Chapter 2
Education, Technology and Design: A Much Needed Interdisciplinary Collaboration

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Abstract In this chapter we defend and underpin our claim that, to improve and innovate education, a novel conception of the role of design in education is needed. What this conception is we will elaborate on, specifically on how it affects design in education as it is customarily practiced. We will translate this conception to the context of technology-enhanced learning (TEL). Because of its potential to have an impact on education, TEL more than any other form of learning demands consciously devised learning designs. Thus, our proposal addresses both the design of learning, in particular learning activities, and the design of educational technology. We focus on human-centred design (HCD), a problem-solving framework underpinned by user involvement in all stages of the process. HCD provides professional designers with a mindset and a toolbox that includes both process and methods. It is multidisciplinary by default and also practice-oriented, context-aware, empathetic and incremental. As such it naturally fits many of educators' everyday realities. Leveraging human-centred design theories and practices will greatly benefit educational design and give it the push it has been missing, we argue. Our proposal focuses on how HCD can enhance and facilitate technology-enhanced learning by (1) focussing on the design of learning activities, (2) involving all its actors in a timely and meaningful way; and (3) affecting its micro, meso and macro levels.

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2.1 Introduction

The notion that education 'lives' in a designed environment hardly becomes apparent in the classroom or lecture room. Although in the early days of the industrial revolution, lecturing (instead of one-on-one teaching) was invented, it now is so much part and parcel of our everyday experience we barely notice education's designed character anymore (Bates 2015). The advent of technology-enhanced learning changed that, for now conscious decisions had to be made on what technologies to include and how to apply them. However, there is a tendency to shun innovations through the application of learning technologies, in particular those that may disrupt existing practice (Flavin and Quintero 2018). In our view this results from a lack of conscious acknowledgement that teaching and learning are essentially designed activities. By focussing on technology-enhanced learning, we aim to show how a conscious design stance may improve education and indeed educational technology as well.

Whereas most physical classrooms layouts and models resemble those of decades ago, the tasks of educators have been deeply affected by the changes in society. We might still encounter that odd educator who just uses a paper textbook for her teaching or keeps using the same written notes year after year to address her students. However, such educators now can only be the exception as the pressure from society on education is mounting and the adoption of technology has become unavoidable. It is our conviction that this push towards change in education—not only incremental but also disruptive—has mostly been done without adequate support. Instead, educators are being asked to take on so many more roles representing equally many different specialities that it is impossible for them—as individuals—to master them all.

Psychologist, conflict mediator, actor, counsellor, coach, technologist, diversity expert, individual empowerment expert, and many other "hats" are pushed on educators. Networked learning is even pushing on more hats, as authors have identified roles such as "the collector", "the curator", "the alchemist", "the programmer", "the concierge", to mention just a few of them (Downes 2010; Siemens 2008). These many roles have then to be interpreted within an increasingly complex classroom orchestration (Dillenbourg 2011), that includes a number of tools and meso and macro levels requirements. Our claim is that this constant push to bring change through the micro-level of the teacher is unrealistic.

Technology is sometimes seen to form the core of online learning, a complement in blended learning and tangential to face-to-face learning. However, this is hardly true anymore, technology is pervasive and its effects are expansive: technology is a constant part of the lives of educators and students; whether it has an "educational" origin or not. Thus, questions such as which technology to incorporate, how to integrate it, when to deploy it, how to assess the results, and what to do next, call for conscious decisions. Such decisions are seldom made (Kirkwood and Price 2016). To remedy this situation we suggest that the integration of technology in education needs to be 'designed' from the ground up, with the support of experts from other disciplines, but with educators leading these design tasks. Furthermore, a human-centred design approach will make a key difference to such design efforts.

Thus, our focus is on the activity of designing technology-enhanced learning. Admittedly, this is also the focus of the Learning Design field (Dalziel et al. 2012; Laurillard 2012), but the term wrongly suggest that learning can be designed. At best the conditions for it can (see also Carvalho and Goodyear 2014; Goodyear 2015). This notwithstanding, we conceptualize Learning Design as a specialisation of human-centred design. Matching the goals of Learning Design, we believe that human-centred design can bring more coherence to the current, rather loosely organised and individually-oriented task of design for learning with Information and Communication Technologies (ICT) tools. To accomplish this, three intertwined aspects need to be addressed: (1) how to incorporate the human-centred design *mindset* in the design of technology-enhanced learning, (2) how to bring the human-centred design *process* in the design of ICT-based activities and educational technology, and (3) how to bring in human-centred design *methods* to the design for learning.

The present chapter elaborates on these three aspects. It is structured as follows. We start with an overview of the two key ingredients of our argument: human-centred design as well as current trends in technology-enhanced learning. Then follows a survey of what is known of educators as designers and an overview of a real intervention that was aimed to guide educators through the design of an ICT-based learning activity. Drawing on our desk research and our own experiences with said intervention, we conclude with a proposal on how, through the incorporation of human-centred design, teams could design more relevant technology-enhanced learning.

2.2 An Exploration of Human-Centred Design and Technology-Enhanced Learning

Many educators pride themselves on being pedagogically (as opposed to technologically) driven in their teaching and learning designs (Anderson and Dron 2011). Without delving into the many possible reasons, we do acknowledge that there are still tensions when it comes to incorporating technology in education. Terry Anderson (2009) uses the metaphor of a *dance* to explain how technology and pedagogy intertwine: technology sets the beat and creates the music, while pedagogy defines the moves. Pursuing this metaphor, we can view Jonassen and Reeves' categories (1996) of how students interact with technologies as three different types of dances, scripted by educators. Their categorial system differentiates between *learning about technology* (technology as a subject), *learning from technology* (technology as a delivery tool) and *learning with technology* (technology as a cognitive partner). When we described earlier the use of technology in education as either incremental or disruptive, it is only the third option—technology as a cognitive partner—that holds promises for educational innovation; whether incremental or disruptive.

2.2.1 *Human-Centred Design*

With Herbert Simon, we believe that design is a problem-solving, process-oriented activity and we subscribe to his idea that: "everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (Simon 1996, p. 111). This quote captures the essence of our point of view: not only designers design but everyone does at some point of time. Nevertheless, we also consider design to be a specialist undertaking. As such, its results profit from a specific mindset, a set of methods and a defined process.

As we already announced our theoretical approach is aligned with the notion of human-centred design (HCD), as it provides this specific mindset, toolbox of methods, and process. Some of these are clearly defined by the six key *principles* that guide the implementation of HCD from the ISO 9241-210 'Ergonomics of human-centred system interaction' (ISO 2009):

1. the design should be based upon an explicit understanding of users, tasks, and environments;
2. users should be involved throughout the design;
3. the design should be driven by user-centred evaluation;
4. the process should be iterative;
5. the design should address the whole user experience; and
6. the design team should be multidisciplinary in terms of skills and perspectives.

We strongly believe that these principles should also guide the conceptualization, implementation, integration and refinement of technology-enhanced learning and educational technology.

As per the first principle, HCD is a design philosophy that incorporates the end user's' perspective at each step of the product or service development. This way both the design process and its results become humanized in a two-way process of information exchange (Norman 2013; Cooper 2004). This is linked with the concept of iteration (principle 4) and fits with current HCD developments such as the idea of "sense and respond" (Gothelf and Seiden 2017), which we will explain later. Crucially, humans are a prominent part of the equation and so we also embrace a bidirectional relationship between users and designers.

In education, there are two main groups of users: educators and students. Note, however, that our focus lies with the meta-level of the design of learning. That is, we do not focus on how learning design affects the learners but rather on the question of how to support educators in their design activities. In our view, the realm of the design for learning—that is, the design of technology-enhanced learning activities—ought to be governed by educators. Thus, in this layered environment that is education, educators are our key target users. Educators—forming education's micro-level—also become the "bridge" with other stakeholders—such as learning technologists or instructional designers—who contribute to the creation of technology-enhanced learning activities and educational technologies per se.

In a HCD process, users are continuously involved in service or product development (principle 2). The ways in which this is done vary depending on the development stage and of course the resources available, both in time and budget. It is key to define evaluative “checkpoints” in order to integrate the users’ feedback into the development of the designs (principle 3). This evaluation process also needs to be designed: how will the integration of that specific ICT tool be assessed? Which inputs will the educator use to decide what to do next?

The fifth principle demands that the effects and, thus, the evaluation of technology-enhanced learning be analysed at the system level. It is not just the tool per se that counts but also how it supports the learning activity, how it is perceived and grasped by the students, how the educator can follow what is going on, etc. The field of Teachers Inquiry into Student Learning (TISL) (Wasson et al. 2016) promotes the idea that the usage of student data is a skill that teachers must develop in order to teach in the information and technology-rich classroom (data literacy).

This proposal, however, takes us back to our previous claim: individual educators themselves cannot be expected to master and orchestrate the increasingly complex and diverse array of tools, resources, activities, data and people that make up learning ecosystems. This is why, distancing ourselves from fields such as TISL or Teachers as Designers (Kali et al. 2015), we bring in principle 6: educators should be surrounded by multidisciplinary teams in terms of skills and perspectives.

To sum up our design stance, we adopt human-centred design as our lens and baseline because:

1. It is a mindset, one that entails a specific and guided approach to problem-solving.
2. It acknowledges the role of humans both as designers and users of design processes, services and artefacts.
3. It is system-aware, it does not take technology or the users out of their context. It concerns itself with the many forces that interact and collide.
4. It is process-oriented and provides a set of methods to address design as a continuous activity based on learning from and improvement of the designed artefacts.

These characteristics, we propose, should provide the guiding principles for the processes of conceptualization, implementation, evaluation and improvement of technology-enhanced learning. Although the design stance we advocate does not restrict its use to technology-enhanced learning contexts in education, it best shows its strength there.

With the growing intricacy and pervasiveness of technology, human-centred design has evolved and branched off into different fields; in spite of their different approaches and names, they all share a focus on the end user of a product or service. Thus, whether one calls it “user experience” (UX), “design thinking”, “service design” or “lean UX”, all are still following the same human-centred design principles.

Whereas in academia, human-computer interaction is the common term for the same concept, user experience (UX) (Kuniavsky 2003) is the most widespread name in the industry and less formal training settings. Design thinking (Buchanan 1992, to cite just one) is also well-known and promotes an empathic, empirical and iterative approach, again very similar to human-centred design.

Service design (Stickdorn and Schneider 2012) openly acknowledged the idea that user experience is holistic and encompasses all moments and levels of a user interacting with a service and not just with the product itself. Thus, the design needs to encompass people, infrastructure, communication and material components of a service. Carvalho and Goodyear (2017) advocate the application of service design ideas and methods in the realm of education since “design for learning is hybrid, involving mixtures of service, product and space design. This hybridity is accompanied by a need for a more complex knowledge-base for design than is sometimes found in discussions of knowledge for university teaching” (Goodyear 2015).

The design of technology-enhanced learning should not only learn from service design but also incorporate more “agile” and novel approaches which—again based on the same HCD principles—call for faster cycles of design to constantly learn from users and, thus, reduce uncertainty (Gothelf and Seiden 2017). As is characteristic of the social realm, educators cannot know beforehand the impact and effects that a given learning activity will have. The Lean UX approach focuses on how to learn about this impact as early as possible to make the necessary adjustments to the designed service or product.

In Lean UX (Gothelf and Seiden 2016) as in the Lean Startup movement (Ries 2011), the design cycles consist of three phases: learn, build and measure. The main difference with HCD—besides the focus on short cycles—is that the process starts with a solution (normally called a ‘Minimum Viable Product’) as opposed to an initial period of investigating the target users. The goal of the minimum viable product is to put the product in the hands of users as soon as possible to gather feedback and improve subsequent product iterations.

Thus, as Gothelf and Seiden (2017) state, any company needs to establish a continuous conversation with its users in order to learn from them and include these learnings in the product development. This approach also involves a shift in focus: instead of working to get “outputs”, teams should aim to get “outcomes”. This is best done through cross-functional and autonomous teams, whose main goal is to learn about the interaction between the users and the designed product or service. These newer HCD approaches have also incorporated the scientific method to guide the validation of assumptions and hypotheses, all aimed at reducing uncertainty.

There have been attempts to strengthen collaboration and combine perspectives of designers, educators and educational technologists, but research on how to organize this is still limited. Researchers have tested the integration of educators in the design processes: research for practice (Shrader et al. 2001); design-based implementation research (Penuel et al. 2011); teachers as collaborative designers (Cviko et al. 2014; Svihla et al. 2015; Voogt et al. 2015); teachers as participatory designers (Cober et al. 2015); or through partnerships (Matuk et al. 2015). Although these initiatives go a long way, they still fail to properly empower educators.

2.2.2 Technology-Enhanced Learning (TEL)

Within technology-enhanced learning, *technology as a delivery tool* is the mainstream mode of adoption of educational technology nowadays. However, *technology as a cognitive partner* is what we strive for. This is true for both educational researchers (Jonassen and Reeves 1996; Ertmer and Ottenbreit-Leftwich 2012; Ertmer et al. 2012) and educational technologists (Brown et al. 2015; Merriman et al. 2016; Dron and Anderson 2016). Thus, these often siloed and tensioned disciplines seem to have a common goal: integrate technology to allow students to do real work and, therefore, facilitate authentic student learning (see also Sloep 2013).

With this aim in mind, several institutions have already worked on the development of post-Learning Management Systems (LMS) solutions. This is the case of the OUNL and Athabasca University, for example. The former, under the name of OpenU, has created a learning system with four distinct environments: the Personal Learning Network, the Course Learning Network; the Professional Development Network and the topic/research networks (Hermans et al. 2014). Similarly, to support the need for social learning, Athabasca University has developed the "Athabasca Landing", an Elgg-based beyond-the-LMS social system (Rahman and Dron 2012). These solutions are part of what Anderson and Dron (Anderson and Dron 2011; Dron and Anderson 2016) define as the "fourth or holistic generation" of educational technology; one that will be deeply integrated within learners' whole lives and those of others.

These new environments respond to the increasing unease with existing LMSs (Kop and Fournier 2013) and the need for more social-oriented, not course-limited environments. About ten years ago, the limitations and constraints of mainstream LMSs gave birth to the Personal Learning Environments (PLEs) concept (Wilson et al. 2007). Whereas the LMS is built around the course concept and intended for formal instruction in particular, the idea behind the Personal Learning Environment is that it is governed solely by the learner. Essentially, PLEs aim to facilitate students' use of technology as a cognitive partner (Rajagopal et al. 2017).

The current state of the TEL art is that there are a myriad of technology tools and devices that currently support technology-enhanced learning, which can be integrated through a "Lego-approach", already foreseen in the PLE literature and now apparent in the Next Generation of Digital Learning Environments (NGDLE) reports (Table 2.1). This next generation is closer to a learning ecosystem: a learning environment consisting of learning tools and components that adhere to common standards and enable different and diverse pedagogies.

This flexibility, disaggregation, modularity, Lego-structure of the upcoming educational-technology environments is extremely challenging from the designers' and users' perspectives since it places the focus on their activities. The underlying characteristic of NGDLE is that learners and educators will be able to shape and customize their learning environments to support their needs and objectives. Yet, still most educational technology is developed without the inputs from educators or educational sciences (Könings et al. 2007, 2014).

Table 2.1 Characteristics of the next generation of digital learning environments

The NDGLE: a component infrastructure to leverage technology for teaching and learning	
The Next Generation Digital Learning Environment: A Report on Research—EDUCAUSE 2015 (Brown et al. 2015)	Next-generation environments must address five dimensions: interoperability and integration; personalization; analytics, advising, and learning assessment; collaboration and accessibility and universal design
The Next Generation Learning Architecture—(Merriman et al. 2016)	The next generation of digital learning environments consists of a marketplace of Enterprise Infrastructure Services and a marketplace of educational applications, of various types or classes, which consume Enterprise Infrastructure Services A new class of applications, the Learning Method eXperience (LMX) provides the context and overall user experience required for a particular educational methodology or pedagogical model
Educational Provisioning System (EPS)—(Hermans et al. 2015)	Rather than implementing provisioning rules directly in an online learning system, the EPS allows for managing provisioning rules independent of the learning application(s) in use. This EPS allows for both managing and processing provisioning rules in order to meet the demands of new online educational formats

On the other hand, due to its component-based architecture grounded in standards and best practices, the NGDLE brings the opportunity to explore new approaches and develop new tools. The success of these learning ecosystems is highly dependant on the processes and activities that actually involve learning science knowledge as well as educators (and at a later stage, students) in the conceptualization and refinement of the educational technologies' features. Without this involvement, *learning* will still not be part of the environment and it will be yet another technology limited to the status of delivery tool at best.

As a result, technology-enhanced learning is at a paradoxical stage. On the one hand, practitioners of all related disciplines—educational researchers, educators, learning technologists—agree on the essentials: (1) learning with technology has yet to mature; (2) technology in education should become a cognitive tool. On the other hand, the means to make this happen have not yet been established.

Our proposal is that HCD provides these means to purposely implement TEL and impact the three levels of learning and teaching—micro, meso and macro. HCD will facilitate the "conversations" between these levels and related stakeholders by providing, first of all, a shared mindset: all work for the end users' (students') needs; and secondly, by establishing a process and the tools that allow one to integrate these needs and context into TEL designs and also the educational technology involved.

In fact, following the NGDLE metaphor of Lego pieces, our approach also puts into play the human pieces. Only with an interplay of disciplines will education include technology as a cognitive tool, will educational technology be designed for its users, and will learning environments be designed for learning. We will do so by screening off a precious yet battered resource: educators. Then, we will see the same evolution as professional designers will soon have to embrace (Manzini 2015; Sanders 2006): both educators and designers will be *enablers*, facilitators and process managers for others to learn and design, respectively.

2.3 Educators as Designers

In the HCD sense, educators are our target users. They are ultimately responsible for the design, enactment and development of TEL activities. They also liaise with their students and with the educational institution they work for. Thus, their role is pivotal in any effort to incorporate the HCD mindset, process and methods in education.

We start by providing an overview of what is known of how educators design and then we introduce the results of an intervention. It was designed to guide educators through a HCD process which was meant to facilitate educators to design technology-enhanced learning activities.

2.3.1 Teachers as Designers, What We Know

By now it should not come as a surprise that we claim designing to be a complex and intricate task. It demands of the designer to take into account and integrate many different and diverse elements. It also requires her to consider the problem and the solution from many different perspectives. This description of design deeply resonates with an educator's work. Teachers must perceive, interpret and enact existing resources, evaluate the constraints of the classroom setting, balance trade-offs and devise strategies—all in the pursuit of their instructional goals (Brown and Edelson 2003). As in design, educators create, adapt and try out resources to fit their specific needs and contexts.

Many researchers such as Brown and Edelson (2003) emphasize this situated and practice-oriented design work that educators accomplish. This pragmatic approach to design means that educators privilege practicality and feasibility (McKenney et al. 2015) and leverage practice-based experiences to make decisions (Roschelle and Penuel 2006). As a result, much relevant teacher design expertise comes intuitively, is acquired on a daily basis and congruent with the teacher's beliefs and convictions.

Schön (1983) defined this kind of intuited expertise as "designerly ways of knowing", which are learned through direct and indirect engagement in authentic design practices, rather than an explicit, formally-represented body of knowledge and skills. According to Schön, professionalism is gained by *reflection-in-action*, which enables the practitioner to think deeply about situations while they are happening, interpret and frame them in particular ways and adapt his/her actions accordingly, as opposed to *reflection-on-action*, which is done after the fact, much as an afterthought.

Extending the research on how educators actually design, according to Matuk et al. (2015) teachers' decisions in customizing technology-enhanced learning materials are the result of interactions between knowledge of their students and the subject matter, beliefs about teaching and learning, and orientations toward technology and their roles as designers. The authors conclude: "Research also indicates that whereas attendance to students' ideas can result in customizations that greatly benefit learning, *issues of practicality primarily drive teachers' intuitive customizations*" (italics ours).

Similarly, Bennett et al. (2015) observed that Higher Education teachers' perceptions of student characteristics, their own beliefs and experiences, and contextual factors are key influences on design decisions. In another study, Boschman et al. (2014) found that the considerations Kindergarten teachers entertained during design were influenced mostly by practical concerns, although their pedagogical orientation, beliefs about how children learn, and convictions of how learning should be supported by teachers also played a role.

So, there can be little doubt that the praxis of teachers involves design:

- As in design, teaching is a highly complex activity that draws on many kinds of knowledge (Mishra and Koehler 2006).
- As with the problem spaces in design, teaching occurs in ill-structured, dynamic environments and, therefore, teaching also deals with what are known in design as wicked problems (Rittel and Weber 1973; Opfer and Pedder 2011; Sloep 2013).
- As in design, teaching is iterative: it seldom happens just once; there is a continuous enactment and tweaking of activities and resources (Pardo et al. 2015; Bates 2015).

While we can see some patterns emerging from existing research—that we further analyse below—some authors (Agostinho et al. 2011; McKenney et al. 2015) also point out how more empirical research is needed to better understand teachers' design practices so as to achieve closer alignment between teachers' needs and their design initiatives.

However, the way in which educators design, also reveals a number of idiosyncrasies:

1. **Teacher designs are experience-shaped**. Kali et al. (2011) talk about "folk pedagogy" (in an apparent analogy to folk psychology), that is, how an individual teacher's ways of teaching are strongly shaped by his/her personal experience of having been taught themselves. Educators can discuss sophisticated ideas of instruction in the abstract, for example on how to incorporate educational technology. And yet, specific design situations activate experiential knowledge, which more often than not leads to traditional forms of instruction.
2. **Teacher designs are underpinned by beliefs**. In 1999, Ertmer (1999) distinguished between two types of barriers that impact teachers' uses of technology in the classroom:

a. First-order barriers are defined as those that are external to the teacher and include resources (both hardware and software), training, and support.
b. Second-order barriers comprise those that are internal to the teacher and include teachers' confidence, beliefs about how students learn, as well as the perceived value of technology to the teaching/learning process.

Although first-order barriers pose significant obstacles to achieving technology integration, the underlying, unconscious second-order barriers have proved to pose the greater challenge (see also Kreijns et al. 2013).

3. **Teacher designs are learner-adapted**. Stark (2000) reported how educators' design decisions were strongly influenced by the perceived characteristics of their students. Bennett et al. (2015) confirm this influence and suggest that these judgements are currently reliant on recollections and impressions built up over time and through contact with students.
4. **Teacher designs are practice-driven and practice-oriented** (Doyle and Ponder 1977; Ertmer 1999; Janssen et al. 2013; Boschman et al. 2014; Matuk et al. 2015). Practicality and feasibility is the key driver of educators when designing: teachers must ensure that the enactment with the students fulfils the learning outcomes and, for that reason, possible barriers have to be reduced to a minimum.
5. **Teacher designs are context-shaped**. As part of the practice-driven component but relevant to take into account as a separate factor, many authors have stated the relevance of context [Bennett et al. (2015) and McKenney et al. (2015), for example]. Context needs to be understood not as the immediate physical space of the classroom but in a broader sense, as encompassing all factors and constraints impinging on the educator. These include the customary meso level of the school and the macro level of national educational policies and whatever bodies oversee and monitor the operation of schools.

From this set of factors, it is relevant to notice that almost all of them operate very much at an unconscious level, are deeply rooted in the experiences and beliefs of educators, and are grouped in what Ertmer (1999) defined as second-order barriers (Kreijns et al. 2013).

Kali et al. (2011) also explored how novices carry out design activities. They report how they exhibit a lack of Schön's reflection-in-action, which derives from experience. Using HCD terms, in their 'rush to implementation" (Goodyear 2015, p. 31) novices skip two key phases of the design process: the exploration phase and the analysis/reflection phase (Hoogveld et al. 2001; O'Neill 2010). They ignore the "fuzzy front end" (Sanders and Stappers 2008) of exploration. But this is a critical phase, one that determines what is to be designed and sometimes what should not be designed; in it designers take into account considerations of many different natures. As such it is a divergent phase. Similarly, novices also often ignore the reflection phase. However, it is an essential step for continuous improvement, like learning by doing. Here too, novices fail to take the opportunity to use the enactment of the learning activities as a source for learning and enhancing their practices.

But what then is it that teachers do know and how does this knowledge affect their design activities? Teaching requires a complex set of knowledges, as illustrated by the Technological Pedagogical and Content Knowledge framework. This conceptual framework (Magnusson et al. 1999) for educational technology builds on Shulman's formulation of "pedagogical content knowledge" (Shulman 1986) and incorporates the role of technology in education.

The relationships between content (the actual subject matter that is to be learned and taught), pedagogy (the process and practice or methods of teaching and learning), and technology (both commonplace, like chalkboards, and advanced, such as digital computers) are complex and nuanced (Mishra and Koehler 2006). The analysis of the interplay needs to consider these components as a whole, in pairs, but also in isolation.

Here, we focus on the pedagogical knowledge only. For a teacher to have this type of knowledge she should understand how students construct knowledge, acquire skills, and develop habits of mind and positive dispositions toward learning. As such, pedagogical knowledge requires an understanding of cognitive, social, and developmental theories of learning and how they apply to students in their classroom (Mishra and Koehler 2006). This is the type of knowledge that one expects educators to master.

Yet, many educators lack this "deep pedagogical knowledge". In the terms of Kali et al. (2011), the pedagogical knowledge of educators often takes the form of 'folk' beliefs. While it is true that educators think in terms of learning outcomes and the change they want to promote, they seldom ground their praxis in theories (Bennett et al. 2015).

This does not mean that educators are not concerned with pedagogy but that, rather than having a coherent and consistent theory of teaching and learning, teachers apply a loose collection of practice-oriented strategies, each one locally coherent, although not necessarily systematically validated. Kali et al. (2011) call this notion "pedagogical knowledge in pieces".

This "pedagogical knowledge in pieces" is adequate for the praxis of teaching. However, it hampers the systematization of learning designs and the conversation with other disciplines. It actually clashes with the idea that one has about what educators know. For an outsider, educators know about pedagogy. It is assumed that they ground their practice in validated theories of learning. This turns out not to be the case. We believe that this gap between how educators operate in actual fact and what other disciplines expect from them is at the core of many problems of the implementation of educational technology.

In summary, teachers are designers of learning, there can be little doubt about that. However, they design in an intuitive fashion, with a focus on direct educational practice, making use of an eclectic collection of pedagogical insights that are more informed by their own practice and perhaps those of others they know about than by theoretical insights. Various authors discussed in the above have argued this position. Many also have wondered how the design abilities of teachers could be improved upon. In an experimental intervention, in the guise of a Massive Online Open Course, we made an attempt to improve teachers' design abilities. We summarise our key learnings in the next section. Details on the experience and its results can be found in Garreta-Domingo et al. (2015, 2017, 2018, accepted for publication).

2.3.2 Teachers as Designers, an Intervention

Earlier we introduced the notion that educators design with a particular mental model of who and what their learners are. Taking into account the characteristics of the students is key to good design; even if this raises the question of the quality of the information that educators have about their students (Bennett et al. 2015).

Research shows that teachers' student-centred beliefs tend to result in more authentic uses of technology while traditional beliefs tend to have a negative impact on the integrated use of computers (Hermans et al. 2008). And, at a broader level, Bennett et al. (2015) reported how many authors have concluded that student-focused approaches to teaching encourage deep approaches to learning, that result in high quality learning outcomes.

These beliefs not only affect the conceptualization of the learning activities but are beneficial also during their implementation and evaluation. A student-focused approach allows a teacher to be responsive to student needs and interests during the enactment of the activities (Postareff et al. 2008).

As Ertmer et al. (2012) confirm, research results suggest close alignment; that is, student-centred beliefs undergird student-centred practices (authenticity, student choice, collaboration). But despite such beliefs there are also constraints that prevent student-centred practices to blossom to the full. In fact, teachers with student-centred beliefs do not necessarily translate those beliefs into learning activities that use technology as a cognitive partner or indeed in activities that use technology at all. Educational practitioners often see technology as a burden, an imposition (Kreijns et al. 2013; OECD 2015). How come? Is education different, are educational practitioners different, or is there an issue with the way technology affects education?

To tackle these issues, we advocate a shift of focus, away from the technology and also, in some sense, away from the students. Educators and educational designers, developers and researchers should primarily focus on the design of learning activities and on how to enhance them through technology. This shift of focus has dramatic consequences. It implies designing *for use* rather than *for users* (Williams 2009). Following the Activity-Centred Design approach (Gay and Hembrooke 2004; Gifford and Enyedy 1995), designers should focus on the activity in order to deliver tools that effectively support users in real-world contexts (Norman 2005; Hoekman 2010). In the educational research realm, the Activity-Centred Analysis and Design (ACAD) framework (Goodyear and Carvalho 2014; Carvalho and Goodyear 2017) advocates the same shift.

The ACAD framework places the learning activity at the centre of the design process and differentiates between three different dimensions: epistemic, set and social (Table 2.2). Like HCD, the ACAD framework acknowledges the interplay of the different components in a system. It is our belief that we need this holistic perspective to build the next generation of digital learning environments and pedagogies and, as a consequence, the next generation of educators and learners (Sloep 2013).

Despite their differentiation between these three design dimensions, Goodyear and Carvalho (2014, p. 57) emphasize the importance to carefully distinguish between

Table 2.2 Learning design dimensions according to Goodyear and Carvalho (2014) and how they were designed in our intervention

Dimensions	Short description	Our intervention
Task structure and **epistemic design**	Epistemic design refers to the knowledge-oriented structure of a network; the activity is goal-oriented and facilitates learning and knowledge creation	A Massive Open Online Course (MOOC) that walks educators through the design process of an ICT-based learning activity of their own making
Structures of place and **set design**	The activity is also shaped by the physical/digital setting in which it unfolds. Thus, the relations between place, tools and activity are key to both analysis and design	A combination of online tools chosen to provide the necessary learning and design support to the design efforts of the MOOC participants
Organizational forms and **social design**	What people do is often influenced by the actions of other people around them, including the instructions, advice, encouragement and warnings they give At a broader level, social norms, rules and habits tend to have an effect, even if other people are not physically around	A set of facilitators to guide participant educators through their design processes; together with the comments and feedback from their peers. And of course the set of norms, rules, etc. that each participant brings along, which are outside of intervention control

what can be designed and what cannot: "We *may* be able to design the thing that is experienced, but we cannot design the experience itself" (italics theirs). The context, the tasks and the tools can be designed; however at learn time learners are likely to reconfigure what has been proposed in new ways (see also Goodyear 2015). As we have seen earlier, this difference between what a designer intends and what actually happens is acknowledged by HCD approaches. It is through a continuous and iterative approach to design that we learn and reduce uncertainty; at each iteration, the team analyses what happened and takes action according to it with the aim of improving the design for the forthcoming iteration and bringing that what happens closer to that which is intended.

Thus, to reiterate a point made earlier, to implement HCD in TEL three intertwined aspects need to be addressed: (1) how to incorporate the HCD *mindset* in the design of TEL, (2) how to bring the HCD *process* in the design of ICT-based activities and educational technology; and (3) how to bring in HCD *methods* to the design for learning. To gather insights into the relative importance of these three aspects, we designed an intervention along the lines of the ACAD model. After briefly introducing the context of our intervention, we explain next its 'set', 'social' and 'epistemic' design dimensions.

The context of our intervention is a Massive Open Online Course (MOOC) on a topic that—as we have seen—many teachers struggle with: the inclusion of ICT in education (OECD 2015). It was intended to offer a genuine professional development opportunity for educators of all educational levels (Garreta-Domingo et al. 2018; Stoyanov et al. 2014). The HANDSON MOOC—implemented under a Lifelong Learning Programme project (http://www.handsonict.eu/)—was open and free. Based on HCD methods and process, the course guided educators through the design of their own TEL activity.

The *set design* of the MOOC included Moodle, for the first edition, and Canvas, for the second one, as the course platform; Moodle/Canvas contained the syllabus, the design tasks as well as the discussion forums. The Integrated Learning Design Environment (ILDE) was the design platform on both occasions; this web platform allows communities of educational designers to co-create and share learning designs both from scratch or by using templates provided (Asensio-Pérez et al. 2017).

The MOOC's *social design* comprised interaction with facilitators and peers in the forums and through weekly synchronous sessions. The first iteration of the MOOC featured three facilitators, experts in Learning Design and HCD. The second iteration was offered in seven languages in parallel, thus there were 15 facilitators who addressed the students in their native language. These facilitators were all volunteers; they had no formal HCD expertise, but were trained to act as process managers for the participants. English was used for instructions and general communications only.

The *epistemic design* was grounded in the idea of studio-based teaching (Mor and Mogilevsky 2013; Reimer and Douglas 2003; Winograd 1990). In this online studio, participants designed a TEL activity that by the end of the course was intended to be ready for enactment in their respective teaching settings. The epistemic design concerns the tasks learners (in our case, educators as lifelong learners) carry out in order to acquire new knowledge. Following our focus on human-centred design to empower educators as designers, our epistemic design mimics a HCD process from considering the user requirements, to conceptualising the solution and, then, testing it on each iteration (Fig. 2.1).

It is not the focus of the present chapter to analyse the results from these two interventions, interested readers are referred to the following papers: set design (Garreta-Domingo et al. 2015), social design (Garreta-Domingo et al. 2017), epistemic design (Garreta-Domingo et al. 2018 and Garreta-Domingo et al. under review). We summarize here what we learned from our inclusion of HCD in technology-enhanced learning:

1. **Incorporating the HCD *mindset* in the design of TEL**
   As "amateur" designers, participant educators showed some designerly concerns and tasks. Interestingly, more pedagogically-savvy educators tended to place the focus on the ICT-tool as opposed to the activity; but educators with little familiarity with pedagogical models and trends, were able to act according to the HCD mindset that was "transmitted" to them through the design tasks (epistemic design) and in the conversations in the forums (social design).

Design Studio for ICT-based Learning Activities - HANDSON MOOC (2)

Week 1: Initiate **Learning goals:** Get acquainted with LDS and define an initial version of the educational challenge.	A1: Introduction to the Design Studio for ICT-based Learning Activities! A2: Set up your Design Studio Journal. It is a tool for you! A3: ILDE Account and Dream Bazaar A4: Peer-mentoring - your dream!
Week 2: Investigate **Learning goal:** Get acquainted and apply HCD methods for user needs analysis. Review educational challenge based on peer feedback.	A5: Get familiar with the persona concept A6: Create your own persona A7: Analyzing context, factors and concerns A8: The objectives of your ICT-based learning activity A9: Revisit your dream and update it A10: Peer-mentoring - Your personas!
Week 3: Inspire & Ideate **Learning goal:** Continue user needs analysis and shaping the learning activity. Start thinking on monitoring the experience.	A11: Define the heuristics for your design project A12: Search for existing ICT-based learning activities A13: Learn about user scenarios A14: Ideate through writing a user scenario A15: Peer-mentoring - The objectives
Week 4: Prototype **Learning goal:** Translate the results of previous tasks into a prototype and assess it with a user or peer.	A16: Prototype your artifact A17: Revisit and update your evaluation heuristics A18: Test your prototype *Advanced authoring and implementation* A19: Consolidate your prototype A20: Peer-mentoring - Consolidate your prototype
Week 5: Evaluate & Reflect **Learning goal:** Receive peer feedback on the design activity. Reflect on the course.	A21: Publish your learning activity A22: Peer-mentoring - Your learning activity A23: Your design studio report A24: Reflect and share your thoughts!

Fig. 2.1 The HANDSON MOOC's (2nd edition) course activities (see also Garreta-Domingo et al. under authors' revision)

2. **Including the HCD *process* in the design of ICT-based activities and educational technology**
   Our intervention also aimed at solving several of the shortcomings that many professional development activities have: our focus was not on the theory or the technology but on a personal educational challenge that each educator wanted to address through the design of an ICT-based learning activity. This made the process much more relevant and meaningful to each participant and, therefore, useful for the desired outcome: to have an activity ready to implement.
3. **Including HCD *methods* in the design for learning**
   Participant educators had a hard time comprehending and actioning some of the HCD methods. The general trend was to assimilate the method to what was already known to them. Thus, we see how many "personas" were just a description

of a real student rather than archetypical ones, and how many "heuristics" were turned into student evaluation rubrics rather than means to evaluate their design.

Taking Carvalho and Goodyear's (2017) service design lens to analyse the insights we gained from the intervention, at the base level of learning (what educators did according to themselves) our interventions were valued very positively and participants would both repeat and recommend the experience (Garreta-Domingo et al. 2015). Nevertheless, at the superposed level of managing their own learning, participating educators did not have the necessary context nor the scaffolding to understand what was expected from them in the case of some HCD methods. We concluded that more introductory tasks as well as a less domain-specific vocabulary would facilitate the of HCD to educators (Garreta-Domingo et al. under authors' revision). Moreover, in line with HCD, educators should be able to practice this new framework as an iterative, in-context and applied activity.

2.4 Conclusions: Empowering Educators as Designers and Team Members

This chapter has explored the design as undertaken by teachers through the juxtaposition of human-centred design and technology-enhanced learning. The relevance of design for education is widely acknowledged. However, in line with the key ideas of HCD, our position stands out in that we emphasize that only *through its related mindset, processes and methods* design can play a key role in the creation of learning activities and of educational technology. We believe that only then design can integrate currently scattered but strongly interrelated activities. What does this imply for teachers?

Traditionally, educators have worked almost always singly. Admittedly, they have to follow curriculum programmes and abide by both educational and institutional guidelines. However, they have mostly operated on their own in their daily practices. Moreover, the traditional tensions between education and technology are still present. Still many educators and educational researchers pride themselves on being pedagogically (as opposed to technologically) driven in their teaching and learning research and designs. Still most educational technology is developed without sufficient inputs from educators or educational sciences.

We have seen how educators approach the design of learning activities and lesson plans. Their practice-oriented, experience-based and mostly intuitive design activities call for a more systematic and professional approach. We have also seen how properly designed interventions can empower teachers as HCD designers. Our empirical research has provided insights in how educators can acquire a design mindset, follow a design process and apply HCD methods, albeit that they need support through an applied learning process.

So, our answer to the question '*how can HCD bring coherence to the currently loosely organised and individually-oriented task of design for learning with ICT* *tools?*' would be the following. Given that educators accomplish design tasks almost on a daily basis, they could—like many designers—benefit from a hands-on, multidisciplinary, collaborative and iterative approach, as advocated by the field of human-centred design. In fact, all actors in technology-enhanced learning design would benefit from such an approach. They may not approach design in the same way, some may not even call it design, but willy-nilly they all abide by Simon's (1996) maxim to *devise courses of action aimed at changing existing situations into preferred ones*.

That said, the design of technology-enhanced learning activities is strongly related to the affordances and features of (educational) technologies. Some, erroneously, still claim technology to be 'just a tool'; but technologies also influence and define their usage, something which is even more relevant if one wants these tools to become cognitive tools. The near future holds promises: thanks to the flexibility, interoperability and distributed nature of the next generation of digital learning environments any learning design could be supported. For this to happen, we first need to design them. The foreseen software architecture allows for a Lego approach, but *someone* needs to decide which are the bricks and how they are to be put together.

As advocated by a human-centred design approach, this *someone* should be a multidisciplinary team. We cannot expect a single individual to master all components, that is, expect teachers to be jacks of all trade. It is the hands-on collaboration among disciplines that will allow for qualitatively high ranking and innovative learning designs, pedagogies and technologies. Educators, instructional designers and educational technologists need to find a common language and common processes. Heeding the maxims of human-centred design will facilitate the emergence of genuine technology-enhanced learning.

We envision, then, how a human-centred design approach will not only impact the design for learning but also the design of educational technology. The learning ecosystem is expected to be in continuous evolution and it is up to the *learning* processes and activities to guide this development. Educators, designers and technologists need to leverage data-driven (qualitative and quantitative) approaches to enhance, inform and intertwine their design spaces.

Indeed, looking further forward we see how the design for learning and the design of educational technology go hand in hand. To make this become a reality, silos need to be broken down and all actors involved need to embrace multidisciplinarity. This can only be achieved if processes, tools and language are shared. It is our belief that human-centred design as a philosophy and process facilitates these two essential changes.

Multidisciplinarity is a cornerstone of HCD in all its different representations and evolutions. For example, the idea of "sense and respond" (based on the Lean startup and Lean UX approaches, as discussed) is based on the existence of small and autonomous teams that have the capacity to learn—build—measure, thanks to a constant "conversation" with users.

Let's then imagine a scenario, one in which cross-functional teams define the design of technology-enhanced learning as well of educational technologies. The educator is the expert on her topic as well as on the classroom orchestration, but she works closely with expert instructional designers, UX designers and educational technology developers. The instructional designers contribute their expertise as pedagogical models. The UX designers are process facilitators, design enablers; they know the methods and they ensure that the user involvement is present at all project stages, they ensure a good user experience by having a holistic view of the different elements at play. The educational technologists are the experts on ICT tools or on the next generation digital learning environment; they are key in making the necessary changes in the technology.

These self-contained teams operate at a micro-level. For them to be successful, a shared mindset and common language, processes and tools are needed. HCD is an iterative process; through complete design lifecycles, solutions are conceptualized, defined, tested and improved. These lifecycles vary in complexity and length. In a lean UX setting, the cycles are fast, we need to learn—build—measure in short periods of time because we're also working in self-contained problems. In a more traditional HCD process, the problems we address have a larger scope and weeks become months. In both cases, the results of the design lifecycles percolate through at the meso-level and progressively the same process, methods and mindset is applied for institution-wide aspects. And this, in turn, impacts the macro-level.

We can also expect another outcome to result from applying human-centred learning design with technology. Through the HCD processes and activities, teachers will learn differently and from these new collaborative, hands-on and iterative experiences they will be able to design new learning activities. As we have seen, educators design based on their beliefs and experiences and tend to fail in the initial and final analysis stages. Providing them with a context that allows them to learn differently, explore before designing and analyse the results before implementing, will have a rippling effect on their learning designs, educational technology and students. As opposed to asking them to become "jacks of all trades", educators would be surrounded by specialists that bring in new perspectives as well as empower them as the designers of learning.

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References

Agostinho S et al (2011) The future of learning design. Learn Media Technol 36(2):97–99

Anderson T (2009) The dance of technology and pedagogy in self-paced distance education. Athabasca University, Canada, pp 1–7

Anderson T, Dron J (2011) Three generations of distance education pedagogy. Int Rev Res Open Distance Learn 12(3):80–97

Asensio-Pérez JI et al (2017) Towards teaching as design: exploring the interplay between full-lifecycle learning design tooling and teacher professional development. Comput Educ 114:92–116

Bates T (2015) Teaching in a digital age: guidelines for designing teaching and learning. Tony Bates Associates Ltd., Vancouver, BC. http://opentextbc.ca/teachinginadigitalage/

Bennett S, Agostinho S, Lockyer L (2015) Technology tools to support learning design: implications derived from an investigation of university teachers' design practices. Comput Educ 81:211–220
Boschman F, McKenney S, Voogt J (2014) Understanding decision making in teachers' curriculum design approaches. Educ Tech Res Dev 62(4):393–416
Brown M, Edelson DC (2003) Teaching as design: can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice?. Evanston, IL
Brown M, Dehoney J, Millichap N (2015) The next generation digital learning environment: a report on research, p 11
Buchanan R (1992) Wicked problems in design thinking. Des Iss 8(2):5–21
Carvalho L, Goodyear PM (2014) The architecture of productive learning networks. Routledge Falmer, New York, London
Carvalho L, Goodyear P (2017) Design, learning networks and service innovation. Des Stud 1–27. http://linkinghub.elsevier.com/retrieve/pii/S0142694X17300649
Cober R et al (2015) Teachers as participatory designers: two case studies with technology-enhanced learning environments. Instr Sci 43(2):203–228
Cooper A (2004) The inmates are running the asylum: why high-tech products drive us crazy and how to restore the sanity, 1st edn. Sams-Pearson Education, Indianapolis, IN, USA
Cviko A, McKenney S, Voogt J (2014) Teacher roles in designing technology-rich learning activities for early literacy: a cross-case analysis. Comput Educ 72:68–79. http://dx.doi.org/10.1016/j.compedu.2013.10.014
Dalziel J et al (2012) The Larnaca declaration on learning design. http://www.larnacadeclaration.org/
Dillenbourg P et al (2011) Classroom orchestration: the third circle of usability—why is paper highly usable in classrooms ? In: CSCL 2011 proceeding, I, pp 510–517. http://infoscience.epfl.ch/record/168741/files/ClassroomOrchestration:TheThirdCircleofUsability.pdf?version=1
Downes S (2010) The role of the educator. http://www.downes.ca/post/54312
Doyle W, Ponder GA (1977) The practicality ethic in teacher decision-making. Interchange 8(3):1–12
Dron J, Anderson T (2016) The future of E-learning. In: Haythornthwaite C et al (eds) SAGE handbook of E-learning research. Sage, pp 1–32
Ertmer P (1999) Addressing first- and second-order barriers to change: strategies for technology integration. Educ Tech Res Dev 47(4):47–61
Ertmer P et al (2012) Teacher beliefs and technology integration practices: a critical relationship. Comput Educ 59(2):423–435. http://dx.doi.org/10.1016/j.compedu.2012.02.001
Ertmer P, Ottenbreit-Leftwich AT (2012) Removing obstacles to the pedagogical changes required by Jonassen's vision of authentic technology-enabled learning. Comput Educ 64:175–182. http://dx.doi.org/10.1016/j.compedu.2012.10.008
Flavin M, Quintero V (2018) UK higher education institutions' technology-enhanced learning strategies from the perspective of disruptive innovation. Res Learn Technol 26(1063519):632–637. https://journal.alt.ac.uk/index.php/rlt/article/view/1987/
Garreta-Domingo M et al (2015) Teachers' perceptions about the HANDSON MOOC: a learning design studio case. In: Proceedings of the European conference on technology enhanced learning (EC-TEL). Springer, pp 420–427. https://link.springer.com/chapter/10.1007%2F978-3-319-24258-3_34
Garreta-Domingo M et al (2017) Design for collective intelligence: pop-up communities in MOOCs. AI Soc 33(1):91–100
Garreta-Domingo M, Hernández-Leo D, Sloep PB (2018) Evaluation to support learning design: lessons learned in a teacher training MOOC. Australas J Educ Technol 33(1). https://ajet.org.au/index.php/AJET/article/view/3768
Gay G, Hembrooke H (2004) Activity-centered design: an ecological approach to designing smart tools and usable systems (acting with technology). MIT Press
Gifford BR, Enyedy ND (1995) Activity centered design: towards a theoretical framework for CSCL

Goodyear P (2015) Teaching as design. HERDSA Rev High Educ 2:27–50. http://www.herdsa.org.au/wp-content/uploads/HERDSARHE2015v02p27.pdf
Goodyear P, Carvalho L (2014) Framing the analysis of learning network architectures. In: The architecture of productive learning networks, pp 48–70
Gothelf J, Seiden J (2016) Lean UX: designing great products with agile teams. O'Reilly Media
Gothelf J, Seiden J (2017) Sense and respond: how successful organizations listen to customers and create new products continuously. Harvard Business Review Press
Hermans R et al (2008) The impact of primary school teachers' educational beliefs on the classroom use of computers. Comput Educ 51(4):1499–1509
Hermans H, Kalz M, Koper R (2014) Towards a learner-centred system for adult learning. Campus-Wide Inf Syst 31:2–13
Hermans H et al (2015) Flexible provisioning for adult learners. J Univ Comput Sci 21(2):206–222
Hoekman R (2010) Designing the obvious: a common sense approach to web application design, 2nd ed. New Riders
Hoogveld AWM et al (2001) The effects of a web-based training in an instructional systems design approach on teachers' instructional design behavior. Comput Human Behav 17(4):363–371
ISO (2009) Ergonomics of human system interaction—Part 210: Human-centred design for interactive systems (ISO 9241-210:2010; formerly known as 13407). International Organization for Standardization
Janssen F et al (2013) How to make innovations practical. Teach Coll Rec 115(7):1–42
Jonassen DH, Reeves TC (1996) Learning wth technology: using computers as cognitive tools. In: Handbook of research for educational communications and technology, pp 694–719
Kali Y, Goodyear P, Markauskaite L (2011) Researching design practices and design cognition: contexts, experiences and pedagogical knowledge-in-pieces. Learn Media Technol 36(2):129–149
Kali Y, McKenney S, Sagy O (2015) Teachers as designers of technology enhanced learning. Instr Sci 43(2):173–179
Kirkwood A, Price L (2016) Technology-enhanced learning and teaching in higher education: what is "enhanced" and how do we know ? A critical literature review, vol 9884(May), pp 1–44
Könings KD, Brand-Gruwel S, van Merriënboer JJG (2007) Teachers' perspectives on innovations: Implications for educational design. Teach Teach Educ 23(6):985–997
Könings KD, Seidel T, van Merriënboer JJG (2014) Participatory design of learning environments: integrating perspectives of students, teachers, and designers. Instr Sci 42(1):1–9
Kop R, Fournier H (2013) Developing a framework for research on personal learning environments. eLearning Papers 35(November):1–16
Kreijns K et al (2013) What stimulates teachers to integrate ICT in their pedagogical practices? The use of digital learning materials in education. Comput Hum Behav 29(1):217–225
Kuniavsky M (2003) Observing the user experience: a practitioner's guide to user research, 1st edn. Morgan Kaufman Publishers, Elsevier
Laurillard D (2012) Teaching as a design science: building pedagogical patterns for learning and technology. Routledge, New York and London
Magnusson S, Krajcik J, Borko H (1999) Nature, sources and development of pedagogical content knowledge for science teaching. In: Gess-Newsome J, Lederman NG (eds) Examining pedagogical content knowledge: the construct and its implications for science education. Kluwer Academic Publishers, New York, Boston, London, Dordrecht, Moscow, pp 95–132
Manzini E (2015) Design, when everybody designs: an introduction to design for social innovation. The MIT Press, Cambridge MA
Matuk CF, Linn MC, Eylon BS (2015) Technology to support teachers using evidence from student work to customize technology-enhanced inquiry units. Instr Sci 43(2):229–257
McKenney S et al (2015) Teacher design knowledge for technology enhanced learning: an ecological framework for investigating assets and needs. Instr Sci 43(2):181–202
Merriman J et al (2016) Next generation learning architecture. http://hdl.handle.net/10609/47481
Mishra P, Koehler MJ (2006) Technological pedagogical content knowledge: a framework for teacher knowledge. Teach Coll Rec 108(6):1017–1054

Mor Y, Mogilevsky O (2013) The learning design studio: collaborative design inquiry as teachers' professional development. Res Learn Technol 21(1):1–15
Norman DA (2005) Human-centered design considered to be harmful. Interactions - Ambient intelligence: exploring our living environment 12(4):14–19
Norman DA (2013) The design of everyday things: revised and expanded edition. Basic Books
O'Neill G (2010) Initiating curriculum revision: exploring the practices of educational developers. Int J Acad Dev 15:61–71
OECD (2015) Students, computers and learning; making the connection
Opfer VD, Pedder D (2011) Conceptualizing teacher professional learning. Rev Educ Res 81(3):376–407. http://rer.sagepub.com/cgi/doi/10.3102/0034654311413609
Pardo A, Ellis RA, Calvo RA (2015) Combining observational and experiential data to inform the redesign of learning activities. In; Proceedings of the fifth international conference on learning analytics and knowledge—LAK '15, pp 305–309. http://dl.acm.org/citation.cfm?id=2723576.2723625
Penuel WR et al (2011) Organizing research and development at the intersection of learning, implementation, and design. Educ Res 40(7):331–337
Postareff L et al (2008) Consonance and dissonance in descriptions of teaching of university teachers. Stud High Educ 33(1):49–61. http://dx.doi.org/10.1080/03075070701794809
Rahman N, Dron J (2012) Challenges and opportunities for learning analytics when formal teaching meets social spaces. In: Proceedings of the 2nd international conference on learning analytics and knowledge—LAK '12. ACM Press, New York, New York, USA, pp 54–58
Rajagopal K, Van Bruggen JM, Sloep PB (2017) Recommending peers for learning: matching on dissimilarity in interpretations to provoke breakdown. Educ Technol 48(2):385–406
Reimer YJ, Douglas SA (2003) Teaching HCI design with the studio approach. Comput Sci Educ 13(3):191–205
Ries E (2011) The lean startup: how today's entrepreneurs use continuous innovation to create radically successful businesses. Currency
Rittel HWJ, Webber MM (1973) Dilemmas in a general theory of planning. Policy Sci 4(2):155–169
Roschelle J, Penuel WR (2006) Co-design of innovations with teachers: definition and dynamics. In: Proceedings of the 7th international conference of the learning sciences, pp 606–612. http://dl.acm.org/citation.cfm?id=1150122
Sanders EB-N (2006) Scaffolds for building everyday creativity. In: Frascara J (ed) Designing effective communications: creating contexts for clarity and meaning. Allworth Press, New York, New York, USA, pp 65–77
Sanders EB-N, Stappers PJ (2008) Co-creation and the new landscapes of design. CoDesign 4(1):5–18
Schön DA (1983) The reflective practitioner; how professionals think in action. Basic Books, USA
Shrader G et al (2001) Participatory design of science curricula: the case for research for practice. In: Annual meeting of the American Educational Research Association, Seattle, WA
Shulman LS (1986) Those who understand: knowledge growth in teaching. Educ Res 15(2):4–14
Siemens G (2008) Learning and knowing in networks: changing roles for educators and designers. http://www.academia.edu/2857165/Learning_and_knowing_in_networks_Changing_roles_for_educators_and_designers
Simon HA (1996) The sciences of the artificial, 3rd edn. MIT Press, Cambridge, MA
Sloep PB (2013) Networked professional learning. In: Littlejohn A, Margaryan A (eds) Technology-enhanced professional learning: processes, practices and tools. Routledge, London, pp 97–108. http://hdl.handle.net/1820/5215
Stark JS (2000) Planning introductory college courses: content, context and form. Instr Sci 28:413–438
Stickdorn M, Schneider J (2012) This is service design thinking: basics, tools, cases. Wiley
Stoyanov S et al (2014) Teacher-training, ICT, creativity, MOOC, Moodle—what pedagogy? In: Gómez Chova L, López Martínez A, Candel Torres I (eds) Proceedings of Edulearn 14, the sixth international conference on education and new learning technologies (EDULEARN 14). IATED

Academy, IATED Digital Library, Barcelona, Spain, pp 5678–5686. http://hdl.handle.net/1820/5463

Svihla V et al (2015) A fingerprint pattern of supports for teachers' designing of technology-enhanced learning. Instr Sci 43(2):283–307

Voogt J et al (2015) Collaborative design as a form of professional development. Instr Sci 43(2):259–282

Wasson B, Hansen CJ, Netteland G (2016) Data literacy and use for learning when using learning analytics for learners. In: LAK 2016, Edinburgh. http://ceur-ws.org/Vol-1596/paper6.pdf

Williams A (2009) User-centered design, activity-centered design, and goal-directed design. In: Proceedings of the 27th ACM international conference on design of communication—SIGDOC '09, pp 1–8

Wilson S, Johnson M, Sharples P (2007) Personal learning environments: challenging the dominant design of educational systems. Je-LKS J e-Learn Knowl Soc 3(2):27–38. http://ubir.bolton.ac.uk/index.php?action=fileDownload&resourceId=289&hash=0382c207c66a9834d4390e0f2be6ed3c52e718e5&filename=iec_journalspr-9.pdf

Winograd T (1990) What can we teach about human-computer interaction. In: CHI'90 proceedings, New York, NY, pp 443–449