Why do we need a new design methodology for learning?

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Designers' theories of learning shape the design of learning technologies, and hence the learner's educational experiences. The impact of theories on the final design product is mediated by their impact on the design process: The theories inform what design parameters to consider, what features of the learners and their environments to pay attention to, and what design goals to target. This is true whether the theories are explicitly evoked in the design process or not. A designer who believes that learning occurs through a stream of reward signals will focus on creating learning environments in which a learner's actions can be interpreted as correct or wrong. In contrast, a designer who believes that learning occurs when students engage in key cognitive processes will design learning environments that are likely to activate these cognitive processes. Without opportunities to surface and reflect on the theories we hold, our understanding of the range of possibilities in the design process remains limited, and our ability to design truly effective or new learning technologies remains stifled. At worst, we might design technologies that end up harming the learners and continue to nurture the design hegemony.

How can designers create opportunities to explicitly engage with their theories of learning, and use them to inform their decisions? This is where design methodologies come into play: they have been developed to structure and guide this process. They inform how to go about approaching a design problem, what factors and parameters to consider, and how to develop and test the prototypes. Some design methodologies such as Human/User-Centered Design, Design Thinking or Activity-Centered Design are general-purpose methodologies that have proven useful in a wide range of design problems, from creating new technologies for communication to workflows in a hospital or new types of services.

Other design methods are more domain-specific. For example, popular design methodologies that target the learning domain are Learner-Centered Design, which is derived from the general-purpose methods, Universal Design for Learning, or Understanding by Design. Learner-Centered Design has played a central role in the gamification of learning activities, using features such as leaderboards, badges, and points to use the mechanics of games to boost the extrinsic motivation of learners to complete them.

In light of this proliferation of design methods, with all their successes, you might be tempted to ask why then we had to write a book proposing yet another design method for learning technologies to be added to the bunch. Through our work as scholars and educators

of learning technologies, we have come to understand that none of the existing methodologies adequately helps designers develop effective learning technologies. The main reason is that they fail to systematically integrate both theories of learning and theories of technology design in the design process. General design methods cannot sufficiently account for the intricacies of education and learning, and design methods for learning experiences cannot sufficiently account for the intricacies of learning with technology.

We need methodologies that help designers to make explicit the theories of learning and technology they draw on and that help translate the theories into design decisions that guide the design process and outcome. We developed our new design methodology with the goal to address these challenges. We call this new methodology **Learning-Centered Technology Design** (LCTD).

We describe LCTD in three parts. In this chapter, we will discuss the first part: what are the different types of goals that must be considered when designing a learning technology, and what are the relationships between these goals. In subsequent chapters, we will talk about where these goals come from, and elaborate on the different factors that should be considered when setting these goals. In the third part, we will describe how a designer can meet these goals through an iterative process of assessment and evaluation.

What are the goals, and how do they relate to each other?

There are three kinds of goals in the Learning-Centered Technology Design framework:

- **Learning goals** (what you want people to learn)
- **LX goals** (the learning experiences you want to make possible with your technology that people will learn from)
- **UX goals** (the ways people will interact with your technology).

The Centrality of Goals in the Design Process

Design is the process that achieves a desired goal which is embodied in a product or process. The **goals** play a central role. Not just because whenever you design you have a goal in mind - whether it's to build a bridge to help people get from one side of the river to the other, or to develop an app for improving people's mental health. Your intention as a designer is to achieve this design goal. However, there is no concise, deterministic way to formulate the design goal, because design is a process through which something new gets created that does not exist yet. At best, we can stake out a goal area or territory that is described in terms of criteria and metrics. How you formulate and specify these criteria and metrics for the design goal influences both what design process you use and how you evaluate your designs.

In the case of the bridge design, the criteria and metrics for a bridge are mostly quantifiable. For example, the bridge should be able to hold a minimum load, withstand winds of a certain strength, or use a minimal amount of materials. The design process resembles more of a multi-parametric optimization problem; different criteria or metrics change the way a bridge design is being evaluated, but other than that they are fairly obvious to interpret and assign.

Things get difficult when the goals defy obvious quantitative metrics. A good example is the domain of mental health. For example, the improvement of mental health as a design goal for an app does not translate into a straightforward and measurable optimization function. What does it mean for a person to be mentally healthy? Does it mean to be more aware of one's mental state so one knows when to seek help, or does it mean to adopt healthy behaviors like physical workouts? And how can an app help a person become mentally healthy? Is the goal for the app to help users become mentally healthy without the app, or to use it continuously to track data for specific recommendations? Each of these possible characterizations has dramatically different consequences for the design and its evaluation. For example, a focus on healthy behaviors might lead to an app that supports the change of habits of individual users, whereas a focus on self-awareness and help-seeking might lead to an app that supports connections with the local community.

Thus, well-defined design goals are central to the design process, influencing every aspect from development to evaluation. And clearly defining design goals for complex domains can be challenging. In this sense, designing for education is much more like designing for mental health than designing for a bridge.

The Multiple Goals of Learning Technologies

When it comes to learning technologies, speaking of a design goal as a single (albeit multi-dimensional) construct does not do justice to the complexities of learning. Learning through the use of technology is different from using technology to achieve a certain outcome. Learning is both a process and an outcome, an experience and a goal.

In a nutshell, in LCTD, there are two major types of goals in designing learning technologies that are inextricably linked: **learning goals** and **design goals**. The **learning goals** of a technology capture **what** you (the designer) want people to learn as a result of using said technology. The **design goals** of a technology describe **how** you (the designer) intend your technology to be used in service of these goals. There are two kinds of "hows" when it comes to using the learning technology: "how" in the classical sense of usability (UX design goals) and "how" in the sense of a learning experience (LX design goals).

Learning Goals

A learning goal is the answer to the question "What do you want people to learn?"

Put less tautologically, **a learning goal captures how you want people to change with your technology.** We interpret "change" in this book in a more expansive sense, which includes one's perspectives, beliefs, attitudes, emotional or physical capacity, and not only a change in knowledge or skills. In other words, a learning goal **does not** have to only take the form of a learning outcome like "*Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically."* This is the kind of learning goal that is often found in educational standards and explicitly describes a change in procedural or conceptual knowledge. However, we consider other types of changes like for example "become more empathetic" as an equally valid learning goal, even though it is not explicitly concerned with knowledge or skill gain.

There are a number of learning technologies designed to meet this goal, such as VR immersion games where you take other people's perspectives or role-playing card games where players have to reflect on different possible behaviors based on different personalities. While these kinds of goals are not directly concerned with a change in knowledge, they have everything to do with change--in this case, a change in the learner's ability to understand and share the feeling of others. Even though becoming more empathetic does not necessarily involve a change in knowledge (as we usually define it in schools,) it still feels natural to call it a type of learning.

There is a starting point (the knowledge, skills, attitudes, perspectives, etc. people already have) and an endpoint (the knowledge, skills, attitudes, perspectives, etc. you want them to develop). The goal of a learning technology is to help bridge these two points - on its own or through the facilitation by teachers and tutors. The only way that a learning technology can succeed in this is by creating specific kinds of experiences, and design goals describe these experiences.

Design Goals (Learning Experience [LX] Goals and User Experience Goals [UX])

A design goal answers the question "What kind of experience do you want people to have with your technology?"

In other words, what (and how) do you want them to do, to think about, to notice, to talk about, or to grapple with? Learning technologies "work" by helping to create experiences that people can learn from. This is crucial to understand. Of course, the main objective of any learning technology is to help people meet learning goals. However, a learning technology can't change a person *directly* in the way that a drill can change a piece of wood. While these sorts of technologies may exist in movies (yes, the Matrix, we know), there are no existing technologies that can change the connections between neurons in the brain so that someone suddenly knows Kung Fu. *What learning technologies are able to do is provide experiences, and it is through engaging in those experiences that people learn.* Different designs provide different types of experiences. The choices that one makes when designing

a learning technology shape these experiences. These kinds of experiences have to be further separated into two kinds of goals: learning-experience (LX) goals and user-experience (UX) goals.

UX goals

UX goals have to do with the usability of a technology. Usability is arguably the primary concern of user-centered design methods. A design that is usable is one that is easy to understand and use while performing its function. *In other words, a usable design is one that minimizes the effort of the user while providing maximal output.* As with every technology, usability is also an important factor in the design of a learning technology. However, a singular focus on usability risks minimizing effort to the point where learning cannot really happen anymore. Learning, after all, is an inherently effortful process, because it is about changing a person. You need to exert some effort to learn - this is what we would call *meaningful effort.* However, a badly designed learning technology might require a learner to remember too much information at once, or to have to click 10 times to get to the desired function - this kind of effort is what we would call *extraneous effort* that is detrimental to learning because it overcharges the cognitive load and limits the capacity available for engaging in *meaningful effort*. UX goals help designers remove unnecessary distractors and minimize extraneous effort and focus on maximizing meaningful effort.

LX Goals

M*eaningful effort* is captured by the LX goals. The LX goals consist of the types of interactions with the technology, and the cognitive and discursive processes involved in this interaction. It is only through providing these specific kinds of experiences that a learning technology is able to support people in meeting the learning goals. You can have a system with great usability (UX design) and no meaningful learning (i.e., all interactions are so easy that you never engage with the core tasks that would make you learn something). You can also have a system with lots of learning experiences but that is so hard to use that you need tens of hours just to understand how the system works, even before you start engaging with the learning activities themselves. That is why LX goals and UX goals are different dimensions: having one does not imply having the other and, of course, we want to have both!

Alignment Between Learning Goals and Design Goals

For a learning technology to be effective, learning goals and design goals must be aligned. It isn't enough for a design to have stated learning goals, LX goals, and UX goals. If these goals are misaligned, the technology is less likely to have a meaningful impact. Misalignment occurs whenever one set of goals makes it harder to meet another set of goals. There are two kinds of misalignment that need to be considered. The first is a

misalignment between the Learning Goals and the LX design goals, and the second is a misalignment between LX goals and UX goals.

Let's consider a made-up example to illustrate the first kind of misalignment between LX goals and learning goals. This example is about a technology that is meant to help people learn to play the guitar. (While the technology is real (see Figure 1 below), the scenario we are describing is made up.) The designer of this technology noticed that children often have trouble learning to play the guitar because they have trouble remembering the chords. For example, when asked to play a C chord many children guess and play a G chord. So, she set out to create a technology with the following learning goal: **help children remember the mapping between chord names and the way they are played.**

To achieve this, she designed a device that clamps onto the neck of the guitar and makes it possible for children to play chords on the guitar by pressing a single button. Each button is labeled with the chord it plays. There is a button for the G chord, for the C chord, for the A minor chord, and so on. When asked to play a G chord, a child no longer would need to guess, but could simply press the right button. Her primary LX goal was that **students would no longer have to guess when asked to play a chord**, which would increase their confidence and enjoyment in playing the guitar.

Figure 1

Can you see how the learning goal (learn to map the chord name to the way it is played) and this LX goal might be misaligned? Yes, people using this tool should be able to play the correct chord when asked to play a C, G, or A minor chord, and it is likely that this would increase their confidence and enjoyment while playing the guitar. But, would that help them learn how to actually *play* those chords? If the tool was taken away,

would you be confident that the person would still be able to play a G chord correctly when asked?

Figure 2

What are some ways that these goals could become aligned? One way would be to change the learning goal. Instead of trying to meet the learning goal of helping children remember the mapping between chord names and the ways that they are played, the designer could reformulate her learning goal to be about increasing confidence and enjoyment of playing the guitar for beginners. This is a simple solution, but in most cases, a designer of learning technologies is invested in meeting the learning goal and is not willing to change it so easily. If she were unwilling to change her learning goal, then the tool itself would need to be changed.

Let's continue with this example to demonstrate the second type of misalignment between UX goals and LX goals. During testing, the designer noticed that some of the children were trying to see which of the strings was being pressed when they pressed one of the buttons, but that the black plastic material made this impossible. She realized that if the plastic were clear, then children would be able to see which strings were being pressed when they were asked to play a specific chord. She remade a prototype with clear plastic and reformulated a new LX goal: **when asked to play a specific chord, beginners would press the button and inspect how and where the strings were being pressed**. By giving them simple songs to play (like "Let It Be" as shown in Figure X) students could experience the satisfaction of playing a real song while also being able to inspect how the chords in the song were being played.

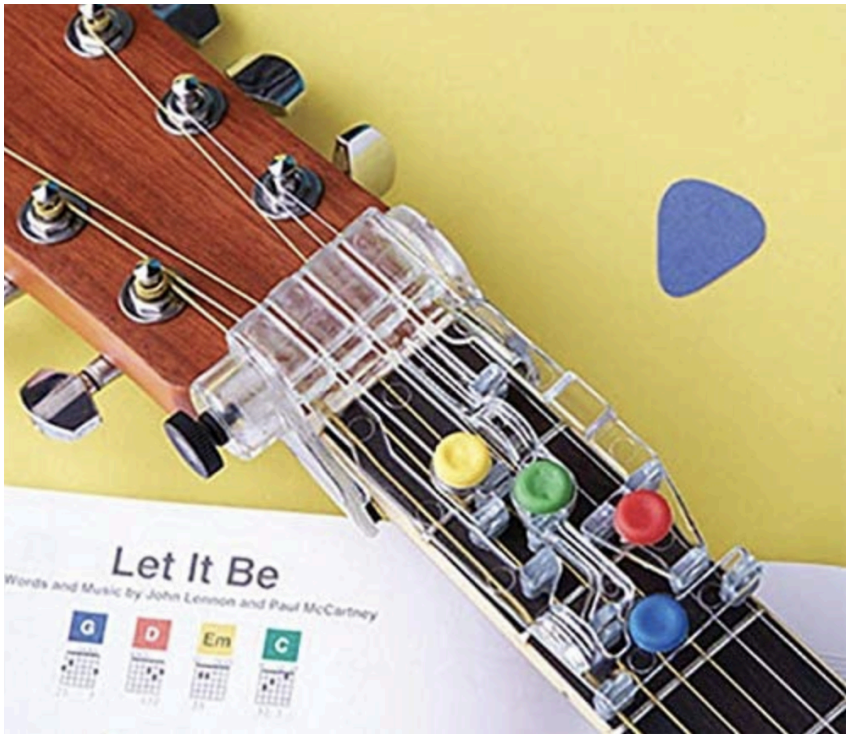

Figure 3

Now, the LX goal and learning goals seemed more aligned. However, when the designer tested her new design with children, she found that they still weren't learning the chords. They were more interested in playing songs by pressing the buttons than inspecting how the chords were being played. And even those students who did inspect how the chords were being played could not remember how to play them once the tool was removed from the guitar.

One of the reasons for this failure is a misalignment between UX goals and LX goals, just like in the first prototype. The tool simply made it too easy to play chords, which removed all of the effort from the learning experience. Meeting the learning goal, in this case, requires trying, failing, and trying again. However, with the new version of the tool there was little room for failure. For a G chord, just press the blue button. A second reason for this failure is again due to a misalignment between the LX goals and the learning goal. Learning to play chords on the guitar is not simply a matter of looking at which strings are being pressed when a particular chord is being played. There is a great deal of muscle memory involved as well. It is important that a beginner learns what it feels like to play a chord, and associates that feeling with the name of the chord.

To address these misalignments, the designer created a radically new prototype. Instead of designing a tool that could be placed on the neck of a guitar, she designed a new kind of guitar neck with LED lights built into it. Buttons with the different chord names were built into the headstock of the guitar, and when a button was pressed the LEDs on the fretboard

would light up, indicating where to press each of the strings. Now, pressing a button would not play the chord, which addressed the misalignment between UX and LX goals. And, to play the chord the beginner would actually need to press the strings themselves, addressing the misalignment between the LX goals and the learning goals. When testing with beginners, the designer found that after a short time practicing with this tool, beginners were able to play many chords even when the lights were turned off.

Figure 4

We present a simple diagram of a well-aligned set of goals below. This alignment serves as the backbone of learning-centered technology design, and we will continue to build on this backbone throughout the rest of the chapter.

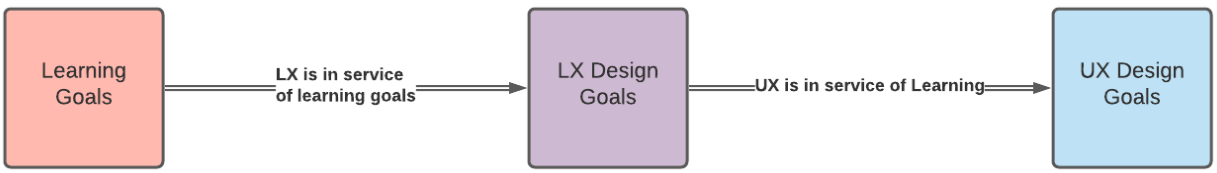

Figure 5