

Designing Interactive Artifacts to Generate New Modes of Engagement in an Academic Makerspace

ISAM
2019
Paper No.:
XX

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INTRODUCTION

While the number of academic makerspaces has been increasing over the last decade, only a few of them have succeeded in building a community of users rather than generating mostly transactive relationships centered on the usage of the machines [1, 2]. Yet, research has shown that successful makerspaces require a sense of community that nurture a culture of innovation [3, 4]. The way to trigger and nurture such community and to develop relational modes of engagement of users within academic makerspaces is scant. In previous research, we adapted the open source design of CAIRN, a tangible apparatus developed to materialize interactions in a Parisian FabLab [5], to study interactions in the makerspace of an American University [6]. Insights from CAIRN in the university context emphasized its potential to trigger reflection on practices in the space and generate a sense of belonging to the space for some users. We also realized that users found the multiple elements complex to grasp and reflect upon, and that after 2 ½ weeks, interactions with CAIRN decreased. We therefore decided to do a follow-up project to further explore the potential for reflection and relational engagement mode by designing interactive interventions taking a rapid prototyping approach. Based on our learnings from CAIRN, Lefebvre’s theory of space [7] and relational art practices [8], we decided to create a series of three short interventions asking simple questions (e.g. What did you do today?) hoping to support reflective practices and possibly trigger a relational mode of engagement with the space. In fall 2018, we ran a twelve-week project to design and build these three interactive interventions: **Tangible Tubes; You Make Me Feel; and Your Totems.**

In this paper, we present the process to create the Intervention Series and the insights we collected during the making and deployment process about nurturing relational engagement. We suggest how these insights can inform the nurturing of a sense of community in academic makerspaces.

MOTIVATION AND INSPIRATIONS

Most literature on makerspaces focuses on measuring foot traffic and machine usage [1, 2]. Several papers have explored the importance of community building but we still have a limited understanding of the mechanism to nurture a sense of community [3, 4]. In particular, there is inadequate understanding of the role of space in triggering and nurturing

community and much of the research on makerspaces tends to embrace a definition of space as an objective geometrical space. In contrast, studies of space inspired by Lefebvre’ *The Production of Space* [7] highlights how space is socially constructed through everyday practice and experience [e.g. 8]. Such views suggest how our modes of engagement with spaces can be deeply relational and how a sense of community can emerge from such mode of engagement.

In this paper, we embrace such a perspective on space as produced through social interactions and practices. We report the design of interventions aiming to trigger a relational engagement with our makerspace instead of the more transactive mode of engagement (i.e. the space is only a geographical location that provides them with a set of material resources) we observed with many users of the makerspace [9].

In order to shift users’ mode of engagement to the space and transform them from passive users of the resources to more active producers of meaning, we experimented with “relational art [...] (which) intends to create not only objects but situations and encounters” [9]. As sources of inspiration, we researched different art installations and interventions as well as the literature on tangible visualizations [5, 10, 11, 12]. The latter explores how one can build physical objects in order to materially visualize data and make these data easier to analyze. In our case, data collection (or analysis) was not the focus. Our aim was to generate new situations in the makerspace and our stance was one of action research and rapid prototyping. We explored how to invite students to participate in and engage with the space more intentionally.

METHODS

A. ITERATING ON PREVIOUS WORK TO IDENTITY DIMENSIONS TO EXPLORE

Our previous work with CAIRN [6] highlighted its affordance for reflectivity (similar to Gourlet and Dassé [5]) and suggested a potential for triggering new modes of engagement— more relational ones – to the space. Yet, we also found that it was difficult to maintain engagement. After 2 weeks, we started noticing less participation with CAIRN. Moreover, we observed that despite our efforts to limit complexity (e.g. by reducing the number of dimensions proposed in the original apparatus), participants still found it difficult to interact with CAIRN. A poster with some explanations of the table and research was added with limited

success. Iterating on our learnings, we chose to focus on only a few dimensions. Inspired by relational art and tangible visualizations, we decided to create three short-term interventions to try to trigger more reflective and relational engagement with the space.

As we were particularly interested in understanding the main activities of the makerspace’s visitors, we decided to explore three practices in our first intervention: making, learning and sharing. For the second intervention, we chose to focus on emotions as they played a role in the perception of space conceived as relational. We focused on the feeling of being inspired in order to investigate how much the space triggered and/or nurtured feelings of creativity. For the third intervention, we explored the relational attachment to machines which are key elements in a makerspace. We were interested in understanding how students might identify or feel proud of certain machines - which ones might be perceived as makers’ totems.

B. DESIGN AND MAKING

In the design and making of the Intervention series, we embraced an iterative design process (See Figure 1). Informed by previous observations from interactions with CAIRN in the space, we asked the question: how can we trigger new modes of engagement within the makerspace, in particular modes of engagement that would be more relational, emotional and personal, rather than transactive? We picked time as one of our main design constraints, which meant creating only short-term interventions. We then brainstormed and sketched different options while looking at design and art installations or interventions for inspiration. We eventually selected three ideas that we prototyped and user tested. Based on these iterations, we sequentially implemented the interventions.

We followed an iterative design process: starting from a question, doing some research to find inspirations, ideating, rapid prototyping some of the ideas and getting user feedback, before doing a series of prototypes leading to the final intervention. In the following sections, we discuss in details each of the interventions and the process we followed to design them.

C. TANGIBLE TUBES

In the center of the makerspace and visible from multiple areas, three clear plastic tubes labeled with the statements: “I learned,” “I worked,” and “I collaborated.” On the ground below the tubes, a simple question was posed - “What did you do today?” - inviting users to reflect on their practices and then visualize them by adding as many colored ping pong balls as they wanted to the tubes (see Fig. 1). No instructions were provided.

Our inspiration for this first intervention were tangible visualizations [5, 11, 12] and interactive installations that invited participants to materialize their activities in a space [13, 14]. Based on our learnings from CAIRN, we realized that students struggled to interpret and navigate the 12 different dimensions CAIRN offered them to reflect upon and describe their activities in the space. We decided to focus on three dimensions. From on labels we used with CAIRN, we

explored different phrases: “I made,” “I worked,” “I collaborated,” “I shared,” and “I learned.” We wrote them on cards and hosted short user feedback sessions with ten students in the space to check how they interpreted each sentence. From these sessions, we learned that students did not necessarily connect with the phrase “I worked,” while “I made” resonated with their experience and activities in the space. We gathered similar insights on “I shared” vs. “I collaborated.” Our final design therefore consisted on three dimensions: “I made,” “I learned,” and “I collaborated.”

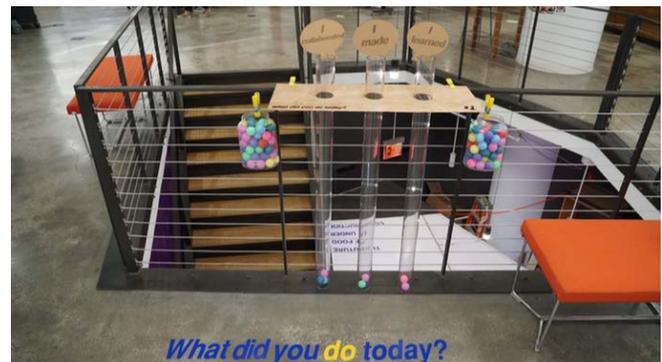


Fig.1 Tangible Tubes

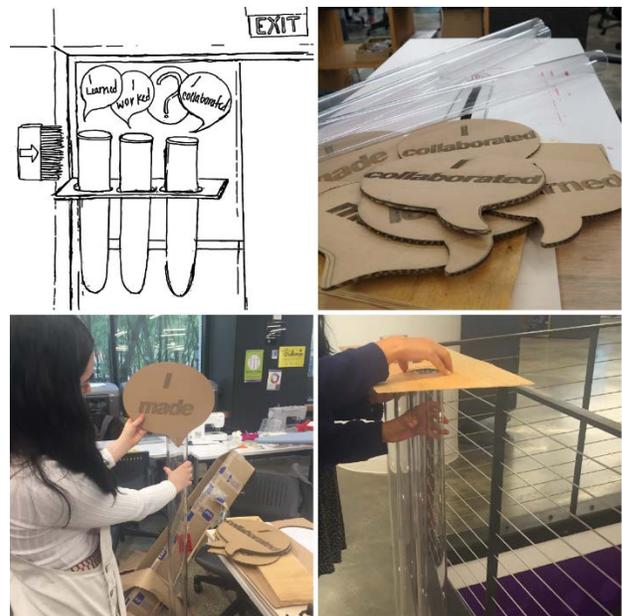


Fig. 2 Fabrication Process for Tangible Tubes

In order to secure large acrylic tubes, we cut circles with the same diameter of the tube into scrap wood with the question “What did you do today?” laser cut onto the left corner. Clips were used to fasten the board holding the tubes to a metal rail in the center of the space. With scrap cardboard, we made voice bubbles with bold text using the laser cutter and mounted them to the top of the tubes.

D. YOU MAKE ME FEEL

The phrase “Inspired Today” was vinyl cut and posted on the floor close to the entrance of the makerspace. Opposite the floor phrase, the same phrase was posted on a pillar. Visitors

were invited to reflect on their relationship with the space - does it inspire them? - and to take a picture they could share with their networks on social media.



Fig.3 You Make Me Feel

Our inspiration for this second intervention was the work of the artist Candy Chang’s street art featuring stencils with “You Make Me Feel So Mahtava” and “It’s Good to Be Here,” which aimed to produce a sense of belonging for the public through their positive and spatial position [15, 16]. We started with a phrase focusing on emotions “Today I feel...,” but eventually decided to be more specific and to instead focus on inspiration because of its association with creativity and innovation. We came up with two phrases - “I feel inspired today...” or “I feel inspired now...” and hosted two feedback sessions to see which one people identified with more. One session was with a group of 24 students who were asked to vote on their favorite phrasing. One of our team members also posted on her Instagram the different options and asked people to vote. The Instagram poll showed a slight preference from the 103 respondents for the phrase “I feel inspired today.” Based on this feedback, we ended up choosing the phrase “Inspired today.”



Fig.4 Fabrication Process for You Make Me Feel

After designing the text “Inspired today” in Adobe Illustrator, we used a Roland GS-24 CAMM 1 Vinyl Cutter to cut the letters into 20”x12” blue and yellow vinyl. This was then applied on the ground in the center of the space and a pillar near the entrance.

E. YOUR TOTEMS

Intervention 3 presents large, all white models of highly used amenities at the makerspace or “totems” of the space. These three artifacts represented the makerspace and the activities taking place there - a table, a 3D printer, and a laser cutter - were modeled with foam core. Users were invited to reflect on their use of different machines and/or show their attachment to these machines and the space in general by “tagging” them with colored dots. The three “totems” were located in three different areas of the space for the first part of the installation, near the objects they represent. For the second week, they were displayed together in a central area close to the entrance.



Fig.5 Your Totems

Our inspiration was Yayoi Kusama’s Obliteration Room [17], which begins as a standard living room, carefully painted white. After supplying visitors with a colorful sticker sheet of differently sized dots, the room turns into an explosion of color. We decided to create 3-D models of some machines used in the space and invite visitors to engage playfully with them and possibly show their attachment to them. We decided to create three artifacts: 3D printer, laser cutter, and a table (as representative of the space where brainstorming activities usually take place as well as a meeting “tool”).

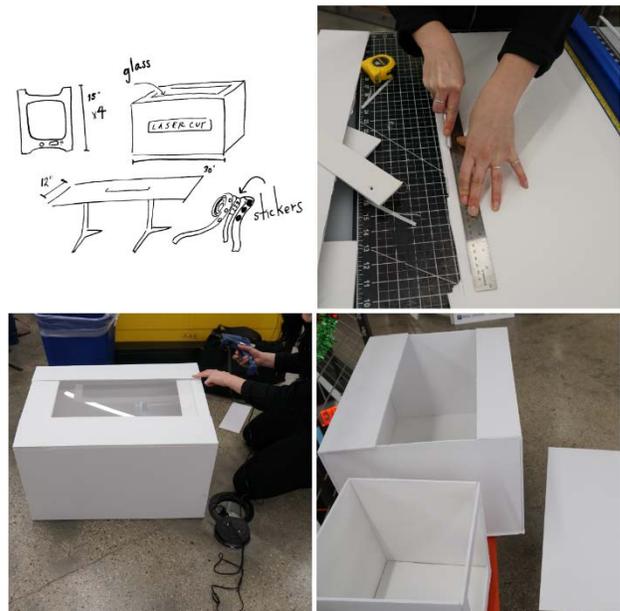


Fig.6 Fabrication Process for Your Totems

Each totem model was designed based a scaled version of their representation. Then, we cut each piece out of white foam core, laser cut logos and details of the machines onto their exteriors, and glued the pieces together. Then the totems

were supplied with different multi colored dot sticker dispensers.

DATA COLLECTION AND ANALYSIS

Data collection for this project was a mix of observations and intercepts of people interacting with the different interventions. We observed both interactions in situ and “outcomes” - e.g. how many balls in the tubes; the number of pictures shared; the number of stickers. Following design research, our interpretative analysis [18] aimed to assess the impact of the design intervention rather than measure numbers of interactions. We also compared and contrasted our observations with previous studies we had done as well as insights we collected during CAIRN. Our aim was to understand how much these interventions afforded a relational mode of engagement with the maker space, inviting students to move away from a more transactional view of the maker space as offering resources - tools and machines mainly - for their projects (curricular and extra-curricular).

INTERACTIONS GENERATED BY THE INTERVENTION SERIES

A. TANGIBLE TUBES

Participants said they loved the question. In fact, when we started prototyping the text, several students stopped by and started taking pictures of the sign. This made us feel confident – erroneously though – of the success of intervention 2. When asked why, they said, they liked the question. “It made me think” added one. Another said: “It’s cool; it looks like tags for concerts on pavement.” In general, participants liked Tangible Tubes because it was easy to understand what were the expected behaviors. One participant wondered if adding some color coding (i.e. connecting a color with a certain activity) would have been better. She eventually concluded that no color coding made the interactions simpler and more playful. Several other participants insisted on the fact that they liked the fact that there were no rules and no color coding.

We observed both individual interactions and a few small groups’ interactions where two or three people passing by the tubes would put some balls in the tubes, shown in Fig. 7. At the end of the intervention (3 days), “learned” was the most selected activity, then came “collaboration” as seen in Fig. 8.



Fig.7 Two Visitors Interacting with Tangible Tubes

All participants emphasized how the intervention was playful and simple. Several participants stressed that the test tubes metaphor resonated with their STEM background (e.g. “it

looks like test tubes”), yet was uncomplicated and they enjoyed this combination.

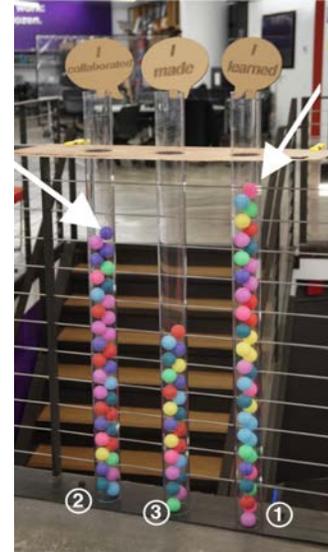


Fig.8 Tangible Tubes After 3 Days

Overall this intervention was the most successful and our insights from CAIRN regarding learning and collaboration were confirmed. Our findings also suggest that a combination of simplicity and playfulness along with some “cultural” familiarity (i.e. test tubes) was generative.

B. YOU MAKE ME FEEL

This intervention was hard to interpret by the users of the space, despite our original assumption that because of students’ familiarity with social media and selfies it would be easy. We found out that many students were unsure of what they were expected to do. For example, when we first showed the stencil to two regulars in the makerspace and asked them if they could engage with the intervention, they were puzzled, and said they did not know what was expected of them. We then created a poster with a picture from social media and hashtags, but this did not seem to help. As we were trying to explain to a member of the makerspace team how to interact with **You Make Me Feel** she concluded, “This is very confusing.” We saw only few students taking pictures during the three days. We also quickly realized that tracking photos was arduous as people often did not use the hashtag.



Fig.9 Picture of Visitors Interacting with You Make Me Feel

This lack of engagement might be due to the fact that the phrase “inspired today” did not “culturally” resonate with engineering students, the main users of the makerspace. The phrase might sound too “artistic” in comparison for example with “what did you do today?” (used in **Tangible Tubes**) which provoked interest and excitement (and picture taking). We also realized that the work of Candy Chang (on which we

built) took place in public spaces and was located in multiple locations. It would be interesting to see how students would react if we had posted this phrase in several locations on campus: would have it increased their interest and willingness to engage with the intervention?

C. YOUR TOTEMS

When we first installed the three totems, little happened (see Fig. 10). While originally this third intervention was going to last three days like the first two, we realized that to cover the totems with stickers we needed time. We decided to extend the intervention to a week, and then to two weeks as we noticed more stickers and some experimentation with creative patterns and locations. It seemed that as there were more stickers, the expectations became clearer as well as the sense of permission increased. Moreover, we also noticed during the first few days that visitors who knew of Kusama's work engaged with the artifacts more easily (see Fig. 11). Therefore, after a week, we moved the models to the center of the space with a reference to Kusama and with this change of location, more people posted stickers. This central location is shown in Fig. 12.



Fig.10 The 3D Printer Totem Day 3

Overall, the makerspace visitors reported a positive experience: "I love putting the stickers on. It gives me a nice feeling." These comments and the interactions with the totems (visually represented by the stickers) suggest that **Your Totems** presents an opportunity for engagement in a more emotional (if not reflective) fashion - possibly being a catalyst for transforming the transactional relationship.



Fig.11 A Visitor Interacting with the Laser Cutter Totem



Fig.12 The Totems Co-Located on a Table with a Label Referring to Kusama

DISCUSSION

We described the design process of an intervention series within a makerspace through the installation of interactive artifacts. We presented the learnings in terms of engagement across these three artifacts. They generated not only interactions, but also conversations about the meaning of these interventions. We noticed differences among the three. In particular, the tangible nature of **Tangible Tubes** and **Your Totems** made them more accessible to users in contrast to **You Make Me Feel**. Moreover, these three interventions were disruptive in the context of an engineering culture because of their aesthetic and affective dimensions. **Tangible Tubes** was the easiest for makerspace users to interact with because the tubes were interpreted as connected to a scientific culture. While playful, the interactions symbolized a categorization process that felt familiar and relatable.

Our experience designing a tangible apparatus (CAIRN) to study practices in an academic makerspace informed the two important design principles of the intervention series: ephemerality and simplicity. We learned with CAIRN that it was hard to maintain engagement with the apparatus "over time" and that too many questions limited interactions with the apparatus [6]. Interestingly, both findings were challenged by our observations of the three interventions. First, triggering new modes of engagement fundamentally involves some cultural change. Yet, culture takes time to evolve and this might explain why participation was not always as high as we hoped. Users often did not feel permitted or were unsure about the rules of engagement, which were different than their usual more transactional engagement with the space (i.e. coming to use the tools and machines they needed). This became salient with the third intervention when students who recognized our Kusama inspiration knew "what to do" and immediately put stickers on the artifacts. And when they "understood" how to interpret the intervention, they enjoyed it (as our observations and intercepts indicate).

Moreover, the interventions were perceived as artistic; thus in opposition to what a makerspace in an engineering school was "supposed" to be. Designing at the borders of different cultures requires patience and persistence while our interventions were by design short and ephemeral. While subtle, these interventions had an impact: some students engaged with them directly; others asked questions; they definitely triggered conversations and signaled to students in

the space that it was more than a repository for machines and tools. A common theme that emerged from our conversations with students who engaged with the Intervention Series was its playfulness, an element that has been emphasized as key to innovative cultures [19, 20] and the maker movement [21]. To create a long-term change, we need to be consistent and multiply this kind of experimentation for a culture of both playfulness and reflexivity to emerge, both key in nurturing more relational modes of engagement with the space. Already, some regular users, who had interacted with CAIRN previously, felt more comfortable interacting with the artifacts we introduced. In the future, we plan to be more consistent and continue to experiment with more artistic forms of engagement.

Another of our design principles, simplicity, emerged from insights from CAIRN: “too much complexity”, we found, was preventing interactions, so we decided to design each intervention around one single question. However, our observations of the intervention series taught us that this was only one dimension that could explain the interactions. In fact, complexity, and the ambiguity it created, might generate richer conversations. Compared to CAIRN, no collaborative discussions were observed nearby the interactive artifacts. This opens up interesting questions to explore for the design of interactive artifacts and the engagements they generate. It suggests the need to experiment to explore the tensions between simplicity and complexity as well as between ephemerality and duration.

Our action research suggests that relational art [8] provides generative ways to invite members of a makerspace to become more active participants. Our observations suggest that some of our interventions were difficult for students to interpret because the kind of interactions afforded by the interventions we designed were too disruptive. We realized that we needed more top down support from the makerspace management to provide a sense of permission as previous studies have highlighted the role of permission in nurturing collaboration in spaces [9]. We should also have engaged more with the TAs working in the space, as we had done with our CAIRN project. In that project, we had found that several student workers had a sense of ownership and pride for CAIRN and became ambassadors for the apparatus. Our main learnings from this project that will inform our future efforts in shifting modes of engagement in the space and nurturing a stronger sense of community are:

- As any culture change, triggering new modes of engagement within a space is a long-term process that requires consistency – that is, multiple and regular interventions.
- This is about changing behavioral norms and a sense of permission is essential. This can be created by the role modeling of the management of the space as well as key members like the student workers.
- It is about navigating tensions – between ephemerality and duration; between simplicity and complexity.

Previous research on maker spaces has highlighted the

importance of creating a sense of community [22], but it is also acknowledged that developing such a community-centered culture is difficult. Lefebvre’s concept of space as socially constructed suggests that experimenting with different modes of engagement through design interventions can be generative of new behaviors and modes of engagement. Our **Intervention Series**, which showed the potential of engaging engineering students in more playful and reflective ways, is a first step in this direction. While each academic makerspace has its own culture, influenced by its team and reflecting the general university culture, we hope our experimentation with design research and relational art practices will inspire other researchers to explore creative methods to engage their users to generate an innovative culture and sense of community. More deeply, for any successful design intervention to take place, and for communities of practice and relational modes of engagement to emerge in maker spaces, it is essential to embrace a socially constructed understanding of space [7, 10].

While our **Intervention Series** focused on interactions within the space, we think that our work can also contribute to recent interest in nurturing emotional intelligence [23] in engineering education [24]. Our intervention aimed to build a culture of self-awareness and self-reflection, two important elements of emotional intelligence. It has been argued that to effectively support emotional intelligence, it must be embedded within an organizational culture where emotional intelligence is recognized [25]. While curricular changes are required [24], using makerspaces to build opportunities for reflection could trigger increased emotional understanding, as students become more reflective and self-aware while developing a sense of belonging to a community.

We plan to incorporate our learnings from designing and implementing the intervention series to inform our next iteration of an augmented CAIRN, as well as to continue designing interactive artifacts that can generate more relational modes of engagement and reflective practices, thus nurturing a community of practice. We believe that this work, which shows that “designerly ways of doing research [...] involve creative acts of making” [26, p. 6] opens up new ways to explore the boundaries between design research and action research, in particular for researchers and professionals involved in academic makerspaces.

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