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Designing Tools for Observation and Assessment in Makerspaces

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ABSTRACT

Makerspaces, especially in their diverse proliferating forms, support a broad variety of learning outcomes. There is rich work in attempting to understand and describe these learning goals. Yet, there is a lack of support for practitioners and educators to assess the learning in their events, without extensive video-recording and documentation. In this paper, we present our design iterations at adapting the Tinkering Studio's Learning Dimensions framework into tools used by makerspace facilitators. Th ese tools are intended to support recording observations, so as to inform the design of events they organize. We fi nd that supporting real-time, informative observation increases granularity of data collected, but also increases the need for training required at the end of facilitators; such tools carry power to transform practice in action. In response, we also present future plans to attempt dealing with current challenges.

CCS CONCEPTS

CCS → Human-centered computing → Human computer interaction (HCI) → HCI design and evaluation methods → Field studies

KEYWORDS

Makerspaces, Assessment, Mobile Application, Observations, Tinkering,

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1 Introduction

Makerspaces foster a variety of learning outcomes. Most known for the technological competencies built through FabLabs [3], the proliferation of makerspaces in schools, libraries, and cities, supports a broad array of practices like sewing, crafts, woodworking, etcetera. Th is has led to makerspaces being powerfully positioned to reframe what counts as valuable learning [10].

From setting up frameworks to describing makers' technical knowhow [4], to developing descriptive modules for transferable content-knowledge [1], there is a growing body of literature working on describing and measuring the different kinds of learning that take place at makerspaces. Th e struggle with finding tools which guide educators and facilitators to focus on valuable forms of learning, has been strongly felt at the emerging makerspace located in the Madison Public Library, called the Bubbler [8].

Having developed a popular and dynamic set of programming over the last 8 years of its existence, the Bubbler's core team members (one of the co-authors) recognized a critical need to find tools to measure the rich kinds of learning taking place in their events, with the goal of designing data-informed programming. Th e Bubbler, unlike many makerspaces and FabLabs, organizes many low-tech events – including screen printing, puppet making, and the like. Moreover, by design the Bubbler acts as a moving, city-wide makerspace organizing events at schools and multiple venues, beyond their central venue at the Public Library's downtown location [8].

As a result, we searched for an assessment framework which aptly caters to the Bubbler's values and goals. Th e Tinkering Studio's Learning Dimensions Framework (LDF) [2] was found to be a popular framework used to analyze and describe learning in tinkering spaces, which fit the Bubbler's requirements suitably. In this paper, we present our adaptations of LDF through a practitioner lens, into tools which were used for observation by Bubbler facilitators. This includes multiple design iterations we went through, a few takeaways from the experience of using such tools, and planned future iterations of these tools.

1.1 Related Work

As described in the previous section, there are a wide variety of frameworks used to analyze and understand learning in makerspaces. LDF, prepared by analyzing videos from STEM-rich tinkering at spaces like the Exploratorium's Tinkering Studio, provides 4 **themes** of learner interactions: Engagement; Initiative and intentionality; Social Scaffolding; and Development of Understanding. Each of these themes encompasses many specific interactions. For instance, an interaction is said to exhibit engagement when learners try something; show emotions such as frustration, joy, pride; or remain around after they "finished".

LDF is content agnostic, while valuing behaviors which exhibit useful skills learned by makers. The framework also provides information about the quality of the event they are participating in. For instance, the abstract nature of the interaction categories, like engaging with "social scaffolding", reflects learners becoming more competent help seekers, help givers, or learning from others in specific ways – and also provides data for [maker] event designers to better understand the conditions which support or cause makers to rely on each other.

This aligned well with the practices of the Bubbler. The organizers need evidence about valuable forms of learning as evidence to support the success of their events, which span a wide variety of content topics; but also as data to inform the design of future events and programming. With this context in mind, the following sections present the various design phases we went through to attempt improving our observation and assessment tools centered on the Learning Dimensions.

2 Design Phases

This project relies on a research practice partnership between the public library and the university [5]. The data used to present our findings include field notes, photos, and reflective conversations between our educational research (and design) team, and the Bubbler's event organizers. In the next subsections, I present 3 phases of how we adapted LDF, and the instruments we adopted to do our job. These sequential design iterations span intermittent testing and work over many months and is an active work in progress. The description of each design iteration is followed by notes about the observers' experience, and the limitations which motivated design revisions.

2.1 Design Phase 1

The Bubbler's mobile status, and efforts to maintain privacy across their diverse populations, limits their ability to video record their events for thorough analyses. This limitation is compounded by the lack of adequate time and people to conduct rich analyses on any bulk of recorded data. This forces event facilitators themselves to be responsible for recording succinct observations and also making sense of them. Thus, using mass data recording with automated analyses,

These constraints made the Bubbler organizers initiate observation recording through a google form. This form was designed to encourage facilitators to reflect on events they organized, and use the Learning Dimensions' themes and interaction examples as scaffolds for recall and reflection.

This design involved entering details about interactions or events in any of the provided dimensions/categories. We saw healthy reflective practice, wherein facilitators would list an interaction each for whichever categories they could recall instances. At a broad level, this form of data entry would give information about which kinds of interactions the facilitator remembered occurring, but not when and how often the different categories occurred. Being limited to post-event recall also limited the varieties of interactions which were recorded in the google form.

2.2 Design Phase 2

To obtain a "thicker" documentation in terms of knowing which categories of interactions took place more often than others, the facilitators used paper printouts of the LDF. This was intended to support relatively real time observation of learner interactions – whenever participants would engage in an interaction of interest, observers would attempt to make a note of the relevant category of interaction on the printout.

This worked successfully to improve our sense of the frequency of different interactions but introduced the challenge of making notes during facilitation. Our facilitators, like many educators and teachers, are often strapped for attention and time and struggled to make detailed records of the interactions taking place. These notes succeeded in providing facilitators with more points to recall and expand on after the event.

This paper prototype, though challenging to use, encouraged us to work on more powerful real-time observation tools, as approaching a temporal record of different interactions provided richer formative feedback on the design of the Bubbler's events.

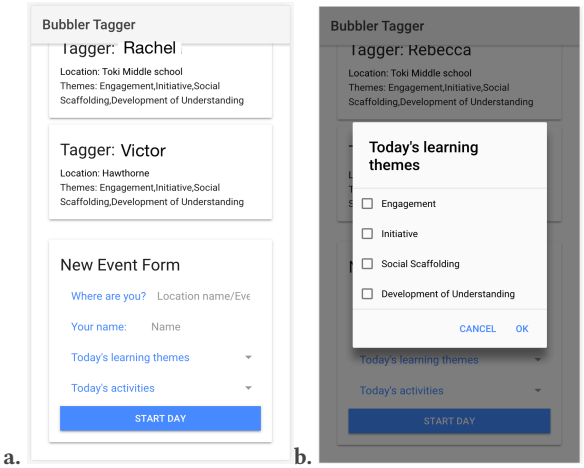
2.3 Design Phase 3

We designed and developed a mobile application to support rich observation and real time data recording (Figure 1).

To log observations for an event, the observer creates a new event, and selects a set of themes to observe (Figure 1, a.), or chooses from a list of existing events. The selection of specific themes to observe (Figure 1, b.) was intended to reduce cognitive overload on observers in the second screen (Figure 1.c). This was also a challenge noticed in the Phase 2, where keeping track of all possible interaction categories was difficult, not just for new users of the system, but even experienced facilitators. Focusing on one or two of the themes to observe enables facilitators to have a manageable list of categories to follow. This also allows the facilitator-cum-observer to make a conscious choice about the kinds of learning outcomes they wish to focus on in their event, by design, and observation.

Once the event begins, and the observer notices a learning interaction they wish to record, they select the interaction category corresponding to their observation (Figure 1.c. – similar to researcher observation tools like BROMP [9]). They then have an option to add data related to this interaction through a variety

of modalities – through text notes, audio recordings, or attached photos (Figure 1.d.). This interaction order was designed to guide observation with the structure of the framework, and allow for detail entry to vary depending on the observers' availability. A basic observation could involve logging the occurrence of an interaction, and a richer observation could have pictures and a descriptive contextual text to describe the learner interaction which took place.



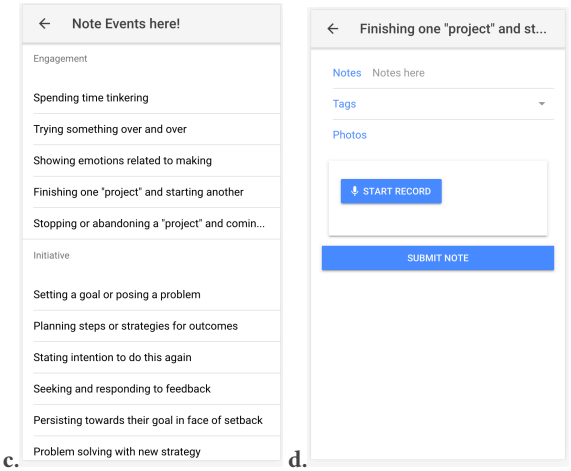


Figure 1. **Screenshots of the mobile app developed for real-time observation.** a., c., **and** d. **being the three consecutive screens seen by the application's users.** b. **shows the theme selection pop-up which appears while making new events.**

We also added a "tags" feature, to note further affective features of the interaction taking place – "willingly, with encouragement, hesitatingly, …". Th is was meant to provide an easy-to-access way of adding richer data about the learning interaction being observed, and to support retrospective data reports presenting summaries of predominantly observed affect in participants (discussed in Future Work and Figure 2). These tags are designed to provide immediate access to a measure on the quality of interactions taking place at an organized event.

This application is reported to be a productive addition to facilitators' practice – the ability to take pictures and audio notes successfully supports prompt recording of an interaction's context, with minimal disengagement from the activity at hand. Additionally, choosing themes at the beginning of an event and seeing a handy list of exemplary interactions to pay attention to, also helps facilitators be more aware of, and ready to observe events of interest in the chosen themes' context.

At the same time, similar to the challenge seen in Phase 2, the need to choose a specific category before recording an observation is a noticeable bottleneck in the process of recording observations. Often times, facilitators notice an interesting action by a learner, and do not want to be concerned with categorizing it immediately as much as recording it. Additionally, events which cover more than one category of interaction also pose an unnecessary load of making a constrained choice and adding additional information in notes.

3 Discussion

The availability of a tool which provides an easy to use context of observation themes and interactions, is seen to affect the facilitator's practice. On one hand, it supports them in paying more attention to events of interest. On the other hand, it draws educator attention away from what is typically seen as their "core" job of organizing and teaching [6].

Being able to add metadata in a predefined framework of categories requires a prior understanding of the framework to choose from such lists at short notice. Th is is in contrast to design phase 1 – having mental space to richly describe events,in response to a form enables easier description of memories, since the observation is not taking away from the event at hand. However, this recording involves separation from running the event itself. Retrospective recording often misses out on details, and is also limited by the number of observations facilitators are able to recall [7].

Overall, the design phases changed the kinds of nuanced data being collected. Design phase 1 allowed for detailed descriptions of some interactions which the facilitators remembered. Th ey had time to record detailed observations, and relate it to multiple categories of learner interactions when translating their memory using LDF's lenses. Design phases 2 and 3 supported a record keeping that had lesser descriptive detail, but increased temporal data (the sense of different interactions happening at specific times during the event), and frequency data (the number of times different kinds of interactions were noticed). Th is additional detail also comes at the cost of facilitator attention. This tradeoff – between data richer in some forms and facilitator time – is yet to be assessed in the eyes of all the involved stakeholders: the facilitators who design future events, as well as understand other decision makers related to the Bubbler whose decisions are informed by claims of outcomes which library staff are able to present.

2018-11-14 15:43:00	Spending time tinkering	Engagement	2 boys have spent 45 minutes pulling nails. They are determined to finish the pallet before the end of class.	Independently
2018-11-14 15:40:29	Seeking and responding to feedback	Initiative	girl trying a new technique for gluing her boards together. seeking feedback from instructor before moving on	Riskily
2018-11-14 15:39:01	Planning steps or strategies for outcomes	Initiative	girl measured wood and worked with instructor to cut it to length on the table saw	
2018-11-14 15:37:06	Setting a goal or posing a	Initiative	girl took newly planed pallet wood and wants to make a wooden pumpkin by	Positively

Figure 2. **Summary view of the last few notes made using our mobile app observation tool.**

4 Future Work

To reduce the training and prior expertise required to use this application, and to build tools who can use the data collected in different manners, we are working on another design iteration of the app, as well as a report presentation tool. Our current plan includes adding the ability to record untagged observations – a facility to add the text, audio, or picture notes without having to choose a category that they belong to. We look forward to exploring how productive this feature is in reducing the need for training to use the app, and reducing the cognitive load on facilitators who want to make observations during their events.

These observations are intended to be used to inform the design of future revisions of the events organized by the Bubbler. For instance, if an event is expected to foster social scaffolding and is targeted towards a specific age group with that goal in mind; but is found to instead provide for engagement much more than social scaffolding – program planners can organize the event differently to better suit the goals the event does accomplish.

Additionally, these assessment tools are used to make reports and evidence-based claims about the kinds of learning that take place at library events – to present to both funders, as well as event audiences (parents, attendees, etcetera). Th is is both a critical job of a librarian (to provide community members with valid information about the value of events being organized), as well as necessary task for continued sustenance of programs (solicit funds based on claims of successful outcomes).

These goals are currently being considered deeply in the design of a report presentation tool (which will build off the data structure collected through our observation tool(s) and presented in a preliminary view in Figure 2).

Overall, building and using a real-time observation tool for makerspace learning has been an enriching experience, not only to expand potential research ground, but also to deepen facilitation practice. Facilitators have had rich and deep engagement with LDF's affordances and limitations, are increasingly well equipped to use it and adapt it in ways best suited for their needs.

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