

Teacher professional development in higher education and the Teknosofikum project

By Magda Pischetola

Nyere forskning har vist, at anvendelse af digitale teknologier inden for de videregående uddannelser indebærer en række pædagogiske udfordringer, som nødvendiggør udvidelse af undervisernes professionelle udvikling. I denne artikel præsenteres den første konceptualisering af Teknosofikum, som er et treårigt projekt (2020-2023) finansieret af Uddannelses- og Forskningsministeriet for videregående uddannelse og videnskab (UFM), der har til formål at fremme undervisernes professionelle udvikling inden for teknologiuddannelser. Artiklen er baseret på data fra den første iteration; herunder definition af den tilsigtede læseplan, indholdsudvikling med fagekspertes og design af læringsaktiviteter. I artiklen anvendes et sociomaterielt perspektiv informeret af STS, kritisk design og feministiske studier. Gennem disse teoretiske perspektiver forstås videregående underviseres professionelle udvikling inden for teknologiuddannelse som viden, der op- og indføres gennem en tilgang til kritisk relationel pædagogik.

Recent studies have acknowledged the pedagogical challenges posed by digital technologies in higher education (HE) and the need to expand teacher professional development. In this paper, I present the first conceptualization of Teknosofikum, a three-year project (2020-2023) funded by the Danish Ministry of Higher Education and Science, aimed at promoting HE teachers' professional development in technology education. The paper draws on data from the first iteration, including definition of intended curriculum, content development with subject experts, and learning activities design. A sociomaterial perspective is adopted, informed by STS, critical design and feminist studies. Through these theoretical lenses, HE teachers' professional development in technology education is understood as knowledge enacted through an approach of critical relational pedagogy.

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Introduction

The rapid growth and diffusion of digital technologies faces not yet established teaching and learning practices in higher education (HE), where a great potential lies (Cohen, Nørgård & Mor, 2020). The need for HE teachers' professionalism is emphasized as an answer to the dramatic changes occurring in society, not least the emergence raised by the COVID-19 pandemic. This entails not merely knowing about available educational tools and platforms, but also considering how teachers comprehend and manage technology in relation to their own subject matter, and with a focus on societal changes (Hansbøl, 2019).

The use of digital technologies in HE was placed at the core of the Danish political agenda in 2007, with an initial focus on digitalization of administrative structures and examinations (Tømte, Fossland, Aamodt & Degn, 2019). As advanced technology and digital solutions become more widespread, it became more urgent to invest in getting young people interested, educated and professionally attracted to the so-called STEM areas – Science, Technology, Engineering and Mathematics. In 2018, the Danish government set a Technology Pact with over 80 educational institutions and business companies, where the following aspects are mentioned: digital empowerment, digital design and design processes, computational thinking, technological ability to act, Informatics as a subject, and disciplinary technology comprehension.

Following the Technology Pact, the government established a Danish Program for Digital Learning, with a focus on a set of knowledge and competencies to be developed by each citizen (UFM, 2018a). The ministerial program addresses HE teachers' professional development in terms of both knowledge and use of digital technologies. It calls for improvements in the quality of teaching, in students' learning outcomes and in education flexibility (UFM, 2018b).

This requirement goes in line with the most recent literature

on teacher technology education. In particular, scholars have referred to the need to expand the theoretical paradigm of professionalism in HE beyond individual skills and capabilities (Bocconi, Chiocciariello, Dettori, Ferrari & Engelhardt, 2016; Englund, Olofsson & Price, 2017; Mathiasen, 2019). In fact, outcomes-based education (Biggs, 1996), measurable results based on efficiency (Anderson & Krathwohl, 2001; Hart, Battye, McCormack & Donnan, 2007), and general competencies frameworks (e.g. DigComp, 2017) are said to reduce teachers' creativity and imagination (D'Cruz, 2021), and build upon instructive models and dualisms (Macfarlane, 2015). A focus on general skills and competencies is also weak because it does not pay attention to "the person as teacher" (Tigelaar, Dolmans, Wolfhagen & van der Vleuten, 2004, p. 253) and a wider spectrum of knowledges that relates to professional growth (Barnett & Bengtson, 2017).

Collectively, these studies underline that the production of knowledge in HE is not separated from everyday experiences and practices, including material processes, personal research interests and politics. This implies for pedagogy an encounter of knowing, being and doing (Dall'Alba, 2009), as aspects that cannot be taken apart.

In this paper, I draw on this literature and propose a sociomaterial framework for technology education, which focuses on the complex entanglement of digital technology and knowledge production, guided by the following research question:

How to address HE teacher professional development in technology education?



The paper presents the first phase of a project named Teknosofikum, which is funded by the Danish Ministry of Higher Education and Science under the abovementioned Program for Digital Learning. The project is held in partnership among four Danish HE institutions – IT University of Copenhagen, Royal Danish Academy, University of Copenhagen - Faculty of Law, and Design School Kolding – and runs for three years (2020-2023).

Through an iterative process in three cycles, Teknosofikum aims at developing a professional course-concept for in-service HE teachers in Denmark. More than 500 course participants will be involved in the project along these iterations and, with their participation, will qualify the sociomaterial conceptualization of technology education that Teknosofikum is proposing.

Theoretical foundations of technology education

In the last three years, a new experimental subject named technology comprehension (teknologiforståelse) was implemented in the Danish primary schools, aiming at fostering Danish children learning through creative thinking with digital technology, in order to participate actively in the democratic society (EMU, 2018). The theoretical foundations of this subject take into account a long trajectory of educational research about media and technologies in the school context, which has brought into focus different concepts. Therefore, they also constitute a rich contribution for this paper.

In this section, I will present the four main areas of knowledge and competencies related to technology comprehension (TC) and I situate them in relation to other concepts that literature has presented over the last decades. The purpose of this exercise is to underline the theoretical relations, differences and similarities of TC with other concepts that are widely present in educational literature, such as computer literacy, digital literacy, ICT literacy, computing, computational thinking, and computational empowerment – which are also mentioned in the Danish Program for Digital Learning. This analysis will provide a general theoretical overview to support the specifics of professional technology education in HE.

The four areas of knowledge/competence comprise *Computational thinking*, *Digital design*, *Digital empowerment* and *Technological ability to act*. Following Tuhkala, Wagner, Iversen & Kärkkäinen (2019), I will cluster the last two, *Digital empowerment* and *Technological ability to act*, as part of one category, which the authors call 'Societal reflection'. In the following, I present the contents of each area and define their relationship with existing literature.

Computational thinking

The first component of TC has its foundation in a concept that was popularized by Jeannette Wing in 2006 as Computational thinking, and more generally in the idea that computing is a fundamental skill for all (Caspersen & Nowack, 2013). The base of this assumption can be found in Seymour Papert (1980) and his constructionist approach, whose central proposition is that learning to program increases pupils' awareness of their strategies for debugging problems and solve them (Allsop, 2019). Papert (1980, p. 11) considered interactive technologies as "objects-to-think-with". He stressed the importance of procedural thinking and argued that this specific way of thinking could be enhanced through programming with LOGO. The connection

of his ideas with mathematical and abstract thinking was seen as a breakthrough in education (Tedre & Denning, 2016), despite the fact that such methods have been a part of human history for long time (Denning, 2017). Computing and Computational thinking became an object of research especially within the field of Computer Science Education.

In the Danish context, already in 1954 Peter Naur contributed to stressing the importance of computers for society and the individual and wrote a large number of articles about the place of computer science in general education (Caeli & Bundsgaard, 2019). Naur understood language, mathematics and computer science as closely related subjects, which provided necessary preparation for life (Caeli & Bundsgaard, 2019). He believed in the need to spread computer science skills among youth and to conceive data as a matter of general human understanding (Naur, 1966), which could shed light on everyday tasks (Sveinsdottir & Frøkjær, 1988). The focus was on both enabling pupils to think logically about computers' processes and critically about computers in society. This perspective has evolved into introducing computers in Danish schools in the 1980s and launch initiatives such as Coding Pirates and Fablab in the 2000s (Caeli & Bundsgaard, 2019).

TC takes a step further and brings this focus of investigation and practice to the fields of educational research and Human-Computer Interaction (Tuhkala et al., 2019). As such, TC places an emphasis not so much on specific elements such as the cognitive/metacognitive processes brought about by computing, but rather on computation as an unbounded process (van Leeuwen & Wiedermann, 2012), which takes into account complexity and nondeterministic behaviors. In this sense, computing is seen as a form of empowerment (Iversen, Smith & Dindler, 2018) and it is expected to foster basic scientific concepts (Denning, 2017; Nardelli, 2019) to support complex problem solving and to gain understanding of values and cultures embedded in digital technology (Caspersen, Gal-Ezer, McGettrick & Nardelli, 2019).

Digital design

Since the UNESCO Grünwald Declaration in 1982, the promotion of different forms of technological literacy has become a core political agenda worldwide. Teachers at all levels are considered key actors in supporting new literacies and both pre-service and in-service programs in the teaching career are encouraged to include a focus on ICT and digital tools and methods (UNESCO, 2019). A vast amount of literature has focused initially on Media and Information literacy

and Computer literacy, and later on Digital literacy and ICT literacy. These concepts comprise a wide range of definitions (Tamborg, Dreyøe & Foug, 2018), which are often overlapping in terms skills/competencies related to digital citizenship (Council of Europe, 2017) and digital transformation (EU Digital Education Action Plan, 2018). In line with this research tradition, TC proposes to understand teachers' digital and computer skills as means, rather than as outcomes (Tuhkala et al., 2019). However, what is new in this perspective is a greater attention given to Design as an area of study and practice that equals computing. Designing a technology implies thinking of society, as any idea of a product or a service has to align with people's uses and needs (Margolin, 1989). In the same perspective, designing learning activities is intertwined with organizing materials, using digital artefacts, tools and platforms, and incorporate didactical design principles within the use of technologies. As such, TC is connected to making and digital fabrication (Smith, Iversen & Veerasawmy, 2016), where materials and artefacts acquire a special focus by relating to practice in an emerging process. On the other hand, iterative design and prototyping allow to face complex problems through social cooperation (Denning, 2017) and thus avoid technological determinism (Oliver, 2011). Moreover, design is increasingly augmented by computing and artificial intelligence and informs intentionally or unintentionally ideologies that are embedded in computational processes (Kaiser, 2019). It is therefore necessary to reflect on how our experience of the world, and our modes of participation relate to the way technologies are designed.

Societal reflection

In literature much attention has been given to critical understanding and use of information, access and use of social media and digital environments, as well as ethical integrity and responsibility related to ICT and the internet platforms. TC presents a more specific approach to societal reflection, as it connects ethics and values with digital solutions (Tuhkala et al., 2019). This approach commits to study techno-cultural arrangements by conceiving technology production as a democratic and empowering domain (Balsamo, 2011). Technological tools are not only meant to solve problems and represent knowledge, but as means and resources to address complex societal problems (Hansbøl, 2019).

Three elements unfold in this perspective. First, the need for the teacher to be able to be critical towards what has been done (Tuhkala et al., 2019). Second, teachers should be able to experiment freely and exercise their imagination of what can be

done with technologies (Nørgård & Paaskesen, 2016) for democratization and change in society. Third, it is needed to ask technologies and Artificial Intelligence what *should* be done for the future of education (Selwyn, 2019). Therefore reflection, as main element of the deepest level of learning (Dewey, 1910), is considered the drive to shape the digital society. All these elements are needed in teacher professional development (Tuhkala et al., 2019), as they comprise complexity as an aspect of teaching and learning (Biesta, 2010).

Based on this brief literature review, some conceptual overlaps unfold. TC comprises other perspectives, which are also present in programs and policies about technology education in academic professional development programs. An important aspect to mention is that the TC subject foundation offers a specific grounding in a Scandinavian tradition of participatory design (Bødker & Kyng, 2018; Smith, Bossen, Dindler, & Iversen, 2020) and usage of prototyping, as methods to include future users in the design of a new product or technology (Misfeldt, Tamborg, Qvortrup, Petersen, Svensson, Allsopp & Dirckinck-Holmfeld, 2018). Participatory design values the process through which democracy, empowerment and learning are pursued; it fosters collaborative work and thinking (Britton et al., 2019). Moreover, prototyping pays attention to the way achievements are sustained and scaled (Halse, 2010). These are valuable design principles in HE, where research is constantly informing teaching practices and curricula. Another crucial aspect to underline, for the purposes of this paper, is the focus on design and computing as fields that work together in shaping our experience of the world, as well as the way we imagine the future (Kaiser, 2019).

On the other hand, some shortcomings arise from the overview of concepts related to TC. First, the very meaning of 'knowledge' production is strongly related to disciplinary contents associated with technology. This reflects the focus of cognitive sciences on a linear understanding of the learning process (Goodyear & Carvalho, 2014; NLEC et al., 2021), as well as mental processes behind a human behavior. Selwyn (2010) points out that this is often a common ground for cognitive psychology and technology-based education. In HE, he argues, many technology-based learning environments such as work-related simulations and intelligent tutoring systems still follow cognitivist lines. These approaches have been criticized for conceiving learning as an individual process and losing sight of the social aspects of human nature (Selwyn, 2010). Against this backdrop, it is necessary to explore more in depth what

Second, according to Denning (2017) the focus on programming and algorithms has created a narrow perception of computational thinking, which in turns generates an overestimation of machine capabilities and misconceptions about their functions. This risk is also present in HE, as discourse about technology can be often polarized and reduced to deterministic or instrumental perspectives (Feenberg, 2017). Technology is not positive nor negative in itself, but it also not neutral, as it exercises some form of agency on society and human activities (Orlikowski, 2010).

These reflections can benefit from the contributions of critical, techno-cultural, sociomaterial and new materialist feminist studies, on which we will draw in the next section to define professional technology education in the context of HE.

A sociomaterial approach to technology education

Sociomaterial theories put emphasis on the role of artefacts and materials, considering them not merely as mediating tools, but rather as agents that exercise some kind of action (Latour, 2005). A core element of sociomaterial theories is hybridity, which refers to a transgression of traditional boundaries and dichotomies (Hilli, Nørgård & Aaen, 2019; Pischetola & Miranda, 2019). In a sociomaterial perspective, when human and non-human entities come together, interactions and negotiations occur, which will form and transform into a specific 'assemblage' (Law, 2004). Nespore (2002) explains that some elements of this heterogenous composition – such as e.g., physical buildings and disciplinary curricula – are more visible. Others, such as e.g., external relations with professional groups and market interests, need from researchers a "network sensibility" (Fenwick & Edwards, 2014, p. 41) or a specific happening (Alizerbeigi, Masschelein & Decuyper, 2020; Pischetola, Miranda & Albuquerque, 2021) to become visible. If we adopt this perspective, we will understand with Barad that "practices of knowing are specific material engagements that participate in (re)configuring the world" (2007, p. 91, emphasis in original).

If knowledge is not something 'out-there' in the world, but rather a result of "webs of relations" (Fenwick & Edwards, 2014, p. 39), learning can be considered an emergent process (Bateson, 1972) which cannot be completely foreseen or planned in advance (Miranda & Pischetola, 2020). In fact, the learning event is resulting from the complex entanglement among all elements that compose a unique phenomenon, including both materials and discursive practices (Barad, 2007; Hasse, 2019).

A central element of sociomaterial perspectives is the concept of enactment, which includes mutual adaptation of the involved participants (Cviko, McKenney & Voogt, 2012). If knowledge production is not abstract reflection but an active contribution to the shape of the world (Fenwick, 2015), different pedagogies are not merely different ways of building disciplinary knowledge through different representations, but rather they correspond to forms of enactment.

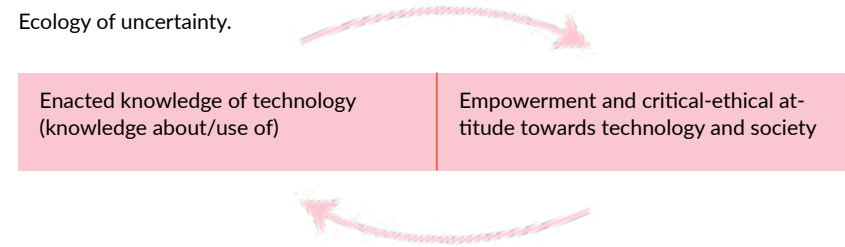
Dall’Alba suggests challenging the idea of knowledge as “absolute and foundational” and proposes instead “a pluralization of knowledges” (2005, p. 363). An implication of this shift of concepts is that knowing is not only a cognitive procedure, but is “created, enacted and embodied” (Dall’Alba, 2005, p. 363).

If we frame knowledge in these terms – as ongoing, plural, and enacted – we understand the limitations of a step-by-step and pre-determined teaching-learning process. Instead, our focus is on pedagogical practices that are both responsive and responsible (Kuntz, 2021; Preissle & deMarrais, 2011), as well as both critical and relational (Ulmer, Kuby & Christ, 2020). The theoretical basis of this endeavor is Freire’s critical pedagogy (Freire, 1996) and feminist studies (Bozalek & Zembylas, 2017; Taylor, 2019), where pedagogy (as any other action) becomes an ethical and political issue. In this sense, knowledge/use of digital technologies can also be understood as empowerment. If we endorse the plurality of ways in enacting complex reality(ies), in order to create empowerment in educational settings, we shall focus less on subject-centering and more on subject-decentering and destabilizing (Fenwick, 2011).

Finally, if we acknowledge with Barnett (2004) that learning and knowledge production are related to uncertainty, we will need to question a closure into certainties (Latour, 2005), and – instead – reintroduce openness, complexity and non-linearity (Miranda & Pischetola, 2020; Osberg & Biesta, 2020) in an exercise of “delving into the darkness” (Dall’Alba & Bengtson, 2019, p. 1481).

Bearing this in mind, technology education can be defined as *enacted plural knowledges about digital technologies that translate into empowerment and critical-ethical attitude towards uncertainty* (see Figure 1 below).

Figure 1.
A sociomaterial perspective on technology education.



In the literature review presented in the opening of this paper, the aspects of empowerment and critical thinking are quite evident. On the other hand, enactment and uncertainty do not appear as central elements of the conceptualization of the knowledge/competence areas of technology comprehension.

When reflecting on how to develop technology education in HE in a sociomaterial perspective, it is evident that teacher professional development should also focus on understanding the critical and mutual relationship (enactment) between technology and (uncertain) society, bearing in mind that designs co-create society (Margolin, 1989). In this sense, technology education enables thinking, researching and acting in a different way.

In the next section, I will describe how the results of this theoretical framework have been translated into a course-concept for teacher professional development, through a participatory design process.

Teknosofikum course and concept

Teknosofikum is a three-year project (2020-2023) funded by the Danish Ministry of Higher Education and Science, aiming at developing a professional course for in-service HE teachers. It brings together four partner institutions – IT University of Copenhagen, Royal Danish Academy of Architecture, Design and Conservation, University of Copenhagen – Faculty of Law, and Design School Kolding – who work at the course design, development and implementation in three iterations. Altogether 500+ course participants from all over Denmark will attend the course along the duration of the project.

The purpose of Teknosofikum is to inform, prepare

and inspire in-service HE teachers to put new digital opportunities into play in their teaching activities and in relation to their subject matters, increasing students' educational benefits. Its initial specific goals are:

1. To provide a diverse group of HE teachers with knowledge and understanding of digitalization and new opportunities for teaching.
2. To prepare and inspire HE teachers to engage with digital learning formats, methods and tools in their own subject and teaching activities.
3. To provide HE teachers with knowledge to guide and supervise students in using digital platforms and tools in their educational programs.
4. To establish a scalable Teknosofikum course which can be made available as an offer to other institutions after project completion.

At the end of Teknosofikum, course participants are expected to have gained a greater understanding of the transformations that digital technologies entail for society and for the field of work in which they are preparing their students. Teachers will acquire knowledge about technologies and will be able to handle several digital tools and platforms. Moreover, they will be prepared to bring into play a variety of technologies in their teaching in a meaningful and relevant way.

The curriculum includes six modules, among which the course participants will attend (at least) five. The modules are developed at the intersection of IT, Law, Design and Architecture, with the ambition to provide interdisciplinary cases and scenarios that can be relevant for HE teachers in other academic fields. The course development is led by the IT University of Copenhagen and organized around a principle of collaboration between 12 selected subject experts (two/module) from the four partner institutions, three educational designers (project manager, postdoctoral researcher and e-learning consultant) and a project group composed by one expert in learning design at each institution. The contents of the modules are briefly described in Table 1 below.

Table 1.

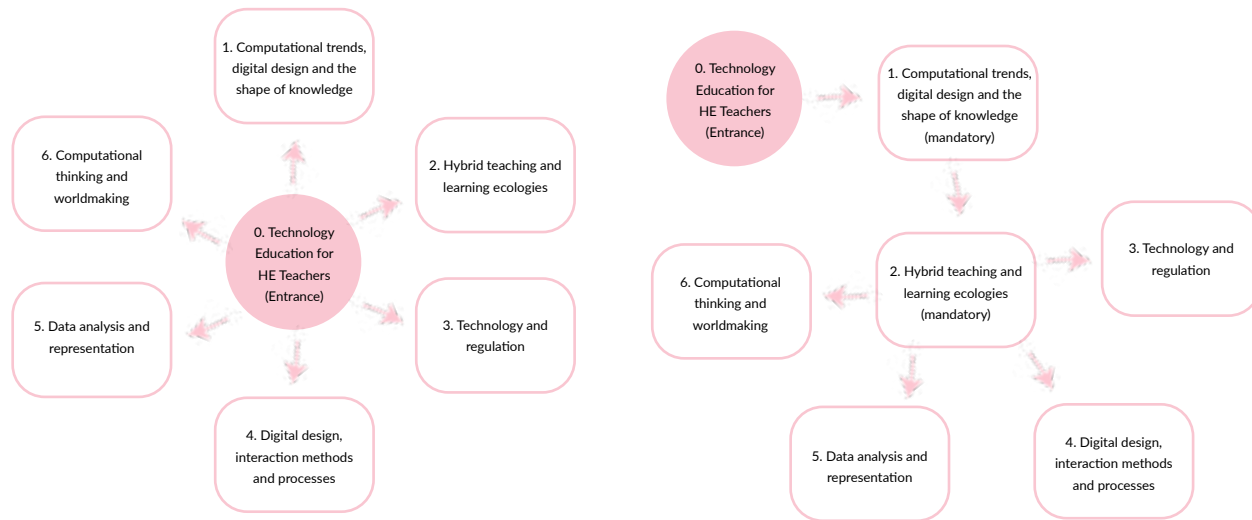
Modules contents description.

	Module name	Module description
0	Technology Education for HE teachers	The module frames the course and presents different approaches to technology education in HE.
1	Computational trends, digital design and the shape of knowledge	The module shows the interconnectivity between computational trends in society, AI systems, design cases and knowledge practices.
2	Hybrid teaching and learning ecologies	The module presents key (double) pedagogical-didactical approaches at play in Teknosofikum with a focus on fostering HE students' technology education.
3	Technology and regulation	The module introduces basic challenges that digitalization and technological advancements pose in the context of "law". This includes the regulation of, by and the impact of technology for the professions and society as a fundamental theme to be considered in teaching in HE.
4	Digital design, interaction methods and processes	The module reflects upon digital design as a creative bridge between technologies, culture and humans. The focus is design thinking, interaction design, methods and processes when working with material narratives for a sustainable future.
5	Data analysis and representation	The module introduces different types of digital data and how they are created, tracked, transformed and visualized.
6	Computational thinking and worldmaking	The module raises critical reflection and evaluation of computing as worldmaking. It aims at developing a critical-analytical mind-set of designing computational artefacts.

The course is developed in two formats, as self-study and as facilitated course (see Figure 2 below). In the self-study format, the course participants are free to navigate across contents and choose the modules that best suit their needs, as it happens in Massive Online Open Courses. Each module has a duration of 5 hours approximately. In the facilitated format, the full course has a duration of 37 hours distributed over 4 months of attendance and held through collaborative activities and discussions. The facilitated course is structured as follows: 2 mandatory modules, 2 modules selected

by the HE institution, 1 module selected by the course participant among the remaining options.

Figure 2.
Teknosofikum course structure as self-study (left) and facilitated (right).



The course is thought to take place differently in HE institutions and from teacher to teacher. This flexibility of formats aims at expanding course attendance after the project completion. In this way, Teknosofikum could become a permanent part of the teacher professional development courses (e.g. Adjunkt Pedagogikum) that already exist in Denmark for novice HE teachers.

Research and development

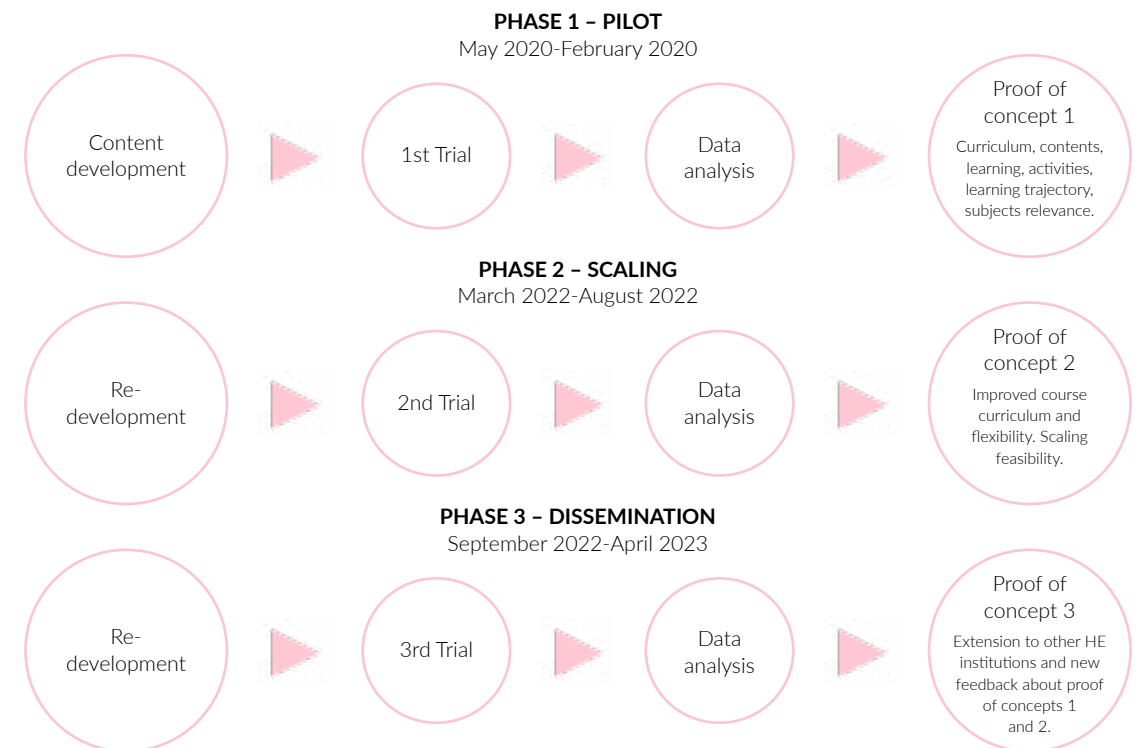
Teknosofikum is conceived as an iterative research and development project, comprising both qualitative and quantitative investigation about HE professional development in technology education. Three main objectives drive this process:

1. Investigating empirically both the processes and the means through which course participants' learning happens in practice.

2. Establishing intensive collaboration and dialogue between research, development and course participants in and across iterations.
3. Engaging theory-inspired in working with and continuously qualifying Teknosofikum as a concept and course.

The course development comprises three trials: 1. *Pilot*, 2. *Scaling*, and 3. *Dissemination*. The final outcome of each phase is conceived as a proof of concept (see Figure 3 below). In each iteration the development of the course is further qualified through new data-informed inquiries into domain knowledge, research-based assessment and re-development. As such, we can consider that each trial represents the chance of a new first phase of preparation and re-conceptualization. This element is what constitutes the strength of the project, as it allows for a broader experimentation from the researchers' team and it shows the possibility to improve and sharp the whole course design.

Figure 3.
Teknosofikum research and development design.



Pilot

In the first phase, the proof of concept is analyzed with a focus on Teknosofikum curriculum and contents, associated learning activities, individual learning trajectories, and how the Teknosofikum modules in practice can be relevant, meaningful and able to connect interdisciplinarily with the course participants teaching practices.

In order to achieve a strong relation between learning processes and “the means by which they are supported” (Cobb & Gravemeijer, 2008, p. 76), mini-iterations are running along the process, to test the first prototype of the course in self-study format, with course participants from the four partner institutions. The first iteration in facilitated format will start in September 2021 and run for four months, with a group of 37 course participants.

Scaling

In the second phase, the proof of concept will focus on the improved concept, course and curriculum and a feasibility assessment of scaling Teknosofikum. The second iteration will run from February 2022 until May 2022, with the duration of four months, involving a total of 125 course participants from the four partner institutions. It is a full deployment of the course, but yet with a relatively small group of participants, from whom we expect feedback to improve the course before a third and final iteration. In this second iteration, both formats will be offered at the same time.

Dissemination

Finally, in phase three, the proof of concept relates to the possibility of extending the course to other HE institutions in Denmark. At this moment, it will be possible to run an assessment of course participants’ experiences of the value of Teknosofikum as add-on to existing HE teacher professional development programs. In this third iteration, 140 participants from the four partner institutions and 190 from other institutions will take the course.

It is worth to mention that this envisioned iterative process is open-ended and might change during the project, as each phase of experimentation (trial) can bring unexpected results to take into account. Bearing this in mind, we understand that data generation along the project will be continuous and informed by all phases and activities. Therefore, we need to document the shifts in the course participants’ appropriation of contents, tools and methods.

To this end, we will use a number of both qualitative and quantitative research instruments. The initially identified research tools and methods are:

- Document analysis to address the background knowledge from the four partner institutions.
- Baseline survey with course participants at the entrance and exit of each module (first iteration) / the whole course (second and third iteration). Total of 500 answers to entrance/exit baseline survey.
- Group interviews with eight course participants of each iteration (including mini-iterations). Total of six to eight group interviews.
- Participant observation during facilitated course at the first iteration.
- Focus groups with all the Teknosofikum supervisors at the end of each iteration of the facilitated course in blended format. Total of three focus groups.
- Feasibility test at four institutions, to assess the scalability of the course after the second iteration.
- Teaching plans’ assessment. Teaching plan is the end product to be delivered by all course participants at the end of each iteration. Total of 500 teaching plans.

In the following, we present the outcome of Teknosofikum preparation in the pilot phase, which required development of contents, materials and resources, and learning activities that might be used as resources for learning when enacted by the course participants.

Results from the pilot

The conceptual work related to the creation of the intended curriculum of the course led to the definition of what Teknosofikum is and is not, which I summarize in Table 2 below.

Table 2.
Conceptualization of Teknosofikum (what is/is not).

What Teknosofikum is not	What Teknosofikum is
Course in general IT and/or digital skills (e.g. PC-driving license)	Course for teachers' professional competences development
Digital technologies as mere tools/instruments (educational technology)	Digital technologies as tools, forms of organization, shape of knowledge (technology education)
Static knowledge of relevant tools and resources for the digital age	Dynamic knowledge of a variety of available technologies and imagined pedagogies
Distance teaching (forgets human relationship as pedagogical core)	Hybrid teaching with a focus on human relationships (critical relational pedagogy)
Digitization (how to make things digital, e.g. wikipedia)	Digitization (how do we organize ourselves around technologies, e.g. in education)
Tips and tricks	Critical/creative thinking to deal with uncertainty

This general understanding of the course-concept allows us to face the project complexity, defined by three main aspects: (1) the dual expected output (self-study/facilitated course) in terms of format and curriculum; (2) the involvement of four partner HE institutions in the course design, development, and implementation; and (3) the ambition to reach/be relevant for a vast amount and variety of course participants across Denmark. Moreover, the initial project description did not present a learning theory grounding the content development and the curriculum. Therefore, the first step in the project was to unfold this complexity, as described in the following.

(1) Format and curriculum

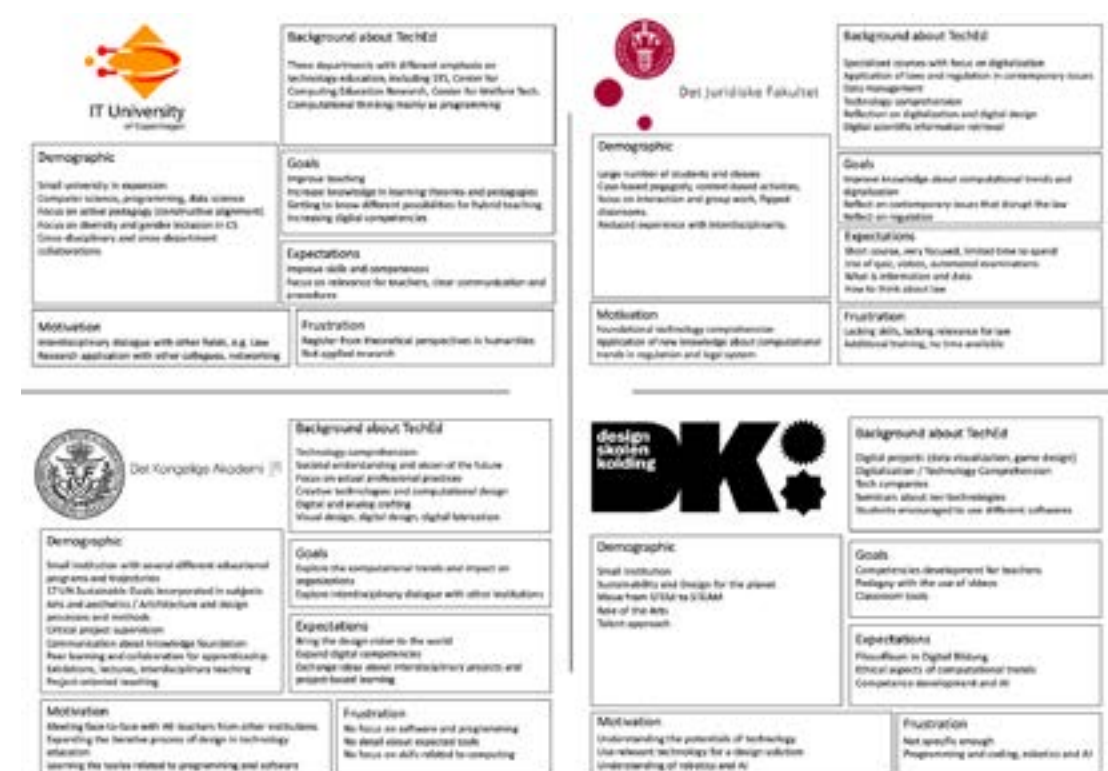
It was assumed from the first moment that some of the contents developed for the self-study format will be reused in the facilitated course. However, in order to design a meaningful course pathway, the educational designer focused initially on the self-study format, given a greater challenge to engage course participants in such a learning modality (Robinson & Hullinger, 2008). With this purpose, a few mini-trials are set to test the contents as self-study course, for the first prototype to be ready by fall 2021. In designing this first iteration of the self-study course, we chose a flexible path for all course participants, not divided in modules but rather in smaller units of

a first stage and give us a greater feedback on the aspects to be improved.

(2) Four partner institutions


The involved HE institutions are very different in terms of size, academic fields of specialization and technology education practices. The initial step of the preparation phase was to study their background and analyze their institutional profiles. Each partner institution made available to Teknosofikum different types of data, thus the document analysis was an exploratory qualitative study that has provided the educational designers with a clearer perception of the different kinds of institutional expertise. The results of this analysis were organized in a participatory design workshop with the use of personas (Figure 4).

Figure 4.
Four partner institutions profiles (personas) based on document analysis.



With this general overview about the institutional knowledge and expectations about the project, the following step was to recruit subject experts for the modules' development. Pursuing a learning design based on critical relational pedagogy, we sought to define not only *what* should be taught in Teknosofikum and *how*, but also *why*. Therefore, a simple template for contents development was provided to all involved subject experts, with the instruction of using it as a loose guideline for their thinking process (Figure 5). The subject experts realized this work partly individually, and partly in meetings with educational designers, which allows for a qualifying dialogical process.

Figure 5. Template for module development with subject experts.



Template for module development – What, How and Why

Module title:

Sub-topic – please complete one template per sub-topic proposed:

Premises (WHY) – please describe briefly what is the importance of this topic as part of the module:

Purposes (WHAT FOR) – please describe what are the main learning achievements for HE teachers:

Intended learning outcomes (ILOs) – please number them and refer to them in the table below:
 After completing the module, the participant should be able to:

- 1.
- 2.
- 3.
- 4.
- 5.
- ...

Contents (what)	Learning activities (how)	Addresses ILO N.	Tools and resources
1.			
2.			
...			

The process of content development with subject experts also entails a series of 4 to 5 facilitated workshops per module, through which two experts discuss their ideas about general topics, specific sub-topics and related learning outcomes. The facilitation process is inspired by the Carpe Diem model (Salmon & Wright, 2014) and adapted to the situated context of each module design and development, through iterative discussions among subject experts, educational designers and the project group. The learning activities drafted during these encounters are fully developed by educational designers and the project group after the workshops and submitted to subject experts for final assessment. Subject experts are also involved in the final step of content production.

(3) Relevance for HE teachers from different fields and scaling

The third element of complexity in Teknosofikum represents also its main criticality. How will the project sustain its scalability? How will scenarios and cases developed by four HE institutions be relevant for other teachers at other universities? In a sociomaterial perspective, theory and practice are intertwined and overlapped (St. Pierre, 2015). Bearing this in mind, we asked subject experts to take into account the following questions, when planning learning activities related to the proposed contents: Does the activity relate to real situations and contexts? Does it promote critical reflexivity, dialogue, imagination and co-construction of knowledge? Do learners engage with uncertainty, chaos and playful wondering (rather than 'right answers')?

Discussion and conclusion

The study aimed at investigating how to address HE teacher professional development in technology education. The first phase of Teknosofikum here presented tries to describe the process to answer this research question.

Initially, it was important to establish a theoretical basis for the conceptualization and understanding of professional technology education that it is adopted in the course design and development. This exercise shed light to three main characteristics that relate the course-concept to sociomateriality, which was chosen as the grounding theoretical approach.

First, the project pursues *enactment* of knowledge in

experimented practices. Course participants are expected to learn and experience teaching strategies in the form of learning activities. They are asked at the same time to apply these strategies to their own teaching and report to the Teknosofikum community challenges and benefits of such an exercise. Furthermore, the facilitated version of the course includes an assessment of teaching plans, which will contribute to qualify the course relevance for a concrete transformation of pedagogical practices. Cases and scenarios from different fields are being developed by subject experts to be included in the prototype and tested in the first trial in the Fall 2021.

A few challenges are set about this first theoretical/practical aspect. Despite the rich contribution of practices that can be found in the four partner institutions, there is an issue regarding the real representation of good teaching practices. Moreover, it is necessary to relate these practices with the needs of different teachers at different institutions, who work with very different epistemological perspectives and disciplinary knowledge. The proof of concept of Teknosofikum after the first phase will tell us about such concrete relevance for teachers or lack thereof.

Second, Teknosofikum seeks HE teachers' *empowerment*, by considering academic work an 'imaginative profession' (Di Napoli, 2014). This means investing in the formulation of good questions by course participants, rather than in the development of contents that give good answers. Multiple paths can be unfolded from different questions about technology. In the perspective of a critical pedagogy, Freire (1985) underlined the importance of generating good questions, as they are the core element for curiosity, and a first step to learning.

In terms of content development, therefore, the project faces a dilemma: on one side, it is important to reduce the complexity of a sociomaterial perspective for HE teacher professional development; on the other, Teknosofikum addresses the objective of developing 'technology imagination' (Balsamo, 2011) which translates into teachers' ability to pose new questions and seek creative answers. How to combine a pre-determined content definition in six modules, which reflects the expertise of the four partner institutions, with teachers' empowerment and open-ended imagination? How to condense the most important contents related to technology education in a limited amount of hours (37 in the facilitated version)? Moreover, a professional development that entails technology education will also stress the situated perspective of pedagogies and teaching practices, remembering also that disciplinary contents shape their modes of inquiry.

Third, the course-concept presents *uncertainty* as part of

the contemporary complexity of HE and it acknowledges the difficulty of preparing teachers for an uncertain world (Barnett 2004). In a sociomaterial perspective that understands knowledge as 'webs of relations' (Fenwick and Edwards, 2014), the most relevant format of the course-concept would be based on discussion among peers and dialogical perspectives, to achieve an exchange of knowledge and practices. However, the self-study version of the course does not provide a space for discussion rather than asynchronous activities (e.g. forums or wikis). The first proof of concept of Teknosofikum will need to qualify a format that takes into account such a challenge.

Another aspect that needs attention in the future of the project is its sustainability and scalability. In line with Niederhauser et al. (2018), we understand sustainability as 'ongoing change' of teaching culture, while scalability is the 'dissemination of change' across different cultural, social and institutional contexts.

At a general level, it might be noticed that sustainability of achievements is a persistent challenge in participatory design processes, and it has been addressed by a large and consistent body of research (Halse, 2010; Misfeldt et al., 2018; Smith et al., 2020). However, we recognize the existence of two more specific risks for sustainability/scalability to be considered in relation to Teknosofikum development and implementation.

First, there is a possibility that the overall design process leads to unsatisfactory outcomes or proves not feasible to implement. This challenge is always present when alternatives to current practices are experimented. At this respect, Edelson (2002) distinguishes between innovation and risk. According to the author, a first element that reduces risk is the grounding of a design research in existing theories and previous empirical studies. A second way to manage risk is through ongoing evaluation, which can help to adjust the design towards better results. Edelson suggests two compelling questions for researchers: is this approach showing enough promise to continue the process? And why is the chosen design (not) yielding the results desired? The author is also stressing that these questions should not be asked too early in the process, when innovation has not had time to happen yet. Nevertheless, they should be asked periodically, to inform about the eventual failure of a specific design, which can be modified or substituted by a new design.

A second and broader risk faced by educational designers at Teknosofikum is the long-term appropriation of new practices by course participants. Recent research reinforces that within the context of HE innovative teaching is sustained by continuity in time, personal investment, and progressive changes in methods and practices (Kocsev, Hansen, Hollow & Pischetola, 2009; Pischetola,

2014; Mathiasen, 2019). The involvement of academic staff in the development of new strategies to enhance transformation of teaching and learning is a crucial aspect to be considered (Tømte et al., 2019). In fact, teacher professional development is proved efficient when sessions are held in a form of a ‘dialogue forum’ (Jääskelä, Häkkinen & Rasku-Puttonen, 2017) and through scenario’s development (Misfeldt et al., 2018) that can develop strong alliances among participants (Bødker & Kyng, 2018).

The next phase of the project, which includes full development, self-study mini-trials and first facilitated trial with course participants, will give a relevant feedback to further qualify the sociomaterial concept of professional technology education in HE that is grounding Teknosofikum.

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