By the Book: A Pedagogy of Authentic Learning Experiences for Emerging Makerspace Information Professionals

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Can LIS curricula dedicated to makerspaces provide an authentic learning experience for future librarians interested in makerspace-adjacent careers? This article presents a case study in which an authentic learning framework is applied to a newly developed LIS graduate-level course on makerspaces. We detail how one class project—entitled "Bibliocircuitry: Old Books, New Ideas"—challenged students to use their newly learned skills to upcycle a hardcover book into a personalized artifact. This article outlines emerging patterns and themes from an analysis of survey responses from 13 of the 15 students in the course. Findings reveal the project readily maps to authentic learning standards, encourages learning, and facilitates reflection (including the negotiation of uncertainty, overcoming debilitating perfectionism, and transformative joy). The study broadens curricular design interventions for LIS educators, highlights the need for deep learning with technologies, and offers an opportunity to narrow the preparation gap between information professionals and the technical and social competencies required in makerspaces. The implications of these findings for the field of LIS pedagogy emphasize the importance of an authentic learning project both to disrupt the absence of LIS maker curricula and to reimagine current one-shot, pressured, makerspace training.

Keywords: authentic learning, LIS education, makerspaces, pedagogical methods

Makerspaces continue to grow in popularity as library services evolve to meet the needs of diverse user populations (Melo, 2020). However, over the past decade, the rapid integration of makerspaces has created a sizable preparation gap for information professionals pursuing careers in these tech-centric environments. Despite this gap, LIS curricula dedicated to preparing students to work in makerspaces are limited (Koh, Abbas, & Willett, 2018; Melo, 2019). While staff training does occur in makerspaces, the experience is commonly characterized as learning under duress: Newly hired professionals are expected to be autodidactic and seek help from peers, but more commonly use online platforms such as YouTube, Quora, and Stack Overflow.

In this article, authentic learning is examined as an approach to help narrow the preparation gap and to help envision possibilities beyond rushed, pressured, and superficial training practices in makerspaces. This study is situated within current research that details the social and technical competencies needed to be successful in makerspaces (Koh et al.,

KEY POINTS:

- Preparing future information professionals requires additional guidance beyond rushed, pressured, and superficial training practices.
- Technical competence and confidence can be achieved through maker projects that allow affective learning experiences alongside technical skill development.
- Authentic pedagogy encourages learning and facilitates reflection (including negotiating uncertainty, overcoming perfectionism, and transformative joy).

2018). Specifically, this case study examined a maker project from an LIS course entitled "Information Professionals in the Makerspace: Critical Theories, Applications, and Practices." We examine a design-based project that asks students to disrupt the familiarity of an everyday object: a book. The course project was inspired by Hancock et al.'s (2014) term "bibliocircuitry," defined as the use of "physical books as platforms for experimenting with computation" and for other exploratory creative methods (p. 78). The project, entitled "Bibliocircuitry: Old Books, New Stories," created space for students to apply their maker knowledge and newly developed technical skills over the course of several weeks. Moreover, the project sought to re-imagine the common training approach in makerspaces known as the "keychain syndrome," whereby makers engage in superficial, one-shot making that does not facilitate prolonged and/or meaningful project development (Blikstein & Worsley, 2016). During the project, students applied newly developed (or refined) technical skills to tell a story about a maker (broadly defined) of their choosing. In assessing the project's success, we sought to answer our main research question: What elements of an LIS makerspace project lend themselves to the authentic learning of maker competences and the development of confidence? In addition, the Bibliocircuitry project was further examined by the following supporting questions:

1. How can LIS makerspace curricula and coursework provide an authentic learning experience for information professionals?
2. What might an unhurried, supported, and intentional makerspace training curriculum look like?
3. How could LIS makerspace curriculum align with Newmann and Wehlage's (1993) five standards of authentic instruction, and with J. Herrington, Reeves, and Oliver's (2014) characteristics of authentic learning?

The application of an authentic learning praxis became a central framework to better understand how classroom preparation could bridge the experiences that future practitioners encounter when working within makerspaces.

The class: Information professionals in the makerspace

In fall 2019, the first author created and taught a new graduate-level special topics course, "Information Professionals in the Makerspace: Critical Theories, Applications, and Practices." At a high level, the goal for the class was to expose students to the technical and socio-political implications of the maker movement in LIS. The class was capped at 15 participants to enable multiple hands-on workshops, to meet the seating capacity of the university's makerspaces, and to keep course expenses to a bare minimum. Students taking the course ranged from a senior-level undergraduate to a PhD student. The costs associated with makerspace technologies and supplies (such as 3D printing and micro-controllers) can be prohibitively expensive for many graduate students. Drawing upon startup funds for materials and from campus makerspaces with resources, the first author designed the course to be offered without additional costs for students. The course cost (including supplies, course readings, and workshops) was $0 for enrolled students.

The university's makerspace network was a major collaborator for this course: Students spent a sizable amount of time learning in the university's makerspace. To further support

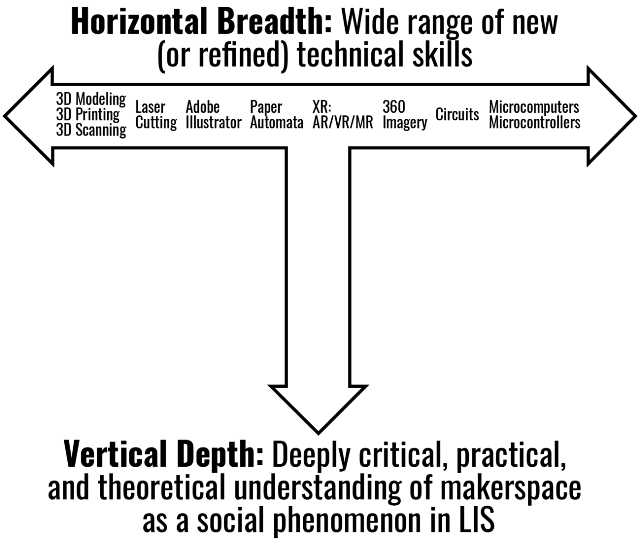

Figure 1: "T-shape" approach to learning maker culture and makerspaces

authentic learning principles, it was critical to provide students with opportunities to work within a makerspace and to collaborate with the staff therein. Students had first-hand exposure to the key dynamics of a makerspace: collaborative, frantic, inspiring, and, at times, intimidating. It was important to provide reasons for students to visit the makerspace; some students found the environment to be intimidating and overwhelming. Some of the course assignments included the completion of various makerspace workshops. The intention was to both provide students with technical training and to provide them with workshop completion credentials (which allowed students to continue using the makerspace technologies after the course).

In addition to grounding the course in authentic learning with respect to the partnership with the university's makerspace, the course was intentionally designed to embody a "T-shape" trajectory to teach maker culture within an LIS context. In terms of the breadth of the course curriculum, an array of common makerspace technologies were taught (represented by the horizontal line of the "T" in Figure 1).

The depth of socio-political contexts discussed throughout the course (represented by the vertical line of the "T" in Figure 1) accompanied the breadth of technologies explored in the course. Topics such as ethics, environmental challenges, racism, and gender biases are issues that continue to confront the maker movement. It was important to contextualize the technology workshops and makerspaces more generally within the socio-political challenges they emerge from and, at times, perpetuate. As such, the aforementioned topics were discussed alongside the technology workshops. The full course learning objectives are detailed in the Appendix.

The partnership with the university's makerspace network and authentic learning principles served as the foundation for the course curriculum; however, it was critical to learn more about each individual student before finalizing the course trajectory. To get a baseline understanding of the group's collective technical competencies, a pre-course assessment was conducted to gauge students' familiarity with makerspace technologies. Students ranked sewing as the most familiar technology. The least familiar technologies were tied: 360-photography, circuits, and 3D scanning. Additionally, the pre-course assessment asked students about their goals and specific interests relating to the course. A pattern of goals emerged, including the following: learn maker skills; do hands-on assignments; apply skills to professional endeavors; and engage making from an equity, diversity, and inclusion framework. A major goal of the course was to improve students' pre-course competencies. Students were able to achieve varying degrees of their personal goals over the course of 16 weeks.

The assignment—Bibliocircuitry: Old books, new stories

"Bibliocircuitry: Old Books, New Stories" was one of three major course projects. Before this project, students composed an (auto)ethnography of a maker, broadly defined, of their choosing. "Bibliocircuitry: Old Books, New Stories," the second project, focused primarily on developing students' technical competence and confidence. For the final project, students worked with makerspace managers to develop deliverables addressing a real-life challenge (e.g., boosting attendance, creating how-to guides). All projects were designed to help students apply their technical knowledge and theoretical understanding of makerspaces within an authentic context.

This assignment included the use of STEM-rich technologies commonly associated with makerspaces. The intention was to move from the "one-shot" instruction or training model to challenge students to engage with a multi-week project that asked them to center their interests, exercise their autonomy, and persevere after inevitable failures. Students practiced using the technologies while managing their visceral emotions of learning something new. This departs from conventional makerspace training that often features superficial learning opportunities (e.g., learning how to 3D print without understanding how to create a 3D model or how to clean a print post-production).

Specifically, the "Bibliocircuitry: Old Books, New Stories" project provided a reflective design challenge: How can we punctuate the familiarity and ordinariness of a book? As mentioned previously, this project uses Hancock et al.'s (2014) term *bibliocircuitry*, defined as the use of "physical books as platforms for experimenting with computation" (p. 78). Reflective design helps uncover "fault lines in the objects, artifacts, or systems being explored" in order to imagine otherwise (p. 76). The class extended foundational understandings of maker culture by both enhanced the concepts learned during the first assignment on a maker and then creating a maker project that engaged their newly learned (or refined) technical abilities. The following features were required in students' final submissions:

1. The artifact had a clear focus on a maker of the student's choosing.
2. The artifact told a story, displayed a scene, captured a feeling, or addressed another aspect of the student's choice. Students were encouraged to be as literal or figurative as they'd like.

Figure 2: Images of "Bibliocircuitry: Old Books, New Stories" artifacts, showcase, and creators. Photographed by Katherine Perales, UNC-Chapel Hill.

3. The artifact included the thoughtful and intentional integration of at least four of the following technologies: 3D printing, laser cutting, augmented reality, paper automata, circuits, and microcontrollers.
4. The artifact was ready for public display, including a descriptive artifact label and propping mechanisms (if needed).
5. A strategic rationale statement was submitted after the public showcase, which reflected on students' making process from inception to display.

The project culminated with a public showcase (see Figure 2), which motivated students to critically consider the user-experience of their book. The showcase provided an opportunity for students to share their work in a real-world context instead of creating an assignment to be reviewed and graded by the instructor solely. As discussed in the upcoming sections, this project extended an opportunity for the researchers to study the possibilities of authentic learning and LIS maker course curriculum.

Theoretical framework

An authentic approach to makerspace education

Authentic learning has a long history in education. Indeed, it was the primary instructional method of the apprenticeship model, in which novices learned by doing in collaboration with experts, long before the factory model of formal instruction flourished during industrialization (Lombardi, 2007, p. 19). Philosophers such as Plato, Rousseau, and Dewey argued the necessity of authenticity in learning, yet it only attained recent acceptance with contemporary educators through the spread of constructivism (Snape & Fox-Turnbull, 2013, p. 51). Recent research incorporating authentic approaches to LIS education includes work on open access publishing (Hicks, 2017), developing communities of practice within school library education (Burns, Howard, & Kimmel, 2016), creating digital learning environments (Johnson, 2016), and designing digital assessment strategies (Pfister & Wilson, 2016). Authentic learning is a constructivist strategy, which conceives learning as an active process. Therefore, individuals uniquely "construct" knowledge through their internalization of new stimuli through assimilation and/or accommodation. As a theory of learning, constructivism provides an overall model of knowledge acquisition, but it stops short of specifying a particular framework for educational opportunities.

Authentic pedagogy offers one strategy of applying constructivist theory to academic coursework by "connecting learning to real-world issues, scenarios and contexts that are meaningful to the learner" (Gilliard-Cook & West, 2014). As knowledge is constructed via prior experiences, successful educators must relate new information to the real world outside of school. Dimensions of authenticity in education include authentic pedagogy, authentic teachers and learners, and authentic activities (Snape & Fox-Turnbull, 2013). Authentic pedagogy situates educational tasks within the context of future use, and innovative educators use authenticity to facilitate the development of deep knowledge, which easily transfers into real-world practices (J. Herrington et al., 2014, p. 32). Types of authentic practices include inquiry-, project-, and simulation-based learning (Gilliard-Cook & West, 2014, p. 60).

Authenticity in the classroom

Restructuring educational activities into authentic learning experiences is associated with stronger academic achievement. In a study of 2,124 students in 125 mathematics and social studies classrooms in 23 K–12 schools in the United States, students of average socioeconomic status with a mean NAEP achievement score increased their academic performance from approximately the 13th to the 60th percentile after exposure to high (rather than low) levels of authentic pedagogy (Newmann, Marks, & Gamoran, 1996, pp. 300–302). High-performing students received even larger rates of scholastic achievement—perhaps because authentic pedagogy builds on prior knowledge and abilities—and gender, race, ethnicity, and socioeconomic status did not affect the impact of authentic academic achievement when prior NAEP scores were considered (Newmann et al., 1996). A smaller graduate-level study on introducing authentic learning into an MBA module found that the addition of authentic techniques yielded greater student enjoyment of the learning experience, as well as better pass rates (Simpson, 2016, p. 62). While no known research exists on applying authentic pedagogical practices to teaching LIS students makerspace technological skills, there is work on technology integration as an authentic practice for future educators.

Authenticity in technology-integrated practitioner training

Using technology as part of pedagogical practice in educator training provides an effective area for engaging student interest. In teacher education courses, integrating technology as part of a greater pedagogical practice offers an authentic opportunity "for acquiring technology literacy as a competency" (Cydis, 2015, p. 69). Moreover, incorporating collaborative and real-world relevant technology is the norm in technology education (Snape & Fox-Turnbull, 2013, p. 53). However, educators must move beyond simply incorporating a digital tool into their work for an experience to be truly authentic.

Ertmer and Ottenbreit-Leftwich (2013), building on the work of Jonassen (1996), propose the use of technology as a cognitive tool and its integration as a means to engage in meaningful work rather than isolated from pedagogical goals (p. 175). Purposeful inclusion of technology through authentic pedagogy relates to twenty-first-century thinking and "is of paramount importance that students make sense of and are able to interact with their world" (Snape & Fox-Turnbull, 2013, p. 67). Moreover, integrating technology is valuable "when used to foster competencies in students to make learning meaningful" as well as increasing student competency with a specific digital tool (Cydis, 2015, p. 75).

Colleges and universities use authentic learning practices to improve student absorption, retention, and transfer of knowledge (Lombardi, 2007, p. 17). Yet authentic learning remains underutilized, as reliance on traditional forms of instruction is often preferred by students due to epistemological preferences, as novices "are likely to use a right-or-wrong, black-or-white mental model" (Lombardi, 2007, p. 23). Moreover, the practical implementation of authenticity in university settings is challenged by political and/or administrative restrictions, as well as the time and resources required to redevelop coursework (J. Herrington et al., 2014, p. 409).

This study uses Newmann and Wehlage's (1993) five standards of authentic instruction and J. Herrington et al.'s (2014) characteristics of authentic learning to assess a graduate-level project that incorporates the use of makerspace technologies. Newmann and Wehlage's standards provide a scale to assess how well a given activity engages student minds. J. Herrington et al. define specific elements of authentic learning and related tasks: authentic contexts, authentic tasks, access to expert performances and modeling, multiple roles and perspectives, collaboration, reflection, articulation of knowledge, coaching and scaffolding, and authentic assessment.

Methods

The authentic learning framework guided our data analysis in response to the main research question: What elements of an LIS makerspace project lend themselves to authentic learning of maker competences and the development of confidence? With this in mind, the first author chose to deploy a survey for data collection. The survey was administered electronically and provided space for students to reflect optionally and anonymously, which

Table 1: Standards of authentic instruction by Newmann and Wehlage (1993) mapped to survey prompts

Standard of authentic instruction	Survey prompts (Likert scale responses: Strongly Disagree – Strongly Agree)
1. Higher order thinking: Learners manipulate information and ideas to create their own meanings rather than simply reciting factual information.	• I personalized my project and was able to incorporate my own ideas.
2. Depth of knowledge: Learners explore central ideas of a topic. Connections are made to previous material without forcing students to gain large quantities of superficial, fragmented information.	• I explored central themes of making and makerspaces through my project.
3. Connectedness to the world: Learners tackle real-world problems and/or use personal experiences as a context for applying knowledge.	• I used tools that librarians and information professionals use in the real world. • I applied my personal experience in my project.
4. Substantive conversation: Learners interact with each other often, sharing is not completely scripted or controlled, and dialogue promotes improved group understanding.	• I interacted with my classmates throughout the process. • Students shared their experience in a way that promoted better group understanding.
5. Social support for student achievement: Educators have high expectations as well as respect and include all students in learning activities.	• I felt included in the project and my achievements were supported. • I felt comfortable taking risks during this project.

helped to elicit candid responses. It provided a clear approach to map the extent to which the five different authentic learning principles corresponded to elements of the project (see Table 1). Additional free-text responses allowed students to provide personalized feedback on learning goals achieved, advice for future implementations of the "Bibliocircuitry" project, as well as specific areas of enjoyment and frustration experienced during the project. Thirteen out of 15 students responded to the survey. The table below outlines the standards of authentic instruction and the Likert survey prompts:

Results

The vast majority of respondents answered "somewhat agree" or "strongly agree" to all Likert prompts, illustrating an almost complete alignment between the "Bibliocircuitry: Old Books, New Stories" project and authentic instruction standards (see Figure 3).

In addition to the Likert responses, free-text survey responses were captured to further identify the alignment between the characteristics of authentic learning (A. J. Herrington & Herrington, 2007; J. Herrington, et al. 2014) and the project features, as outlined in Table 2.

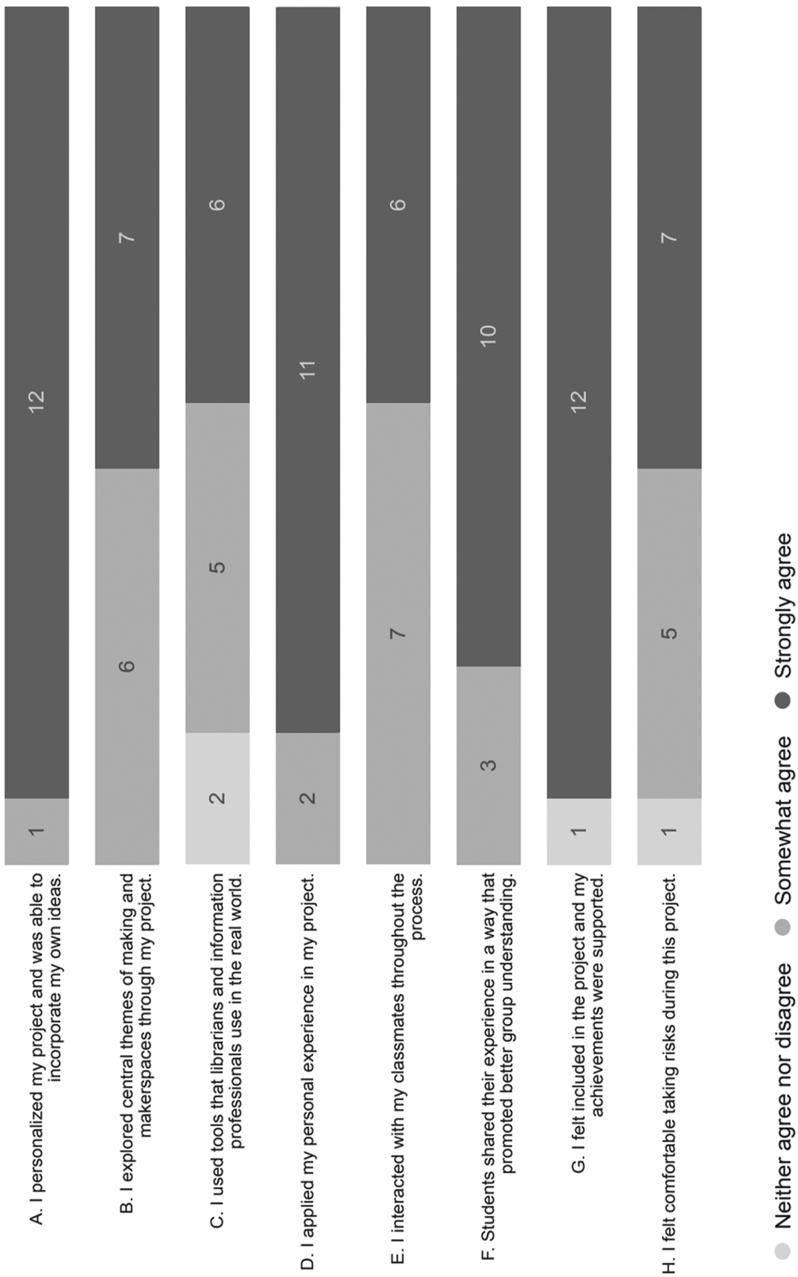

Figure 3: Likert-scale survey responses to related authentic instruction standards.

Table 2: Characteristics of authentic learning (A. J. Herrington & Herrington, 2007; J. Herrington et al., 2014) associated with project features and responses

Characteristic	Project features	Survey responses
Authentic context	The real-world use of makerspace tools provided "the purpose and motivation for learning" within a "sustained and complex learning environment that can be explored at length" outside of class (J. Herrington et al., 2014, p. 403).	"This project really showed me how much I love doing creative work with physical media and also demonstrated to me that I'm capable of learning how to use new tools! So it's very encouraging and inspiring in that way—I'm interested in continuing to learn new tools and pursue more projects."
Authentic activities	Students incorporated popular technologies used by makerspace professionals in the field without being prescriptive. Activities require "students to define the tasks and subtasks needed to complete the activity," and "create accomplished products valuable in their own right," while allowing "competing solutions and diversity of outcome" (J. Herrington et al., 2014, p. 404).	"Having the skills and the training to create projects using 3-D printing filament, laser-cutting, and paper-circuitry are absolutely things I will incorporate into future projects and goals of all kinds."
Access to experts and modeling	Professional staff provided demonstrations of the tools used. Mini "flash projects" were assigned to practice using the technologies outside of the project itself.	"[Future students should] recognize and be grateful for the tools and resources available to you here at UNC, not many other campuses have the kinds of Makerspaces we've got! They're free to utilize, so make the most of them!"
Multiple roles and perspectives	Students also acted as mentors and outside resources for each other during "think/pair/share activities," which took place in class after each flash project. For example, one student learned the necessary code for deploying .WAV files and shared her findings, positioning her in an "expert" role.	"Learning how to integrate tech with other tech/making skills was really important to me for learning how to design lessons for school kids. I like thinking about how multiple competencies can be used together to create a bigger product, not just learning one skill and regurgitating it."
Collaborative construction of knowledge, reflection, articulation, coaching & scaffolding	Beyond acting as resources for one another during class time, students used online forums to provide tips and tricks to working with each tool, reflect upon their process, and articulate their ideas.	***Collaboration:*** "All my ideas for getting this one mechanism to work in my book [were] failing. . . . Luckily, someone asked if I need help and I said yes. Collaboration made finishing this project possible. I asked for help a lot—it was always worth it." ***Reflection:*** "I learned that sometimes my dreams aren't the reality. Which is totally fine! I liked getting experience pivoting for a deadline and still seeing great audience interaction with my piece even if it wasn't what I had initially planned."

(*Continued*)

Characteristic	Project features	Survey responses
		Articulation: "This project helped reinforce the idea that as a librarian, I don't have to be an expert on any one thing. I do, however, need to be willing to learn and try. I came into this class having never used the technologies and am coming out more confident and excited about how I could see them in the future."
		Coaching & Scaffolding: "This project gave me experience with various technologies that I can bring into the job market . . . having the orientations built into the class was useful because I can now use them for my own projects."
Authentic assessment	A design showcase event allowed students to "demonstrate their effective performance with acquired knowledge…with others" (J. Herrington, et al. 2014, p. 404).	"If possible, always have an exhibit for the books for people to walk around and interact with the piece. It was incredibly rewarding to witness after putting so much effort into this project."

In addition to mapping characteristics of authentic learning, the researchers also reviewed survey responses for larger themes. The emerging themes offered important insights regarding authentic learning and affective experiences during a multi-week maker project.

Discussion

The "Bibliocircuitry: Old Books, New Stories" project allowed for a full expression of emotions and reflection throughout the making process and showed clear indications of authentic learning. Two key themes emerged from our analysis: issues with time management with respect to debilitating uncertainty, and transformative joy achieved through stress. The full list of themes is organized in distinct sections below. These themes contain significant overlap and collectively inform one another to illustrate a larger depiction of the project and its relation to authentic learning principles. The implications of these findings for the field of LIS pedagogy emphasize the importance of an authentic learning project to both disrupt the absence of LIS maker curricula, and to reimagine current one-shot, pressured, makerspace training.

Problems with time management with respect to debilitating uncertainty

Survey responses revealed that the development of students' technical competence and confidence were preceded by stressful project conditions. Time management and uncertainty emerged as prevalent themes in the data. Students' frustration with time management came up in 20 unique instances throughout the free text-based responses. Procrastination, specifically, was heavily cited as a source of irritation. For example, one student remarked, "This isn't a new discovery, but I procrastinated a decent amount during this project. I also didn't gauge how long tasks would actually take. I thought this one component would take about an hour, but it ended up taking way longer." Responses like this were not surprising; many students were not confident and/or unfamiliar with the tools presented. However, the data revealed an interesting relationship between students' frustration with time management and internal stressors they possess. Underlying anxiety may have provided a confounding variable that influenced feelings of time management issues as well as uncertainty more generally. Students remarked on a heightened level of anxiety and uncertainty as new technologies were introduced throughout the course. Supported risk taking was intentionally designed into this project and course curricula. However, this method of scaffolding became another hotspot for uncertainty to fester, especially as it pertained to assessment.

Although time management and uncertainty aligned with key characteristics of authentic learning, this project departed somewhat from authentic assessment. While the authors designed a public showcase for student projects, the process of creating the books could not be extracted from the power differentials endemic to the classroom environment (and the lingering reminder that the project would be ultimately graded). The historically political and power-fraught dynamic of the classroom inherently stunts the generous possibilities that uncertainty could otherwise provide (Freire, 2000, p. 72). Student survey reflections revealed a desire to temper assessment uncertainty with more transparency, such as structured check-ins, candidness about how unsettling not knowing is, and dedicated time to talk openly about grading in order to diminish its power over the creative process.

Although feelings of uncertainty yielded some student discomfort, it was an intentional feature (not a bug) of the project. Incorporating uncertainty into the project authentically replicated the uncertainty often undergirding makerspace dynamics, which are often in flux and in a constant state of transition (Koh & Abbas, 2015, p. 119).

Perfectionism

Under the larger theme of uncertainty, perfectionism offered another emergent narrative revealing students' difficulty with starting their work and persevering through project challenges. One student noted, "I'd say this is part of a larger lesson I've learned through grad school, but basically I paralyze myself by having too high of standards for anything I produce . . . I need to chill and just make something without putting pressure on myself to have it be the BEST thing." While some students pointed to the external time constraints of the project as sources of stress, others noted pressure stemmed from unrealistic expectations they placed upon themselves.

Eight of the 13 respondents described self-imposed stressors, which were amplified by their own perfectionist tendencies. Specifically, one student noted, "Yes, I felt very frustrated in the first couple weeks before I had my ideas fully sorted out. I felt a lot of pressure (mostly from myself) to create something amazing and felt like I didn't have the time to accomplish it. I navigated it by doing a lot of brainstorming and trying to lower my own expectations." Student responses outlined highs and lows with the project, which sometimes seemed contradictory: How could debilitating perfectionism lead to gratification and even enjoyment? As one student reflected, "I learned that something doesn't have to be perfect to be a beautiful work of art. So, through this project, I found that it was okay for me to have fun while also working hard." Even as the project's openness was a source of unease, respondents indicated their appreciation for risk taking, and data revealed that uncertainty and perfectionism often led to desirable outcomes. These associated feelings of unease—while not openly welcomed by students—were necessary to facilitate metacognitive reflection along with promoting technical competence and confidence.

Transformative joy through confidence

> *"I learned that I do fear the unknown, as going to use the laser cutter was very intimidating and stress-inducing, but that did make the final product that much more satisfying."—Student response*

Participants noted the enjoyment of the making process as much as they expressed their frustrations with it, highlighting the recursive nature of stress and achievement. One student reflected, "Once I started working on the physical book, I got so into the process and generally felt that it was a thing I felt good about doing. I think that when I saw that certain parts were definitely going to work and [was] able to solve problems and fix mistakes were the individual moments when I most felt proud of myself." These small, recurring victories reminded students of the joy associated with making and enforced their confidence making with maker tech and uncertainty. Ten respondents described their newfound confidence and their desire to apply their skills in the future. One student noted, "This project help[ed] reinforce the idea that as librarian, I don't have to be an expert on any one thing. I do, however, need to be willing to learn and try. I came into this class having never used the technologies and am coming out more confident and excited about how I could see them in the future." These responses revealed a reconciliation between the tensions of uncertainty and joy. Authentic learning standards (e.g., connectedness to the world and depth of understanding) combined with the project's prolonged duration enabled this reflection and reconciliation (Tan & Calabrese Barton, 2018). Student uncertainties and struggles with perfectionism gave way to transformative problem posing and solving (Freire, 2000, p. 83).

Furthermore, broader learning experiences took place in parallel with specific technological skill development. For example, some students needed to persevere through the frustration of designing a file for the laser cutter, setting up materials, experiencing the stress of realizing their settings did not cut through the plywood, and coming to terms with the time and resources wasted. Overcoming these kinds of affective experiences in concert with acquiring technological skills pointed to an important narrative of an authentic maker project: perceived career preparation. As one respondent acknowledged, "Completing the assignment allowed me to authentically experience the creative process of other makers and better prepared me for the realities of working in a makerspace—and training others to use related technologies in the future. I now understand the frustration of waiting for hours to use a laser cutter and figuring out how to clean 3D printer heads when they become jammed. Perhaps more importantly, I am more aware of the affective aspects of making and how emotions can influence design and practice."

Students' perception of uncertainty recursively shifted throughout the project, and its importance was seemingly affirmed with the culmination of the project: a public-facing showcase. Four students described experiencing a heightened sense of joy and accomplishment when observing people viewing their project. Students were asked if they had a proud moment during the project, and one student noted this about the showcase: "There were a lot [of proud moments], but definitely watching people interact with and enjoying my book was just so amazing." Another student highlighted the impact of having an audience could have on new makers: "I think for me it was seeing people actually interact with the piece, I think that is really powerful for new makers." Authentic learning principles were mapped throughout the project development and were evident in the way in which students envisioned their future working with these maker technologies.

Limitations and future directions

This case study focuses on one set of student responses from a single course being taught for the first time. As such, the sample size is decisively small because the findings are exploratory and inform the next phase of this project's development. Next steps for this research include a survey of LIS programs that offer classes on makerspaces and/or twenty-first-century emerging technologies and analysis of related coursework.

The scope of this study does not account for the unique circumstances that all makerspaces are experiencing. As such, this work provides privileged recommendations. Although this article advocates for deep, reflective maker-training curricula and/or a formalized LIS maker course, many makerspaces do not have the staff or financial resources available to offer learning experiences, expert guidance, and the time to build and reflect throughout a project.

While the course and project detailed in this paper occurred before the COVID-19 pandemic, the next iteration is being adapted for emergency distance learning. This transition presents several challenges: most significantly, limited access to makerspaces on campus. However, creative possibilities have also emerged, offering new opportunities for future makers. The first author and course instructor is currently developing making kits for each individual student, which will include much of the same technology distributed in the prior in-person course (e.g., microcontrollers, circuitry accessories, hand-sewing equipment). Some makerspaces now offer virtual 3D printing options, where students can upload their designs through an online portal and print their work without having to physically insert a USB drive into a printer. Interactive and communal making experiences can also occur online through video chats, discussion forums, and even virtual reality meetups, providing yet another authentic learning maker experience for students. Moreover, authentic work like the "Bibliocircuitry" project can provide a much-needed creative outlet during these unprecedented times.

Although the pandemic has complicated making in communal makerspaces, there are clear advantages arising from its constraints. For example, future LIS students and educators who have been unable to physically access a makerspace could leverage new remote resources. More so, the broader impacts of remote learning extend beyond the LIS field. Remote learning provides making opportunities for community members who historically have not been able to visit a makerspace because in-person participation was not feasible. Specifically, people with disabilities, caretakers, and folks with work schedules that conflict with a makerspace's open hours are examples of communities that may now have alternative methods of access to making opportunities, although there is still much work to be done.

Conclusion

This case study reveals findings from survey responses collected from students enrolled in an LIS course designed to narrow the preparation gap for future information professionals interested in working in a makerspace. Specifically, this article sought to examine the key features of an extended makerspace-based project developed to promote students' development of technical competence and confidence. The data illustrated key features of an LIS makerspace course centered on student learning and reflection as framed by authentic learning principles.

Findings suggest that the technical competence and confidence needed for future information professionals to excel in a makerspace career can be achieved through maker projects that allow affective learning experiences alongside technical skill development. Students worked through frustrations regarding time management and perfectionism while utilizing makerspace tools to develop an artifact they proudly shared with a public audience. Small victories became transformative reminders of the joy associated with making, while also bolstering confidence. These accomplishments were made possible through prolonged contact with the "Bibliocircuitry: Old Books, New Stories" maker project. The authors therefore recommend ensuring that future training unfolds over the course of several weeks to allow for reflection and deeper understanding. Adaptations planned for future iterations include offering remote coursework.

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Appendix A:

Course Learning Objectives

By the end of the 16-week course, students were expected to be able to

- develop a theoretical, reflective, and practical understanding of makerspaces and their evolving role in universities and communities;
- identify the ethical implications associated with STEM-rich environments such as makerspaces and the technologies therein;
- articulate the affordances and limitations of the maker movement phenomenon through critical inquiry and analysis;

- develop skills and familiarity with a range of technologies conventionally found in makerspaces through a series of flash projects;
- define key terms such as maker, makerspace, and maker movement, and develop an understanding of how these terms vary across cultures, communities, and regions;
- identify ways to devise makerspace environments that are locally situated, dynamic, and founded on values of equity and inclusion; and
- engage in a pro-help, pro-question ethos throughout the course.