



## Digitalization of teacher education: Are we prepared for epistemic change?

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### Abstract

This paper examines emerging epistemologies in the wake of increased digitalization and the extent to which student teachers are prepared for such epistemologies in their teacher education (TE) programs. Although there are a number of studies on digital epistemologies, few have examined the implications of digitally extended, embedded, and embodied cognition and the ensuing epistemic practices. This study's analytic focus is partly on a number of project proposals that reflect some of these trends and partly on two surveys of (and some interviews with) student teachers at two universities who were engaged in developing their professional digital competence (PDC) as part of the TE programs. The surveys and interviews indicate that TE tends to focus on the *use of* digital technologies and less on addressing deeper, epistemological issues in efforts to foster student teachers' PDC. These findings signify a gap between emerging epistemological trends and how student teachers are prepared for such trends. We conclude by suggesting a focus on digital, epistemic, and transformative agency for TE to cope with the increased digitalization of epistemic practices.

**Keywords:** digitalization, epistemology, teacher education, transformation, agency

### Introduction: Digitalization and epistemology

Historically, digitalization in teacher education (TE) has equaled preparing future teachers to work in technology-rich environments and to master diverse digital applications to promote, for example, collaboration, presentation skills, and subject-specific knowledge production (Lund et al., 2014). The applications have affected the practices they became embedded in and to varying degrees. For example, long before the Internet enveloped

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classrooms and leisure activities, Stefan Heim (1987) noted how the word processor afforded a type of writing unconstrained by linear progression; the writer could experiment with structure, words, and syntax. Heim showed that this impacted not only people's writing but also how people *think* when writing.

More recently, scholars have been intrigued by the way digitalization transforms or challenges such epistemic practices and have called for "digital literacies" (Lankshear, 2003; Lankshear & Knobel, 2006). An epistemological perspective on digital literacies requires that we rethink how we gain knowledge and by what means. Thus, digital literacies have come to equal a set of social practices that involve meaning-making. This involves dealing with change in the world, change in our concept of knowledge, and change in ourselves as knowers (Aagaard & Lund, 2020; Lankshear & Knobel, 2006).

Historically, education in general and TE in particular have upheld a division of labor between human agent(s) and digital technologies. The human agent has been the executor of actions, the decision-maker, and the prime *doer* in educational efforts. Digital technologies have been considered mere tools, mediating educational efforts and activities without interfering with the human aim, purpose, and outcome of educational activity. Consequently, people often treat digital technologies as gadgets that serve humans in certain ways.

In this paper, we argue that the relationship between humans and digital technologies is shifting. This has severe implications for how people construct knowledge and arrive at valid responses to complex challenges. Also, with the rapid development in robotics, artificial intelligence, and objects with intent (OwIs), we increasingly experience non-humans as partners and, potentially, masters. We will not engage in any speculative or science fiction-inspired conjecture about the future. However, if TE programs aspire to foster professional digital competence (PDC, see Kelentrić et al., 2017, for the complete framework) and educate student teachers for today's schools, teacher educators and student teachers need to be aware of and respond to the epistemological consequences of people's access to and use of (mobile) hardware and assorted software. Focusing on Norway, we find an increasing number of highly digitalized schools (Fjørtoft et al., 2019), but extensive research shows that TE in Norway has focused on promoting student teachers' PDC only to a limited extent and somewhat arbitrarily (Gudmundsdottir & Hatlevik, 2018; Lund et al., 2014; Krumsvik, 2016). However, there are indications that some TE programs can rise to this challenge. Against this backdrop, we therefore raise the following research questions:

1. How does digitalization impact epistemology?
2. To what extent does TE prepare student teachers for epistemic work in digitalized contexts?

## Data and methodological approach

We answer the first question partly theoretically by consulting extensive scholarly work and partly empirically through content analysis (Stemler, 2001) of project proposals submitted to the Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education (DIKU) in 2018. We selected 35 proposals that focused on active learning, understood as students' active educational efforts involving, for example, problem-based learning, case-based learning, inquiry and explorative learning, deep learning, and various forms of “flipped” teaching.<sup>2</sup> The questions asked in the DIKU application template provided insights into how higher education (HE) institutions connect digitalization and educational quality and how knowledge work develops at the micro-level. Therefore, we expected to find cutting-edge proposals and views of learning, digitalization, and educational quality that connect to epistemological aspects.

The project proposals came from a wide variety of programs. We highlight two cases; one from a health-care program and one from geoscience. Although discipline-specific, these two empirical cases are also relevant for TE pedagogy and didactics: In the health-care case, teacher educators tried to prepare students for sensitive or awkward situations that were difficult to fully understand by merely reading and discussing relevant literature. In the geoscience project, didactics drawing on academic and experiential knowledge relevant for STEM subjects was developed. Preparing for challenging situations and drawing on diverse types of knowledge is very much a TE-related endeavor.

Six researchers collaborated on the analysis of the 35 proposals. We identified and categorized a series of challenges—educational, pedagogical, technological, and resource-related issues. We also mapped what kind of problems the proposals set out to solve, how the applicants intended to solve them, and to what extent they referred to policy papers and/or scientific arguments (Aagaard et al., 2018a; Aagaard et al., 2018b). This comprehensive study provides two selected snapshots that aim to capture change: empirical carriers of how digitalization influences and transforms epistemological practices.

The answer to the second question is based on a descriptive analysis of two surveys from two universities and five focus group interviews conducted at one of the universities. It is important to note that the surveys and interviews were not designed to answer our particular research question but to evaluate efforts in TE to digitalize and enhance student teachers' PDC. Nevertheless, the material provides us with two “still images” of student teachers' perceptions of PDC in TE. In addition, the surveys indicate what TE has focused on in recent years to prepare students for work in digitalized learning contexts and to what extent TE addresses epistemological issues.

The first survey was answered by 92 student teachers in their sixth term of the master's program (66% of the entire cohort [ $n = 196$ ]). The survey included 20 questions (Likert

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<sup>2</sup> The full project proposals are not publicly available. However, short presentations of all proposals can be accessed at the following URL: <https://old.norgesuniversitetet.no/prosjekter>. Note that the full proposals and the short versions are in Norwegian.

scale and open-ended questions) and was developed to evaluate the students' experiences with and reflections on their development of PDC, their general use of digital artifacts in TE, and in particular their use of the Canvas learning management platform. Based on the survey, student teachers were invited to the focus group interviews (see Brevik et al., 2019, for an extended presentation and analysis). In the following, we refer to both the responses to the survey and the ensuing focus group interviews.

The second survey is from a different university, but here, too, the intention was to evaluate student teachers' experiences with and perceptions of how their PDC competence was fostered in TE. The cohort comprised 182 respondents from the first three years of the TE master's program. Items were answered using a Likert scale, but one question was open-ended and allowed students to submit free text.

### Digital artifacts and affordances

Digital resources are often referred to as *tools*. A tool is an everyday concept for things that typically are made to do something in a more efficient, less tedious, or more economical way. Consequently, the quality of a tool is often evaluated based on a cost–benefit analysis and less on its transformative potential. *Tool* as an everyday term does not indicate people's broader intentions of developing a resource or how it has transformed situations and practices. However, the scientific concept *artifact* does (Säljö, 1999, 2010). This explains why the term *tool* has been criticized for being reductionist and instrumental when applied to digital technologies (Orlikowski & Iacono, 2001).

As the first syllable in the scientific concept *artifact* suggests, it is something human-made for certain purposes within a specific cultural–historical context. Artifacts can be material but also discursive (scientific concepts), symbolic (alphabets), or even social (specialized practices). Artifacts are of cultural significance, are developed over time, and are carriers of historically and collectively developed insights. In addition, artifacts come with the potential of *transforming* the cultures they are introduced into, not by their inherent qualities or features but as a result of the interplay between artifacts and humans' capacity for transformative agency (Arievitch, 2017; Brevik et al., 2019; Lund et al., 2019). Artifacts function as gatekeepers to social practices, societies, or cultures (as the plowshare to an agricultural society) and as “glue” or connective material (such as the alphabet) for those who have appropriated them. Thus, artifacts suspend the Cartesian separation of mind and world, cognition and context. These properties bring to mind the notion of affordances—that is, the opportunities and constraints arising from agents interacting with artifacts (Aagaard & Lund, 2020; Gibson, 1979; Kennewell, 2001). Thus, teachers' and students' perceptions of how well digital resources afford their pedagogical and didactic plans will impact how they put them to use. The notion of affordances has played an important role in human–computer interface design but also increasingly in the design of technology-rich educational environments and trajectories (Kennewell, 2001; Lund & Hauge, 2011).

Digital artifacts (hardware, software, and infrastructure) carry insights developed across a number of domains (mathematics, linguistics, and informatics). Digitalization affords more precise and sophisticated representations of a phenomenon than printed text. For example, in the case of math and natural science, we can by way of models, simulations, animations, and augmented/virtual reality represent very abstract processes, such as hypotheses or dependencies—phenomena that are impossible to study “live,” such as volcano eruptions and earthquakes, or phenomena that emerge over generations (e.g., climate change, nutrition patterns). In language and communication domains, machine translation (spoken and written) improves at rapid speed and impacts reading and other communication practices.

Also, digital artifacts do not merely reflect the intentions programmed into them (delegated agency); they can also be “perceived as having need-based agency” (Rozendaal et al., 2019, p. 25) by their human counterparts (e.g., avatars, chatbots, or digital/virtual pets used in elderly care). Increasingly, they appear as collaborative and communicative partners. For example, Lil Miquela, an artist and model for a well-known fashion enterprise, had 1.6 million followers on Instagram in 2019. In 2018, people found out that she was an avatar created using computer-generated imagery. The same year, *Time* magazine featured her in its 25 Most Influential People on the Internet line-up (Facer, 2011). Such development hints at future situations where the boundaries between humans and non-humans become blurred. As Rückriem (2009) argues, digitalization is a fundamentally transformative factor that increasingly rests on interagency and networking between humans and non-humans. This is where we venture into the realm of digitalization and epistemology.

### **Epistemologies: Digitally extended, embedded, and embodied cognition**

The trends described above (e.g., how phenomena are digitally represented, how communicative spaces emerge, how problem-solving becomes collective and collaborative, suspending constraints in space and time, etc.) explain why digitalization impacts epistemic practices. For TE, it doesn’t just involve preparing student teachers for more than “mere” teaching; it involves student teachers becoming designers of educational activities, practices, and environments where digital resources are put to use in ways teachers have not been prepared for (Lund & Hauge, 2011). We aim to build an argument for why digitalization and digitized educational practices have epistemological consequences that deeply affect educational practices and consequently TE.

Traditionally, epistemology has responded to questions such as (1) What is the nature of knowledge? (Where) Is knowledge located?; (2) How do we come to knowledge? By what means have we come to knowledge?; and (3) What are the limits of our knowledge? What is the scope and dimension of our knowledge? (see also Magrini, 2009). While the

questions have remained constant, scholars observe that over the past decade, epistemology has gravitated toward the value of *understanding* rather than *knowledge* (Carter & Kotzee, forthcoming; Pritchard, 2013). In our case, it is particularly question 2 (above) that connects digitalization with epistemology and also requires understanding such processes. In the following, we identify three perspectives that have epistemological implications—extended, embedded, and embodied cognition or understanding.

These three perspectives can be traced back to “a surge of attempts to draw out the epistemological consequences of views according to which cognition is deeply embedded, embodied and/or extended” (Vaesen, 2014, p. 426). These views share the enactivist claim that cognition depends on the cognizers’ interactions with their environment and that “cognitive states and processes can extend beyond the boundaries of the cognizing organism” (Ward & Stapleton, 2012, p. 89). A number of studies have taken this view as a point of departure for discussing how digitalization impacts epistemologies (see e.g., Clark, 2008; Ludwig, 2015; Lynch, 2014). We have elaborated on this approach elsewhere (Aagaard & Lund, 2020), but it can be summarized as follows.

*Extended* cognition is perhaps the more conventional way of thinking about digitalization—that is, how pocket calculators, spellcheckers, smartphones, and a plethora of extremely sophisticated instruments have increasingly taken on a more cognitive load and serve to engage with humans in distributed cognition (Hutchins, 1995 is a prime example). One well-known example is the car that takes control over a situation where a potential head-on collision involving several young passengers is avoided by swerving across the sidewalk, killing or maiming an elderly pedestrian. Who programmed the car? A professorial team of moral philosophers, computer scientists, or people from insurance companies? Regardless of programmer(s), the car is given extended cognition and can decide an outcome. The knowledge that, in turn, is activated with potentially fatal consequences is located outside human minds. This phenomenon also generates ethical dilemmas. In education, a common concern is that extended cognition makes students less motivated to remember things and read academic texts. Others suggest that extended cognition calls for educational programs that foster “performative competence” (Säljö, 2010)—that is, where students learn through appropriating and using artifacts while solving real-life problems with several possible responses.

*Embedded* cognition plays a vital role when we design new educational spaces, workplaces, cars, kitchens, and, not least, spaces and sources of entertainment. Objects with intentions (OwI)—such as a ball programmed to respond to a child’s agency, a jacket that makes you feel safe by responding to body signals of nervousness, or a bedside lamp that lulls you to sleep—become embedded in human activity as collaborative partners (Rozendaal et al., 2019). In other words, digitalization is increasingly *embedded* in both mundane and scientific practices to the extent that it is ubiquitous but invisible. The consequence is that humans as social agents also become increasingly embedded in practices, situations, and spaces permeated by digitalization. At the time of writing this article, the COVID-19 virus has enforced more or less immediate and total digital embeddedness of

educational practices in Norway. In addition, the blurring of boundaries between physical and virtual contexts is on the rise. For example, a student teacher finding a particular paper on, for example, “classroom management” or “formative assessment” in a digital research database is immediately presented with a vast number of potentially just-as-relevant papers to be accessed and downloaded. Embeddedness also explains the everyday experience of being contacted by a party offering to sell you something that the party already knows you are interested in (from having tracked your keystrokes over time). This is made possible by just one simple algorithm that testifies to such embeddedness; your personality is to some extent shaped by your “likes.” This is, of course, big business and potentially paves the way for the manipulation of our beliefs, attitudes, and values. In this way, digital technologies structure our cognition (Huebner, 2013).

However, digital artifacts do not only afford extended or embedded cognition; they are also becoming *embodied*. Embodied artifacts are nothing new; glasses, hearing aids, and pacemakers have existed for ages, the first-generation “wearables.” But when we now have access to glasses with augmented-reality functions and implants (microchips, “health-care chips”) that analyze blood sugar and cholesterol levels and even capture cancer cells and send the data to our cell phones, technologies are not merely add-ons but integrated agents that monitor our existence and influence our decisions. In this way, digitized information becomes internalized in our biological and cognitive endeavors (Lynch, 2014). These perspectives raise extremely important ethical issues. When is shared information beneficial? Will insurance companies have access to such information? We are not merely being monitored by satellites and CCTV but carry potential spyware in our bodies. Consequently, the embodiment of digital technology is the third perspective that connects digitalization to epistemology. This phenomenon challenges TE programs in terms of deciding how to prepare students for both working life and a social presence with ethical dilemmas that arise as digital technology becomes increasingly embodied.

The categories *extended*, *embedded*, and *embodied* are not discrete or without gray areas, but they might still help us analyze and reflect on the complex relationships between humans and digital technologies, including epistemological and ethical implications. The implication is that we encounter multiple and very different epistemologies that are context-dependent (Bricker & Bell, 2016). Educational possibilities are exciting, but the risks are formidable. This is why TE institutions and higher education in general have an extraordinary responsibility to address epistemic consequences of digitalization and not just focus on administration, infrastructure, and course design.

### **Empirical snapshot #1: Project proposals**

In the 35 project proposals we analyzed, there were a variety of programs and cross-disciplinary proposals with the same intentions: to promote student active learning and

(thus) enhance educational quality. Before we turn to two cases, we briefly summarize the tendencies we found across the proposals.

First, in most of the proposals (there were notable exceptions) the connections between digitalization and educational quality were vaguely described and rarely backed up by research literature. This echoes Lillejord et al.'s (2018) finding in their systematic review of teaching with technology in HE: "One paradox identified is that academics appear not to be using a *scholarly approach* when implementing technology in education" (p. 4, emphasis in original).

Second, compared to project proposals from earlier years, we identified a clear trend from a focus on technology *per se* toward efforts to take on pedagogic (subject), didactic, and subject-specific challenges. Also, the projects were more grounded in institutional strategies and less dependent on key individuals and beacons, as was often the case in previous project proposals (Dørum & Grepperud, 2015). This indicates a trend toward institutional and collaborative approaches to digitalization in education.

Third, we found a tendency to perceive digital technologies as a range of *resources* and not merely as "tools" applied for administrative or financial purposes. The submitted proposals reflected a willingness to take risks, and transform and transcend practices to achieve results that have hitherto been unattainable or difficult to accomplish.

We will let two proposals serve as empirical carriers of the second and third trends mentioned above. The first proposal was titled "What Remains Unsaid in Communication." The pressing challenge the applicants wanted to solve was as follows: An MA program in mental health should prepare students for professions in which they will meet people who have experienced sexual abuse, drug addiction, or diseases associated with stigma. Consequently, the MA students need to learn to communicate with clients about sensitive or "taboo" issues. Traditional lectures, seminars, and literature studies had proven insufficient, resulting in students feeling "lost" in communicating about sensitive issues in practicum and working life. The proposal attempted to break out of this problem situation and impasse by developing a specific digital resource. Based on real-life cases told by clients, the HE institution, in collaboration with the clients, planned to develop virtual avatars and scenarios. The scenarios would include stops where students would have to make decisions about how to proceed and what to say. The interlocutor would be a teacher or an avatar programmed for certain character traits, initiatives, and responses. Colors would visualize emotions, and comment boxes would visualize thoughts. The students' communicative strategies could be recorded and replayed for joint discussions. The resources were developed to transform the program; what previously was left unsaid and was therefore difficult to "teach" has now become accessible for students and teachers to "experience." The combination of digital resources and educational design made it possible to break out of a problem situation that had dogged the MA program and transformed recurrent restrictive situations into opportunities for learning and self-reflection. The situations in the virtual simulation change, but so will the participants as they become more active, aware of, and sensitive toward their own roles. They may become better prepared



for the work they will encounter as professionals. The project proposal aims to break away from existing and constraining epistemic practices and develop new practices with greater ecological validity and educational quality. Epistemologically, we see how extended and embedded technologies amount to a “lived experience” for the students—that is, an embodied approach but without technologies physically entering the human body. While the project targets health students, it has considerable relevance for TE and teaching practices where sensitive situations and themes abound.

In the second proposal from geoscience, the active student is at the center of the proposal and is inducted into the role as a student-researcher through collaborative and inquiry-based learning. Geologic and geographic phenomena are studied on campus and in the wild, and the two types of knowledge, academic and experiential, become mutually constitutive of the students’ learning trajectories and professional expertise. The technologies that afford this transformation of the existing theory-laden program are iPads for all students, the use of 3D model applications, and virtual reality. The result is a “mobile classroom” that exists independent of time and place. Such a design allows the students to record and document their learning—observations, reflections, and discussions—in real-time and *in situ*. In addition, the educational design makes it easier to connect local phenomena to global trends and challenges. The digitalized design combined with the expanded opportunity for the student to become an active student-researcher affords a meta-perspective that would be difficult for the student to adopt in a more recipient- and theoretically dominated program. Epistemologically, we see how digitally extended and embedded epistemic work involving different types of knowledge overcomes constraints in space and time; minds, hands, and possibly emotions and cultures connect.

The two project proposals also involve a “lived experience” (i.e., there is an embodied aspect added to the extended and embedded epistemologies). We find similar epistemological aspects across nearly all the proposals from across all programs and disciplines—history, foreign languages, math, arts and crafts, and a series of cross-disciplinary projects. Thus, we argue that the two cases serve as empirical carriers of epistemic aspects that are relevant across domains and, therefore, highly valid for TE with its multitude of subject didactics, pedagogy, and practicum. Although the two highlighted projects cannot be generalized into what is typical, they amount to a strong indication of the epistemic practices that take shape when digitalization meets education (for an extended discussion, see Aagaard & Lund, 2020).

## **Empirical snapshot #2: Student teacher surveys**

To what extent does TE prepare student teachers for epistemic work in digitalized contexts? Our second snapshot seeks to respond to this question. We summarize the results of the analysis of two extensive surveys, one with ensuing group interviews, conducted among student teachers at two different universities.

In the first survey, we found that 43% of the 92 respondents reported that they had developed their PDC to some extent during practicum, while 34% reported that they had developed their PDC to a great or very great extent during practicum. Regarding university lectures (in pedagogy and didactics), the numbers were similar; 40% said lectures had developed their PDC to some extent, while 29% said lectures had developed their PDC to a great or very great extent. Some items addressed the student teachers' experiences with planning instruction that included use of digital technologies. While 48% confirmed that they had experience with this to a great or very great extent, 52% reported they had experience with this to a certain extent only or not at all. These percentages indicate that on a collective level, the student teachers experienced advancing their understanding of PDC while they were divided about having operationalized this competence in practice situations.

In one of the assignments in the TE program, student teachers were required to connect their practice experiences with digitalization to scientific approaches and studies. Only 5% criticized this assignment, which required an agentic stance toward research. However, in the group interviews, one student teacher revealed that he did not see how research related to teaching competence. Another responded that finding and summarizing a research paper was "pointless." But we also heard student teachers envisioning new models for future teaching practices, adopting a more transformative stance. One of the student teachers argued for "the teacher with the researchers' eye" to develop digital strategies for the classroom, an indication of potential research-informed professional practice.

Because the intention with the survey was to evaluate institutional initiatives to prepare student teachers for professional work in a digital age, the data only provide indications and instantiations of student teachers' stances regarding how TE prepares them for epistemic work in digitalized contexts. They expressed both enthusiasm for and resistance toward using an online collaborative learning environment, some finding it irrelevant for their teacher education. On a collective level, the student teachers seemed to experience a conflict of motives—investing in PDC or opting for minimal effort. Some envisaged a way out of the conflict by carrying on without engaging in PDC; others acknowledged the need for PDC to expand beyond the status quo as teachers. This conflict of motives indicates that these student teachers were not sufficiently prepared for connecting digitalization to research-informed epistemic practices.

The second survey was also designed to evaluate initiatives for promoting student teachers' PDC, but at a different university. Of the 182 respondents, 69% agreed or very much agreed that they knew what PDC entailed. This is in itself noteworthy because the term, from teacher educators' perspectives, is still notoriously fuzzy and has been subject to many different interpretations (Lund et al., 2014). This percentage is substantiated by 68% saying they agreed or very much agreed that they had gained experience with producing digital resources with video and sound, by 60% saying they had gained experience

with collaborative digital resources, and by 63% saying they had gained an overview of digital resources commonly found in schools.

Regarding how the student teachers felt in terms of being prepared for issues relating to copyright, personal security, social media, identity, behavior, and risks, the responses were more divided. Between 17% and 34% reported they had not gained any insights at all. Meanwhile, 66% reported they had developed an understanding of how to recognize digital bullying to a small extent or not at all, and 52% reported they had developed an understanding of how digitalization might influence democracy to a small extent or not at all.

One interesting category in the context of the present paper was the one concerning how student teachers reflected on what would most help them develop their PDC. Ninety-five percent stated that exploring digital resources during practicums would be very useful/interesting or useful/interesting. In addition, 83% stated that they found it useful/interesting to do tasks and assignments in which one has to decide how to best use digital resources to boost one's own or others' learning. Thus, we see indications of an explorative attitude. Without overstating its importance, we argue that such an attitude serves as a prerequisite for engaging in a broad repertoire of epistemic work and, potentially, transformation.

One open-ended question asked in the second survey was, "Do you have suggestions as to how TE can prepare student teachers for teaching in a digital age?" As in the first survey, the responses were mixed. Approximately half of the suggestions pertained to getting to know applications or engaging in the more tool-oriented aspects of digital resources. However, in the remaining half we find many voices emphasizing the need to explore the affordances of digitalization in practice situations (and even making this mandatory) to connect digitalization to specific school subjects and to increase student teachers' awareness of ethical and social dimensions.

So, to what extent does TE prepare student teachers for epistemic work in digitalized contexts? Both the surveys and the interviews indicate that TE tends to promote *understanding* and to some extent the *use of* digital technologies. However, as neither survey includes epistemologically oriented questions or connects digitalization to potentially transformed epistemic practices, we cannot expect student teachers to make such connections. The absence of epistemic issues in the questionnaires is in itself an interesting finding, indicating these do not figure in institutional interpretations of what PDC entails. Given the trends outlined in the introduction (e.g. impact of AI on education and practices, non-human partners and decision-makers) to this paper, a more epistemic approach to digitalization seems essential in TE. We cannot ignore the impact digitalization has on the most fundamental activity of all educational institutions—knowledge work—what forms it adopts in a digital age, and under what conditions and by what means we advance our knowledge.

## Transformative digital agency and implications for teacher education

We have posed two research questions that we argue TE will need to respond to in order to make TE programs meaningful, ecologically valid, and future-oriented. The first question asked how digitalization impacts epistemology. By examining trends in digitalization and research on the relationships between artifacts and human agents, we found that digitalization involves transformation, not merely augmentation or reinforcement of existing epistemic practices. We identified three distinct manifestations of transformed epistemic practices as digitalization moves from extended and distributed cognition toward increasingly embedded and embodied cognition. The brief analyses of project proposals provided a snapshot of epistemic changes that emerge in HE in general and, therefore, with implications for how PDC can be understood in TE.

A further look into future-oriented but scientifically sober literature emphasizes these trends. For example, Facer (2011) points to rapidly emerging collaborative endeavors between HE and local communities involving collective intelligence and crowdsourcing. She asks fundamental questions such as “As we create new tools and technologies to project and record our identity and hold our memories, what new types of being human might open to us?” (p. 43). Such questions connect digital epistemologies with human ontology—what it means to be human in a digitalized world. Her response is “to recognize children as being connected to a unique constellation of networks of people, tools, information and processes intimately *embedded in and interconnected with their tools*, their environment and their social networks” (p. 55, emphasis added).

If we turn to recent developments in, for example, robotics and artificial intelligence (AI), Facer’s more general observations become hard realities for TE. Although robots cannot replace teachers, they may well have a future as teacher assistants. Still, although robots may possess infinite patience and provide just-in-time relevant assistance to pupils struggling with math or reading, “the purpose of a robot is not simply to understand a situation, but rather to respond to it” (Serholt et al., 2017, p. 627). This is a most important distinction, as it takes us into the fundamental difference between intelligence and consciousness, the latter being the hallmark of the human condition (see e.g., Tegmark, 2017 for an updated and insightful discussion of progress in and possible limitations of AI). This difference is also at the heart of Harari’s (2017) influential book on the near future of man: “Over the past half-century there has been immense advance in computer intelligence, but there has been exactly zero advance in computer consciousness” (p. 361). Still, Harari’s epistemological credo links the human agent to the digital resources: “Connecting to the system becomes the source of all meaning” (p. 449).

The bottom line is that digitalization not only impacts epistemologies and epistemic practices but fundamentally transforms them. We have argued that this is a most pressing issue for TE to attend to. The question that arises is whether we do this and if so, how and to what extent.

When we juxtapose the two empirical snapshots (proposals and surveys), we see that there is quite a distance between what emerges as digital epistemologies and epistemic work and how student teachers are prepared for this development. The surveys and interviews mostly reflect an emphasis on the use and mastery of digital artifacts, while epistemological implications seem to be underestimated. Closing this gap requires that TE becomes more aligned with epistemological shifts and expansion along the lines that we have shown as a response to the first research question. Our core argument here is that digitalization requires teacher educators and student teachers to cope with and develop *transformative* digital agency—that is, agency to identify educationally challenging situations and turn to relevant digital resources (and other resources) to transform the problem situation into a constructive and teachable event (Aagaard & Lund, 2020; Brevik et al., 2019; Lund et al., 2019; Sannino, 2015; Stetsenko, 2017). Transformative digital agency involves designing and enacting educational practices where the division of labor between humans and non-humans is not always clear but where the educational responsibility firmly rests with human agents—in this case the teacher educators and student teachers—on their way to preparing for the teaching profession in a digitalized world.

Of course, this request is too complex and convoluted to be solved by introducing a simple and normative procedure. Transformative digital agency emerges as a truly dialectic principle; the agent changes as the problem situation is transformed. Nevertheless, as an epistemic focus seems to be deficient in TE, we suggest that teacher educators apply some principles in their future efforts to prepare student teachers for a working life where epistemic work changes due to digitalization. We envisage TE programs that involve a series of relevant practice cases where student teachers do the following in collaboration with teacher educators on campus and schools:

1. Discuss and exemplify relationships between human agents and digital technologies in view of partnerships that involve extended, embedded, and embodied cognition. There are also ethical implications (e.g., cyberbullying, copyright, plagiarism), but these are beyond the scope of the present paper (but see Aagaard & Lund, 2020).
2. Experience so-called problem situations characterized by alternatives with several possible outcomes, complexity that might leave the student teachers passive or confused, or challenges that cut across subject domains and involve documenting novel forms of problem-solving.
3. Work on resolving the problem situation(s) by turning to available resources. These may be digital, as highlighted in the present paper, but may also be analog or discursive/conceptual, symbolic, social, etc.

Space allows for only a brief example of such a problem situation. One student teacher reported (in an online forum) her experience that in her English class, several students kept quiet, although she suspected they were quite proficient. Taking on this problem

situation, she discovered by way of interviews that these students in their leisure time engaged in gaming practices that required sophisticated collaboration and communication in English. Through an innovative design for her English lessons, she then introduced the class to a role-playing game that bridged goals in the syllabus with the out-of-school practices she had discovered, thus stimulating her hitherto reticent students to engage in the English class activities. The result was so promising that she extended the design into a larger project for the class. This case and other problem situations together with the deeper theoretical foundations are analyzed in more detail in Brevik et al. (2019) and Aagaard and Lund (2020). Also see Brevik (2016) for an in-depth analysis of gamers' expansive practices.

## Conclusion

In this paper, we have identified and exemplified some trends in digitalization that involve shifts and expansion of epistemologies and, consequently, in epistemic practices. However, we have also shown via surveys and interviews with student teachers that neither the surveys themselves nor the student teachers' responses to them connect to or correspond with the digital challenges that are currently on the rise. Beyond the epistemologies we have focused on in the current paper, there are also important social and ethical dimensions that TE needs to connect to classroom management and the general goals of the curriculum (Aagaard & Lund, 2020). In sum, these are daunting issues. However, if TE aims to be ecologically valid for a society where we arrive at knowledge through extended, embedded, and embodied digital resources, then it urgently needs to address such issues. We have outlined one possible approach by suggesting the principles of transformative digital agency as one way to constructively deal with epistemological challenges of digitalization.

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