Designing and Implementing a Lightboard Learning Experience for Instructors Through the Learning Engineering Process

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***Abstract*—The Residential Education team at the Massachusetts Institute of Technology (MIT) followed the learning engineering process to design and implement a learning experience for instructors that prepares them to create videos for students using the Lightboard lecture capture system. The content of the online module was designed to emphasize evidence-based instructional practices, primarily through video examples of instructors experienced in using Lightboard demonstrating these best practices. A critical component of the learning engineering process is iteration, and the team navigated two major iterations to the implementation of the learning experience. This paper details each iteration highlighting the specific design decisions and design justifications, and forwards the practice of tracking such work throughout the implementation. Design decision and justification tracking is a practice that can help a team ensure an implementation remains learner-centered and backed by evidence from the learning sciences, while taking into account other factors in the implementation context such as constraints of the technology, timeline, and institutional resources. The paper concludes by underscoring the practical implications of tracking design decisions and justifications for a team following the learning engineering process to implement effective instructor learning experiences.**

Keywords—learning engineering; learning experience design; design process; instructor training; higher education

I. INTRODUCTION

In the summer of 2020, the Residential Education team at the Massachusetts Institute of Technology followed the learning engineering process [5] [7] to design and implement a learning experience in the form of an online module for instructors that aimed to support their efforts in creating Lightboard videos. Lightboard videos are a form of lecture capture where instructors write on a lighted glass pane facing a camera [1]. Making explicit the underlying assumption of how this work supports the community of practitioners, it is assumed that impacting student learning begins with instructor preparedness to effectively utilize the Lightboard technology based on pedagogical actions grounded in the learning sciences [6]. Given this, the goal for this specific learning experience was to make instructors aware of best practices backed by evidence from the learning sciences and exemplified in authentic demonstrations of these practices enacted by colleagues from across the institution.

The design team engaged in several key learning engineering practices to achieve this goal, including cycles of creation, implementation, and investigation [4]. This paper will focus on the implementation part of this process, specifically key design decisions that were made as the implementation context changed over the course of a year and a half and resulted in two major iterations. The initial design challenge was to create a learning experience to address the need for instructors to be supported in Lightboard technology in the context of COVID-19 emergency remote instruction, where the pedagogical affordances of Lightboard videos could help address teaching and learning challenges of the time. This implementation context then changed as the institution adopted a new learning management system, Canvas. This led to a key pivot in the approach, and the second design challenge of adapting the learning experience to Canvas so that it increased awareness of and lowered instructors' barrier to entry to the learning experience.

Ensuring that the reworked learning experience remained learner-centered and effective for instructors was the central focus of the second iteration of design. To help navigate these evolving implementation conditions, the practice of tracking design decisions and justifying them by citing institutional constraints and affordances (e.g., technology, resources, timeline) along with heuristics and principles extracted from the learning sciences were used. Furthermore, this approach enabled iteration of the online module by keeping in focus the principles that underlie creating an effective learning experience while also addressing changes to the implementation context.

This paper describes the Lightboard technology and the existing research on Lightboard pedagogy that influenced the design of the learning experience (and remained constant across iterations) in Section 2. Framed by the learning engineering process, Sections 3 and 4 discuss the practice of design decision and justification tracking in the context of the implementation across both iterations of the work. Finally, potentials for the next iteration of the online module and a recap of the practical implications of tracking design decisions and justifications for a team following the learning engineering process to implement learning experiences are discussed in Section 5.

 ISBN: 978-1-61208-985-0

II. BACKGROUND: LIGHTBOARD TECHNOLOGY AND PEDAGOGICAL UNDERPINNINGS OF LIGHTBOARD INSTRUCTION

A. Lightboard Technology

Creating Lightboard videos involves both hardware and software. The Lightboard itself is a large panel of glass with LED lights around the edges, which causes the markers to fluoresce on the board. A camera captures the instructor and their writing through the glass. The result is luminous writing floating in front of the instructor, who faces the camera while writing/drawing and interacting with the material on the board. Through video capture software, the video is mirror-imaged to correct left-right reversal of the visuals. At the institution, the Lightboard, video and audio capture system, and video workstation are housed in a studio on campus. The goal of the learning experience is to prepare instructors to walk into the studio for the first time and produce a Lightboard video that utilizes established pedagogical approaches that maximize the effectiveness of content delivery.

B. Lightboard Pedagogy

While instructional approaches associated with the use of Lightboard videos are not particularly new, the understanding of best practices associated with creating videos continues to evolve [2] [6] [11]. Despite this evolving understanding, many Lightboard users are mostly unaware of the theoretical and practical underpinnings of effective instruction with a Lightboard. To address this, the learning experience (where instructors are the learners) and the content within the experience (to teach instructors how students learn effectively through Lightboard videos) pull from research that has been done on the impact of Lightboard videos on learning, using the frameworks of Cognitive Load Theory, Cognitive Theory of Multimedia (CTML), and Social Learning Theory [8].

Much of the research about the effectiveness of Lightboard is associated with the fact that Lightboard leverages the natural mode of lecturing at a board (a primary instructional approach) with the key difference—and affordance—being that the instructor is facing the audience while presenting the written and visual content. In this way, Lightboard facilitates teaching as a "dialogue with students," where students get an unobstructed view of the instructor and can detect contextual and non-verbal communication cues that are missed when the instructor's back is to the audience. This engagement, via greater visual connection with the instructor (i.e., as posed by Social Agency Theory) [10] combined with the affordances of learning through video (i.e., as posed by CTML) [9], informs a set of Lightboard best practices and behaviors. Focusing on these practices is a crucial way to support and encourage instructors to enact effective strategies on camera.

The technical and pedagogical considerations for creating Lightboard videos described above heavily influenced the design decisions in the first iteration of the learning experience and comprise the content that was kept at the forefront during the second iteration as the implementation context changed. Understanding these key technical and pedagogical underpinnings allowed the team to be well-started to track design decisions and justifications throughout the learning engineering process for this learning experience implementation.

III. FIRST ITERATION: MITX PLATFORM, SUMMER 2020

A. Implementation Context

The three subsections below describe key contextual factors about the learners (instructors), the timing of creating the learning experience, and resources available for designing and building the online module, all of which influenced baseline design decisions for the work.

1) Learners: The target learner population consisted of MIT faculty, instructors, teaching assistants, and other course team members (collectively referenced as "instructors" moving forward in the paper) who are interested in using Lightboard technology as a way to teach sections of content for their courses. Some instructors may have an understanding of instructional best practices associated with Lightboard, but most users are unaware of the theoretical and practical approaches that underlie these practices. While the majority of existing instructors who have utilized the Lightboard since it became available in 2016 were primarily from STEM disciplines (physics, mechanical engineering, chemistry, etc.), the learning experience was designed to be inclusive of any instructor from any department who may want to use the Lightboard.

2) Timing: Given a Lightboard video's multimedia format and emphasis on the social presence of the instructor in the video, there was increased interest among instructors in using Lightboard during the period of emergency online instruction caused by the COVID-19 pandemic. Supporting instructors with this via an online module was a primary reason the learning experience was created. Although the immediacy of this need drove some decisions, the reality was that the module needed to exist beyond the emergency situation and the content had to remain broadly applicable and amenable to future use beyond its initial implementation. Other initial design decisions were influenced by this context, including ones aimed at addressing the teaching and learning challenges presented by the period of emergency remote instruction. For example, it was conveyed through the content that Lightboard videos do not have to be perfectly "polished" and that producing videos where instructors present authentically and naturally as though giving a live lecture would more closely resemble the in-person teaching that students value but that was lost during remote instruction.

3) Resources: The learning experience was built on the residential instantiation of MITx, a Massive Open Online Course (MOOC) platform based on Open edX. The various technical affordances and constraints of this platform

 ISBN: 978-1-61208-985-0

influenced the implementation context and shaped many of the design decisions (discussed more in Section 3 B below). For example, the way content could be contained and structured on a given page of the platform influenced how video clips were woven with text. Another major resource was access to the insights and experiences of a Lightboard "power user," a lecturer in physics who has used the technology frequently since 2016. Following a human-centered approach within the learning engineering process [4], the interview with this key stakeholder elicited insightful dos and don'ts of creating videos, how to use the studio equipment, and other tips that were valuable in shaping the language of the content. Additionally, the design team was not able to access the Lightboard studio in person at this time due to pandemic-related restrictions on campus, which limited the ability to include robust images and videos of the studio to accompany content pertaining to the workflow of creating a video in the studio.

B. Design Decisions and Justifications

During the design process, the team maintained a design decision tracker in Excel with references to design principles and heuristics backed by the learning sciences to help guide the creation of content, media to deliver the content, sequencing, and interactivity in the course. This tracking system was also used to note contextual and technological constraints to the project, which justified certain specific decisions that were made. Examples of design decisions that were tracked are included in Table 1.

TABLE 1. EXCERPT FROM DESIGN DECISION TRACKER

Design Decision	Justification
To illustrate Lightboard best practices, leverage existing videos featuring faculty in favor of recreating videos, because it is more authentic, engaging, and fosters motivation if the faculty "see themselves" in a variety of video examples.	*Based on principle of learning:* Learners are more likely to be motivated if they feel capable, know when and who in the world carries out such tasks, and have resources that someone in the real world engaging in that task would have [3].
The organization/flow of the learning experience content will be linear: intro → technical specs & process → best practices & pedagogies → use cases → additional resources	*Based on technical constraint:* It's challenging to weave content, as MITx is naturally set up to have a linear approach to content delivery. Weaving can mean making links/jumps to other sections, which should be avoided for a course like this as long term maintenance of such links will become impossible.

Some design decisions were based on research from the learning sciences, such as the first item in Table 1. The team wanted to include video clips of someone exemplifying the recommended Lightboard instructional best practices (as informed by the theoretical frameworks discussed in Section 2 B above) through their on-camera behavior. Ultimately it was decided to use clips from existing Lightboard videos created by instructors who had been early adopters of Lightboard. Informed by design principles related to learner engagement and motivation [3], it was decided that instructors seeing their peers demonstrate Lightboard best practices would make for a more impactful learning experience than alternative approaches, like having members of the design team create these videos.

Other design decisions were based on constraints in the implementation context. As an example, the second item in Table 1 points to limitations with what could be done with the MITx platform. The platform lends itself to learners working through materials linearly. While this addressed the goal of creating a learning experience that instructors could work through, there was the additional goal of instructors being able to go back to the content at any point to reference or refresh on certain tips that would help them while they were creating videos in the studio. It was decided to keep the content in a linear fashion which led to the subsequent decision to create a one-page Quick Start Guide. This was meant as an additional just-in-time resource that was associated with the online module but gave instructors the ability to save or print it out with important reminders from the learning experience.

C. Design Results in the Implementation

The first iteration of the learning experience, in MITx, was made available to instructors in August 2020. It is important to note that access to the Lightboard studio at that time was extremely limited due to the pandemic. This resulted in very few new users being able to engage in the Lightboard onboarding process involving this learning experience in the first month or so of implementation. However, the learning experience was released to a preliminary group of testers from the team, which produced qualitative feedback that was used to inform updates to the design decisions that had been tracked. Given that implementation is not limited to a full release or full-scale implementation of a product or solution [4], this "mini" implementation still produced data that led to another round of improvements to the design [7].

The team monitored Lightboard studio usage and planned to continue iterating on the learning experience based on any feedback from the first batch of instructor users. These plans were given a new direction when it was decided the module would move platforms from MITx to Canvas, the learning management system adopted around this time. A key influence in this decision was the absence of data (null results) from the initial MITx implementation around instructor usage. The lack of users, and as a result usable data, indicated a need to pivot to a platform that would lead to increased engagement and a more reliable data stream about that engagement.

IV. SECOND ITERATION: CANVAS PLATFORM, FALL 2021

A. Implementation Context

In the fall of 2021, the Lightboard learning experience was transitioned from the MITx platform to the Canvas. This

constituted a major change in the implementation context, which resulted in updates to previous choices as well as new design decisions. The three subsections below describe changes to the key contextual factors discussed in Section 3 A above (learners, timing, resources), and how design decisions were iteratively updated based on these influences.

1) Learners: The online module on Canvas was equally available to instructors as it had been on MITx, open to any instructor who self-selected to take it. The major change for the learning experience would be how instructors accessed the online module. Adapting it to a new learning management system increased awareness of and lowered the barrier to the learning experience because instructors were already using Canvas for their course sites and therefore did not have to sign up for a different platform (i.e., MITx). Additionally, since the online module became located within a "Canvas Resources for Instructors" public Canvas site rather than its own standalone course, instructors could also encounter it as an option while browsing other Canvas resources.

2) Timing: While both major iterations of the learning experience were due to changes in instructional conditions, the second iteration was specifically due to the rollout of Canvas rather than changes resulting from a global pandemic. This meant new opportunities to update and improve the online module's content. In addition to revisiting the design decisions that had been tracked in the first iteration—to ensure key decisions were maintained during platform transition—there was also the opportunity to revisit and address feedback from testing of the first iteration that had been deferred. For example, content pertaining to the technical workflow of creating a video in the Lightboard studio was improved with photos and video from the real studio as well as more robust explanation of steps. This was possible because the team was able to access the studio on campus this time around and walk through the process, making for more authentic and accurate content compared to the first iteration of the learning experience. Relocating all content onto another platform also allowed for the opportunity to make other edits to improve the learning experience, like being able to easily link to and cross-reference related resources that were already maintained elsewhere on the Canvas resources site.

3) Resources: As stated above, the Lightboard learning experience transitioned from being a standalone course on MITx to becoming a module on an existing "Canvas Resources for Instructors" Canvas site. Working to fit the learning experience within the existing site while still functioning as a "course" resulted in revisiting design decisions pertaining to how the content would be outlined and organized. The goal of the learning experience itself remained aimed at preparing instructors to create Lightboard videos in effective and pedagogically-sound ways, but now the connection between Lightboard videos and Canvas as the instructors' learning management system had to be made more explicit (i.e., Lightboard is one option in a suite of tools, anchored by Canvas, available to help instructors improve and innovate their teaching using available technology).

B. Design Decisions and Justifications

A key practice in transitioning the Lightboard learning experience to a new implementation context was revisiting and updating the design decision and justification tracker started for the first iteration of the module. The details recorded in this tracking system facilitated further decision making about where to improve the design and what aspects integral to the goal of the learning experience to maintain during the platform transition. Part of this systematic approach to tracking design decisions included certain decisions being flagged as priorities to revisit, giving the team strategic entry points to the next round of iteration without rehashing every decision on the tracker. Overall, 8 of the 19 core decisions (just under half) tracked during the design of the first iteration were revisited and improved for the second iteration.

One such prioritized redesign decision was including video clips of instructors demonstrating effective instructional behaviors behind the Lightboard—a key part of the learning experience with a solid justification cited for why this was an approach to delivering content (see Table 1 above). As such, this was not a decision that was going to change during the transition to Canvas. However, the transition afforded the opportunity to revisit which video clips had been chosen and to switch out some of those original clips with videos that even more effectively demonstrated the content or represented more of a variety in disciplines and instructors using Lightboard. For example, a video was added of an instructor who had not previously been featured using the Lightboard during a live Zoom session, which also represented a use case not previously highlighted in the module.

The sequential organization of the content also comprised a key part of the learning experience, but the initial justification for this decision (see Table 1 above) was revisited because MITx was no longer the platform imposing technical limitations on the design. The Modules feature of Canvas lends more flexibility to structure the content as both a linear course for learners to work through as well as a resource where instructors can go for materials on a more ad-hoc basis. This resulted in a revision to the original design decision, including adding more outline/table of contents pages and jump links to facilitate instructors navigating to specific content they may need at any given moment.

C. Design Results in the Implementation

As previously noted, the transition of the Lightboard learning experience from MITx to Canvas entailed the content now being nested within an existing site for instructors that provides resources about Canvas and other tools for teaching and learning. It would now serve the dual purpose of informing instructors how to make effective Lightboard videos and demonstrating and modeling Canvas

 ISBN: 978-1-61208-985-0

features and functionality by way of delivering that Lightboard content. The latter of these addressed the need for instructors to experience the more advanced capabilities of Canvas. For example, all video clips were embedded in Canvas pages via Panopto, the main video platform integrated with Canvas that instructors were encouraged to use. Similarly, the few reflection questions throughout the module, originally built using MITx's specific question type functionality, were now built using functionality specific to Canvas (i.e., ungraded surveys).

While data about how instructors have engaged with the learning experience on Canvas is still pending, this latest implementation sufficiently accounts for the new platform's affordances and constraints while continuing to honor the well-justified design decisions made during the first iteration of the learning experience.

V. Conclusion and Future Work

Working through iterations in the design of a learning experience is a hallmark of the learning engineering process. For the Residential Education team at MIT, two major iterations of a Lightboard learning experience for instructors occurred when the implementation context changed from one platform to another. Further iterations to the learning experience as it currently exists on Canvas are anticipated, particularly when Canvas releases new or updated features, so technological affordances and constraints will continue to shape future iterations. Additionally, with Canvas's data stream, the collection and analysis of data about instructor engagement will drive future iterations. This data exploration will likely serve as the next entry point into strategically revisiting prior design decisions and tracking new design decisions for the third iteration.

For practitioners and teams doing similar design work, it is critical to consider how design decision and justification tracking is a learning engineering practice that can ensure an implementation remains learner-centered and backed by evidence from the learning sciences while still addressing contextual factors. Such a practice directly affects the implementation being worked on and affords the flexibility to navigate changes to that implementation or context should they arise (through tracking). It also allows the design team to examine what worked and what hasn't worked (through revisiting), referring back to why a design element was implemented in the first place (through justifications), and iterating while keeping learners' needs at the forefront (through strategically flagging entry points into the next iteration). While these specific approaches to the practice of design decision tracking may vary depending on a team's context and goals, the Lightboard learning experience case demonstrates how design decision and justification tracking across implementations ultimately helps support instructors in learning to use technology.

Acknowledgment

We thank James R. Cain for providing technical support with the Lightboard and access to the studio at MIT. We also thank the Residential Education team at MIT Open Learning for supporting this work.

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