalisation, society, and agents, focusing on how digital technology use relates to and impacts epistemic practices, epistemic beliefs (Korthagen & Kessels, 1999; Severance et al., 2016) and epistemic cultures (Foray & Hargreaves, 2003). This demands professional engagement and an open, inquisitive-yet-critical, inquiring, and responsible approach to digital technology use.

The dimensions, instrumental and epistemic, are not separated by a clear boundary and might even be intertwined. However, they are analytically useful when investigating the research question. Introducing them implies taking a new approach to PDC. By investigating whether teacher educators continue to emphasise the instrumental dimension or also engage in addressing issues related to the epistemic dimension, we contribute to the discussion about what PDC entails and how it can be studied. After all, the concept is still in the making (Almås et al., 2021, p. 73).

Study context and method

Context

The background for the mentioned R&D projects at the institutions we have selected for this study was that the Norwegian Ministry of Education, in 2017, granted them €9 million. The initiative was called "Digitalisation in teacher education". Focus was on primary school teacher training and all five institutions applied the mentioned Norwegian PDC framework (Kelentrić et al., 2017) in efforts to prepare students for being teachers in digitally infused schools. From 2018 to 2021 a wide range of project activities was initiated. Examples were national network meetings, small-scale R&D projects, workshops and TeachMeets where experiences where shared, technical support at labs, distribution of online resources, access to professional development courses and webinars as well as collaboration with schoolteachers.

Oxford Research evaluated the initiative in 2022 and found that the projects were successful in the sense that the involved teacher educators and schoolteachers tended to describe the initiatives in

positive terms, had become better at using digital technologies, and had developed more subject-specific digital competence through knowledge sharing. Further, an increased experience with the use of digital tools, but also an increased understanding of the difference between digital competence and PDC was registered. Others (Amdam et al., 2022) identified that the government funding had impact on how PDC was addressed in strategic documents and programme plans. Nevertheless, Oxford Research concluded that given the size of the grant, the significance for the teacher educators' PDC seemed limited (2022, p. 2).

The development of the questionnaire used to gather the data analysed in this article was initially a project initiative to survey how the teacher educators across the five institutions (Daus et al., 2019) and subjects (Hjukse et al., 2020) promoted student teachers' PDC. Five of the co-authors of this article, led the mentioned projects at this time and co-created the first version of the questionnaire together with two representatives from the Nordic Institute for Studies of Innovation, Research and Education (NIFU) in 2018, with expertise on quantitative methodology.

The PDC framework (Kelentrić et al., 2017) with the seven competence areas and associated learning outcomes was the conceptual point of departure. Since the learning outcomes were too broad to be applied "as is" in the questionnaire, they were operationalised. For example, under the area "Leadership of learning processes", one of the learning outcomes is to "foster a desire to learn by clarifying learning objectives and using diverse forms of feedback and assessment for learning in a digital environment" (Kelentrić et al., 2017, p. 8). In the questionnaire, more precise statements were presented. An example is: "In my teaching, I facilitate for student teachers to learn: 1) How digital resources can be used to lead learning processes; 2) How digital resources can be used in diverse types of assignments; 3) (How) to use digital resources to create diverse forms of assessment; 4) (How) to create their own digital learning resources; 5) How to be a teacher in a 1:1 classroom; and 6) (How) to prevent digital nonsubject-related activities". While we categorised 1, 2, 3 and 4 as instrumental, 5 and 6 were categorised as epistemic.

The survey was piloted and revised in collaboration with teacher educators, before it was distributed to the five institutions in 2019, revised and conducted again in 2021. Selected data from this last survey are analysed in the present article. Our intention is not to compare the results from 2019 and 2021, but to investigate systematically a recurring concern we had towards the end of the projects – that it was difficult to engage teacher educators in reflecting upon and actively addressing issues related to the epistemic PDC-dimension. (For additional details regarding the R&D projects, respondents, and the survey, see Pedersen & Vika, 2022.)

Procedure and measures

Because we took a new approach to PDC by investigating whether teacher educators continue to emphasise issues related to the instrumental dimension or address more epistemic possibilities, challenges, or concerns, we lacked theoretically predefined and validated instruments (see Appendix 2). To analyse the extent to which teacher educators address the PDC framework's instrumental and epistemic dimensions in their teaching practice, we categorised all survey items on the seven PDC areas as either instrumental or epistemic. Items pertaining to how technologies are used or can be used in education were categorised as instrumental, whereas items requiring reflection on the mutual relationship between digitalisation, society, and agents, focusing on how digital technology use impacts epistemic practices, – beliefs, or – cultures were categorised as epistemic. An inter-rater reliability procedure was used. First, two of the co-authors independently classified the items and compared their results, before the rest of the research team discussed and finalised the suggested categorisation (see Table A1 in Appendix 1).

Three PDC areas – namely (1) "Ethics", (2) "Leadership of learning processes" and (3) "Interaction and communication" – were chosen for further analysis because they included both instrumental and epistemic items, as addressed further under the analytical approach. "Subjects and basic

skills", as well as "Pedagogy and subject didactics", contained only instrumental items, whereas "School in society" and "Change and development" contained only epistemic items.

(1) five items, (2) "Leadership of learning processes" was measured with six items and (3) "Interaction and communication" was measured with four items. The questions and their respective categories are displayed in Table 1. All questions are measured on a four-point Likert scale ("Not at all", "To a little extent", "To some extent", "To a large extent") (DeVellis & Thorpe, 2021).

Data and sample

The survey was distributed to 698 teacher educators within primary and lower secondary teacher education at the five institutions, whereof 55.7 per cent completed it leaving us with 389 respondents. In average the respondents were 47 years old, 64 per cent were female, and 65 per cent had previous school teaching experience. The study was registered and approved by the Norwegian Centre for Research Data.

Analytical approach

We empirically investigated how teacher educators emphasise instrumental and epistemic issues when teaching student teachers by comparing instrumental PDC items with epistemic PDC items from the same PDC area. This was done to ensure that we compared their emphasis on epistemic and instrumental items, and not how they emphasise different PDC areas. Considering that the variables are measured on a four-point Likert scale, and that observations of the variables that are to be compared are derived from the same individuals, it was appropriate to employ a statistical test that can handle ordinal data and not assume independence in the observations. We used the Wilcoxon signed rank test, the nonparametric equivalent of a dependent t-test, as it accounts for the number of individuals who score lower, higher or the same on two variables and tests whether the difference is statistically significant (Field et al., 2012, p. 667). Statistical significance was determined for differences with a p-value < 0.05.

Results

Descriptive statistics

We present the descriptive statistics from teacher educators' responses in Table 1.

The table displays the response distribution, number of responses (N) and mean for each variable included in the analysis. The responses to instrumental items generally skew more towards the higher end of the scale, than the epistemic.

In the "Ethics" area, 65–93 per cent responded to some extent or to a large extent on instrumental questions, while 41–70 per cent responded the same on the epistemic questions. Furthermore, the mean is higher for all the instrumental questions.

Similarly, in the "Leadership of learning processes" area, 56–80 per cent answered "to some extent" or "to a large extent" for instrumental questions and 30–43 per cent for epistemic questions. Again, the means are markedly higher on instrumental questions.

Finally, we observe a similar pattern in the "Interaction and communication" area, although it is less distinct than in the first two. Altogether, 74–86 per cent of the teacher educators responded "to some extent" or "to a large extent" on the instrumental questions, while 54 per cent responded the same on the epistemic question about "How digital communication may influence relations and collaboration between teacher and pupil". However, the other epistemic question, "Developing a sharing culture", diverges from the previously observed pattern. The question has the highest mean of all "Interaction and communication" questions, with 88 per cent responding "to some extent" or "to a large extent".

Table 1. Descriptive statistics, including *N* and mean.

	Question	Not at all %	To a little extent %	To some extent %	To a large extent %	N	Mean
(1) Ethics	*In my teaching, I facilitate student teachers' learning about:*						
Instrumental	Guidelines for personal data protection	12	23	33	32	312	2.9
	Copyright law	7	16	41	35	311	3.0
	Source criticism and correct use of sources	1	6	27	65	310	3.6
Epistemic	How to discover, prevent and handle digital bullying, harassment and unwanted behaviour	25	35	30	11	310	2.3
	How to develop pupils' digital responsibility	8	22	48	22	311	2.8
(2) Leadership of learning processes	*In my teaching, I facilitate student teachers' learning about:*						
Instrumental	How digital resources can be used to lead learning processes	6	19	51	25	305	3.0
	How to use digital resources for diverse types of assignments	3	17	51	28	304	3.0
	How to use digital resources to create diverse forms of assessment	7	25	49	19	305	2.8
	How to create their own digital learning resources	14	30	40	16	305	2.6
Epistemic	How to be a teacher in a 1:1 classroom	25	32	34	9	305	2.3
	How to prevent digital nonsubject-related activities	30	40	26	4	305	2.0
(3) Interaction and communication	*In my teaching, I facilitate student teachers' need to gain experience with:*						
Instrumental	Digital collaboration	2	12	46	40	305	3.2
	How digital tools can be used for supervision	6	20	47	27	304	2.9
Epistemic	Developing a sharing culture	2	10	48	40	305	3.3
	How digital communication may influence relations and collaboration between teacher and pupil	17	29	39	15	301	2.5

Is there a difference in how teacher educators emphasise instrumental and epistemic issues?

As shown, the descriptive statistics demonstrate that teacher educators in our sample generally selected higher response categories for instrumental than epistemic questions. Using the Wilcoxon signed-rank test, we statistically test whether they scored significantly higher on instrumental items. Table 2 displays the percentage of teacher educators who responded more positively and negatively to instrumental and epistemic items in the "Ethics" area. The instrumental items are presented in the column to the left, while the epistemic items are presented in the top row.

The left-hand side of the table indicates that 50 per cent or more of the teacher educators responded more positively on the instrumental items than on "How to discover, prevent and handle

Table 2. Signranktest ethics: percentage of teacher educators that responded more positively and negatively on instrumental vs. epistemic items, including *N* and corresponding *p*-values.

	How to discover, prevent and handle digital bullying, harassment and unwanted behaviour				How to develop pupils' digital responsibility			
	% Pos	% Neg	N	Prob > |z|	% Pos	% Neg	N	Prob > |z|
Guidelines for personal data protection	50.6	10.3	310	.001	27.3	25.4	311	.644
Copyright law	57.7	7.1	310	.001	34.7	18.6	311	.001
Source criticism and correct use of sources	78.9	1.3	308	.001	57.6	3.2	309	.001

Table 3. Signranktest leadership in the learning processes: percentage of teacher educators that responded more positively and negatively on instrumental vs. epistemic items, including *N* and corresponding *p*-values.

	How to be a teacher in a 1:1 classroom				How to prevent digital nonsubject-related activities			
	% Pos	% Neg	*N*	Prob > |z|	% Pos	% Neg	*N*	Prob > |z|
How digital resources can be used to lead learning processes	53.0	3.9	304	.001	64.6	4.3	305	.001
How to use digital resources for diverse types of assignments	60.3	4.0	302	.001	70.6	4.3	303	.001
How to use digital resources to create diverse forms of assessment	48.5	8.9	303	.001	59.2	5.6	304	.001
How to create their own digital learning resources	38.6	17.8	303	.001	48.7	11.5	304	.001

digital bullying, harassment and unwanted behaviour", while 10 per cent or less responded more negatively. The remaining teacher educators responded the same on both questions. The percentage that responded more positively is greatest for "Source criticism and correct use of sources", in which 80 percent responded more positively. A statistically significant difference was found between how teacher educators responded to the instrumental items compared with the epistemic question "How to discover, prevent and handle digital bullying, harassment and unwanted behaviour" ($p < .001$).

The right-hand side of the table indicates that teacher educators responded more similarly to the instrumental ethics questions compared with "How to develop pupils' digital responsibility". No statistically significant difference was found in how teacher educators responded to "Guidelines for personal data protection" compared with "How to develop pupils' digital responsibility". The difference is significant between "Copyright law" and "How to develop pupils' digital responsibility". About 35 per cent responded more positively on the instrumental question "Copyright law" and 19 per cent responded more negatively, i.e., 46 per cent responded the same. A statistically significant difference was also found in how teacher educators responded to "Source criticism and correct use of sources" and "How to develop pupils' digital responsibility". Moreover, the difference is far greater than the other comparisons with "How to develop pupils' digital responsibility". Around 58 per cent of the teacher educators responded more positively to the instrumental "Source criticism and correct use of sources".

Table 3 displays the percentage of teacher educators that responded more positively and negatively on instrumental and epistemic items in the "Leadership of learning processes" area.

On the left-hand side of the table, we observe that 39–60 per cent responded more positively on the instrumental "Leadership" items than on "How to be a teacher in a 1:1 classroom", while 4–18 per cent responded more negatively on the instrumental items than on "How to be a teacher in a 1:1 classroom". All differences are significant at the .001 per cent level.

The right-hand side of the table displays the comparisons between "To prevent digital nonsubject-related activities" and instrumental "Leadership" items. Generally, teacher educators emphasise "prevent digital nonsubject-related activities" less, compared with the instrumental items, than "How to be a teacher in a 1:1 classroom". Furthermore, 49–71 per cent of teacher educators responded more positively on the instrumental "Leadership" items than on "To prevent digital non-subject-related activities", while 4–12 per cent responded more negatively. All differences are significant at the .001 per cent level.

Table 4. presents the percentage of teacher educators that responded more positively and negatively on instrumental than epistemic items in the (3) Interaction and communication area.

From the left-hand side of Table 4, we see that "Developing a sharing culture" diverges from the pattern we have seen until now. The percentage of teacher educators that respond more positively on instrumental "Communication" items is either equal to or significantly less than the percentage of teacher educators that responds more negatively. Thus, even though "Developing a sharing culture" is categorised as an epistemic issue, no evidence has been found that teacher educators place

Table 4. Signranktest interaction and communication: percentage of teacher educators that responded more positively and negatively on instrumental vs. epistemic items, including *N* and corresponding *p*-values.

	Developing a sharing culture				How digital communication may influence relations and collaboration between teacher and pupil			
	% pos	% neg	N	Prob > |z|	% pos	% neg	N	Prob > |z|
Digital collaboration	13.1	13.1	305	.933	54.5	4.7	301	.001
How digital tools can be used for supervision	10.5	35.9	304	.001	41.2	10.6	301	.001

less emphasis on "developing a sharing culture" compared with the instrumental communication items.

The right-hand side of the table indicates that teacher educators place greater emphasis on instrumental "Communication" items compared with "How digital communication may influence relations and collaboration between teacher and pupil". Altogether, 41–55 per cent of the teacher educators responded more positively on instrumental "Communication"-items, while only 5 and 11 per cent responded more negatively, respectively.

Discussion

The research question addressed in this article is: *What characterises teacher educators' facilitation of student teachers' PDC development?* We statistically compared survey questions regarding instrumental and epistemic issues in three of the seven areas from the Norwegian PDC framework and found that teacher educators scored significantly higher on all the instrumental items than the epistemic, with the following exception. No evidence indicates that teacher educators place less emphasis on providing experiences with "Developing a sharing culture" (categorised as epistemic), compared with "Digital collaboration" and "How digital tools can be used for supervising" (both categorised as instrumental) when they teach student teachers. Teacher educators score significantly higher on "Developing a sharing culture" than on "How digital tools can be used for supervising". In sum, the findings suggest that teacher educators facilitate students' learning about personal data protection, copyright law, source criticism and correct use of sources, digital collaboration, using digital tools for supervising and how digital tools can be used to lead learning processes, create diverse forms of assessment, and create their own digital learning resources. The focus is on how digital technology can be used for various purposes, in addition to giving student teachers experience developing a sharing culture. However, student teachers are taught less about promoting digital responsibility; how to identify, prevent and deal with digital bullying, harassment and unwanted digital behaviour; how digital communication may impact human relations and collaboration; what it implies to be a teacher in 1:1 classrooms; and how to prevent pupils from spending their school hours on digital activities that are not relevant to their learning.

The findings imply that even in institutions that for three years had had a specific focus on promoting PDC, teacher educators still focus on instrumental skills and need to face the challenge of addressing epistemic PDC issues. Below, we discuss the findings considering previous studies, and possible reasons for why promoting the epistemic PDC-dimension in teacher education might be more challenging than promoting the instrumental. Last, we suggest possible initiatives to help teacher education moving forward.

Previous and present efforts to prepare student teachers for a career in digital contexts

The R&D projects at all the teacher education institutions taking part in this study aimed to facilitate the PDC development of teacher educators and student teachers, emphasising both the instrumental and epistemic dimensions from the PDC framework. Nevertheless, our quantitative study suggests that promoting PDC in teacher education remains an instrumental endeavour and

supports tendencies that previous scholars have identified (Aagaard & Lund, 2020; Tveiterås & Madsen, 2022). The epistemic item "Developing a sharing culture" is an exception. A possible reason is that promoting a sharing culture was a key principle in the R&D projects across the five teacher education institutions that participated in this study. As Oxford Research (2022) has identified, teacher educators developed subject-specific digital competence through knowledge sharing initiatives taken in the projects.

In line with previous research (Hjukse et al., 2020; Nagel et al., 2023; Novella-García & Cloquell-Lozano, 2021; Örtegren, 2022), we question the risks associated with paying limited attention to the epistemic dimension. For example, if future schoolteachers are not sufficiently prepared to discover and prevent digital bullying, harassment, and unwanted digital behaviour, it might become difficult, and even impossible, for some pupils to engage in knowledge work or grow as individuals and be able to participate in a (digital) democratic society. Also, if student teachers are not adequately prepared for 1:1 classrooms, they will be poorly qualified to exploit the pros and prevent the cons associated with each pupil having constant access to their computer when learning. Therefore, we argue that researchers, teacher educators and policy makers must concurrently address both the instrumental and epistemic dimensions of PDC in the future.

Professional digital competence – a concept "in the making" calling for conceptual clarification

There are several reasons that might explain why it remains hard to engage teacher educators in teaching the epistemic PDC dimension. One is that PDC still is a fuzzy concept "in the making" (Almås et al., 2021, p. 73) and that shared conceptual understanding is a premiss in PDC development. When Starkey conceptualises PDC based on research from 2008 to 2018, epistemic PDC issues are not mentioned. However, when examining how PDC has been conceptualised within the Norwegian research community over the past decade, we observe that the epistemic dimension has become clearer. For example, in 2016 Gudmundsdottir and Ottestad suggested that PDC included "generic digital competence", which implied "digital communication, digital information/data processing, digital responsibility and production in digital environments" (p. 28). Four years later, Aagaard and Lund (2020) added that in addition to such instrumental skills, "generic digital competence" could also be observed through "deep, conceptual understanding of the artefacts involved, the affordances that emerge and how these relate to underlying and fundamental assumptions about learning and teaching" (p. 80). This example illustrates how conceptual understanding keeps evolving (Tveiterås & Madsen, 2022), lately paying more attention to how people's use of digital technologies raises questions related to fundamental epistemic understandings and practices. Further, Lund (2021) has suggested that "policy documents need to shift their focus from an instrumental view of digitalisation towards educational practices and the connections between digitalisation and epistemic work" (p. 37). By introducing the epistemic dimension to the instrumental dimension, we contribute to a more precise conceptualising of PDC, which can help teacher educators and policy makers to attend to both dimensions.

Epistemic development calls for transformative agency

In line with others (Nagel et al., 2023; Novella-García & Cloquell-Lozano, 2021; Örtegren, 2022), we contend that it is necessary to transform epistemic practices if teacher education is to ensure that student teachers are educated to "firmly place human interests and the knowledge-producing sectors in focus when facing the digital surge" (Aagaard & Lund, 2020, p. 2). However, this requires that teacher educators develop their pedagogical understandings and knowledge views, i.e., their epistemic beliefs (Tondeur et al., 2017), which has proved to be challenging (Knorr Cetina, 1999; Korthagen & Kessels, 1999; Severance et al., 2016).

For example, to teach student teachers "how digital communication may influence relations and collaboration between teachers and pupils", teacher educators must acknowledge that the premises for relations and collaboration change when communication occurs digitally. Epistemic beliefs and teaching practices are tightly linked to teachers' perceptions of knowledge and learning (Foray & Hargreaves, 2003; Tondeur et al., 2017). Such perceptions tend to be rooted in subject-specific academic traditions (Tondeur et al., 2017, p. 556) and epistemic cultures stemming from teachers own education (Foray & Hargreaves, 2003). Further, the consequences of focusing on something new, in our case the epistemic dimension, are unknown. Nevertheless, today's use of digital technologies causes tensions and challenges roles, learning activities, tasks, and assessment (Aagaard & Lund, 2020). Teachers can choose to ignore these, but a better and more responsible alternative is to pay attention to them and search critically for adequate responses as a community (Cattaneo et al., 2022; Nagel et al., 2023).

Identifying tensions and challenges and trying to deal with them is often referred to as transformative agency (Haapasaari et al., 2016; Lund & Vestøl, 2020), which we have already briefly defined. Transformative agency necessitates experimenting with new ways of learning and accept that the control over its consequences is limited. This is not easy for educators who are expected to strive for successful results. Teacher educators engaging in transformative agency must be willing (and capable) of relating to these contradictory innovation forces (Hoholm, 2011). However, when reading across studies (Aagaard et al., 2022; Brevik et al., 2019; Jónasson, 2016; Pettersson, 2018; Severance et al., 2016; Tondeur et al., 2017), we find reasons to believe that transforming institutional practices can be supported through institutional priorities and collaborative problem solving.

The Norwegian PDC framework has been criticised for not focusing on transformative digital agency which is a driving force for developing epistemic practices to the better for learning (Aagaard & Lund, 2020; Brynildsen et al., 2022; Gudmundsdottir & Hatlevik, 2020). Also, teachers' attitudes and willingness to approach digital technologies with epistemic openness; in an open and curious, but still critical, investigative, and responsible manner, is neglected in the framework (McDonagh et al., 2021). This lack of epistemic focus is also evident in our research. In line with several scholars (Aagaard et al., 2022; Brevik et al., 2019; Lund et al., 2019), we suggest including transformative agency to PDC as concept, and place professional engagement and an open, inquisitive-yet-critical, inquiring, and responsible approach to digital technology use within the epistemic dimension.

Concluding remarks

In this article, we have introduced "instrumental" & "epistemic" as professional digital competence (PDC) dimensions. These categories can be used analytically in future processes of conceptualising PDC, both nationally, but also internationally. Further, we have revealed that teacher educators tend to focus on the instrumental PDC dimension, and contributed to research on how student teachers are prepared for digitally infused schooling contexts (Starkey, 2020, p. 52). We have also suggested to provide teacher educators and teachers with collaborative agentive and responsible roles and that TE institutions set the epistemic dimension on the agenda. Last, our study invites further examinations, both of how different conceptualisations of PDC address epistemic issues, and how to further unpack the epistemic competencies needed to be taught in times of AI and in the digitally infused school context.

Disclosure statement

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Appendices

Appendix 1

Table A1. Categorising PDC-items as instrumental or epistemic.

	Instrumental	Epistemic
Subjects, basic skills, and pedagogy and subject didactics I facilitate for the student teachers to learn how different digital resources can be used in school to:	Stimulate/ encourage/ help pupils to achieve the competence aims in the subject Motivate pupils Support the development of all five basic skills in and across subjects	
Pedagogy and subject didactics I facilitate for student teachers to learn how different digital resources can be used in school to:	Facilitate explorative and creative learning activities Create varied learning activities Adapt content to pupils' individual needs Facilitate deep learning	
School in society I facilitate the teacher students to develop a subject-orientated reflective relation to:		How digital developments may create divides in society How digital developments influence the schools' responsibility for bildung/ education How digital developments change the role of the teacher How digital developments influence children's and youths' childhood environment How digital developments influence participation in democratic processes
Ethics In my teaching, I facilitate for the student teachers to learn:	Guidelines for personal data protection Copyright law Source criticism and correct use of sources	How to develop pupils' digital responsibility How to discover, prevent and handle digital bullying, harassment, and unwanted behaviour
Leadership of learning processes In my teaching, I facilitate for the student teachers to learn:	How digital resources can be used to lead learning processes To use digital resources to create diverse forms of assessment To use digital resources for diverse forms of assignments To create their own digital learning resources	How to be a teacher in a 1:1 classroom How to prevent digital non-subject-specific activities
Interaction and communication In my teaching, I facilitate for the student teachers to develop experience in:	Digital collaboration How digital tools can be used for mentoring/ supervising	Developing a culture for sharing/ sharing culture How digital communication may influence relations and collaboration between teacher and pupil
Change and development In my teaching I facilitate		Relevant research about, and methods for, integrating digital learning resources into teaching

Table A1. Continued.

	Instrumental	Epistemic
for the student teachers to get insight in:		National steering documents linked to learning and teaching in a digital environment
		Importance of digital developments for their professional practice
		How they can independently develop their own professional digital competence further
		Discussing digital resources with the professional community to develop teaching
		Strategies to keep up-to-date concerning new digital resources and research (on digital developments/use of digital resources in teaching)

Appendix 2

We used confirmatory factor analyses of unidimensionality to investigate whether we could use the instruments designed to measure the PDC areas as latent measures of the instrumental and epistemic dimensions of PDC. We treat observed variables as ordinal and use the weighted least squares estimator with means and variance adjustment (WLSMV). Of the PDC-items, 16 are categorised as instrumental, and 18 are categorised as epistemic. Neither the instrumental, nor the epistemic items, have satisfactory unidimensional fit to the data (Instrumental: $\chi^2 = 7534.955$, df = 120, $p < .001$, CFI = .86, TLI = 0.84, RMSEA = .17, SRMR = .12; Epistemic: $\chi^2 = 11162.831$, df = 153, $p < .001$, CFI = .94, TLI = 0.93, RMSEA = .13, SRMR = .08).