Design principles for higher education teacher development

– the Teknosofikum course/concept

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Abstract

This study moves from the research question: *how to design a professional course/concept for the development of higher education teachers' digital competences*? It presents Teknosofikum, a project funded by the Danish Ministry of Higher Education and Science between 2020 and 2023. The outcome of the project is a course for higher education teachers with a focus on digital competence. Grounded in sociomaterial theories, digital competence refers here to the capacity to develop agency towards professional changes driven by technology. It comprises teachers' abilities to evaluate *why, when, how* and *with what effects* to include digital technologies in teaching. The study draws on qualitative and quantitative data gathered through design-based research along the first three course iterations, with a total of 64 participants. The findings show the emergence of three design principles: (i) *relational approach to technology;* (ii) *praxis*; and (iii) *organized non-linearity*. These principles will guide the final format of Teknosofikum course/concept.

Introduction

In the last three decades, the professional development of higher education (HE) teachers has been increasingly associated with technology, particularly the use of new platforms and digital tools (Compton and Jones, 1998; Jones, 2009; Lawless and Pellegrino, 2007). Research on teacher development programs indicates that the most effective approach does not include focusing solely on technological knowledge, but rather providing an integrated combination of technological, pedagogical, and content knowledge (Lee and Kim, 2014; Thompson and Mishra, 2007). Experimenting with technologies might be challenging for some teachers (Bovill et al., 2015), as it involves acquiring new skills and handling open-ended processes (Howard and Gigliotti, 2016). Therefore, using digital tools in pedagogical settings may be difficult despite the private and daily use of digital tools (Riedner and Pischetola, 2021). Additionally, the institutional context naturally frames the teaching and thus also the possibilities for choosing specific teaching activities and tools (Guppy et al., 2022). This indicates that we need to question the instrumental assumption that technology is an additional tool to teaching and accept that the pedagogical use of digital technologies requires a change in mindset as well as the mastery of new intellectual abilities (Pischetola, 2020).

The need to focus on HE teachers' digital competences in professional development programs has been even more evident with the sudden pandemic-induced pivot to emergency remote teaching (Vieira and Pischetola, 2022), as technologies have shown their power to shape the relationships between teacher and students (Pischetola et al., 2021) and radically transform the learning environments (Guppy et al., 2022; Jónsson et al., 2022). Some authors have even predicted a post-pandemic fundamentally new form of

digitally infused teaching (Cesco et al., 2021; Watermeyer et al., 2020), which might also reshape the for-profit educational technology commercial interests around the HE future (Bayne and Gallagher, 2021; Williamson and Komljenovic, 2022). These issues must be critically discussed and analyzed within spaces dedicated to professional development, as part of the competences that they need to develop (Núñez-Canal et al., 2022). That is, teacher professional development programs include both learning to cope with digital technologies for pedagogical purposes and understanding that teaching is always a complex process, influenced by internal and external factors (Englund et al., 2017).

In this paper, we present Teknosofikum, an ongoing collaborative project held by four HE institutions, which aims at developing a course/concept for HE teacher professional development in Denmark. The project has been running since March 2020 and will find its conclusion in the end of 2023. The methodology chosen to develop and study the process of the course development is design-based research (Cobb and Gravemeijer, 2008; Easterday et al., 2018). This approach was used to realize prototypes of the course informed by data that were collected and analyzed iteratively, as it will be described along the paper. The following research question guides the study here presented: *how to design a professional course/concept for the development of higher education teachers' digital competences*?

The literature on teachers' digital competences is vast and comprises technical skills, the ability to use technologies meaningfully, the ability to evaluate digital technology with a critical eye, and teachers' motivation to participate in the digital culture (Ferrari, 2012; Ilomäki et al., 2016; Selwyn and Husen, 2010; Silva et al., 2019). In 2018, the European Commission broadly defined digital competence as "the confident, critical and responsible use of the technologies from the society of information for work, entertainment and education" (European Commission, 2018: 9). Recent systematic reviews have shown the increasing interest to analyze digital competences in HE settings (Basilotta-Gómez-Pablos et al., 2022; Zhao et al., 2021). Most of these studies are based on the European Framework for the Digital Competence of Educators (DigCompEdu), which is articulated around six competence areas that teachers must develop to promote effective, inclusive, and innovative learning strategies, using digital tools (Caena and Redecker, 2019; Llorente-Cejudo et al., 2022; Lu et al., 2021; Punie and Redecker, 2019).

Collectively, these studies show that the most critical competence for HE teachers is being able to establish *why, when, and how* to include technologies in their teaching (Kirkwood and Price, 2013), and *with what effects* for the learning environment (Pischetola, 2021a). This implies an active commitment from teachers in challenging themselves to broaden their competences, which

some authors have related to the broader concept of teachers' agency (Brodie, 2021; Miranda and Pischetola, 2020). This will be our starting point to understand HE teacher development as a process where digital technologies acquire situated meaning within educational settings.

To study HE teacher professional development with a focus on teacher agency, we adopt a sociomaterial approach, which allows us to explore the relationality between spaces, materials, contents, activities, and interactions in a situated environment (Decuypere, 2019). Sociomaterial perspectives focus on practices in the making and consider agency as *a distributed property of the educational environment* (Fenwick and Edwards, 2011, emphasis added). Their contribution to the educational field has been shifting the attention from the discursive analysis to the significance of materiality. This change of focus from a human-centered perspective to a relational perspective can help revealing the interconnectedness among policies, technologies, practices, discourses, and actors, and understand agency as emerging from associations (Nespor, 2004). Thus, in a sociomaterial perspective, agency does not merely describe a capacity of the individuals, but a quality of their engagement with the environment (Priestley et al., 2015). In this sense, agency is conceived as a process of individual becoming that can transform the broader context where the individual is acting (Decuypere, 2019). In a global context where HE institutions are challenged by the constant transformation of the teaching and learning settings, digitalization, and post-pandemic pedagogical and organizational restructuring, investing in teacher agency has the purpose to improve the quality of teaching, and therefore also the outcomes in terms of students' learning (Rapanta et al., 2021).

The sociomaterial approach will guide our study of the iterative design and development of Teknosofikum course/concept. In the next section, we will explore more in depth what it means to define design principles for such a complex environment.

Designing for HE teacher development

The concept of learning design can be defined as the plan that articulates the learning possibilities for a specific course or program (Hansen and Dohn, 2019). The learning design gets operationalized through design principles, which function as guidelines making explicit the actions along the course/program that will enable the desired learning achievements (Dohn and Hansen, 2018).

The literature on HE professional development distinguishes roughly between two types of design principles: those that address the *content* of learning and

those that address the *process* through which learning is achieved (Aldon et al., 2019; Hawley and Valli, 2007). Most often though, these two categories are blurred and influence each other, as content knowledge is always tied to the context and the needs of a specific group of teachers. Providing teachers, for example, with general information about instructional strategies (*content*) does not usually result in concrete transformation or improvement of teaching; the teachers also need to experience – and discuss – the different strategies they are expected to implement (*process*): they do so through designated learning trajectories (Hansen and Dohn, 2019). Thus, in this perspective, creating professional development opportunities means supporting teachers in reconsidering their practical teaching knowledge and comparing what they have been doing with the new practices that they are learning (Hawley and Valli, 2007).

Several scholars have pointed out that content knowledge changes faster than practices (Borko, 2004; Lampert et al., 2013), as it is difficult for teachers to enact new content knowledge in their daily practices (Kazemi and Hubbard, 2008). This means that although content knowledge is essential for practice, it is not sufficient to be good at teaching (Cook and Brown, 1999). This is even more evident when we focus on professional development of digital competences. What content knowledge should be provided to HE teachers, in a technology-driven world that is constantly changing? What kind of processes should be implemented in a professional development course to convey both pedagogical knowledge and content knowledge to the participants? What kind of digital competences should be prioritized in a diversified group of teachers?

Research has shown that teachers' beliefs, experiences, and habits are somewhat difficult to change (Hawley and Valli, 2007; Pischetola, 2020), but it is widely acknowledged that active involvement and critical reasoning about practices are crucial elements for renewal (Korthagen, 2017; Rapanta et al., 2021).

Materials and methods

The study presented here follows the methodology of design-based research (DBR) with the group of course participants as analytical unit. DBR offers a method to investigate real-life settings and to address their complexity, while designing an intervention (Cobb and Gravemeijer, 2008). In the last two decades, it has increased in popularity among educational researchers, and even more in studies investigating technology-mediated or technology-enhanced learning environments (Easterday et al., 2018; Wang, 2020). In fact, it is argued that DBR can enhance the role of digital technologies in improving

teaching and learning practices, by understanding technology as a process and a value-laden system (McKenney and Reeves, 2012).

DBR is a paradigm that encompasses different methodologies, which have in common the aim of improving educational practices through researchers' active involvement in real-world settings (Wang and Hannafin, 2005). As such, it is indicated as a bridge between educational research and practice, and a method that leads to the innovation of the learning processes (Juuti and Lavonen, 2006; Ørngreen, 2015).

Two characteristics of DBR are relevant for our research focus. First, it provides a setting where researchers take on the role of designers and develop their actions through multiple methods and procedures (Collins et al., 2004). Through a concrete action by the researcher/designer in a situated context, and by experimenting alternative paths to current practices, DBR seeks to promote innovation in educational contexts (Barab and Squire, 2004). Second, DBR requires significant and constant dialogue between theory and practice (Geitz and de Geus, 2019; Ørngreen, 2015). In fact, DBR is conducted in a multifaceted or even chaotic range of settings and requires a solid theoretical framework to grasp the complexity of ongoing experimentation (diSessa and Cobb, 2004).

Cobb and Gravemeijer (2008) suggested a model for educational design research displaying three phases: (1) preparation – which includes design and planning of the experimentation – (2) experimentation in a situated context, and (3) retrospective data analysis and evaluation. The first phase is the most challenging as it requires a definition of clear and detailed instructional goals, as well as the construction of an envisioned learning trajectory for the participants. This aspect is also stressed by Easterday et al. (2018), who provide a detailed description of the first phase as comprising focus on the problem, understanding of the problem, and defining the goals. The authors report a vast number of projects that use the DBR iterative model in different educational contexts. Their conclusion is that DBR represents a meta-methodology in which an "empirical development of the theoretical" (Easterday et al., 2018: 148) occurs in line with the development of a product, such as multimedia tools (Mayer, 2009), lesson plans (Sandoval, 2014) or networked organizations (Bryk et al., 2015).

Other studies have used the iterative DBR model to develop teaching experiments (Abrahamson, 2015; Stephan, 2015), educational games (Bressler et al., 2021; Gresalfi, 2015), and learning technology tools (Wang, 2020). Within higher education, DBR has been productively employed in projects related to blended learning (Ustun and Tracy, 2020) and curriculum revision (Hilliger et al., 2020), showing how iterations are a powerful tool to

improve the theoretical grounding of a project (Geitz and de Geus, 2019), as well as the prototyped products. As several authors have stated, DBR allows for the development of effective learning strategies in overlapping phases of research and development, and the process is never linear (Easterday et al., 2018; Wang, 2020).

In our theoretical foundation, the term 'sociomaterial' is a reminder that we always need to take into account both aspects – the social and the material – in how teachers' practice is shaped (Leonardi, 2012). This means putting in dialogue situated contexts (e.g. disciplinary fields, institutions, professional communities) with digital technology (e.g. tools, platforms, artefacts, learning environments) in HE education. In this encounter between the social and the material, HE teachers' personal experiences, learning theories and reflections about technology in education become crucial to develop professional digital competence in teaching.

In what follows, we present a project where DBR was used to collect data and develop a course/concept for HE teacher professional development in three iterations. The forementioned research phases – preparation, experimentation, and retrospective analysis – were repeated at each iteration. The study draws on quantitative and qualitative data from surveys, online forums, online synchronous meetings, on-site workshops, and group interviews with the course participants. With the aim to qualify the design principles, the paper focuses more in depth on the third iteration, which was the first one held in both formats (hybrid and online), with similar activities replicated for on-site and online participants.

The Teknosofikum project

Teknosofikum is a project funded by the Danish Ministry of Higher Education and Science under the Program for Digital Learning, which addresses HE teachers' professional development in terms of knowledge and competences related to digital technologies (UFM, 2018). The project is developed collaboratively by four HE institutions – IT-University of Copenhagen (leader institution), Royal Danish Academy of Architecture Design and Conservation, University of Copenhagen Faculty of Law, and Design School Kolding – between 2020 and 2023.

The outcome of the project is a course in hybrid and online formats for HE teacher professional development with a specific focus on teachers' digital competences. Grounded in sociomaterial theories, digital competence is here understood as a necessary skill to develop across the different professional landscapes (Hasse, 2017). This means not only knowing how to use digital technology, but also reflecting on the actual professional changes that are

driven by its use. As Fenwick and Edwards (2016) stress, the interplay between big data, automated decision-making processes, and predictive analytics has a significant impact upon professional practice and responsibilities. Ultimately, the course is oriented at supporting HE teachers in their development of agency towards educational and societal changes (Pischetola, 2021b), which include reflecting on their new professional roles and responsibilities, such as designing and monitoring students' achievements, and helping them develop their autonomy and responsibility towards learning (Núñez-Canal et al., 2022; Rapanta et al., 2021). The covid19-related disruption experienced by HE institutions has also posited new organizational challenges, which can generate productive critical reflections on professional transformations (Cesco et al., 2021; Williamson and Komljenovic, 2022).

The project started with an interdisciplinary perspective at the crossroads between the fields of Law, Computer Science, and Design and now also invites other fields in HE more broadly. The cross-institutional team working at the project is composed by four educational designers (project manager, postdoctoral researcher, e-learning consultant, and workshop facilitator) and three IT and communication designers (web developer, visual designer, and video editor). This team works in dialogue with the project group, which is composed by one/two faculty member(s) at each partner institution. Moreover, subject experts are hired for the development of *ad hoc* topics for the virtual learning platform, with a workload that varies from 20 to 30 hours per topic, depending on the subject.

Following a sociomaterial approach, the design of Teknosofikum considers theory and practice as strictly and mutually related. In this sense, teaching practice is driven by a theory in use, that is, epistemic and pedagogical beliefs that might be more or less explicit (Pischetola, 2020). On these grounds, the course wants to provide HE teachers with reflections both on theoretical and practical knowledge, on both technological and pedagogical knowledge (Thompson and Mishra, 2007). This includes enhancing critical-reflective attitudes towards the complex relationship between technology and society. Based on this premise, the educational designers have framed the course around three main learning outcomes, which were established at the start of the project with the aim of improving HE teacher digital competences:

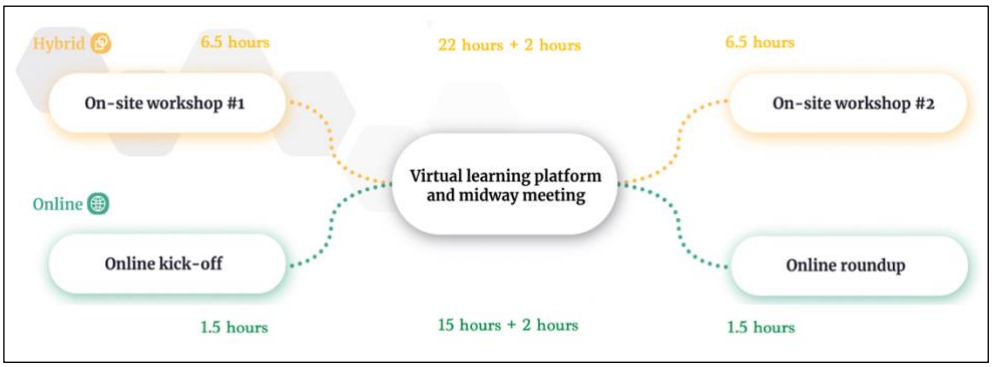
- Expanding HE teachers' knowledge about educational technologies, tools, and platforms.
- Enhancing HE teachers' critical reflection upon technological trends, innovations, and dilemmas in specific disciplinary fields.

- Increasing HE teachers' capability to use educational technologies autonomously and creatively in teaching activities.

To achieve these goals, a varied set of activities are prepared in the participants' learning trajectory: discussions about pedagogies and learning theories; collaborative and interdisciplinary peer feedback; teaching experiments with new strategies, tools, platforms; self-study and self-assessment.

The course is implemented in two different formats: hybrid (37 hours) and online (20 hours). The two learning paths have in common a self-study part where the participants access a virtual learning platform and choose topics of their interest. See Figure 1 below for a visual representation of main steps and related workload of each path.

Figure 1 – Visual representation of the two Teknosofikum learning paths.



For the whole duration of the project (2020-2023), Teknosofikum is running twice a year, in Spring and Fall semesters. The data presented in this paper were gathered in the first three iterations of the course – May 2021, October 2021, and March 2022 – held in online (1st and 3rd iteration) and hybrid (2nd and 3rd iteration) formats, with a total of 64 participants. The participants were recruited from the four partner institutions (with one additional institution at the 3rd iteration) and distributed as follows (see Table 1).

Table 1 – Participants at the first three editions of Teknosofikum.

Participants	**Iteration #1** (May 2021)	**Iteration #2** (October 2021)	**Iteration #3** (March 2022)

Hybrid format	--	22	20
Online format	7	--	15

The participants were evenly divided among teachers in junior positions (one PhD student, nine post-doctoral researchers, four teaching assistants, and 14 assistant professors) and senior positions (5 associate professors and three professors with special responsibilities). At the third iteration, 18 part-time lecturers have also participated.

Each institution has recruited the participants in different ways, through internal communication channels (newsletters, faculty meetings) and top-down requirements from head of departments. In a few cases, Teknosofikum was attended by teachers who could choose electives within their teacher development program (in Danish: Universitetspædagogikum), which is a compulsory course for all junior in-service HE teachers in Denmark.

Following sociomaterial theory, emergence is a crucial concept for empirical research. By drawing on the collected data and with a retrospective analysis at each phase of the project, the format of the course has changed radically from the first iteration to the third iteration. This can be expected in a DBR setting, where the initial theoretical frame informs the research process and it is mutually transformed by the results (Geitz and de Geus, 2019). At this respect, Bell et al. (2004: 83) clarify that design principles are "generated inductively from prior examples of success and are subject to refinement over time as others try to adapt them to their own experiences". In this sense, we could consider the inductive emergence of Teknosofikum design principles as a form of distributed agency within the learning environment (Fenwick and Edwards, 2011). In the next section, we will examine in detail how data collected at each iteration have contributed to shape the design principles of the Teknosofikum course/concept along the way.

Data collection and organization

It is important to highlight that the design principles for Teknosofikum were not made explicit in the initial project description and had to be discussed iteratively by the team of educational designers. Thus, at the first iteration, the core principles for the course were established inductively from the project description. In the first preparation phase, these principles were then analyzed with a sociomaterial approach, although some issues regarding the language employed and the content organization reflected the original plan for the course (Pischetola, 2021b). From the second iteration, the sociomaterial lens is applied more consistently to the data analysis, as it will be clarified.

For the sake of clarity, we will present the data and the respective analysis divided in three iterations. The reason for this choice is that it would be more difficult for the reader to follow the changes of the course at each re-development phase without an explanation of the previous results. In fact, in a DBR approach, each new iteration of the course uses previous data as grounding the following transformations. The design principles of the course are thus reanalyzed and reformulated at each time.

Teknosofikum initial plan

Teknosofikum was initially conceived as divided in eight modules of which minimum five would compose the whole learning path for the hybrid format. The first two modules were considered mandatory for all the participants, the next two modules were supposed to be selected by each participant HE institution, and one module would have been selected individually by the course participant among the remaining options (Table 2).

Table 2 – Initial modules' description.

Module	Initial description
1. Digital learning (mandatory)	The module is about understanding the role change from expert teacher to facilitator with digital support. How is this done and what tools can be used for what? The module will introduce blended learning, flipped classroom, distance learning, and the use of Learning Management Systems (LMS).
2. Computational trends, thinking and doing (mandatory)	The module is about digitizing society. It illustrates digital democratic participation (computational empowerment) and demonstrates how data can be used (computational practices) as well as presents digital trends (computational perspectives).
3. Design in a digital world	The design module introduces design thinking methods in two ways: Design management works with development processes and methods of collaboration, co-design, innovation, and physical learning spaces. Visual design works with tools for producing, distributing and consuming digital productions as well as intro to graphic products.
4. Digital law and rights	The module introduces basic legal challenges that digital development brings. From law issues and data protection to the use of digital technologies in law enforcement (digitization-ready legislation, the use of machine learning in decision-making and legal tech) as well as an overview of ethical dilemmas.

5. Digital Macro trends	The module introduces a range of topics such as Big Data, Machine Learning, Artificial Intelligence (AI), Automation (bots), Internet-of-Things (IoT), Augmented Reality and Virtual Reality (AR / VR), Blockchain, Data and Registry Interconnection through a wide range of cases, such as linking GPS location data and automated case management.
6. Data analysis and data visualization	The module introduces different types of digital data and how they are created, tracked, transformed, and visualized. From data-driven user survey to practical use of analytics tools like Google Analytics, Social Insider, Maze, etc. and how new insights can be created through data visualization.
7. Introduction to programming and IT thinking	The module introduces coding, where students learn how to program from scratch and write very simple programs. There will be a focus on the "IT mindset" used when programming.
8. Intro to basic IT user	The module is about getting a basic understanding of the computer from a user perspective. There will be hands-on training in getting to know your computer, updating options, downloading and installation, browsing, common presentation tools, connecting to other media and devices, and self-help.

By analyzing the project description, we may infer a few assumptions that have become the initial design principles.

First, the content is pre-determined. There is a clear idea of what HE teachers need to know in the contemporary society, from programming to data analysis, from computational trends to digital law. In this sense, digital competence is framed initially as knowledge about these issues, and technology is understood as a tool that supports professional practices. A first design principle that we induce from this assumption is thus the following one: *Instrumental approach to technology*.

Second, the learning path is pre-defined, from module 1 and 2 (compulsory modules) to the modules that are chosen at an institutional level and, finally, to the module that the course participants are free to choose by themselves. Our second initial design principle is then *Linearity*.

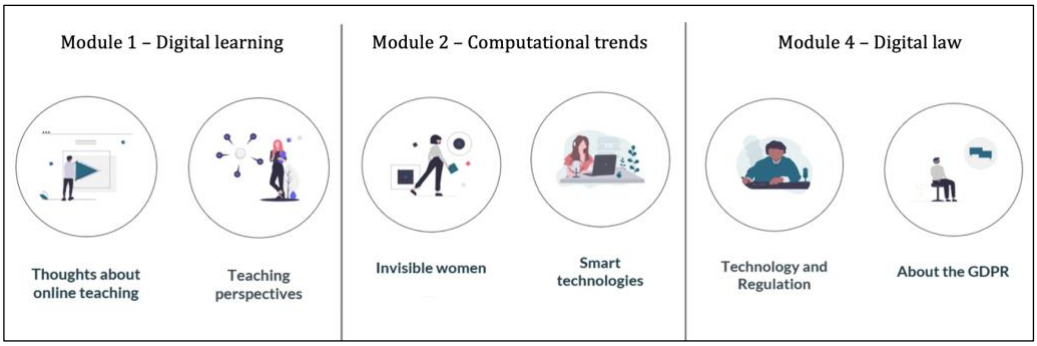
Finally, Teknosofikum started with a need analysis around digital competences of HE teachers in Denmark, which were defined in three main categories: 1) understanding of the possibilities of digi tization in order to bring digital perspectives, methods and tools into play in their own subject and their own teaching; 2) developing abilities to use relevant digital learning formats in their own teaching; 3) learning how to guide students who use digital platforms and tools in their studies. To summarize this analysis, we will use the keyword *Skills*.

It is also interesting to notice that among the eight modules composing the course, only the first one, named "Digital learning", was devoted to pedagogical content (with a focus on the uses of technology in teaching). The remaining seven modules were addressing knowledge and skills related to digital technologies.

Teknosofikum first iteration

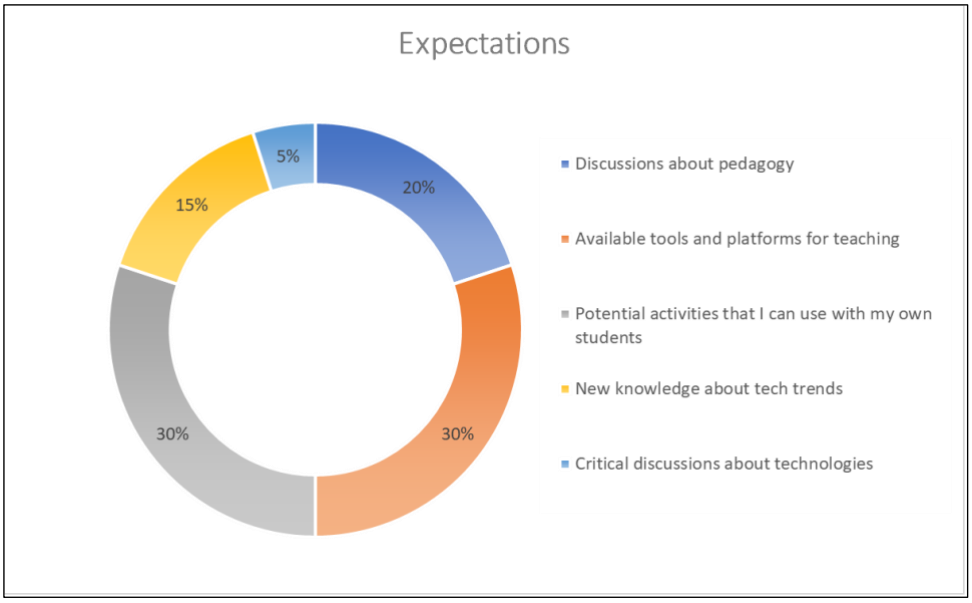
During the preparation for the first edition of the course (January-April 2021), the team of educational designers followed the initial plan, despite recognizing some distance of the design principles from a sociomaterial perspective. They developed topics belonging to three of the eight modules, as a prototype of the full course (See Figure 2 below).

Figure 2 – Virtual learning platform at 1st prototype (May 2021).



These topics were tested on a small group of seven participants who attended Teknosofikum as asynchronous self-study online to be completed in a one-week time. The participants filled an initial survey about educational tools and platforms, roles of digital technology in their professional practices, and their expectations about Teknosofikum. They also gave their feedback about the presentation of the topics (comprising recorded videos, podcasts, and articles online) and the related debates in forums. When asked about their expectations, they mainly mentioned "Activities to do in their teaching", "Tools and platforms" and to a lesser extent "Pedagogical discussions" (Chart 1).

Chart 1 – Expectations about Teknosofikum (May 2021).



At the end of the course, the participants were interviewed online in three groups (3, 2, and 2 participants, respectively). The interview lasted approximately one hour and focused on two main questions: the definition of HE teachers' digital competences for the post-pandemic university and the relevance of a professional course such as Teknosofikum. In what follows, we report a few excerpts from the interviews that summarize our results:

> I really liked this discussion on what are the roles of you as a university professor. Are you a teacher or a facilitator or an instructor or all, are you some, are you none? I think that this goes in the direction of thinking how we can make teaching better. I think it´s useful to bring different kinds of scenarios (A. – Law).

> Digital competences? I don't think that's the most important part because you can always find the tools! The most important part is to be open to the ideas, to think about teaching in creative and student-centered ways, to put yourself in the student's position. I think creativity and playfulness will be really relevant competences (M. – Design).

> I think [teacher professional development] is process-oriented. I think it´s very much about, you know: how do you approach teaching? What kind of activities you do, as a teacher? Tips-and-tricks might not necessarily work, but certain ideas or some kind of a data is helpful, even though it might not be applicable in your own field. […] What I would really like would be sharing examples of how other teachers did it, what was inventive and how they were thinking outside the box. Because I get really inspired from other people's examples of teaching (C. – Computer Science).

> I think just creating a platform where you have good teachers who share their ideas and these spaces, these wikis, where you can have a dialogue with people, is the most interesting part [of Teknosofikum] for me. To hear other voices and see how people are actually facing the same challenges and they have different solutions (K. – Design).

Data analysis

A result that emerged in this first iteration was the declared preference for content about pedagogy (teaching perspectives, methods, theories) rather than about technology (GDPR, regulation, smart technologies). The reasons for this, the participants said, were the relevance of these topics for the present/future of hybrid teaching, the need to rely on a community of practices, the chance that Teknosofikum offered to reflect on their own teaching perspectives, the innovative ideas that they could share with others. On the contrary, the topics that were strictly related to technology were defined as "too trivial" or "not critical enough" and dismissed as generally known. This result was extensively discussed by the educational designers, who understood that the content on the virtual learning platform needed to be tailored for a public of teachers with very different background in terms of subject matter, digital skills, teaching experience, and professional interest in technology. However, one element of commonality existed: despite their great differences in terms of background, the seven participants had stated unanimously that they were expecting to find more pedagogical insights.

How to rescope the course in this sense, without merely focusing on "tips-and-tricks" for using digital tools in teaching? How not to replicate the support that institutions already offer to HE teachers in terms of the design of learning activities and the use of digital technology? And how to create value from the knowledge and expertise in IT, Design, and Law of the four partner institutions?

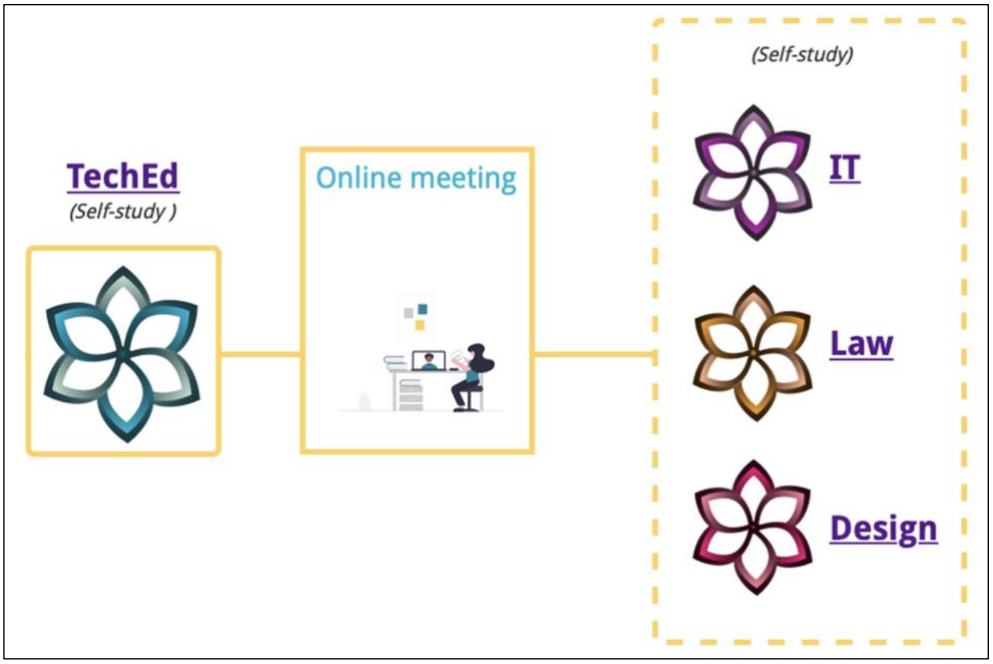
The team decided to focus on activities that would allow the course participants to *think critically* about technology, rather than accessing new knowledge about technological trends. The focus should be on the critical relationship between technology and society, as well as technology and education, with a problematization of the agency of all the elements that compose a teaching situation. On these grounds, a sociomaterial perspective was developed more consistently for the second iteration, as it will be clarified in the next section.

Teknosofikum second iteration

The second edition of the course (October 2021) built on the results from the first trial. At this point, two of the three initial design principles had shifted: from a *Instrumental approach to technology* to a *Critical approach to technology*, and from *Skills* to *Practices*. In fact, the common ground of Teknosofikum participants is not specific digital or pedagogical skills. What HE teachers from different fields and disciplines have in common is that they are all teachers, and they are keen to share their thoughts about teaching with peers[1].

The third design principle of *Linearity* was maintained in this second iteration, although the new structure of the course did not present topics, but rather modules, respecting the concept given by the initial project description. The contents were clustered in four disciplinary modules: TechEd (introduction), Design, Law, and IT (Figure 3).

Figure 3 – Virtual learning platform at 2nd prototype (October 2021).



This second edition of the course was planned to last six weeks in a hybrid format, comprising two workshops at the start and at the end of the course, as well as one facilitated online meeting after the first compulsory module (TechEd). With this new structure, the educational designers hoped to separate more clearly the pedagogical content from the modules related to

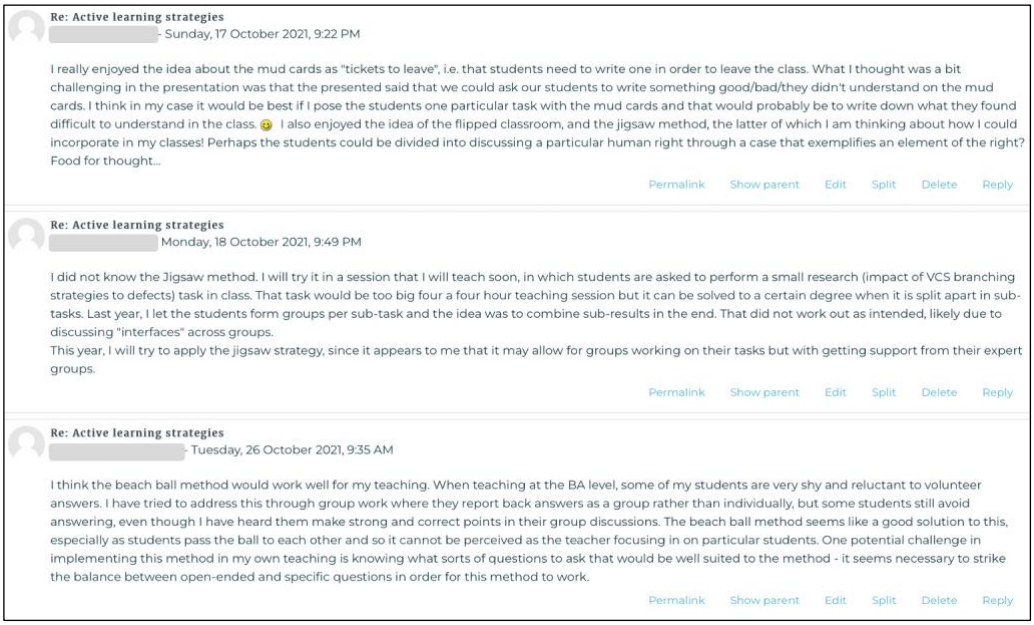
[1] It must also be acknowledged that the vast experience as former/current HE teachers of the team of educational designers played a crucial role in this shift from the design principle *Skills* to its reframing into *Practices*.

technological trends in the different domains, to attend the suggestions given by participants at the first iteration.

The participants were then invited to choose at least two of the three modules that followed the introduction, based on their own academic/professional interests and expertise. The time estimated per each module was a total of 5 hours, and they were required to complete at least 15 hours of self-study in the virtual learning platform.

The participants were extremely active both at the two on-site workshops and in the discussions occurring through forums in the virtual learning platform. The activities that attracted the highest interest were the ones related to concrete examples and/or strategies for teaching. In the following image (Figure 4), we present a screenshot of the most participated forum (16 posts), related to the topic "Active learning strategies" in the TechEd module.

Figure 4 – Posts in the forum "Active learning strategies" (October 2021).



At the midway online meeting, it was possible to confirm the participants' engagement and their appreciation of the TechEd module. Here we report some of their statements:

> I really liked those active learning tools, especially. I think that that helped me a lot in moving forward with my education, and I also liked the podcast/video exercise. […] I think I would consider doing it in my next courses as well" (R. – Design).

> I found that your way of organizing the topics helped me, actually. I could use with my students to talk about different styles, because also my students have different backgrounds and different skills (F. – Computer Science).
>
> It's nice to be reminded of both the analog and the digital tools (…) and it's good to avoid this separation again, because variety strengthens active learning" (K. – Law).

The other modules – IT, Law, and Design – were not as much appreciated by the 22 course participants of this second iteration. The average score for topics that was given in the final survey was below 6, on a scale from 1 to 10 (see Chart 2).

Chart 2 – Feedback about the three modules on technology at 2nd iteration (October 2021)

Topics within the three technology modules (IT, Law, Design)	#Answers (tot = 22)	Average (scale 1-10)
IT: Machine Learning	12	5.6
IT: Big Data & AI	10	6.4
IT: Smart Technologies	9	5.2
Law: Regulation OF Technology	11	5.5
Law: Regulation BY Technology	11	5.7
Law: How tech is changing the legal field	12	4.8
Design: Technology and Design	8	4.4
Design: Human-Technology relations	10	5.3
Design: Creativity and prototyping	8	3.4

However, it must be noticed that few participants had completed the required 15 hours of self-study, and this could be partially motivated by the educational designers' choices in relation to the learning path. It was established to unlock the content of the three last modules only after the online meeting, when the participants would have completed the first compulsory module. This happened to generate miscommunication about the overall workload of the course, as the participants did not have the full overview of the content.

Moreover, the participants were confused about some of the presentations, as it shows in the following excerpts from the group interviews that were held at the end of the course:

> The anthropological perspective [on technology] seemed a tad perhaps too abstract. It seemed to be a discrepancy between sort of very hands-on kind of videos like the Active learning strategies (A. – Law).
>
> Are we talking about technology as the vague term that is just the umbrella term for everything pretty much these days? […] it would be nice to have that framed a little more (P. – Design).
>
> There's this idea of paying attention to technology […] and then you ask us to start using technology in your own practice uncritically! (T. – Design).
>
> I thought Teknosofikum was more sort of digital tech oriented. […] I would have wanted a little bit more of something that's a little bit new to me, at least (S. – Law).
>
> We're speaking of the technology, but not meeting the technology. I'm a little surprised (M. – Design).
>
> I'm still kind of confused by the content. I don't know if I understand what I should get out of this. […] Is this for students, for educators? Is this for technology being used by students as part of their education? It this for educators using technology in support of their educational practices? (H. – Computer Science).

Data analysis

At the end of this second iteration, it was clear to the team of educational designers that the design principle *Linearity* should be changed, in order to provide a learning path that could meet the variety of needs and expectations expressed by the course participants. Moreover, from the point of view of the re-development of the course, this result showed the importance to define more clearly the conceptual background of each new subject presented in the course. Technology is not conceived in the same way in Design, in Computer Science, in Law, and in Education. Directing the Teknosofikum concept towards a design principle of *Non-linearity* appeared as a solution to these dilemmas.

From the data collected at the workshops, another important result emerged. The course participants found particularly interesting those activities that related their practices to an existing theoretical background (Pischetola et al., 2022). The group discussions led to a deep exploration of personal beliefs, values, and assumptions that the course participants had in their teaching (with or without knowing). Each teacher was compelled to think consciously about their own educational design and technology use – or lack thereof – and to explore the learning theories that were guiding their actions.

The encounter of theory and practices is called "praxis" in literature (Kemmis, 2010) – a concept that in HE allows exploring "the consequences of what we

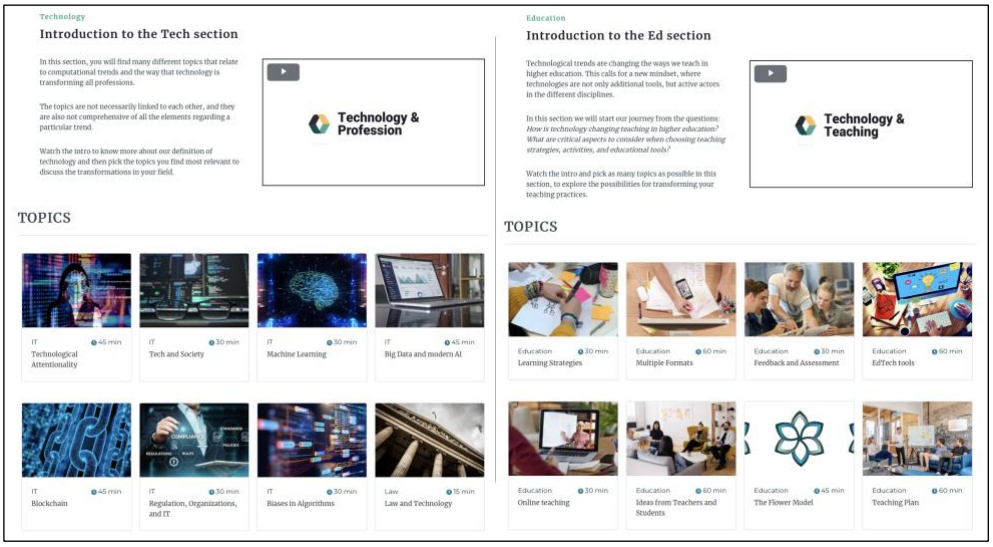
do as teachers and university communities, both intentionally and inadvertently" (Langelotz et al., 2020: 3). Praxis is the continuous encounter of theory and practice, of action and reflection (Schön, 1983). In this sense, it provides a powerful concept from a sociomaterial perspective, which aims at analyzing the agency of all the actors involved in the environment – including theories, personal beliefs, and policies (Decuypere, 2019). Grounded on this analysis of the second iteration results, *Praxis* became thus our last design principle, substituting the previous keyword *Practices*. In the next section, we will explain what this choice has meant empirically.

Teknosofikum third iteration

The third iteration of the course occurred in both hybrid and online formats in March 2022. Drawing on the previous two iterations and the results described in the above sections, two out of three design principles had been re-defined, from *Linearity* to *Non-linearity* and from *Practices* to *Praxis*.

The evolution of these principles was evident in the content re-development and in the visualization of the learning path (in Figure 5 below some of the topics can be visualized). The element of *Non-linearity* completely disrupted the initial division in "modules" and made the educational designers reorganize the course per "topics" instead. No more disciplinary fields were outlined, to let the participants choose what they were most interested in. The only division that was kept among the topics was the one between two broad categories: *Technology* and *Education*.

Figure 5 – Virtual learning platform at 3rd prototype (March 2022).



The other shift from *Practices* to *Praxis* allowed Teknosofikum to be framed not only as a space for shared reflections, but also of learning about epistemological and theoretical differences among the disciplines (Pischetola et al., 2022). The course participants' feedback about this change was very positive, as it is evident in their statements during on-site workshops (Figure 6) and online meetings (Figure 7).

Figure 6 – Feedback from course participants during on-site workshops at 3rd iteration (March 2022).

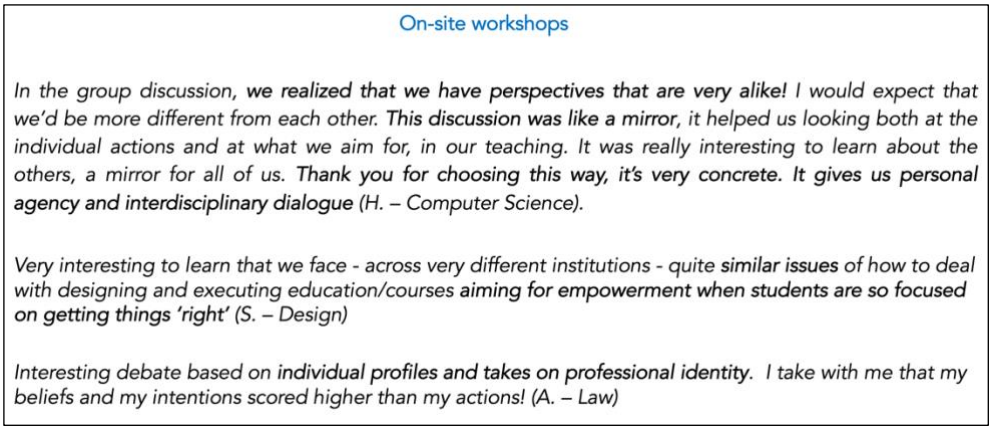


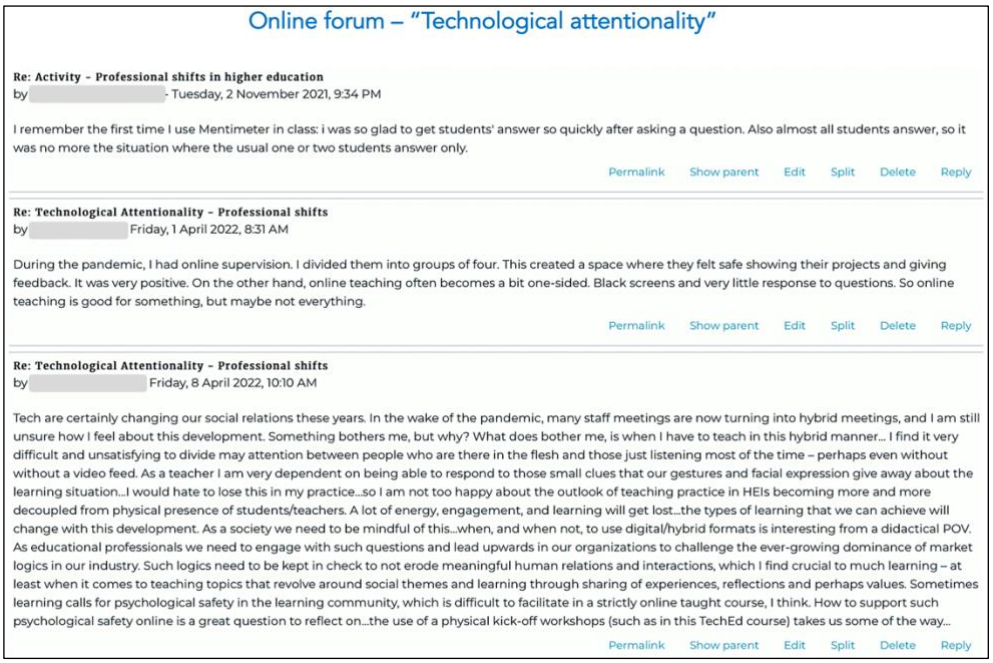
Figure 7 – Feedback from course participants during online meetings at 3rd iteration (March 2022).

The design principle earlier defined as *Critical approach to technology* had not been modified at this last iteration. The course participants were very engaged in discussions both online and on-site. They became increasingly more familiar with the format of a video/audio presentation and a tailored activity at the end of each topic, which was often a critical reflection about the content presented. They even complained when they thought that the critical aspect was missing, as it appears in these two excerpts from the online meetings:

> I think that if I was to introduce this topic into my teaching it would be through critical deconstruction of its politics and the political/moral economy of its various implementations. In short, technology as the problem, not as the solution! (G. – Computer Science).
>
> I've read some articles and listened to some podcasts talking about how this technology is bad for the environment, but this was not brought up in any of the videos. That just puzzled me. Is the environmental factor not something that the experts even care about? Just puzzled me (M. – Social Sciences).

Moreover, the posts in the forums from the previous iterations, had been left by the educational designers (see Figure 8), in order to build a community around these topics, that could also exchange ideas in different time framings. This choice helped the participants to engage with the content and feel that there was an ongoing peer feedback among them.

Figure 8 – Posts in the forum "Technological Attentionality" (March 2022).



However, the general rates of the topics did not change very much in comparison whit the second iteration, which indicated the need to invest (even) more on the quality of the content production and re-development.

Moreover, some of the topics did not have a high number of posts in the online forums and it was difficult for the educational designers to figure out the reasons behind this. In Chart 3 below, we present an overview of all the forums and the participants' engagement in each of them.

Chart 3 – Engagement in forums related to each topic at the 3rd iteration (March 2022).

Topic	**# Posts**
Technological Attentionality	28
Risks and benefits of modern AI	19
Law & Technology – Legal issues in your teaching	8
Tech and Society - All fields	6
Human-Technology Relations	5
Machine Learning	5
Biases in Algorithms	4
Regulation OF Technology	4
Critical Literacy in Computing	3
History of Technology	2
Human- Tech Activity – Modelling Ethical Design	2
Regulation BY Technology	2
Smart Home	1
Creative Coding	0
Regulation, Organizations, and IT	0
Technology and the Legal Field	0
Blockchain – Law	0
Total	90

In the final survey, the space for typed answers gave the opportunity to complement this data with qualitative data analysis. We report here a few excerpts from the participants' anonymous feedback:

> Over all I think it is a good journey ;-) But it also requires that you have time and space to go into it. For me it works best to do the course in a short time periode. I took notes watching the videos and I highly recommend this! The notes made me able to navigate when I had to do the tasks.

> I liked it. The tech part was very interesting (or at least the modules I took were). I think that, further down the line, when there are more participants, the forum and discussion parts of the course will be really vibrant and interesting too.

> More content and better clustered in typologies (e.g. critical, practical, theoretical,...) could be helpful

> I would really like to see more participants from outside the ITU (my own institution). More cross pollination!

> Firstly, the facilitators were engaged and organised, that was great! but overall I felt like there were many box ticking exercises that I struggled to find super relevant - or too much content spread too thinly. I would have liked more time getting to the 'meat' of ideas and topics with other the other participants fx. I also hoped for a more critical discussion on what happens when digital teaching tools replace analog tools. Fx. it was mentioned by one participant, that teacher of the year award at the law school was won by someone who had banned laptops and wrote everything in chalk. I would have loved to have heard his reasoning!

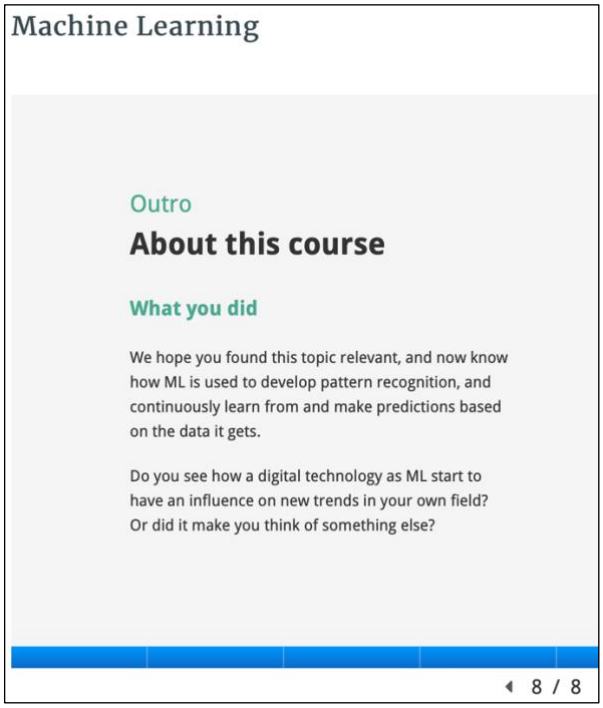
Data analysis

The overall conclusion from this analysis was the need for yet another revision of the design principles. In fact, the *Critical approach to technology* did not seem to include and address all the nuances that each disciplinary field, each professional experience with teaching, and each participants' personal/research interests brought on the table. Despite the valuable contribution of critical takes on digital technology, this approach showed shortcomings in terms of how to do things differently (Bardzell et al., 2012), or how to operationalize in teaching some of the disruptive perspectives on technology that the course participants had met.

On the other hand, the *Non-linearity* principle that was introduced at the third iteration, combined with the growing amount of topics in the virtual learning platform, appeared to be sometimes overwhelming for the course participants. It resulted in very fragmented engagement that did not gather enough posts in the forums, leaving the participants with the feeling of a lack of time to cover all the topics that they would have wanted to explore.

These two design principles were therefore rediscussed one more time by the educational designers, giving as a result the concepts of *Relational approach to technology* and *Organized non-linearity*. The first one was concretely applied in the virtual learning platform as a new format of each activity, which is now ending with an open question, such as the one in Figure 9.

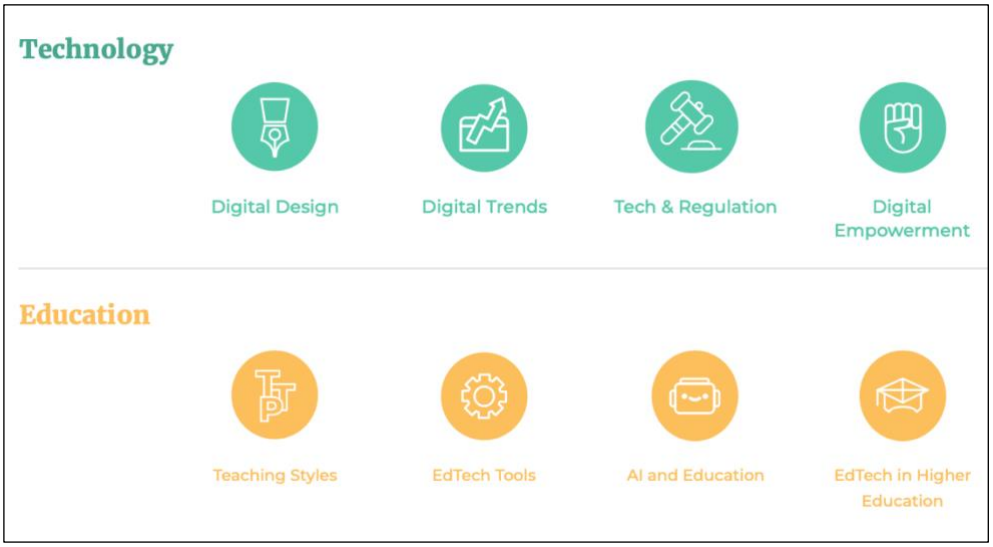
Figure 9 – Example of a question added at the end of a topic ("Machine learning" – Final version).



The idea is to provide course participants with final reflections about the topics that they have accessed, in order to make them relate the new knowledge with what they already know. The concept of praxis (Kemmis, 2019) is also present in this relational conceptualization of technology, as well as the concept of reflection in action (Schön, 1983).

The design principle that we called *Organized non-linearity* emerged from the need to give participants a support in navigating the contents. In the final version of Teknosofikum, the topics of both categories (Technology and Education) have been reorganized in eight clusters (Figure 10).

Figure 10 – Organization of topics in clusters (Final version).



The participants are invited to realize an initial self-assessment, and based on the results of it, they are profiles as “Education explorer”, “Balanced profile”, or “Technology explorer” (Figures 11, 12, and 13). Each profile has a different suggested path to explore the contents. It must be noticed that the paths are never completely green or completely yellow. The hybridity between the two categories of Technology and Education is always maintained, in a sociomaterial perspective. In fact, the Technology section has always a focus on how to bring the critical reflections proposed in each topic to the different teaching settings, while the section of Education always attempts to discuss the presence of technology in higher education, in terms of digitalization processes, as well as the newly generated ethical issues and commercial interests that permeate the educational landscape.

Figure 11 – Profile “Education explorer”.

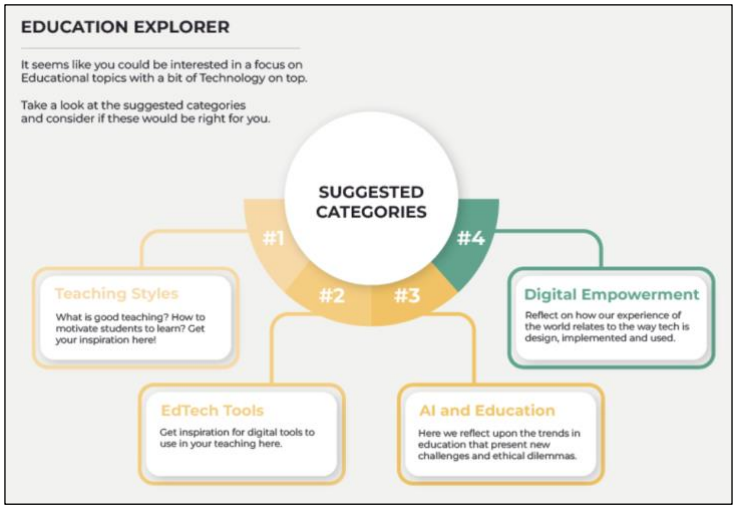


Figure 12 – Profile "Balanced".

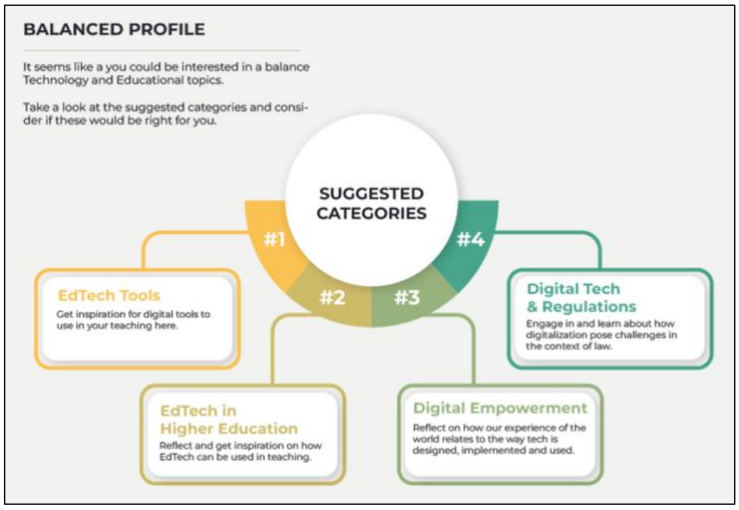
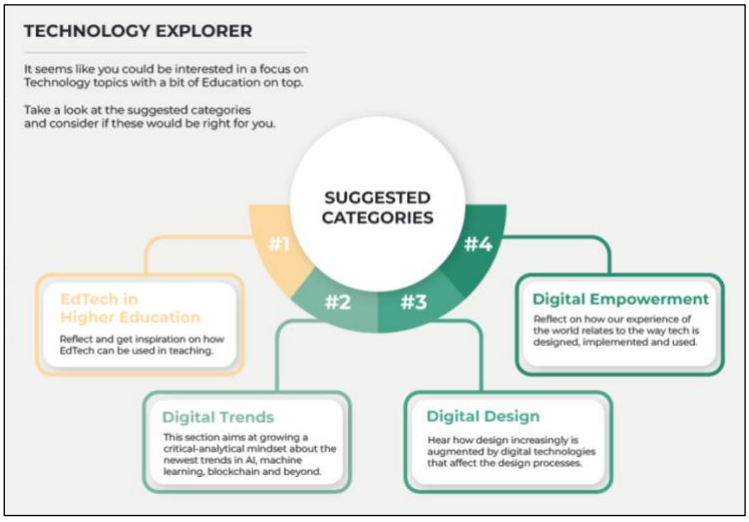
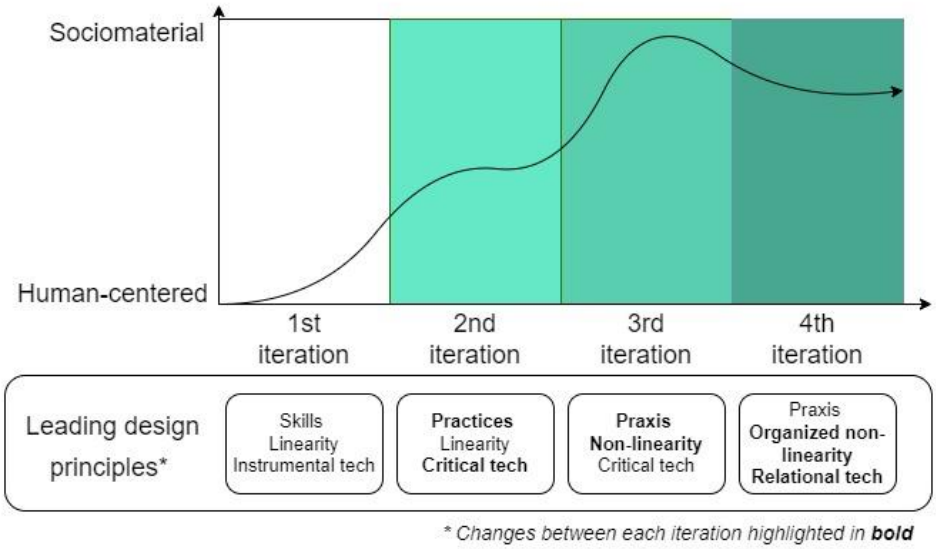


Figure 13 – Profile "Technology explorer".



To sum up the transformation of Teknosofikum design principles along the first three iterations of the course, a visualization is offered in Figure 14 below.

Figure 14 – Evolution of Teknosofikum design principles.



In the next section, we shall address this process in a retrospective analysis, as Cobb and Gravemeijer (2008) suggested to do in the end of a study that employs the methodology of DBR.

Discussion and retrospective analysis

The study has shed light on the evolution of the design principles resulting from the iterative process of Teknosofikum. The final three design principles are (1) *Praxis,* (2) *Relational approach to technology* and (3) *Organized non-linearity*. In what follows, we analyze each of them from a sociomaterial point of view.

1) Praxis

At the end of the third iteration of Teknosofikum, the data has shown that the focus on *Praxis* (rather than on Practices) has brought a stronger relationship between theory, practice, and reflection in action (Schön, 1983). The literature on praxis highlights the need for asking critical and uncomfortable questions about teaching in HE (Langelotz et al., 2020), to address challenges such as the digitalization of learning spaces and widespread outcome-based university models (Ejsing-Duun and Pischetola, 2022).

In the Teknosofikum course, the concept of praxis can be used to create a reflective space among teachers, to problematize their familiar practices and look for "unasked questions" (Thelin, 2020: 2). It can also be applied to discuss more broadly the universities public mandate (Wright and Greenwood, 2017) and the purposes that will guide the role of universities in the post-pandemic future (Bayne and Gallagher, 2021). Whenever digital tools and educational technologies are in focus, the concept of praxis proves useful to produce empirical grounding of policies, expectations, and discourses in HE (Bagga-Gupta and Dahlberg, 2019; Heinsfeld and Pischetola, 2019).

2) Relational approach to technology

The focus on a *Relational approach to technology* has problematized the need to critique the *status quo* of digital trends in society, inviting the participants to imagine better uses for digital technology in their own situated contexts. In a sociomaterial analysis, this means also reinventing the curriculum (Nespor, 2004) and the structures that are considered as stabilized in each disciplinary domain (Fenwick and Edwards, 2011).

The data analysis shows that, in the design of the course, there has been a gradual change of focus from a human-centered perspective (first iteration), which had knowledge and skills as main outcomes of a professional development course, to a more disciplinary perspective (second iteration), to a perspective that can help disclosing how digital technology and its trends are interconnected with economic, political, social, educational, and cultural issues (third iteration). In this sense, different actors were in focus at each iteration – the human, the disciplinary field, and the network. The data has shown that this last format of the Teknosofikum course/concept offers a

richer platform for debating critical issues related to digital tools and teaching and generating creativity about future possibilities for HE (Bayne and Gallagher, 2021).

3) Organized non-linearity

Organizing non-linearity was the key element for managing a project as complex as Teknosofikum. With the final format guided by this design principle, the course participants are allowed to take responsibility for their own learning path (Gravani, 2012), as they can choose what, how, and when to access the topics that they are mostly interested in. This provides a learning path that can meet the variety of needs and expectations expressed by the course participants and triggers their agency for the development of the (self-assessed) relevant digital competences (Brodie, 2021). In fact, the participants are now provided with a map to navigate the (many) topics that the virtual learning platform offers both in Technology and in Education. The contents are divided in clusters, and there is an indication of which competences each cluster focuses on.

What can be observed in the overall data analysis, besides the fact that the design principles have changed consistently along the three iterations of the project, is that they have also changed in terms of focus: from a more knowledge-based, instrumental, and skill-based perspective on technology and education to a more relational perspective; from a top-down approach to a bottom-up approach that takes participants' needs as a starting point; from pre-determined content and pre-defined learning path to teachers' agency and responsibility. The core notion of emergence can be used to explain this complex process of knowledge creation in a sociomaterial perspective (Fenwick and Edwards, 2011). In fact, inductively emerging results at each iteration were driving the redirection of the project increasingly closer to a sociomaterial proposal for HE teacher professional development. This included for example reflecting on complexity of the learning environment in which HE teachers are developing professional competences and understanding agency as something that teachers develop together, in a process of sense-making of the technological tools (Decuypere, 2019). Moreover, the invisible "doing" of the digital technology was exposed (Pischetola et al., 2021), both in the group activities proposed at the on-site workshops and in the forum discussions, both in the discussions about hybrid teaching and in the considerations about new HE teachers' professional roles (Hasse, 2017).

The DBR iterative process has shown its strength in tiding the theoretical framework not only to the design of the project, but also to its contents and structure. In fact, the way Teknosofikum has been developed is the same one

that the course tries to implement, that is, through peer feedback, active-oriented participation, teacher collaboration, and the recognition of messiness and uncertainty in learning processes (Pischetola et al., 2022).

A final aspect that has emerged from the data analysis is the importance to build a community of HE teachers, which can be achieved by shared practice, ownership, and co-design (NLEC et al., 2021). A community that can help dealing with the professional demands driven by technology. In line with the former research on teacher professional development, we defend that a teacher professional community is developed around shared responsibility and engagement in connecting contents, especially if the aim of an educational program is to create advances in knowledge, rather than just completing a task. Using peer interaction as a critical design principle (mostly during workshops and facilitated online meetings) can support focusing on communal problems and promote participants' contributions, to encourage them to build on each other's input.

The participatory methods that were implemented have allowed the project to benefit from the participants' feedback at each iteration. The content was then revised and redesigned (sometimes deleted) by taking into considerations their very different expectations, needs, critiques, and suggestions for improvement. Thus, the course participants have become co-designers themselves, contributing significantly to find a format that could attend the heterogenous public of HE teachers from different fields and institutions. They have supported the development of a concept of teacher professional development that was not in the initial description of Teknosofikum.

We recognize that building the newer course iteration on the previous one might give some shortcoming to the project, as the cohort of teachers is different at each time, as well as the participants' specific needs. However, as Easterday et al. (2018) point out, the fact that in DBR designers choose different methods at each stage allows for quickly rejecting ineffective prototypes and identify potential successes for the future stage. This is what happened at Teknosofikum as well. The third iteration built on *both* the first iteration and second one, reintroducing for example a principle of organization of contents that was first disrupted (see the trajectory of the third design principle described in the data analysis above).

Conclusion

Contemporary trends in higher education have set the need for teachers to continuously develop their digital competences. However, there is no consensus among educational designers about the content/format that a professional course for HE teachers should have.

Most programs of HE teacher professional development do not make explicit the relationship between beliefs, actions, and experimentation (Kazemi and Hubbard, 2008). The critical task for educational designers is precisely to make pedagogical theories accessible to teachers, through reflection on their practices – or the encounter of theory and practice in praxis. However, educational designers should also be aware of the differences imposed at a local level by the institutional culture and the communication practices (Bagga-Gupta and Messina Dahlberg 2019), as well as institutional constraints and obligations (Hasse, 2017).

The study here presented is in line with previous research on HE teacher development, which shows that the most successful programs are the ones that consider adult learning as a specific educational context (Knowles, 1990), where appropriate methods, activities, and materials are used to meet learners' interests and preferences (Jones, 2009). In these programs, self-direction and self-diagnosis of problems are very common design principles and can help the participants to expand their own competences (Gravani, 2012). HE teachers are not always reflective and self-regulated, but they direct and adapt their teaching practices based on what they experience with their students (Korthagen, 2017). In a sociomaterial perspective, HE teacher professional development needs to aim at teacher agency (Brodie, 2021; Priestley et al., 2015) while, at the same time, consider the specificity of the space-time-material elements involved in each learning environment (Nespor, 2004). Teknosofikum evolved to be a proposal of HE teacher development as a process of peer learning, where not only practices are constantly shared, but theories are also explored, made explicit, discussed. The participants were active in discussing their practices through theoretical lenses and learning theories, they asked for more critical reflections, they appreciated the feedback of peers and the community that was established.

The study moved from the question: *how to design a professional course/concept for the development of higher education teachers' digital competences*? In a retrospective analysis, we can see that the project was conceived to be a cross-disciplinary collaboration among four HE institutions that did not have a deep understanding of each other's work and expertise. However, even in their initial absence, the design principles discussed by the team of educational designers were important guidelines for the design of the virtual learning platform, the development of topics, and the institutional communication about the learning trajectory. They have evolved based on the openness that the project has acquired along the way. This iterative development process has built a hybrid, sociomaterial, common approach to technology, supporting the materialization of a networked learning space (NLEC et al., 2021) which was also a safe space of peer feedback and shared ideas.

Along the research-based development of Teknosofikum course/concept, the attempt was to establish constant relations among practices, theories, beliefs, actions, reflections, and future abilities to act, where all the actors have a role in shaping the environment (Decuypere, 2019; Fenwick and Edwards, 2011). The study has shown that such a relational space can trigger teachers' curiosity to broaden their digital competence, and their responsibility to transform their professional practices.

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