A Badge, Not a Barrier: Designing for–and Throughout–Digital Badge Implementation

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ABSTRACT

We synthesize insights from a multi-year project involving the design and implementation of a digital badge system with youth co-designers at a science center. Using stakeholder interviews and surveys, participatory design session data, and user analytics, we identify the sociotechnical, sociocultural, and technical challenges of long-term badge implementation and propose several recommendations for the design and implementation of future badge systems. By identifying these challenges and providing recommendations that foreground stakeholder values and participation, we show how to support implementation throughout the entire design-to-implementation cycle.

CCS CONCEPTS

• **Human-centered computing** → **Participatory design**; *Interaction design process and methods*; *Empirical studies in interaction design.*

KEYWORDS

Digital badges; informal education; sociotechnical system; participatory design; design recommendations; implementation; design methods

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Figure 1: Digital badge images

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1 INTRODUCTION

Over the past decade, digital badges (also known as micro-credentials) have gained prominence in education and technical fields as an alternative to traditional forms of credentialing such as transcripts, certificates, and diplomas [9, 45]. Proponents of digital badges have sought to use them to make learning and accreditation more inclusive by allowing learners to represent a wide variety of skills gained outside of formal education environments [12, 22, 59]. Digital badges are web-enabled icons (see Figure 1), accompanied by metadata, such as the issuer, criteria, and date earned, that provide evidence of an achievement or skill, such as completing a course or learning a programming language [12]. In popular

parlance, they are often compared to video game achievements and scouting badges. Although some researchers and practitioners resist such comparisons because of their informal, recreational associations, others embrace the gamification label and the potential benefits of the motivational and extrinsic reward structures of games [9, 44, 52, 54, 55, 69].

Although there is much interest in digital badges for learning, badges still face barriers in wider implementation and adoption [29, 59]. Research on digital badging has shifted from initial implementations to deeper explorations of stakeholder viewpoints, motivations, and learning, as well as the badge design process itself [5, 20, 22, 67, 76]. There is still a great deal of skepticism surrounding digital badges, however, especially because of stakeholder doubts about their credibility and validity [21, 22, 29]. Practitioners have also expressed concerns about how digital badges can be integrated into existing workflows and practices [20–22, 59]. Launching, integrating, and sustaining a new digital badge system requires substantial effort, time, and funding, which can be taxing on educational organizations with limited resources. Although other domains, such as healthcare and business [4, 32], have faced similar challenges in implementing sociotechnical systems, educational settings—especially informal settings—face distinct resource constraints and unique challenges. The various practical factors can make administrators, educators, and learners hesitant to embrace digital badges and fully integrate the technology into their programs. What can researchers and designers do to address this issue?

In this work, we focus on anticipating and addressing challenges of digital badge implementation within the design process itself. We also consider the value of extending co-design practices into the implementation phase. The practical implementation of new technologies, particularly learning technologies and sociotechnical systems, is often one of the most difficult components in the overall research and design process because it requires a deep understanding of and appreciation for existing organizational and cultural practices and how the designed system can be adapted for and integrated into these practices [4, 18, 32, 34, 66, 73]. The ongoing process of implementation, user testing, adaptation, and evolution is crucial to the success and sustainability of a badge system, even after the system is launched. Until recently, much of the literature on digital badges examined design, proof-of-concept, and piloting, rather than more longitudinal analyses of how badge systems are integrated–or not–into existing practices [10, 35, 59, 63, 70]. Other areas of interaction design, such as health informatics, have explored sociotechnical systems on a longer-term basis and have encountered similar issues [4, 32]. Although we can glean valuable insights from this body of work–such as the reluctance of some stakeholders to move to digital records and the challenges of working with varied groups of experts, practitioners, and users [32]–educational systems such as badges face their own distinct challenges as they strive to present and support learning across settings. In this paper, we focus on the long-term progression from design to implementation of a badge system designed with and for members of an out-of-school science program.

To generate design recommendations that address the challenges associated with designing for long-term implementation, we examine an ongoing, multi-year research-practice partnership based in an informal science learning program located in a city in the Northwest United States. Data include stakeholder interviews with youth, college admissions officers, and human resources officers regarding the benefits and challenges they associated with digital badges, field notes and artifacts from digital badge system design sessions, system usage analytics, surveys and interviews with youth about badge-related experiences in their program, and notes and reflections on the badge onboarding process. Our analysis was guided by the following research questions:

(1) What challenges did stakeholders face during the implementation of the digital badge system?
(2) How can implementation challenges be anticipated and incorporated into the initial design process?
(3) What role can ongoing co-design play during the long-term implementation of a digital badge system?

Through this work, we examine multiple years of data from this research-practice partnership, identifying the challenges associated with the design and implementation of a digital badge system for informal education. The data analysis process revealed three categories of implementation challenges: sociotechnical, sociocultural, and technical, and these challenges comprise the primary contribution of this work. Utilizing these categories, the research team developed a set of guiding recommendations for aiding in the implementation of a digital badge system in informal education environments, the secondary contribution of the paper. Our empirical insights and recommendations will inform future work addressing the design and implementation of digital badges. We also believe that this work and the resulting recommendations have broader applicability to the design and implementation of other learning-focused sociotechnical systems.

2 RELATED WORK

Digital Badges and Badge Systems

In recent years, digital badges have become increasingly central to discussions about alternate forms of assessment and credentialing [9, 29, 46, 70]. Proponents, pointing to features like evidence-containing metadata and transportability across contexts, claim that badges have the potential to recognize learning in a richer, more transparent, and more

equitable manner than traditional credentials such as diplomas [29]. Although badges are intentionally flexible and adaptable to a variety of environments, to date they have primarily been designed and created by those in positions of power, such as educators, researchers, and commercial companies, creating potential value tensions as stakeholders negotiate agency and authority [12, 37, 59, 62].

Although they are a fairly new learning technology, digital badges have been used in a variety of different educational settings and with different age groups, ranging from elementary school classrooms to university courses and even professional development contexts [1, 2, 5, 10, 26, 27, 35, 63, 67, 70]. Badges have also been part of discussions around gamification in education [54]. This work tends to focus on badges as a motivational tool used within a specific learning setting [44, 55]. In the current work, we approach badges as a sociotechnical system designed to support learning in a particular setting but also to connect learning across contexts and even contribute to students' emerging identities as learners [21, 47].

Much of the current momentum around badges can be traced back to 2013, when the MacArthur Foundation's Digital Media and Learning (DML) initiative, in partnership with Mozilla, HASTAC, and the Bill and Melinda Gates Foundation, offered grants to develop and research digital badge systems for learning. Projects in this area multiplied, creating a surge of what is sometimes referred to as "badge evangelism" as well as several outspoken skeptics [12, 41, 52, 59, 69]. A core source of continued skepticism centers on gaining sufficient stakeholder buy-in for badges to gain meaningful and widespread value [20–22].

To date, the bulk of research on badges has focused on their *potential* rather than the *actual* impact of their long-term implementation [46, 48]. Initiatives such as Mozilla's *Open Badges* have worked to create a uniform standard for microcredentials, ostensibly to gain more acceptance and thus wider use [48]. Emerging work has also focused on the interoperability and extension of badges, as well as considering them a tool for learning rather than documentation of it [5, 48, 59]. Much of the work focusing on the actual implementation of digital badges covers initial designs and pilot studies. These are valuable but cannot speak to longer-term utility and integration [10, 48, 59, 63], a limitation also faced in other areas, such as healthcare [32].

Most directly connected to our current work, Hickey and Willis (2017) articulated a set of design principles addressing general wisdom for developing badge systems based on the 30 pilot projects funded by the MacArthur Foundation from 2012 through 2015 [48]. Building off of previous work on badges and motivation [76], these design principles focus on promising contexts for implementing badges, how to recognize learning with badges, the use of assessments for badges, and motivating learning with badges [48]. In our current work, we look more specifically at the challenges that surface when implementing a badge system over the long-term. Thus we offer initial design recommendations aimed at addressing those challenges in a way that considers the values of the community in all aspects of the project cycle.

Value Sensitive and Participatory Design for Learning

We draw on Value Sensitive Design (VSD) and Participatory Design (PD) to inform our understanding of the role of stakeholder values in the design and long-term implementation of a digital badge system. VSD uses a tripartite methodology of conceptual, empirical, and technical investigations to focus heavily on the stakeholders and values involved in design [38, 60]. Because of the complexity of stakeholder groups and values within projects that involve children and/or teenagers, such projects are rich ground for a VSD focus, although only a few research projects have focused on these demographics, and as of yet, VSD and learning environments have rarely connected in explicit ways [18, 33].

Additionally, VSD researchers have focused on sustainable and multi-lifespan design, building off of reflective approaches to consider longer-term impacts [39, 40, 61]. While we do not engage with the full tripartite methodology of VSD or operate on a multi-lifespan timeline in this work, we do make use of the ideas of stakeholder analysis and value tensions to probe how stakeholder values influence implementation and integration of an informal learning system, particularly when combined with a participatory design (PD) process. Other areas of interaction design and information science have also conducted long-term design work that stresses the involvement of stakeholders and their values [4, 32], but the equity-focused principles of VSD are best aligned with the current work and the learning sciences insights discussed below.

The history of PD is based in the democratization of the workplace, particularly in the development of technologies for workers [8, 34]. Other researchers have applied this core concept to a wider breadth of projects and stakeholder groups, moving to broader community applications, including children and teenagers [23, 36, 51, 77]. Most aligned with our current work, Druin and related KidsTeam researchers work from the concept of cooperative inquiry, in which children and teens are considered design partners and their expertise as youth is highly valued [24, 25, 42, 77]. Teens can be a particularly challenging stakeholder group, as explored in prior work [3, 5, 31, 67]. Teenagers are particularly aware of the power dynamics at play and thus may be more hesitant to express certain views, particularly in the presence of supervisory figures [67].

Recent work by several scholars further explores the idea of whether children are equal design partners and how the relationships and roles between the children and adults can change over time [5, 67, 68, 78, 79]. In the current study, we engage in an ongoing PD process with youth stakeholders and their support staff to develop, implement, and refine a digital badge system that supports their learning in an after-school science interpretation program. We examine the ongoing PD process as an important component in designing for long-term implementation and integration.

Insights on Implementation from the Learning Sciences

The field of education, much like some areas of HCI [4, 32], has long grappled with questions of practical implementation, studying what students, teachers, and schools do with curricula and other educational interventions after the initial design phase is complete [30, 65]. Prior work in the learning sciences emphasizes the value of ongoing "research-practice partnerships" in such projects [14, 15, 65]. An early example of such partnerships is *The Fifth Dimension* (5D), which established an after-school mentor program to improve elementary students' academic achievement [16]. Researchers and practitioners involved in 5D foregrounded the in-situ experiences of the learners and mentors to incorporate their context-specific values and practices. By approaching teaching and learning as a partnership among stakeholders, developers of the program were able to create a sociotechnical system adaptable to local contexts.

Design-based implementation research (DBIR) grows out of this and other learning sciences work, e.g. [6, 11, 13, 43, 72]. DBIR is a *process-oriented* research approach in which stakeholders build relationships to support an exchange of ideas and develop shared goals around a co-designed intervention. This partnership requires a long-term commitment among stakeholders to work together to build capacity for implementation and transform existing practices and policies [65]. Because DBIR is concerned with creative adaptation for new practices, it requires the systematic study of the "formative interventions" [28], and this necessitates close attention to social, cultural, and historical values at work across disciplines of practice at different scales of time, people, and contexts [53], much like work in sociotechnical systems [4]. This process does not follow a linear problem-to-solution trajectory. As Penuel [64] points out, it requires an understanding of the "working infrastructures" [75] of those involved in the design tasks so they can be redesigned to sustain the new intervention. Often, the new intervention must be redesigned to accommodate existing working infrastructures.

An example of DBIR is the work of Penuel and colleagues [65] at the Middle School Mathematics and Institutional Setting of Teaching program (MIST) who were involved in the development of a curricular intervention in formal learning environments with researchers, teachers, and administrators. Their findings highlight the importance of developing co-design strategies with stakeholders for the implementation of their new approach to mathematics instruction as ongoing, even after they created the curriculum together. In our work, researchers, program staff, and teens developed formative design tasks together to promote digital badge integration into the current workflow of the science program.

3 METHODOLOGY

Project Context

For the broader digital badges research project, still ongoing as of this publication, the research team began working with a youth science interpretation program at a science center in the Northwest United States starting in 2015. The program includes high school students from diverse backgrounds who work with science center visitors at different exhibits within the museum. Between 60 and 70 students are enrolled in the program at one time, varying by cohort size, graduations, and so on. Youth move through a curriculum in which they demonstrate proficiency with skills and knowledge related to the various stations on the science center floor and are promoted to levels of seniority once they develop expertise in the required areas. A small group of adult support staff train and supervise them. The structure of this program–with clearly articulated learning pathways and target skills–is thus well-suited to a digital badge system that recognizes students' achievements and makes learning pathways visible to all stakeholders.

Our project is a research-practice partnership intended to design, develop, and evaluate a digital badge system for the youth interpretation program to facilitate their day-to-day program functions and to provide a visual, mobile, and social way for the youth in the program to share their achievements with internal and external audiences [5, 20, 21, 67]. Building on previous pilot work at the science center [20] and drawing on best-suited methods from PD and DBIR as discussed above, this multi-year project was specifically aimed at exploring how a digital badge system would function on a longer-term basis in an informal learning setting.

As an ongoing, multi-year project, this work involves many stakeholders, and our mixed methods approach aims to gather both a breadth and depth of their perspectives [5, 21, 67]. Science center support staff and youth science interpreters participated in the on-site portion of the project and are the primary focus of the current analysis. The youth science interpreters were diverse in background and attended a variety of schools in the surrounding area, which is comprised of both urban and suburban neighborhoods. The demographics for the youth who participated in the surveys

Table 1: Student survey demographics

Surveys	Spring 2016 (n = 64)	Spring 2018 (n = 50)
Ethnicity	Asian 45.3%, White 45.3%, African American 9.4%, Hispanic/Latino 14.1%, Native Hawaiian/Other Pacific Islander 4.7%, Other 4.7%	Asian 34%, White 22%, African American 18%, Hispanic/Latino 8%, Asian, White 8%, Native Hawaiian/Other Pacific Islander 2% Other 8%
Gender	Male 40.6%, Female 57.8%, Other 1.56%	Male 44%, Female 52%
Age	Mean (SD) = 16.43,(1.17), Age 14 (n=3), Age 15 (n=10), Age 16 (n=21), Age 17 (n=18), Age 18 (n=10), Age 19 (n=2)	Mean (SD) = 16.74,(1.01), Age 14 (n=2), Age 15 (n=4), Age 16 (n=13), Age 17 (n=18), Age 18 (n=12), Age 19 (n=1)

are displayed in Table 1. Interview participants were a representative subset of the survey sample. All of the youth were considered part of the stakeholder group and invited to participate in the interviews and surveys, with voluntary participation in all cases, and a smaller subset participated in the design sessions.

Overview of Research Activities

Over the past three years, we have worked closely with the science center staff and the badge developer to collaboratively design, implement, and iterate on the badge system. The timeline of these research activities is discussed below, and summarized in Table 2.

In Year 1 (2015-2016) of the project, the research team brought ideas for a badge system generated from earlier pilot work [20] at the science center to a participatory design group comprised of five youth science interpreters and two adult support staff. These team members worked together with the researchers monthly over the course of the school year (nine sessions) to develop the initial badges, pathways, and interface design for the badge system website, using participatory design techniques such as *stickies*, *layered elaboration*, and *big paper prototypes* [5, 77]. During this first year, the research team also interviewed 30 community stakeholders (college admissions officers and human resources managers) about their experiences with and knowledge of digital badges. At the end of the year and prior to the launch of the badge system, the research team surveyed 64 and interviewed a subset of 36 youth science interpreters about their science interests and experiences, as well as their familiarity with and perceptions of digital badges. The final portion of the interview was a contextual interview [7] in which we invited youth to explore the badge system prototype and asked them questions about their impressions [21].

During Year 2 (2016-2017), the first iteration of the digital badge system launched, with design sessions continuing. Following the launch, the research team began to collect badge system usage analytics. A new group of seven youth designers worked with the research team and support staff to develop new features for the website and assisted in user testing, identifying bugs, and overcoming other issues in the custom interface designed for the science center. This interface used the main badge system website as a backend. Towards the end of Year 2, the research team applied for supplemental funding to enact the new design features developed by the participatory design team. Researchers also found that many students were still not logging into the badge system on a weekly or even monthly basis, and so they began to introduce onboarding trainings and include more announcements during meetings.

Year 3 (2017-2018) largely focused on the implementation of new features designed in Year 2, as well as formalizing badge onboarding trainings and methods for integrating the badge system into students' daily workflows at the science center. The third participatory design team, comprising 4 youth, focused on the schedules of the youth science interpreters and the features that would allow the youth to share their experiences outside of the program. New features, such as customizable portfolios and a program calendar, were introduced around the middle of Year 3. The implementation of the system trainings, which involved more senior youth program members training others, showed a marked increase in use of the website. At the end of Year 3, the research team conducted post-implementation interviews and surveys, building off of the Year 1 protocols and with the same voluntary participation (see Table 2).

Data Analysis

The research team collaboratively examined the substantial corpus of data collected over the first three years of the study in order to identify challenges and develop design recommendations for the design and implementation of digital badge systems and other sociotechnical learning technologies (see Table 2 for a summary of the data). Such syntheses of several years' worth of research data have precedent in prior studies in education [19, 50, 71]. Additionally, long-term reflective and/or synthetic work has been conducted in various areas of HCI and interaction design, from developing design guidelines through extensive literature reviews to

Table 2: Research activities summary (* denotes supplementary/secondary sources)

Phase	Research Activities and Badge System Status	Data Sources
Year 1	1st year design sessions: initial features Community stakeholder interviews Pre-implementation / Baseline student surveys and interviews Badge system in development	Community stakeholder interviews (n = 30) Youth pre-implementation surveys (n = 64) Youth pre-implementation interviews (n = 36) Design team interviews (n = 11) Design session memos and artifacts Meeting notes and correspondence*
Year 2	Badge system launched at start of Year 2 2nd year of design sessions: additional features User testing	Design session memos and artifacts Meeting notes and correspondence* Website analytics
Year 3	3rd year of design sessions: implementation Post-implementation student surveys and interviews Badge system feature updates and UX changes	Youth post-implementation surveys (n = 50) Youth post-implementation interviews (n = 19) Design session memos and artifacts Meeting notes and correspondence* Website analytics

extracting key insights by reflecting on decades of work in healthcare e.g., [4, 32, 80]. We build upon these precedents by combining insights from prior work in the learning sciences and digital badging with several years of rich empirical data. Through a process of collaborative reflection and open coding [17, 49, 57, 74], the research team worked to develop emergent themes and focus on the most salient design implications that would address integrating a new sociotechnical system into an existing informal learning program.

The research team engaged in an idea-generation process to develop an initial set of challenges, which were then organized into several categories [58]. The Year 1 interviews had previously been coded for opportunities and challenges [21]. We drew on this coding schema to review and code Year 3 interviews and surveys. From there, the authors reviewed the data set elaborated in Table 2, focusing on the analytic memos from the design sessions, the website analytics, and the interviews and surveys. Once the full set of implementation challenges had been identified, the authors reviewed the challenges, discussed any disagreements or discrepancies, and refined them accordingly [49, 58, 74]. Additional research data, such as email correspondence, meeting notes, and design session artifacts, were also used as points of triangulation [56].

We identified three categories of challenges associated with digital badge system implementation: sociotechnical, sociocultural, and technical (see next section for definitions of each). For each individual challenge, we reviewed the data to identify proposed and/or implemented solutions. For instance, when faced with the challenge of many students not being aware of the badge system and its place in the science interpreter program, we developed and implemented badge onboarding trainings that allowed the students to teach each other about the badge system and how it functions within the program. We used the insights from this process to generate several design recommendations for use in the development of digital badge systems and more generally for education-based sociotechnical systems.

4 FINDINGS

The primary contribution of this paper is a set of badge implementation challenges, divided into three main categories, shown in Table 3. *Sociotechnical challenges* address the intersection between the technology and human behavior, focusing on the conditions surrounding the use of the badge system, such as creating time within students' work schedules for them to interact with the system. These challenges mostly operate on an individual or small group level and involve direct system interaction. *Sociocultural challenges* address the context specific values, beliefs, and cultural practices of those involved with the new technology that is being introduced [16, 28, 43, 64]. Our analysis surfaced sociocultural challenges relating to how stakeholders' perceptions of badges (such as perceptions of their credibility and professionalism) affected their integration and implementation into the existing ecosystem. By examining these different challenge types as they relate to integration and implementation, as well as our solutions to these challenges, we were able to derive a set of guidelines for badge system implementation. These challenges impact a broader group of stakeholders, including those beyond the bounds of the science center. *Technical challenges* are the usability issues that arose when stakeholders interacted with the badge system directly and

the logistical issues that resulted. Although technical challenges are common in interaction design and implementation work, they are still a key factor in badge implementation and necessary to understanding badge system use overall. By examining these different categories of challenges as they relate to integration and implementation, as well as our solutions to them, we were able to derive a set of design recommendations for badge system implementation.

Sociotechnical Challenges

The sociotechnical challenges faced during badge system implementation fell into three main categories: *awareness*, *access*, and *relevance*, and addressed how the badge system functioned within the daily operations of the science center, affecting the immediate stakeholders and how they interacted with the technology directly.

Awareness. The first major challenge was that many students were simply not aware of the system, and science center staff who were not directly involved in the project were unfamiliar with how it functioned. Additionally, new staff and students periodically joined the program and had to be brought up to speed, while the more senior students eventually left the program, creating gaps in knowledge. New students and staff were unaware of the fact that the badge website had been designed by students in the program. When asked about it in interviews, students posited that it had been created by the science center management or an outside group, not the student-centered PD process that had occurred.

After identifying this challenge of awareness, the researchers engaged in several activities to raise awareness of the badge system throughout the program. Research team members worked with the science center staff and badge developer to create a website landing page containing an introduction to the badge system and its role in the science interpreter program. The research team also worked with the co-design group and staff to develop a badge onboarding training, which included a training script that introduced students to the badge system and its purpose in the program, showed them how to navigate its features, and clarified any points of confusion. A researcher visited the science center several times over the course of a year to onboard students using the training script. Badge trainings are now a formal part of the periodic daylong trainings that students undergo upon first joining the science interpreter program and when they advance to higher levels in the program.

The website usage analytics revealed that there was greatest engagement with the website when the researchers were present at the science center and leading activities associated with the system, such as trainings or design sessions. Spikes in activity were closely aligned with the dates and times of the trainings and other visits, averaging about eight users on days when researchers were present and only two users per day overall, with 10 users on February 11 and March 10, 2018, both dates of design sessions. More recently, the program staff included a section about the badge system in the official handbook that students receive upon joining the science interpreter program, making the badge system a more formal and permanent component of the program.

Access. Once the badge system had launched, it became apparent that while staff and students expressed interest in and excitement about the system and its affordances, design team students mentioned that they rarely checked their badges, partially because they did not have time in their highly regimented schedules at the science center. While the research team had been co-designing with the design team students (and interviewing and surveying the program members as a whole), the system itself had not become integrated into existing workflows. Accessing digital devices to use the badge system also proved to be a barrier. For instance, the tablets that had been purchased as part of the project were not available to the students much of the time because they had to be secured in a locked cabinet, and sometimes they were not charged. Though the students could technically check their badges on their personal devices, phones were not permitted on the exhibit floor.

After identifying this challenge of access, the research team worked with the staff to find ways to allow the students to access the badge system more easily during breaks and other scheduled times, such as ensuring that one of the office tasks was checking that the tablets were charged. Researchers also worked to design a workflow for regular use of the system, engaging in PD sessions with the students to explore their science center schedules in detail and examine which badge system activities would fit into available timeslots, such as sending a message to a staff member or applying for a badge. With the assistance of the students and staff, we identified small time blocks throughout the day when badge system activities were convenient. Staff agreed to mark these blocks as badge time on students' daily schedules.

Relevance. There were also challenges associated with updating and awarding badges, which related to their relevance within the broader program. Staff mentioned that they only awarded badges every few weeks, which meant that students had less incentive to check their badges often and did not see them as an essential part of their day-to-day activities. This lag was partially due to the complexity of the backend, mentioned previously, but also the workload of the staff. Additionally, any time the staff wanted to add a new badge to the system or update badge criteria, they had to pass the information through the research team. While we could perform basic criteria updates and create new badges, anything more complex had to go through to the badge system developer

Table 3: Three categories of badge implementation challenges

Sociotechnical Challenges	
Awareness	Students, staff unaware of badge system
Access	Students have trouble accessing badge system during daily workflow
Relevance	Students, staff do not understand the role of badges in the program
Sociocultural Challenges	
Value	Students, staff do not appreciate unique value that badges contribute
Credibility	Stakeholders question the credibility of badges
Privacy	Stakeholders express concerns about student privacy
Technical Challenges	
Usability Issues	Students, staff face problems in navigating user interface
Troubleshooting Process	Communication lags, barriers to changes and fixes

(see Technical Challenges, below). These delays meant that students were not as incentivized to see badges as relevant to their science center experience.

Both the workflow and badge training designs previously discussed allowed the students and staff to exert more control and ownership over the badge system while ensuring that the system would become integrated into the program. As staff members became more aware of the badge system and its role in the program, they grew more comfortable in taking on responsibilities such as scheduling trainings and ensuring that badges were granted.

Sociocultural Challenges

The sociocultural challenges we identified were closely tied to the sociotechnical challenges, as they both are rooted in the institutional practices of the science center. What makes the sociocultural challenges more complex is that they include an attention to the broader ecology of digital badges, regarding design history, external value, and their application across institutional boundaries. Three categories of sociocultural challenges raised by stakeholders were: *value*, *credibility*, and *privacy concerns*.

Value. Neither program staff nor students were particularly familiar with digital badges prior to the project, and they expressed doubt initially about what value they would contribute to the program. The principal investigator spent an entire year in discussions with program staff and more senior science center administrators about the value of badges before they agreed to invest time and resources in the project. Even once they had agreed to participate, staff seemed hesitant to take ownership of the system early, deferring to researchers on certain aspects, such as trainings, and not updating badges promptly. The program was well established and smoothly run prior to the introduction of badges, and so it was not immediately clear how the badge system would enhance what was already working well. Participation in the PD sessions and other research activities helped the staff overcome their hesitations. When new staff joined the team, they too had to become acclimated with the project before understanding the value of the digital badge system. The personal relationships developed between staff and researchers also helped to gain staff acceptance.

Most of the students interviewed at the start of the project were only passingly familiar with badges from sites such as Khan Academy. In the pre-implementation interviews (see Table 2), 42% of the students also did not see badges as necessary or different from previous forms of assessment and did not see that they added any particular value to documentation of their accomplishments. The aforementioned badge trainings were a way of introducing the students to the value of badges, as well as demonstrating how they differed from and improved upon other forms of assessment, such as being able to check learning pathway progress independently and at any time, rather than having to ask a staff member

Credibility. Concerns regarding the value of badges were closely tied to doubts about their credibility. Many students were excited about the potential of badges, with 78% of students in the pre-implementation interviews saying that they felt badges would be a credible way to display accomplishments and 75% expressing a generally positive view of badges overall (see Table 2). At the same time, they questioned whether college admissions officers and potential employers would see them as credible, given that they looked so different from the standard resume or college application. One student mentioned that he did not think that they would be that useful in professional endeavors *"...because of the way that it looks, it also feels like a video game. It's very graphic-y, animated, if you will."* This sentiment was shared by other

students, who thought the badge system looked too unprofessional to be considered credible, despite a consensus that the system laid out learning pathways in a helpful way and provided a visible record of accomplishments.

Our interviews with area employers and college admissions officers surfaced some of the same concerns, with credibility raised most often in the community stakeholder interviews as both a challenge and an opportunity. Stakeholders felt that the badges had the potential to represent credible evidence of skills and accomplishments but only once they were endorsed by reputable institutions and more broadly accepted in educational and professional spheres. The professionalism of badges was also a concern for potential employers. One employer said of the badge profiles shown on the website, *"If I got a resume like that, I would reject it. They are cute and feel good, but [...] they don't look professional to me."*

Addressing issues of credibility represents a complex challenge extending beyond this project alone. Although we have taken steps to alleviate credibility concerns through stakeholder education, our efforts are just one part of a larger set of initiatives required to gain broad acceptance. Much of the outreach we have done to date has been through this project, including scholarly publications, interviews and discussions with college admissions officers and human resources representatives, collaborations and discussions with other researchers focusing on digital badges in education, and providing information to the public through online resources.

Privacy. Community stakeholders' concern about privacy issues related to how much information would be shared publicly through the badge system about individual students, given that the majority of the science center students are minors. Students also expressed this concern in the pre-implementation interviews, particularly as they had been warned by teachers and parents about how colleges would view their social media presence. Students also mentioned that they wanted control over which badges they shared and with whom. Digital badges are intended to be easily shared and displayed, but users may have different perspectives about the degree to which they want to share their achievements publicly.

In the case of the current badge system project, we took upfront measures to safeguard students' privacy by creating a closed platform that only students and staff could access. To give students control over sharing their badges externally, we co-designed a feature that allowed them to create badge portfolios that can be shared with those outside the program. These portfolios are customizable and only include the personal information and badges the students wish to share, allowing specific portfolios to be created for internship applications, scholarships, and so on.

Technical Challenges

Both students and staff experienced initial usability issues when the badge system was launched in 2016. For instance, the separate badge-issuing backend was a point of difficulty and frustration for the staff, as it required going through a separate site rather than the front-end website created for the science center program. Though the research team arranged for the badge system developer to train all of the staff on how to use the site and award badges, the staff still found the process unintuitive. While the user-facing badge system website for the science center was developed with student and staff co-designers, the backend website used for issuing badges was not part of the project's design process, and thus many of the challenges related to it required developing workarounds. Students were also sometimes perplexed when they received emails with the badge system branding rather than that of the science center, since the notifications were sent from the backend website. Working with the badge system developer, the research team was able to develop a routine for diagnosing usability issues and contacting the correct people, as well as introducing student onboarding trainings (as previously described) to reduce the incidence of problems overall.

Another set of technical challenges related to how changes in the system were processed and implemented. The research team worked directly with the science center staff and the badge system programmers, but those two groups did not interface directly following the launch of the badge system [67]. After the initial round of user testing and refinement, students on the design team expressed interest in a variety of additions or changes, such as messaging options and a calendar, but each required a layered communication and approval process, which often took months. The badge system programmers were also contracted by the researchers, and each change required funding. At certain points, changes could not be made until additional funding was approved. Changes to the science center curriculum also required changes in the badge system, which also had to be communicated to the system developer. New cohorts of students required new sets of user accounts, which also required contact with the badge developer. The research team facilitated these communications and changes, supporting the stakeholder groups as the system evolved.

Overall, technical challenges were surfaced and resolved through processes such as ongoing user testing, communication and negotiation among stakeholders, and student and staff training. The research team regularly visited the science center and followed up on any technical issues, continuing

the relationship developed during the initial participatory design process.

5 DISCUSSION AND IMPLICATIONS

Though digital badges are still an emerging learning technology, we argue that more attention needs to be paid to the *how* and *for whom* [66] of designing for long-term implementation and integration if badges are to reach their full potential as viable alternative learning credentials. We synthesize several years of work on a digital badge research-practice partnership–with both those who issue and those who earn badges, as well as those who will reference badges for enrollment or hiring decisions–focusing on design as a process of development and integration [14, 30]. Recognizing the site-specific nature of this work, our intention is not to create a product that can be scaled up and used across institutions but rather to work through locally defined issues that occur when stakeholders develop a badge system together, from the ground up.

Each kind of challenge that we identified in the current work impacts the potential integration and implementation of a badge system [5, 48], and failing to appropriately address these challenges may cause the system to fail [4]. Technical challenges such as usability problems feed into stakeholder perceptions of utility and support, and a failure to establish the value and credibility of the system will result in less stakeholder investment, which means less general awareness and use overall. If a goal for badge systems is to promote learning across settings and validate students' informal educational experiences, a system that is not meeting stakeholder needs–and thus does not get used–fails to accomplish that goal.

Not all challenges to implementation are easily addressed, and many of the sociocultural issues are still ongoing in our project, such as the broader acceptance of badge credibility, consistent with our previous findings and related work on digital badge systems [22, 46, 47, 59]. Nevertheless, as a secondary contribution of this paper, we draw on our findings to propose a set of design recommendations to address each of the three categories of challenges associated with badge system design and implementation.

Design Recommendations for Badge System Implementation

1. Sociotechnical Recommendations.

1a. Maintain regular researcher presence on-site to raise stakeholder awareness and ownership of the badge system. In a PD project or research-practice partnership, stakeholders should be given considerable voice in design and implementation processes. For this project, the student design team helped design not only the badge system interface, but also the badge onboarding trainings that introduced their peers to the system. Staff were also closely involved in the design and implementation of the badge system, which gave them a better understanding of digital badges overall. Use the design process—which we suggest should be extended into the implementation phase—to build a lasting relationship with the badge stakeholders. If they are not enthusiastic and engaged it can be difficult to create a lasting impact, as they will be unlikely to take ownership of the work and day-to-day operations in the absence of the researchers and designers.

1b. The badge system should support the specific learning goals of the program and integrate into the existing educational workflow, becoming an integral part of the assessment practices. Develop a deep understanding of the learning ecosystem in which the badge system will function and articulate how the system will support the assessment of student learning. Each educational setting that implements a badge system will function differently, and the system should reflect that. A sociotechnical system that functions well must fit into, not on top of, existing workflows. Extending the co-design work into the implementation phase will help ensure that the badge system works within the context of existing workflow and assessment practices. In our work, we used ongoing co-design sessions with students and staff to identify opportunities in students' schedules for them to engage with the badge system and helped them select specific badge-related activities for different time blocks. These sessions also allowed us to identify programmatic changes and incorporate them into the badge system, such as designing new badges for new curricular elements and updating assessment criteria as needed. A thorough understanding of the curriculum also allowed us to determine when and where it was best to have trainings and work with the staff to integrate badge administration into their calendars as well.

2. Sociocultural Recommendations.

2a. Situate the badge system in the values and educational goals of the community by providing clear context and explanations for the system's role in the program's learning pathways. When introducing a badge system, there is always a learning curve, both for the researchers/designers and the stakeholders. To ensure that the stakeholders understand the goals and benefits of the badge system, we facilitated workshops and trainings with staff and students so not only would they have a clear understanding of how the badge system worked with their curriculum, but they would also have information that they could share with others about badges. Although it might be difficult for a single digital badge initiative to resolve a widespread, systemic challenge like credibility, we addressed issues such as privacy and value by working closely with the design team to make the system work for the science center, customizing the sharing features and co-designing trainings.

2b. Support outreach and awareness of the badge system by providing students, educators, and other stakeholders with the tools and language to communicate and share their badge achievements with a broader audience. Although badges are useful within a given educational program, part of their value lies in the ability to share one's accomplishments beyond program boundaries. This is unlikely to happen without intentional support, however. Develop plans for outreach and work with co-designers to find ways to raise awareness of the badge system and its functions. Within the science center, we made sure to visit morning meetings to remind the staff and students of the badge system. The co-designed trainings also provided the students with language to share the badge system with others. Additionally, we interviewed a larger group of community stakeholders, spreading the word about digital badges to college admissions officers and hiring managers, which also informed the local implementation.

3. Technical Recommendations.

3a. Ensure that the badge backend and frontend communicate and integrate clearly and cleanly to meet stakeholder needs and minimize confusion. Many badge systems build off of a preexisting badge platform (e.g., Credly, Badgr, iRemix) and thus use a backend that is larger and more general than the individual program. In such cases, it is important to explain to users how the front- and back-end relate to each other, including which aspects of the system are customizable to the program and which aspects are constrained by the infrastructure of the underlying badge platform. Our badge administrators were staff at the science center who needed orientation to understand how the frontend and backend worked together, and the students were initially confused about receiving emails about the badges from the backend badge platform, which was unfamiliar to them. Be sure to explain this to all stakeholders, including the badge developers, who may not realize this potential source of misunderstanding.

3b. Support communication between the different groups involved in the badge system design process and facilitate usability and new feature work on an ongoing basis. As with any sociotechnical system, a badge system will need maintenance and many will need to be updated with additional features and changes. Even the educational programs themselves may change, requiring technical support to update the system with new badges, criteria, or even pathways. Badge systems in particular often involve interdisciplinary groups of programmers, educators, and designers working together, and researchers and practitioners need to be aware of the dynamics at play [67]. Without a clear mechanism for ongoing user feedback that students and staff can access, technical issues are likely to arise that will derail successful implementation and use of the system. Although this may seem obvious, those who do not work in "technical" fields may not feel empowered to address problems or contribute ideas. Continuous user testing and discussions with stakeholders about how the system is working—such as the ones we performed—will serve dual purposes of keeping the technical side running while also reminding the users to engage with it.

Our design recommendations refocus sociotechnical systems for learning, specifically digital badge systems, on long-term implementation *with* stakeholders rather than short-term, proof-of-concept deployments *for* them [66]. This work builds upon previous badging work, including broader design guidelines for digital badges, as well as related work in other areas of interaction design [4, 32, 47, 80]. We synthesize work in design and the learning sciences to focus on digital badge implementation as an ongoing, collaborative process. Too often, a top-down approach to implementation ignores the culture and history of institutional or organizational practices. One conscious choice we made was to avoid words classically associated with technology in the HCI and design space. Rather than advocating for the adoption or assimilation of outsider practices (that may very well prove successful in one context), we consider how integration and implementation of a sociotechnical intervention should be focused on the adaptation of practices to meet the needs of local stakeholders [43, 64–66]. Although this work focuses on digital badge systems in particular, designing for implementation and integration has far broader applications and implications for sociotechnical systems in educational settings, and we hope to inspire further discussion and reflection.

6 LIMITATIONS AND FUTURE WORK

We collected rich and varied data over the course of several years, giving us deep insight into our research questions. While we believe that the empirical insights and design recommendations presented here hold applicability beyond the current project, further research involving badge systems and other sociotechnical systems in different learning contexts is needed to ensure the generalizability of our findings.

With respect to future directions for our work, we are currently engaging in a set of in-depth case studies with students from the science center to examine longer-term badge use impacts. As the project continues, we will be able to gauge the impacts of our solutions and design recommendations on an even longer scale. In future projects, we see great potential in long-term studies and meta-analyses to further evaluate and refine the design recommendations, incorporating more diverse projects and settings.

7 CONCLUSION

In this work, we present a set of empirically derived badge system design and implementation challenges surfaced in a multi-year badge design research-practice partnership along with corresponding design recommendations. These contributions not only provide guidance and insight for addressing technical, sociotechnical, and sociocultural challenges that arise in digital badge projects but can also potentially be applied more broadly to the design of a variety of sociotechnical systems for education. This research aids a broad range of scholars, designers, and educators in creating projects that focus not only on the values of stakeholders but also on implementation and long-term design.

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