How Learning Experience Designers Make Design Decisions: the Role of Data, the Reliance on Subject Matter Expertise, and the Opportunities for Data-Driven Support

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ABSTRACT

Learning Experience Designers (LXDs) play an increasingly consequential role in the creation of courses and training materials that meet the needs of diverse learner populations and the growing class scope. Emerging design requests for scalable and effective courseware introduce new challenges in Learning Experience (LX) design practice while providing an opportunity for researchers to understand LX workflows and design new tools to improve them. This paper presents an interview study with 21 LXDs from 18 different organizations with the goal of understanding LXDs' collaborative relationships with subject matter experts (SMEs), data needs, and contextual challenges. We further perform a survey study to validate the challenges and probe into LXDs' attitudes toward a suite of data-driven solutions. We find that LXDs demonstrate a strong desire to collect data to inform their design - including target learners' prior knowledge and relevant design precedents. LXDs want support in better collaborating with SMEs, acquiring and processing diverse learner data, identifying relevant research studies to communicate their design decisions, understanding domain-specific material, and creating quality materials (especially questions). We discuss LXDs' concerns regarding automated solutions such as the lack of contextual understanding, over-reliance on automation, and data privacy before elaborating on the implications for future work.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**; • **Applied computing → Computer-assisted instruction**.

KEYWORDS

Learning experience design, instructional design, interview, survey, data access

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1 INTRODUCTION

Learning experience (LX) design refers to the process of creating learning experiences that enable learners to achieve the desired learning outcomes in a human-centered and goal-oriented way [2]. In both higher education and industry settings, learning experience designers (LXDs) play an increasingly consequential role in the creation of courses and training materials that meet the needs of diverse learner populations [13, 23, 30, 31, 49] and massive learner population [48]. We have seen the role of LXDs expanding in scope and impact as universities and corporate entities more readily accept the input of LX professionals [30, 49], where LXDs are called on to support the development of learning experiences of diverse delivery formats and finer-grained sizes [31]. To illustrate how LX design works in practice, here is an example scenario where an LXD named Tea helps a university instructor redesign their course:

> *Tea first spends a considerable amount of time reviewing the lecture videos and slides of the course. During 1-1 meetings with the course instructor, Tea asks questions like "Which concepts in this lecture video are the most challenging for a novice?", "Which content from this video is the most important in tackling the assignment?" Based on the instructor's input, Tea helps break down a long complex assignment into smaller pieces and map them with lecture videos. Furthermore, Tea develops self-evaluation questions and inserts them in the lecture videos to encourage active learning of the content.*

LXDs' processes and inputs in practice are highly variable [51, 55]. As an example, one study showed that less than 50% of LXDs completed needs assessments, task analyses, and follow-up evaluations [55], which are commonly used data-driven approaches in LX design. At the same time, a growing body of literature shows that there is an incomplete picture of how LXDs make decisions

[8, 44], and novices in particular struggle with making informed design decisions in optimizing learning outcomes [12, 18]. With the movement of learner-centered design [12, 17] and data-driven design [35, 45], LXDs increasingly need to take advantage of diverse data sources to help them make design decisions. However, *there is a lack of understanding* on what types of data are available and what types of data are desired by LXDs in their practice.

Different from other design disciplines such as UX design, in LX design, a closer partnership between LXDs and subject matter experts (SMEs) is required to produce high-quality academic courseware and professional development opportunities [28, 29, 38, 49]. The interdependence between LXDs and SMEs added new challenges in LXDs' decision-making processes, especially when expert input is not available. However, it is not clear how SMEs' input help LXDs make their decisions. An in-depth understanding of the information exchange between LXDs and SMEs could help inform tools that better leverage SMEs' limited time, and help LXDs make decisions even when SMEs' input is not available.

Various tools have been built for supporting LX design work [1, 6, 24], but most existing tools are in the form of spreadsheets, process diagrams, and simple interfaces without added automated intelligence. Little work has explored the challenges described above and the design requirements for data-driven solutions to augment an LXD's abilities in data collection, collaboration with SMEs, decision-making, and design.

In this work, our overarching goal is to shed light on LXDs' varying access to data in their design and decision-making processes. We also aim to understand the challenges LXDs experience in their workflows, specifically around the collaboration with SMEs, with the goal of informing data-driven solutions to support LXDs' work. Hence, we carried out an in-depth interview study with 21 LXDs from 18 organizations (including universities and companies).

From the interviews, we learned that: (1) The collaborative relationship between LXDs and SMEs is a critical factor that drives the design process. LXDs rely on SMEs' expertise in the subject domain to make design decisions. This includes providing feedback to students, breaking down learning objectives, aligning instructional materials with learning objectives, and making adjustments to specific teaching assets, e.g., slides. All of these tasks require domain expertise, which cannot be completed by LXDs alone. Participants shared that when they had more access to SMEs, they were better able to make substantive improvements in design. LXDs also shared strategies they had employed to engage with SMEs and make the collaboration more productive. (2) LXDs leverage three major categories of data in their design process, including data about target learners, data about target content, and data from evaluation in design iterations. LXDs often have varying degrees of access to data, which impacts their design workflows. LXDs wish to receive support in accessing the necessary data to aid their design. (3) LXDs reported challenges they had encountered in their design processes, including communicating with SMEs, keeping up with content knowledge, creating early prototypes, synthesizing multiple data sources for decision-making, and creating assessment activities.

Based on the challenges surfaced from the interviews, we created 10 vignettes to probe into LXDs' attitudes towards data-driven solutions through a survey study. The survey study further triangulates that LXDs have a strong desire to receive support on their collaboration with SMEs, e.g., getting recommendations of learning sciences research studies to increase SME buy-in of certain pedagogical methods. Moreover, participants preferred solutions where they had full control over the technology. LXDs expressed concerns when they thought the AI-based solutions were not flexible enough or took away human-human interaction opportunities.

2 RELATED WORK

2.1 Existing LX Design Process Models

There has been a plethora of LX design and instructional design models to help LXDs structure their design process. One of the earliest models, the ADDIE model, depicts instructional design as five linear and sequential phases [4, 10]. Similarly, Gagne outlines nine events that must occur in a learning experience to ensure the effective transfer of information from short-term to long-term memory [20]. Other models, e.g., ARCS, place a focus on engaging learners and keeping them motivated [16, 27]. In recent years, LX design models begin to emphasize prototyping and eliciting feedback from learners. For example, the SAM model and newer, iterative versions of ADDIE emphasize rapid prototyping and encourage continuous feedback and improvement [5]. But there lacks a contextual view of LXDs' processes and challenges in practice, e.g., the types of data they used or desired at various stages of design. These problems grow rapidly with the class size or the diversity of needs. In this work, we focus on LXDs' authentic practice and identify their data needs, their collaborative relationships with key stakeholders, and their contextual challenges.

2.2 Challenges in LX Design

First, managing and digesting data from different sources is challenging, especially as the amount of data we collect and store grows exponentially. LXDs find it hard to keep track of and fully conceptualize important data to meet the design requirements, e.g., ensuring adequate coverage for each learning objective, and satisfying the constraints imposed by the development platform [32]. Moreover, LXDs need support to help them analyze learner background information and the design requirements[12, 18]. Second, effectively collaborating with clients and SMEs has been a challenge for LXDs [21]. This is often because the stakeholders (e.g., SMEs) are not aware of the steps involved in LX design. SMEs may have an oversimplified view of the design process and do not understand the amount of input necessary from themselves for a successful outcome. On the other hand, it requires sophisticated skills from LXDs to obtain feedback from stakeholders and resolve disagreements[21]. Third, research has surfaced resistance from SMEs and clients to adopting new LX design processes or methods, particularly in traditional educational environments where established practices are deeply entrenched [39, 47]. In this study, we aim to obtain an in-depth understanding of the collaborative relationship and information exchange between LXDs and SMEs. Moreover, we aim to understand the sources of data LXDs are currently using or desire to use. This will take advantage of the large amounts of data collected for effective, collaborative solutions between LXDs and SMEs, and facilitate data-driven decision-making by LXDs.

2.3 Towards Intelligent Tools for LX Design

2.3.1 Systems to Support LX Design and Engineering. The first generation of intelligent design tools was limited by the technological capabilities of the time. In the 1990s, for example, a series of CASCADE (Computer ASsisted Curriculum Analysis, Design, and Evaluation) tools offered workflow support using rules engines [36]. More recently, researchers have created tools such as Learning Design Studio (LDS) [32], which defines a pattern language of design elements (i.e., a learning task taxonomy) that forms a "grammar" for constructing learning experiences. Specifically, LDS provides a dashboard for LXDs to plan and make course-level designs, e.g., defining learning objectives and aligning learning tasks with objectives. Other notable authoring platforms include CTAT [3], the Open Learning Initiative [6], ASSISTments [24], and Canvas [1]. However, these platforms mainly support resource management, without much intelligent support on instructional decision-making and material creation as is necessary for scaling these systems to meet demand.

2.3.2 Integration of Learning Analytics in Design. Learning Design Studio is an example of growing research interest in the integration of learning analytics and learning design, also called design analytics [9, 32–34, 43]. Design analytics can support LXDs' decision-making [26]. To give a few examples, questionnaire data from previous or prospective learners helps LXDs build learner personas [40]; Student data in learning management systems [46] and teacher dashboards [53] helps instructors visualize student progress and adjust instruction; Students' responses and performance from previous versions of a course help teachers identify common misconceptions [50] and inform future iterations [3]. These systems demonstrate that the increased availability of various forms of data enables novel design analytics that can support data-driven LX design work. However, the design analytics mentioned above rely on the specific data sources available in each individual course. There is a lack of understanding of how LXDs collect, process, and use such data in practice, and what types of data they wish to collect to better inform their design.

To summarize, existing tools to support LX design are still largely in the form of guidelines [14], static process diagrams [19], and simple interfaces that capture inputs visually or chronologically without added intelligence [25, 32]. While prior work has seen success integrating learning analytics to help instructors improve courses iteratively, each individual system relies on the type of data that is available in a particular course. There lacks a comprehensive understanding of what data sources are available to LXDs in practice and what data they desire to use. While at the same time, we learned from the literature that LXDs' design processes are highly variable, and LXDs experience challenges in making informed decisions to optimize learning outcomes, and effectively collaborate with SMEs. To better support LXDs' work at scale, it is critical to understand their data needs across contexts, their collaboration with relevant stakeholders, and their contextual challenges.

3 STUDY 1 - INTERVIEW STUDY

3.1 Positionality

We understand that our professional identities and research goals would nevertheless shape our perception of these interviews (c.f., [52]). We are a group of five researchers (with a mix of academic and industry experience) in educational technology and learning experience design. Three of us are academic researchers in human-computer interaction (HCI). The other two specialize in learning science and education; one oversees an LXD organization at a university and one has been an LXD in industry.

3.2 Recruitment and Participants

To recruit participants, one researcher searched active job posts using the keywords "learning experience design" and "instructional design" on LinkedIn and identified 27 different job titles (including Curriculum Designer, Instructional Designer, Instructional Technologist, Learning Experience Designer, etc.) across 23 industries (including Medical Tech, Non-Government Organizations, Higher Education, Financial Services, Automotive, etc.). Considering the diverse job titles of LXDs, we recruited participants by sharing recruitment information through various channels including researchers' contacts, LinkedIn, and online forums. 29 people responded to a recruitment questionnaire asking for their job titles, main product category, and a brief description of a typical LX design project they had done recently. In the end, we recruited 21 participants. 57% of them self-identified as women and 43% self-identified as men. 24% of participants were 20-30 years old; 52% were 31 - 40 years old; 19% were beyond 40+ years old; 5% preferred not to say. 86% of participants' jobs were located in North America/Central America, 5% in Europe, 5% in South America, and 5% working remotely. In terms of highest degree earned, 10% had Bachelor's Degrees, 71% had Master's Degrees, and 19% had Ph.D. degrees. Their years of experience varied too, 43% worked 1-3 years, 24% worked 4-6 years, and 33% worked over 7 years in the field. Finally, 19% were working in small businesses (less than 50 people), 33% in medium businesses (51-200 people), 38% in large businesses (over 200 people), and 10% did not report their company size. A detailed description of the participants can be found in Appendix Section A. Link to Appendix: https://osf.io/k24us/?view_only=f96c5a2600c94704a7b33056b7d87bf7

3.3 Interview Procedure

We conducted semi-structured interviews via Zoom, each lasting around 90 minutes. The study is IRB approved. Participants were paid a $50 Amazon Gift Card for their participation. We asked participants to walk us through specific LX design projects that they recently led or participated in, step by step. During each project walk-through, we asked participants to elaborate on how they collaborated with SMEs, effective design practices, ways they interacted with data throughout the design process, and the challenges they encountered. To better support the design of adaptive learning experiences for an increasing number of diverse learners, we also asked participants to suggest additional types of data they would like to access and put to use in their practice.

3.4 Interview Data Analysis

We transcribed the interview recordings and then applied thematic analysis [11] to analyze the transcripts. First, two researchers independently coded the interview transcripts and focused on design contexts, workflows, collaboration with SMEs, good practices, challenges, and existing and new opportunities for data use in LX design.

Researchers gave identifying labels to excerpts that referred to specific projects but did not label excerpts that referred to LX more generally. Two researchers met twice a week for seven weeks to review and revise each other's codes and discuss the emerging themes. Second, all codes generated in the first round of coding were moved into a spreadsheet and assigned a category, either "design contexts" (i.e., the context information of a specific LX design project), "workflows and good practices" (the temporal order of activities that the LXD conducted for a specific LX design project), "challenges" (i.e., the challenges that the LXD encountered during a specific LX design project), "collaboration with SMEs" (i.e., collaborative relationship and information exchange with SMEs), "data use and needs" (i.e., the data that the LXD used or wished to use for a specific LX design project). We further synthesized the themes based on initial codes. In Section 4 that follows, we report findings from the 33 LX projects participants shared during the interviews.

4 STUDY 1 RESULTS

We organize our findings in response to the three research questions. First, we summarize the collaboration process and information exchange between LXDs and SMEs. Then, we identify the data needs of LXDs to fully support their design decisions. This includes the types of data LXDs need, where they acquire the data, and what the data is used for. Finally, we go over the challenges faced by LXDs. We will refer to each interview study participant as "P<number>" when quoting their thoughts.

4.1 Collaboration Between Learning Experience Designers and Subject Matter Experts

We summarize the collaboration relationships and information exchanges between LXDs and SMEs. We highlight that, compared to other design disciplines, LXDs require closer collaboration with SMEs for effective LX design. In addition, in many authentic design scenarios, SMEs are the course instructors who are the decision-makers, so getting SMEs on board with learning design decisions is another important aspect in the LX design process.

4.1.1 The collaborative relationship between LXDs and SMEs impacts LXDs' design processes. We observed that LXDs and SMEs have different collaboration processes from project to project, and to a large extent, the collaborative relationship could determine LXD's design processes. SMEs may exhibit varying expertise in instructional design and different levels of motivation and willingness to make themselves available to LXD collaborators. These qualities formulate dynamic collaborative relationships between the LXD and the SME. For example, many LXDs worked with faculty who have a fair amount of teaching experience (e.g., P17), while others worked with SMEs who had little related knowledge in LX design (e.g., P9) which may require more effort in communicating design decisions. As for motivations and availability, P19 worked with SMEs who were highly motivated to turn their design proposal into a fully realized design, while P10 worked with an SME who was not convinced of the benefits of LX design and provided limited opportunities for discussion. We summarize the relationships between LXDs and SMEs into the following three categories: (1) LXDs play a decision-making role with SMEs providing content or subject input (e.g., drafting learning content and/or providing feedback); (2) LXDs and SMEs work in partnership with each other and generally share responsibilities; (3) SMEs make final decisions where LXDs play an active role in drafting content and providing actionable options.

We found that when LXDs need SMEs to draft content or make final design decisions, SMEs' availability could largely influence the design process. For example, P3 mentioned that they did not have sufficient meeting time with SMEs to address their questions about the content domain. P3 wished to collaborate with SMEs in a more agile way where they could distribute tasks through both synchronous and asynchronous collaboration channels. Regardless of the collaboration type, LXDs voiced that having substantive access to SMEs benefits the design process by accelerating and deepening designers' understanding of a new knowledge domain, allowing them to iterate designs more effectively. For example, by acquiring content knowledge from the SME, P17 was able to provide more in-depth design recommendations for a data mining course that was an unfamiliar topic for him. He was empowered to forge closer alignment between lecture videos and assignments, break down long complex assignments into smaller ones, and develop high-quality meta-cognitive scaffolding to improve activity designs with input from SMEs. In contrast, P17 had difficulty evaluating the cohesion of course materials with learning objectives when working with an SME who had limited time and availability. Similarly, P19 benefited from an SME's input on creating five distinct learner personas before designing a MOOC. The learner personas helped P19 to reflect on the design goals of the course and made sure that the course could attract a wider audience.

4.1.2 Information exchange between LXDs and SMEs. As non-expert in the knowledge domain, LXDs must work closely with SMEs to ensure satisfactory design outcomes. In this section, we describe the information exchange between LXDs and SMEs, and the support LXDs desire to receive from SMEs, as surfaced from the interviews.

First, LXDs and SMEs often establish a collaboration on a specific project without knowing each other before. LXDs wish to learn more about SMEs' knowledge and experience related to LX design or instructional design, as well as their teaching philosophy. For example, P6 thought it would be very helpful to learn about a faculty member's opinions on lecture-based and discussion-based learning ahead of time in order to better prepare for the collaboration. P15 also found it very useful to allow LXDs to quickly see SMEs' instruction preferences (e.g., how different instructors would give feedback in response to a particular error).

Second, LXDs rely on SMEs' expertise in the subject domain to make design decisions. This includes providing feedback to students, breaking down learning objectives, aligning instructional materials with learning objectives, and making adjustments to specific teaching assets, e.g., slides. All of these tasks require domain expertise, which can not be completed by LXDs alone. Participants shared that when they had more access to SMEs, they were better able to make substantive improvements on design. Participants shared different ways of eliciting feedback from SMEs. For example, P1 played a supporting role when their SME designed the project of an online course. Since the SME did not have teaching experience before, P1 provided worked examples of projects based on the SME's ideas to facilitate the collaboration. P15 found it hard to directly extract learning objectives from their collaborating SMEs. Instead, they presented students' performance (e.g., videotapes of students doing a certain task) and had the SME assess the scenario and comment on what is good and what is missing. P9 shared that it was very helpful when the SMEs provided evidence for corresponding pain points so that the design could be more targeted to address common misconceptions. LXDs also got input from SMEs on the priorities and expected outcomes of the course. For example, P17 would ask the collaborating SME, "What are the critical things students need to learn from this lecture in order to do this homework?". Based on the SME's response, P17 gave the instructor suggestions to reduce the content in lecture slides when there is too much covered in one lecture. Similarly, P13 asked probing questions to SMEs such as "What do students have to be able to do first?" to drill down and get detailed (e.g., enabling learning objectives.

Third, LXDs collaborate with SMEs to evaluate the design materials, especially when there was limited access to target learners during the design iterations. For example, P13 interacted with SMEs to help them spot bad questions when developing assessments for a nursing program. P17 shared that when they were able to create prototypes, it helped them get concrete feedback from SMEs on how to iteratively improve the design, e.g., redesign a slide, or change the wording of a question.

In summary, the information exchange between LXDs and SMEs is substantial. LXDs rely on SMEs' input at different stages in their design, including 1) early stage of the project to understand SMEs' teaching preferences, the core learning objectives, and learners' pain points; 2) throughout the design process to check their understanding of the subject matter is accurate, and to make design decisions such as what feedback to give students when an error occurs; 3) in a later stage of the project to evaluate and iteratively improve the product.

The LXDs interviewed in the study gave examples of different strategies they used to engage SMEs and elicit feedback. This includes asking targeted probing questions, providing SMEs with worked examples and initial drafts, showing student performance to elicit targeted feedback, and presenting prototypes instead of abstract design ideas. The strategies shared by the LXDs inspired the vignettes and solutions we introduce in Study 2.

4.2 The Data Needs of LXDs

We identify three main sources of data LXDs leverage to make instructional decisions. Specifically, we want to show how each type of data may facilitate the design for global learners, and what support is needed for data access and usage.

4.2.1 Data about target learners: background and demographics, prior knowledge, and misconceptions.

Getting sufficient information about target learners is critical for LXDs to make design decisions, however, they have varying access to such data in different projects. In this section, we summarize all the data about target learners LXDs have used or want to collect and present examples of how these data may impact designers' decision-making.

We found that with more information about target learners' backgrounds and demographics, including location, education level, employment status, motivation, and interest, LXDs can better gear their designs toward learners' needs. To gather appropriate learner data, LXDs often went to great lengths to obtain this data using various approaches, including surveys, prospective learner profiles, knowledge of SMEs, and recruitment information.

> *"[When I was unable to interact with target learners directly], I would just find prospective learner profiles, such as using LinkedIn and see why would certain people [want to take the course I am designing], and I just even use my own judgment to create factors seeing what they were doing, why they were doing such things, how they were doing and what would motivate them... Based on these, [I will think about] this activity or this reading, will it help these students effectively?"* - P8

To design for global learners, LXDs took special care to understand learners' backgrounds, so that all the materials used in the course are open-access and appropriate for diverse audiences. As an example, for a MOOC with a global audience, P19 created multiple learner personas, including assumptive and aspirational personas [40], using learner profile data and fictionalized data. P19 also found the data about target learners from the MOOC platform to be quite limited in terms of building a comprehensive understanding of the learners and wished to get more information including learners' interest in other courses on the platform, employment status, career paths, and goals, etc.

Next, to include proper objectives and content in large-scale learning experiences, it's critical but challenging to obtain the target learners' prior knowledge. It was often construed by designers to go beyond domain knowledge and could include learners' cultural knowledge, technology literacy, existing knowledge, and skills in the target domain. For example, after P19 knew that the target learners for the MOOC would be from Europe (thus with limited knowledge of US history), they made the suggestion to add more background information in each of the lessons. P5 intentionally simplified the technical operations required for learners who were not "tech-savvy".

Many LXDs valued data about learners' misconceptions and struggles in the targeted domain and wished to have more direct access to this information. Multiple data collection methods were applied. For example, P15 was able to observe the mistakes learners made while performing target tasks and then qualitatively analyzed the data to synthesize the common mistakes and derive the learning objectives. To design a training module for sales managers, P9 interviewed target learners to understand the common obstacles in their regular sales activities. P3 interviewed SMEs to understand target learners' struggles in the domain and generate learning objectives based on these. When past performance and completion data are available, LXDs may also use them to identify or infer common misconceptions and mistakes. In another example, P7 evaluated students' quiz responses to decide what to modify and what to add. P8 was able to access qualitative course evaluation feedback and summarized potential solutions tackling their reported learning challenges (e.g., providing constructive feedback).

4.2.2 Data about target content: relevant existing designs and domain knowledge.

We identified two types of data about target content from designers' practices: relevant design precedents and domain knowledge. First, accessing design precedents (e.g., an existing version of a course) can help LXDs gain domain knowledge and also serve as a starting point to restructure or make improvements. Second, LXDs need to develop a basic level of domain knowledge to have meaningful conversations with SMEs and make all manner of design decisions.

Related design precedents could be (1) existing versions of the course or training module to be redesigned, and (2) existing LX designs with the same or related topics or goals, which can be found through clients, SMEs, or online searches. When designers have an original version of the design, they may have different revision goals, such as evaluating the instructional alignments, transforming the mode of delivery (e.g., P10 created an online version of an existing residential course), redesigning for a different audience (e.g., P5 redesigned an existing graduate-level course for industry practitioners), or iterate to more interactive and engaging media (e.g., P21 transformed existing text-based instructional materials into interactive instructional videos to engage students with interactive assets such as embedded quizzes, link-chains). As for reusing existing related designs, P13 shared LX design projects with three different scenarios: (1) design for a related topic overlapping with an existing design (e.g., design Environment Science based on Intro to Biology); (2) introduce similar content in a different sequence (e.g., design a Psychology course in chronological order or topical order); (3) redesign based on how SMEs want to adjust the existing course; (4) redesign for a new medium (e.g., online or blended delivery method).

When the prior design of the exact same topic is not available, it is common practice for LXDs to explore existing designs with similar topics in order to gain a deeper understanding of commonly-covered topics and scope, instructional strategies, and design outlines in the target domain. For example, to design a game for kids to develop scientific knowledge, P16 and their team collected and talked through existing related designs and analyzed the interaction mechanisms used in these to determine desired or undesired features. This process provided them with initial design insights and got the team on the same page about design expectations and preferences. P7 also found the timing in comparable courses to be very helpful for informing their own pacing and providing data to stakeholders who are concerned about learning efficiency.

> *"We couldn't find any very helpful data to help us understand how to teach the client service team to understand the client's needs and to customize user data visualization. We couldn't find an existing course or research on that. So we just returned to some more generic search like ... how to do storytelling, and how to visualize customer data. And then we picked and chose those insights and see what we can apply in our project."* - P20

Developing domain knowledge quickly and effectively is one of the biggest challenges LXDs face, and yet doing so successfully has a large impact on the design quality. To develop domain knowledge efficiently and effectively, LXDs have found that the most useful data source is the input from SMEs. SMEs may point LXDs to relevant materials or LXDs may interview SMEs to deepen their own domain knowledge.

> *"I could stop and ask [the SME] which of these concepts are going to be the most challenging for novice students, and which ones are going to be very important for them to tackle the assignment. So collaboratively we could do an instructional analysis ... and then develop nice understanding checks for self-evaluation, better basic meta-cognitive strategies."* - P17

LXDs also access existing online resources (e.g., Wikipedia articles or YouTube videos) to help familiarize themselves with content. In many cases, LXDs simulate the experience of being a novice learner. It can be challenging for designers to find the most effective learning materials while also trying to learn. For example, P19 tried to learn some basic concepts about Python and Jupyter Notebook by searching online tutorials and discussion forums but was unable to locate accurate and appropriate content. Therefore, P19 asked for help from people with domain knowledge to find high-quality, introductory learning materials. A number of factors influence how proficient an LXD must become in a domain, such as the quantity of content that needs to be created or revised, the access to relevant design referents, and the availability of SMEs.

4.2.3 Data from evaluation in design iterations. Data generated from design evaluation at different iterations is another important source of data designers use and desire to access. Overall, designers would like to have the resources to collect concrete and honest evaluation data from learners, which requires well-designed evaluation questions [54], e.g., P5 thought the final course evaluation questions were very leading. Moreover, testing a learning design can be uniquely challenging since it poses cognitive loads on the participants. P21 found it hard to get usable data when participants were not willing to invest the cognitive effort to learn new things during prototype testing. Participants shared that testing with low-fi prototypes could be a viable solution before functional prototypes were developed.

> *"We tested low-fi prototypes and see if the flows make sense and if they can get what we want to convey... That can give us a better sense of what the final product would look like [for different design ideas], and we use that [low-fi prototypes] to test and compare different ideas."* - P21

For learning experiences serving global learners, there was limited access to target learners during the design iterations. Many designers evaluated the design with the design team or SMEs, either by expert heuristic evaluation or evaluating the LX from novice learners' perspectives. When designers have access to different groups of testers, they found feedback from different stakeholders to carry different values. For example, P21 collected feedback on the learning content from SMEs because they had a more holistic view of the knowledge domain and collected feedback from target learners on usability, language/wording, etc. LXDs wanted to have control over what evaluation metrics and performance data to collect across contexts. For example, P21 requested detailed performance data on the assessments to help polish the writing of the questions and feedback. P7 wanted learners' interaction data in the platform to inform the pacing of the course and demonstrate the (in)effectiveness of certain course elements. P14 wished to have data evaluating learners' experiences from both cognitive and emotional aspects.

4.3 Contextual Challenges Faced by LXDs

4.3.1 Getting SMEs on board with design procedures and decisions - "I need evidence to convince SMEs of this new design for better engagement". LXDs play an essential role in enabling learners to achieve desired learning outcomes in an engaging experience [42]. However, as mentioned by some participants, not all SMEs appreciate the contribution from LXDs and the collaboration process between SMEs and designers could be rough and inefficient. Two main reasons identified from the interviews include 1) SMEs' missing knowledge in LX design and learning sciences, as also pointed out in [49]; and 2) SMEs' limited availability for participation. Pointing out such challenges in collaborating with SMEs aims to serve as constructive support for designers to get sufficient input from SMEs within a limited amount of time, especially for a new knowledge domain with a high entry level.

SMEs are experts in content but often non-experts in pedagogy and learning science, learner-centered design processes, and delivery platforms. Therefore, many of them hold some common misconceptions in LX design which lead to: (1) defining ineffective learning objectives (e.g., P9 finds it challenging to get SMEs to realize the core learning needs of the target learners beyond lecturing); (2) ignoring the value of alignment and transparency in the learning experience (e.g., P5 needs to constantly check if the SME-drafted assessments are covered by the instructional materials; P13 had to constantly remind SMEs to check the alignment because they tend to design in a content-driven approach by thinking about what they want to write like writing papers or textbooks); (3) difficulty working with new media (e.g., it took efforts for P12 to guide SMEs to create accessible and clear instructional videos). More importantly, when a designer proposes modifications to address these misconceptions in the content drafted by an SME, it could be challenging to get the SME on board with the suggestions, especially when the SME plays a decision-making role in the collaborative relationships with the designer. In addition, P17 mentioned the trust issue due to SMEs' unfamiliarity with LX design:

> *"I think establishing a good level of trust, where they understand why I'm asking these questions [about the content] is very, very important. So as long as there's a level of comfort and understanding that I'm here to help create a good learning sprint for your students, and so the [more] questions I'm asking ... I might make stronger recommendations than others."* - P17

4.3.2 Interacting with overwhelming information about content knowledge within a limited time - "I feel I'm always behind". An LXD may work on a data science course followed immediately by an art course, which places a requirement on the LXD to quickly digest a huge volume of subject matter information. In order to have meaningful conversations with SMEs and offer concrete suggestions during the co-design, LXDs need a certain level of domain expertise themselves. For P17: *"I wish there was a way I could get content knowledge quicker. So that I can feel I can keep up with conversations and don't feel like I'm slowing down the process."*

Furthermore, designers' limited domain knowledge leads to an increasing amount of uncertainty in the project [7] and may lead to suboptimal design outcomes. P21 previously spent too much time trying to fully understand the materials beforehand and now wants to become comfortable to design with only knowing the structure and surface of the content. P15 found it difficult to narrow down the essential and doable learning objectives from plenty of content: "The challenge was there is incredibly rich [content to teach]... selecting something that's doable for students was a challenge.". With a very limited understanding of the domain, P17 only has time to provide basic suggestions on alignments rather than creating a more robust and richer LX: "I always try to do my best to stay up to speed with the faculty member, but it almost feels like I'm running behind, just because I don't have enough [content knowledge]" In addition, to make use of existing content materials, it also requires domain knowledge. P13 finds that some design components lifted from other existing learning products without careful consideration may result in a mismatch with the learning objectives.

4.3.3 Prototyping and learner testing along an iterative LX design process - "I am stuck with having to create the overall experience to find out if it works or not" . Learner testing is the most straightforward way for designers to select which solution to pursue from a list of initial design ideas [15, 22, 35, 41]. However, in reality, designers encounter many challenges in iteratively designing the LX through prototyping and testing.

First, a coherent learning experience is essential for learners' understanding of certain types of learning experiences, and thus they are challenging to design and prototype. For example, it would be hard to chunk a project-based learning course or an educational game into small pieces, and then actually test out the engagement or effectiveness of those small units before the entire learning experience is fully developed (e.g., P14 has to create the entire experience in the game to find out if it works or not). Second, learner testing is uniquely challenging since completing learning activities requires cognitive effort. LXDs shared that it was difficult to find motivated participants who were willing to dive into the learning experience to give designers concrete feedback.

Additionally, participants also shared frustration about the lack of transparency on the techniques and practices people use across LX contexts. As an example, P9 shared that "My observations so far, it's like, in the instructional design industry, there is still comparatively no transparency in terms of the information techniques, and how people work. Yes, we do have models, but like really? [Now at a big company] I have a lot of information and resources, but when I was in a start-up, it had nothing." This also calls on researchers and practitioners to focus on LX design practice and increase the transparency of techniques and tools utilized in practice.

4.3.4 Synthesizing multiple data sources for informed design decision-making - "The process is unpredictable, messy, and iterative". Providing design for diverse and global learners, LXDs need to work with various stakeholders and process large amounts of information within a very limited time. This could be very overwhelming and hard to track across different design phases, especially for making further design decisions or getting different stakeholders on board. P13 worked on a courseware design project in which multiple SMEs were involved but were disconnected. P13 tried hard to keep track of the different pieces of content created by SMEs: "We already have all these branching scenario activities...and then we end up with 50 of those activities and we don't have any writing assignments. ...but I'm trying to get people into the habit of having those blueprints so they can see exactly where the gaps are, where we have too much of one thing and not enough of another."

Designers mentioned three types of essential data that need to be constantly referred to 1) Learner persona, which represents background information of target learners. It should be revisited several times during the design to ensure that the design decisions are in accordance with the intended audience (e.g., P19). 2) Prerequisites and learning objectives of different learning units. P13 wants to visualize the knowledge dependencies between learning units because "sometimes you can take out entirely a concept and not really disrupt the course. And sometimes, you have to be careful about what you remove, because then students don't have the prerequisite knowledge"; 3) Critical design decisions and their supporting evidence. P16 finds it helpful to track the high-level ideas that excite people so that the team does not get lost in a sea of intermediate documents. P3 shared that it helps to get stakeholders on board in the later design stage to justify the design decisions made earlier in the stage.

4.3.5 Creating assessment activities - "Coming up with quality distractors is the hardest part as instructional designers". The interview study showed that designers found it challenging to ensure that (1) the description of activities is clear without ambiguity in the language (P9); (2) good distractors are provided in multiple-choice exercises which can require learners' attentive thinking (P21); (3) the feedback provided in the assessment activities is informative (P21); (4) the assessments are authentic in a way that they can prompt learners to transfer learning into real-life practice (P11); (5) assessments are versatile and not limited to one format (P16).

5 STUDY 2 - SURVEY STUDY

Following the interview study, we summarized the main challenges LXDs experienced during their design processes. To further validate the surfaced challenges and probe into LXDs' attitudes towards data-driven solutions to address such challenges, we performed a subsequent survey study. In the survey, we presented 10 vignettes that were sourced from the interview study where a solution accompanied each challenge. The survey study served two goals: 1) to validate the challenge and needs identified from the interviews; 2) to probe into LXDs' attitudes towards scalable solutions to support their design workflow. We will refer to each survey study participant as "S<number>" when quoting their thoughts.

5.1 Survey Design

Two authors with an LXD brainstormed solutions to address the challenges surfaced from the interview study. The team iteratively narrowed down to 10 vignettes as summarized in Appendix Section B. Each vignette first describes the background (a challenging LX design scenario), the solution (potential tool to tackle the challenge), and the outcome (potential impact of the solution). An example vignette is shown in Figure 1. Following each vignette, we asked 5 questions, including Likert-scale questions where participants need to rate their level of agreement to the following statements: (1) "This vignette reflects an authentic situation that I've been in before" and (2) "I would like to use the solution proposed in the story in my own design processes". Each Likert scale question is followed by an open-ended question including "What aspects of your experience are captured authentically by this vignette?", "What aspects of the proposed technology do you find compelling?", "What are your concerns about the solution proposed?". We piloted the survey with an experienced LXD and further clarified the questions.

5.2 Recruitment and Participants

We went through the same channels to recruit participants as we did in the interview study, including researchers' contacts, LinkedIn, and LX design online forums. 47 people responded to the request but only 20 people ended up completing the whole survey. The participants are from 13 different organizations. The survey took 45-1hr to complete. The study is IRB-approved and participants were paid a $20 Amazon Gift Card for their participation.

5.3 Survey Data Analysis

We converted all the Likert-scale answers into numeric values (Strongly Agree = 5, Strongly disagree = 1), and calculated the average and standard deviation for each question to determine the authenticity of the situation and the likelihood that the participants would adopt the solution. We then analyzed the responses to the open-ended questions using affinity diagrams [37].

6 STUDY 2 RESULTS

6.1 Authentic Needs Confirmed by LXDs

6.1.1 LXDs need empirical evidence to help themselves and their collaborating SMEs make informed decisions. 11 of the 20 participants described the need to cite relevant research studies as an effective way to convince stakeholders and SMEs to commit more resources to the LX design process. The participants also bring up the issue that some SMEs may not fully understand the suggested learning methods, especially if the suggestions differ from the SMEs' past experiences. Meanwhile, some SMEs can be overly focused on the content itself. There is a strong need for intelligent, scalable solutions to properly communicate the efficacy of learning design methodology to SMEs for effective collaboration. Several examples which utilize Artificial Intelligence (AI) and data engineering are further elaborated upon in section 6.2.1.

6.1.2 LXDs need efficient ways to create more agile early prototypes. Prototyping is both a time-consuming and a valuable process for LXDs. One participant described their typical prototyping process as: "We do wireframes and small scale mockups all the time and they certainly take time to do, we sometimes have to split the work up to make sure they are done on time." - S10. LXDs shared that SMEs tended to have difficulty picturing the end product and vision without seeing something concrete. Helping SMEs interact with early prototypes is necessary for productive collaboration. "I strongly agree that it is easier to get SMEs to comment when they are looking at something." - S18. There's a huge opportunity, with the advances in AI, to support rapid prototyping. However, the related data-driven solutions proposed received mixed feedback (section 6.2.3).

6.1.3 LXDs need support in assessment development. Many participants agreed that the need to come up with high-quality, objective-aligned assessment questions (typically under significant time constraints) was a large responsibility of LXDs. It takes time to think into detail about the assessment questions they create, especially if

Story 8 - SimCourseBank for recommending prior course designs

[***Background***] Mark is an LXD working at an ed-tech company. When he designs new online courses, he often finds that many existing course designs and related assessment materials are underutilized. Without sufficient content knowledge, it's hard for Mark to decide which existing course materials are the most appropriate to re-use in a new course. Mark also wants to get inspiration from similar prior courses to make design decisions.

[***Solution***] **SimCourseBank** is proposed to help LX designers **identify similar prior designs**. SimCourseBank is a repository of learning experience design projects. LX designers can share their completed projects with meta-level data to SimCourseBank. The meta-level data includes learning objectives, types of learning tasks, length of the course, target learners, etc. When Mark works on a new LX design project, SimCourseBank can help Mark retrieve relevant prior designs and course materials. For example, Mark is designing a new course that is about online communities, which is interdisciplinary of human-computer interaction, psychology, social network, etc. SimCourseBank retrieves materials from other interdisciplinary courses and suggests final project formats for Mark.

[***Outcome***] With the recommended prior designs, Mark does not need to design from scratch. Instead, Mark builds upon the existing designs and gets inspiration from them.

Figure 1: Example vignette used in the survey. This vignette is positively received by the participants. It receives an authenticity score of 4.2/5 (in response to question "This vignette reflects an authentic situation that I've been in before"), and an adoption score of 4.2/5 (in response to question "I would like to use the solution proposed in the story in my own design processes").

the LXD is less familiar with the subject matter or has less access to SMEs. Furthermore, several participants commented that "coming up with quality distractors is the hardest part as instructional designers" - S15. They specifically called out the difficulty of creating good distractors in multiple-choice exercises.

6.2 LXDs Likes and Dislikes About the Solutions

6.2.1 Popular solutions - What LXDs liked. **Efficiently searching through relevant research studies and prior LX designs** One of the most popular solutions rated was *StudySearch* which helped LXDs to search relevant learning science studies to back up instructional designs. Most participants liked the solution because they consider it to save time and can substantially support LX design. "An easy to use, searchable, and accessible database of relevant research studies would be very helpful when designers need to validate design decisions, but can't identify relevant research." - S4

Another popular solution was *SimCourseBank*, as shown in Figure 1. *SimCourseBank* recommends prior course designs that may be relevant to an LX project. One participant illustrated how our current systems have not grown to effectively utilize large amounts of data: "In huge organizations, content is underutilized all the time, resulting in different parts of organizations creating content from scratch, wasting so much time and money!" - S3

Support on MCQ question generation *Quizmaker*, a tool to support the generation of assessment questions, was very positively received by the survey participants. Several LXDs shared that the process of collaborative question writing was the reason they liked the solution: "I like that I can control the input. I often use a similar kind of formula approach when writing assessment questions and I ask SMEs to fill in the blank. This tool would fit really well into how I already think about and work on assessment questions" - S3. Beyond that, the participants liked the potential for AI to suggest options for multiple-choice assessment questions: "If the distractors generated can be used with little editing or even 10% are useful, I will be compelled to use the tool every day." - S15

6.2.2 Unpopular solutions - What LXDs dislike. **Some things should not be automated** One unpopular solution was *QueSME*, which generates questions to help LXDs communicate with SMEs. One participant commented: "Facilitating a meeting and keeping people on track is a more fluid skill that I don't think just asking good LXD questions would do to help." - S10. Most LXDs shared that holding live discussions, raising questions in the moment, and adjusting for tone was incredibly important to build rapport with SMEs. Beyond that, a large number of participants worried about the quality of questions generated (e.g. "Most topics required complex and nuanced questions that could not be adequately captured in a pre-sourced question bank" - S6).

LXDs need to learn subject matter the hard way *QuickRead* was proposed to help LXDs process and learn new content knowledge quickly through the curation and summarization of domain-specific materials. Many participants worried that LXDs who use the tool would "feel distracted or lose detailed insights" (S7) and "lose context by only reading short summaries" (S6). Beyond that, there is a concern about the depth of domain knowledge LXDs may acquire with the tool. One participant commented "Gives only basic understanding and not necessarily deeper conceptual understanding that the course likely will want to teach." - S10

6.2.3 Vignettes that receive mixed opinions. **The efficacy of rapid prototyping** *EZPrototype*, a tool for generating early prototypes automatically, received split ratings from participants. There was a shared understanding that prototypes were necessary and effective. One participant commented: "I spend a lot of time creating prototypes and proof of concept ideas to get faculty feedback and buy-in. If a tool could quickly create prototypes that I could modify, I think it would save me a lot of time, and perhaps expose me to different prototype ideas I hadn't considered." (S14). However, participants expressed concerns regarding the flexibility of such tools. Participants asked questions including, whether the generated prototypes were "flexible so they can be refined based on the situation." (S4), or " customizable to unique needs of a specific product or an organization?" (S6), of if "it could actually limit the designers thinking and ability to evoke rich design judgments" (S16)

6.3 Solutions for Easier LXD-SME Collaboration

Four vignettes concern the collaboration between LXDs and SMEs. Among these four, *StudySearch*, *EZPrototype*, and *QuizMaker* had the highest average "problem authenticity" scores and "the likelihood of adoption" scores (as seen in Appendix Section B). The survey study validates the findings from the interview study that the collaboration between LXDs and SMEs is very important to LXDs' work. However, there is a gap of viable solutions to support the collaboration. One important note is that *QueSME* (automatically generating questions to probe SME knowledge) was one of the least "adoptable" solutions as rated by participants. Although participants strongly agreed that the scenario reflected an authentic need. Based on the participants' comments, we found that participants did not like AI-based solutions when they considered genuine rapport building as the essence of the interaction.

7 DISCUSSION AND IMPLICATIONS

7.1 LXDs' Challenges and Data Needs

From Study 1, we learned that the collaboration relationship between LXDs and SMEs is a critical factor that drives the design process. LXDs rely on SMEs' expertise in the subject domain to make design decisions. Participants shared that when they had more access to SMEs, they were better able to make substantive improvements on design. LXDs shared strategies they had employed to engage with SMEs and make the collaboration more productive, e.g., asking targeted probing questions, providing SMEs with worked examples, etc. We identified three major categories of data in LXDs' design processes, including data about target learners, data about target content, and data from evaluation in design iterations. In addition, we found that LXDs' work is also impacted by the platform's constraints and the company's design guidelines. All participants expressed a strong desire to access the necessary data to aid their design, in particular data about target learners. Future solutions in the space need to prioritize giving LXDs access to learner data. Lastly, LXDs reported challenges they had encountered in their design processes, including communicating with SMEs, keeping up with content knowledge, creating early prototypes, synthesizing multiple data sources for decision-making, and creating assessment activities. In addition to the challenges, LXDs also shared the techniques they had employed to cope with such challenges. Importantly, participants found there was a lack of transparency in the LX design community on techniques and practices people use. This also calls for more work to understand LX design in practice and increase the visibility of LX design in research communities such as Learning@Scale.

7.2 LXDs Prefer Technology-based Solutions Where They Have Full Control

We categorize the solutions proposed in the survey study into two groups: 1) Augmenting LXDs' capabilities using technology. The LXD has full control over how to use the technology. 2) Automated methods that provide end-to-end outcomes for LXDs to edit. The survey results indicate that the participants prefer solutions where they have full control over the technology. We found that many participants did not trust fully automated AI solutions for a variety of reasons, including the limited capacity for AI to truly understand the context, LXDs being too reliant on automation, requiring more time from LXD to edit an AI-generated output than having LXDs create content from scratch, concerns about data privacy/security, and concerns about the quality of input data (since data itself is hard to come by). In contrast, the solutions where LXDs were given full control in the process received higher ratings. With regard to the solutions using AI, some participants expressed concerns on the adaptability of the solutions. For example, whether such tools offer sufficient customization and refinement opportunities for LXDs in their subsequent design. Participants also expressed concerns that the reliance on such tools might stifle an LXD's creativity. Several participants commented that: "this would limit me to only existing templates and would not allow for any novel designs/ideas" (S19) and "it could actually limit the designers thinking and ability to evoke rich design judgments." - S16. Additionally, we do see that participants highly value human-human interaction and rapport building between stakeholders in the process. Even though participants strongly agreed that they needed support on the communication with SMEs, they did not like the solution where the system offered probing questions for them to ask SMEs.

7.3 LXDs Show Strong Desire for Data-Driven Solutions that Target Their Pain Points

LXDs very vocally express their desires for support targeting their biggest pain points: (1) collaboration with SMEs who have limited prior experience in LX design, (2) creating early prototypes to convey design ideas effectively, and (3) developing high-quality assessment questions. Therefore, tools need to be created to address such pain points, while also creating space for LXDs to have in-depth reflective thinking. For example, to support easy prototyping, tools can help with the creation of standardized or repetitive elements, whereas giving LXDs opportunities to further refine such designs. Furthermore, LXDs preferred solutions that manifest a combination of crowd-sourcing and automated methods, which increases the reliability of produced outcomes.

8 CONCLUSION

LXDs play an increasingly consequential role in creating courses and training materials. It's critical to support their work to improve the learning opportunities we provide and help such learning experiences reach a diverse group of learners in a scalable way. This work proposes a first and comprehensive view of LXDs' design practice through an in-depth interview and survey study. We demonstrate that the collaboration relationship between LXDs and SMEs drives the learning design processes. LXDs employ techniques to better engage with SMEs to keep up with the domain content and make informed design decisions. We also surface LXDs' desire to access data that can improve their design. LXDs share the challenges they have encountered in the design process and effective coping strategies. We find that LXDs have a strong desire for data-driven solutions that target their pain points. This work calls for more work to increase the visibility of LX design practice in research communities such as Learning@Scale.

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