‘Re-mediating’ Learning

Kemi Jona, Lauren Penney, and Reed Stevens
kjona@northwestern.edu, Lauren.Penney@u.northwestern.edu, Reed-Stevens@northwestern.edu
Northwestern University, School of Education and Social Policy

Abstract: Building on our own and others’ research about productive features of non-school learning environments, we describe a new experimental infrastructure for the organization and mediation of learning called FUSE. Activity in FUSE is mediated by a website and supported by an adult facilitator (typically a teacher, librarian, or other youth educator). Based on emerging research from the more than 4000 young people that have participated in FUSE in 30+ schools, libraries, and summer camps in the Chicago area, we have begun to characterize how the affordances of the FUSE website are supporting a shift in the material organization of learning in the in-school classrooms in which it is implemented. We describe how FUSE ‘re-mediates’ learning by providing individualized learning pathways, dynamic arrangements for learning, alternative forms of ‘assessment’, new roles for the teacher, and a rethinking of how curriculum materials are produced.

Keywords: technology, interest-driven learning, design, STEM, STEAM

Introduction

In this paper we describe a new experimental infrastructure (cf. Stevens, 2007) for the organization and mediation of learning. This infrastructure provides a coherent system of learning, ‘teaching’, and assessment that leaves behind the ways in which current education systems of teaching, testing, and curricula discourage interest, foster maladaptive motivational patterns (Dweck, 1986), and sort young people **out** of further academic pursuits (particularly more challenging scientific and technical fields – Seymour & Hewitt, 1997; Ames & Archer, 1988; Margolis & Fisher, 2002). First, we review some of the intrinsic challenges to transforming school-based learning practices with technology. We then describe how our new infrastructure, called FUSE, ‘re-mediates’ learning by providing individualized learning pathways, alternative forms of ‘assessment’, new roles for the teacher, and a rethinking of how curriculum materials are produced.

Intrinsic barriers to transforming the organization of learning with technology

The material organization of learning in traditional Western schooling has remained largely unchanged, despite numerous attempts at reform (Becker, 1972; Varenne & McDermott, 1998; Cuban & Tyack, 1995). Technologies that have been introduced into classrooms have largely acted to reinforce rather than transform traditional structures and routines. A technology that is illustrative of the kind used widely in schools to maintain rather than transform the material organization of learning is the electronic whiteboard. Nominally intended to provide the teacher with an interactive computer display at the front of the room, this technology has for the most part simply provided teachers with an electronic method for displaying material to the whole class, replacing previous technologies of the overhead projector, chalkboard, and whiteboard. The electronic whiteboard changed neither the roles of teacher and student nor the organization of learning in the classroom.

Introducing technologies such as laptops and (more recently) tablets into schools has been heralded by both vendors and school leaders as a vehicle for transforming the traditional organization of classroom learning. Yet these technologies have largely failed to dislodge the teacher from directing learning from the front of the classroom; failed to break students free from lockstep progression through static curricula irrespective of actual learning outcomes; and, ultimately, failed to shift the initiative and ownership of learning from teacher to students. A promising exception are new blended learning models (Horn & Staker, 2014).

Collins & Halverson (2009, 2010) document the long history of innovative technologies that have failed to dislodge the industrial age structure of mass education. They identify a number of tensions between entrenched practices of schooling and the affordances provided by technology. These include:

- **Uniform learning vs. customization.** Current educational practices are based on a “mass production notion of uniform learning.” These practices include sorting students into age-based (rather than expertise-based) levels and administering common assessments. Even though these assessments are based on a notion that all students should learn the same thing in the same period of time, the system permits students to progress from one grade level to the next on the basis of only the most minimal mastery (i.e., anything but a failing grade allows one to move to the next class or grade).

- **Teacher as expert vs. diverse knowledge sources.** Despite widespread acknowledgement that we are now in an era of exploding knowledge production and instantaneous access, modern schooling is still largely based on the concept that knowledge is fixed and that a teacher's primary role is to present what is known to his or her students. This notion places teachers in the once-reasonable but now impractical position of all-knowing experts whose job is to pass on their expertise to students (who can now look up anything on their mobile phones faster than a teacher can respond).
- **Standardized assessment vs. specialization.** The high stakes assessments currently in dominant use require that every student learn the same things at the same time, yet technology now affords alternative forms of performance-based assessments such as video games and simulations (Hilton & Honey, 2011). Reputation-based measures of expertise grounded in communities of interest or practice are now typical in affinity groups including, for example, open source coding communities.

The traditional organization of classroom learning has been ossified and reinforced by layers of bureaucratic and administrative constraints. It is practically impossible for individual teachers to significantly change the material organization of learning in their classrooms, even if many secretly wish to and recognize how poorly the current system serves their students. Could a thoughtfully designed program, supported by technology, provide the requisite infrastructure to help teachers make a shift that many have long sought?

FUSE Studios

We are beginning to see evidence that such a shift is indeed possible. Building on our own and others' research about productive features of non-school learning environments (Bevan, Bell, Stevens, & Razfar, 2012; NRC, 2009; Barron, 2006; Stevens, 2000; Stevens, Satwicz, & McCarthy, 2008; Davis & Fox, 1999; Ito et al, 2013; Gee, 2007a, 2007b; Squire, 2003, 2011), we have created FUSE—a learning environment organized around a set of challenge sequences that 'level up' the way video games do. Some of our challenge sequences are software-based, including 3D design, digital music editing, app development, etc. For others that require physical materials, inexpensive, pre-packaged kits are provided (e.g., LEDs, breadboards, e-textiles, etc.).

The organization of learning in FUSE is mediated by the FUSE website and supported by an adult facilitator (typically a teacher, librarian, or other youth educator). Currently, more than 4000 young people have participated in FUSE Studios, exploring over 20 challenge sequences in 30+ schools, libraries, and summer camps in the Chicago area. Based on these experiences, we have begun to characterize how the affordances of the FUSE website are supporting a shift in the material organization of learning in those in-school classrooms in which it is implemented. (For an overview of FUSE, see http://www.fusestudio.net/program-design.)

Customization through choice

Youth participants have significant choice in FUSE Studios, a dramatic difference from their experiences in schooling. Participants choose whether to work alone or with others; they choose which challenge sequences they will explore; and they choose how long to work on a challenge sequence and when to move to another.

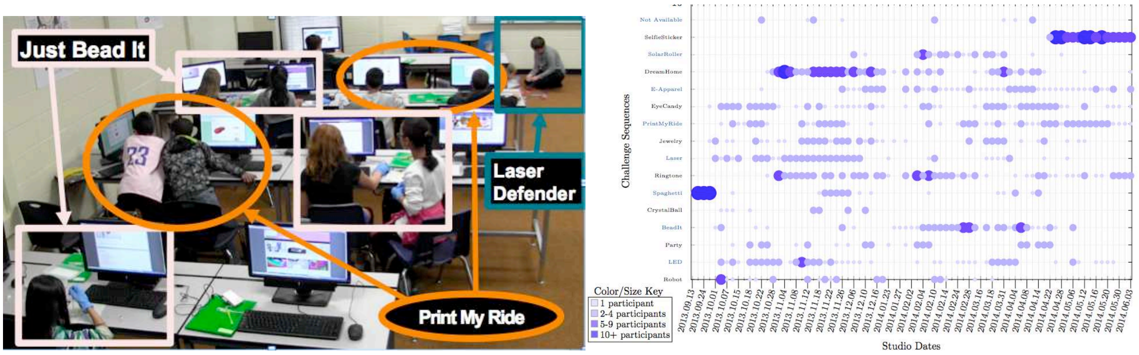

Figure 1. Left: An in-school FUSE Studio (color boxes indicate which challenges are being pursued); Right: Challenge popularity across the school year (each row is a different challenge, darker color and larger size indicate more participants).

Figures 1 & 2 depict the various arrangements and groupings for learning that emerge organically within a typical in-school FUSE Studio. Upon entering the room, students log on to their account on the FUSE website and select a challenge to work on – either continuing a previously started challenge or starting a new one. Often the teacher need say nothing to his or her students – they immediately transition to productive engagement.

In order to provide an interest-driven, free choice infrastructure for learning, by definition there must be a wide range of challenges available for participants to choose from (see Figure 1 right, and Figure 2). The website scaffolds participant engagement and provides a participant's first layer of support while engaged with a challenge. Each challenge in a sequence has its own resource page consisting of short "how to" videos with tips on getting started, and answers to the most frequently asked questions. Participants each have their own unique login, allowing the website to track their progression through different challenge sequences. Participants can upload files, pictures, videos, and other artifacts to their online account to "save" multiple iterations of their work-in-progress. Completing levels unlocks higher levels in the same challenge sequence; just like in video games, participants must finish level one before moving on to level two. To complete a challenge level they must upload a final "completion artifact" (the self-documentation of level completion is discussed further in the 'assessment' section below). Similar to a Facebook feed, our site provides information about which challenges peers are engaged in and allows for sharing of completion artifacts. Clicking on a fellow participant's name highlights their profile showing what other challenges they have completed and thus the areas with which they might be able to help another participant.

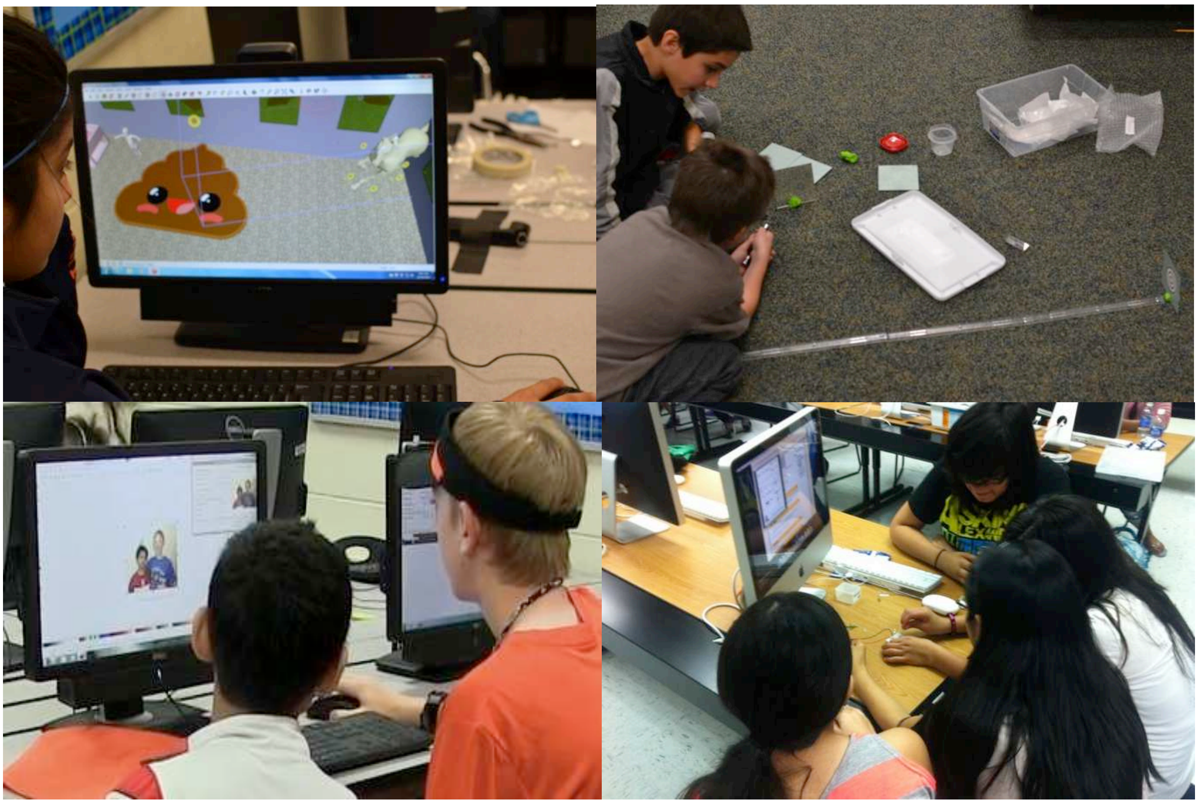

Figure 2. Examples of the diversity of material organizations for learning that occur in FUSE Studios. Participants dynamically arrange and rearrange collaborative groupings and individual activity with both material and online resources. Challenges illustrated here include (clockwise from upper left): *Dream Home, Laser Defender, LED Lights,* and *Selfie Sticker*.

The FUSE website structures and supports a participant-driven organization of learning. Each participant creates a customized rather than uniform learning experience by choosing the challenges that interest him or her, by working individually or with one or more peers, and by stopping and restarting challenge sequences at will. By indicating the leveling up progression for each challenge sequence, the website also provides clearly demarcated pathways to deepening expertise that each participant can choose to follow based on their own interest in doing so.

The FUSE web site logs participant activity and completed challenges allowing us to track which challenges participants are choosing and not choosing, and what levels they are completing or abandoning. From this web data, we generate ‘activity maps’ (Figure 3, below). Our analysis of these activity maps has revealed a number of distinct patterns of participant engagement. For example, the participant whose activity is represented on the left in Figure 3 simultaneously worked on a variety of challenge sequences before pursuing Selfie Sticker exclusively (green dots, top right) at the end of the school year (the time period depicted in the map). In contrast, the participant whose activity is represented on the right in Figure 3 shows a much more focused pattern of engagement. This participant sticks with one challenge sequence at a time, generally pursuing that sequence through the final level. These are just two of a growing set of identifiable engagement patterns we are observing in the data. The design of FUSE, supported by the website, not only facilitates this diversity in the organization of learning, but also illustrates the significant variation in preferred approaches to learning that a thoughtfully designed and technology supported program can enable. These activity maps stand in stark contrast to the teacher-controlled, uniform pace and progression of lessons that is the hallmark of traditional schooling.

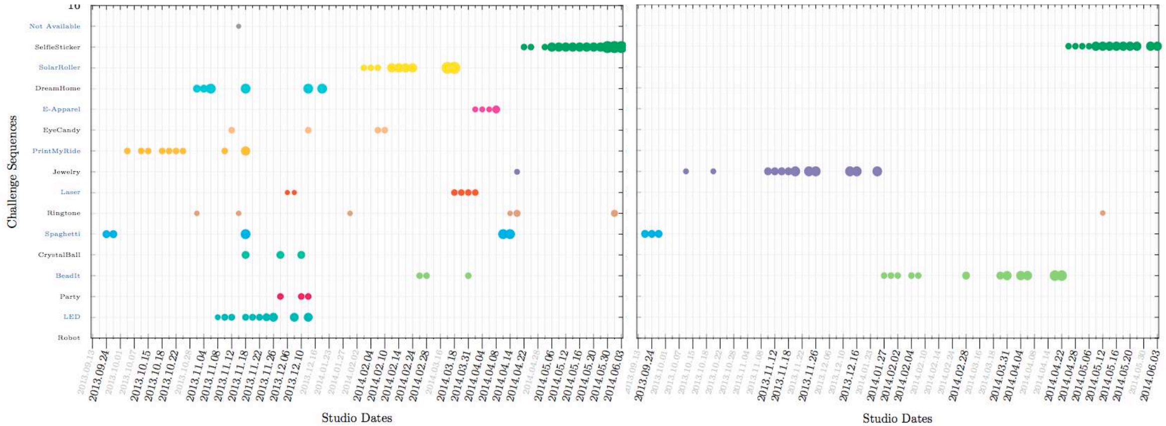

Figure 3. Activity maps from two 6th grade participants in the same classroom across one school year. Each row lists a different challenge sequence (also represented with different color dots), while each column represents a date that the studio was in session. Larger dot size denotes leveling up to more difficult levels in each sequence.

Dynamic and flexible learning arrangements

Prior work (Stevens, Satwicz, & McCarthy, 2008) and our ongoing observations of FUSE have provided evidence that when youth participants are in the room together, they will be drawn to get involved with each other’s challenge work. The differentiated levels of participation with particular challenge sequences that evolve naturally under this model over time multiply the possible sources of ideas, hints, help, and feedback in the room beyond those provided by teachers or other mentors. FUSE builds on Cole’s (2009) work on the Fifth Dimension, a long-standing, successful after-school program, where peer-to-peer mentoring is ubiquitous. There, as in FUSE Studios, peers have differentiated experience; some are oldtimers and some are newcomers (cf. Lave & Wenger, 1991). This stands in stark juxtaposition to traditional schooling where everyone learns the same thing at the same time and pace.

The FUSE program design, with support from the FUSE website, enables more dynamic and flexible arrangements of participants in the room—arrangements which are mediated by the participants themselves and not the teacher (a few of these many arrangements are illustrated in Figures 1 & 2 above). One particular example in a 5th grade classroom highlights the nature of these arrangements and how they evolve organically based on differentiated experience and expertise. Our *Solar Roller* challenge sequence invites participants to build a solar-powered car that can travel a target distance with and without a light source using a provided kit of materials including gears, photovoltaic panels, capacitors, etc. When this challenge sequence was launched partway through the school year, it attracted the interest of many participants who wanted to try it. Unfortunately, because only one kit of materials was available in each classroom, participation was reduced to one “user” at a time. In one classroom, we observed several boys agreeing to collaborate as a group so they could all try it together (Figure 4). At first, all boys tried designing a vehicle independently, however, Arjun soon took leadership and combined the ideas into one vehicle. All of them suggested ideas for building the roller, and when testing time came, they each took ownership for different aspects of the testing. For example, John had a fancy watch and used it to track the roller’s time to reach the goal distance, until they found a stopwatch and he started using it instead. Arjun seemed to have the most success with the light used to make the vehicle move, so he took that responsibility. Ian noticed the light cord kept getting stuck on the table, causing the light to stop powering their vehicle, so he took responsibility for keeping the cord clear of obstacles (see

Figure 4). As their design and testing progressed, they all found meaningful ways to contribute to the group. This group even pooled their money, purchased a similar kit of materials from another website, and brought it to school to use in additional experimentation and development that went beyond the challenge sequence on the FUSE website. This group worked on this challenge together multiple times over the course of three months. While there were five members of this group, not all members participated at all times; occasionally one and often all of them would take a break from this challenge to work on a different challenge.

This example highlights one of the many ways participants dynamically and flexibly positioned themselves in productive learning arrangements. This group worked cooperatively on their car design, while each boy filled a different role during testing that helped their team move efficiently towards their goal. These roles emerged dynamically as they worked together and developed expertise in different aspects of their vehicle testing. They themselves decided when to pursue this challenge and when to work on a different challenge sequence. Other arrangements of independent and collaborative work are shown in Figures 1 and 2.

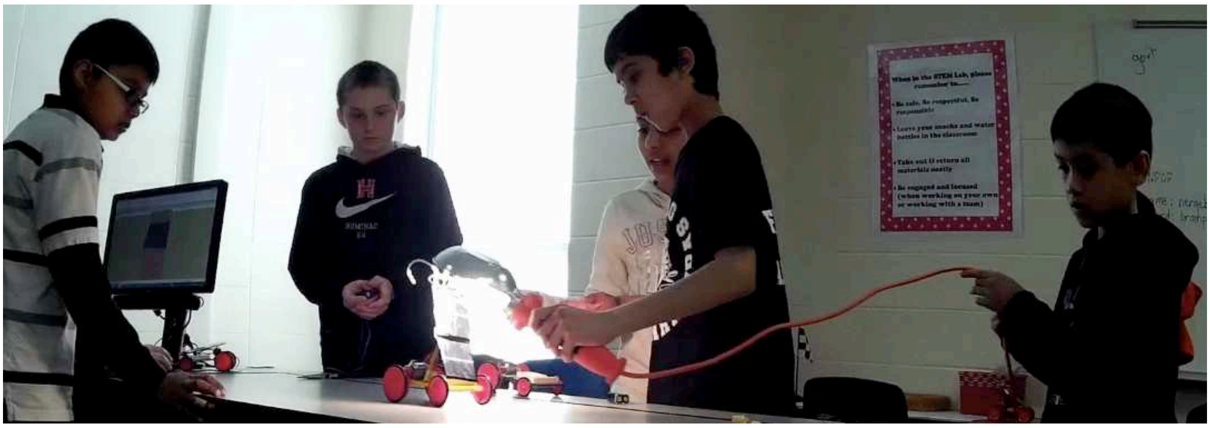

Figure 4. A dynamic grouping of participants testing out their *Solar Roller* car.

Alternative forms of 'assessment'

Another difference from school is that FUSE participants are never graded and they self-document their completion of challenges, which unlocks subsequent challenge levels in a sequence. Our approach to assessment seeks to balance the need to recognize participants' achievements in a fair way (i.e. that they have been active participants in completing a challenge) with the concern of not wanting students to fall back into the learned helplessness with respect to self-assessment and achievement recognition that is so common in schooling (Dweck, 1986). We accomplish this using a combination of careful challenge design and a documentation and endorsement process.

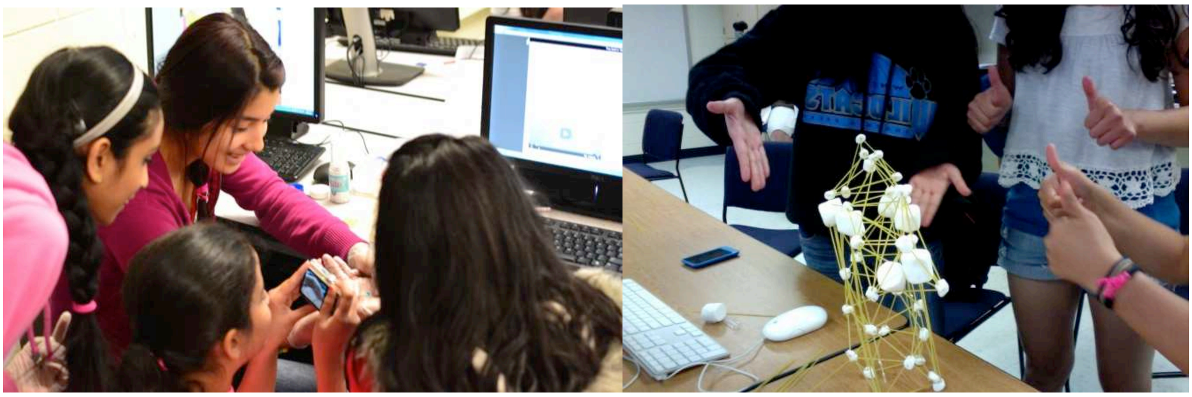

Figure 5. Participants self-documenting success on a challenge (Just Bead It, left; Spaghetti Structures, right).

Our alternative to standardized assessment involves designing challenges that have a clear criterion of success: a light either goes on or it doesn't, a robot navigates to the finish line or not. We want a participant's success at achieving the challenge to be obvious both to the participant and to others in the room. Once a participant has succeeded at a challenge, they self-document their success by capturing and posting a photo or video of it on our site, or by uploading a digital artifact (3D design, mobile app code, etc.). The image on the right in Figure 5 below shows a group of girls documenting their completion of a *Spaghetti Structures* challenge. What is especially striking is that they are in the picture with their artifact-an indication of pride and ownership in their work that is rarely seen when students complete a math worksheet.

By shifting the ownership of 'assessment' away from the teacher and to the participants themselves, we make a move toward investing participants in the quality of their own artifacts, towards a sense of pride of accomplishment. In fact, we have observed numerous occasions where participants have gone well beyond the requirements of completing a challenge and have become deeply invested in an artifact they are creating. One girl spent nearly 12 weeks refining the design of her earrings for the first level of the jewelry design challenge. She could have easily gone on to complete the remaining levels and numerous other challenge sequences in that time, but she chose instead to invest in producing something that met her own standards and personal goals.

Changing the role of the teacher

In FUSE, adults play a facilitative or coaching role, rather than delivering direct instruction and coordinating grading and assessment. This arrangement is driven by both theoretical and practical considerations. Practically speaking, the diversity of challenges makes it unreasonable to expect a teacher or other facilitator to be expert at such a broad range of topics, tools, and skill sets. We have found, however, that this realization has been liberating rather than intimidating for teachers. It seems that the very diversity of challenges has forced the recognition that *a priori* mastery of all challenges is impractical. Freed from the traditional role of being the all-knowing expert, teachers have embraced their new role in FUSE as a coach and fellow problem-solver. Participants often become more expert at certain challenges or technologies (e.g. the 3D printer) than the teacher. We have observed numerous examples of the teacher referring questions to one or more of the participants who have become recognized in the room for their deeper expertise.

Reconceptualizing production of 'curriculum'

Our approach to designing activities in the form of challenges and sequences is very different from traditional curricular design approaches (e.g., Wiggins & McTighe, 1998). The traditional approach begins with a set of disciplinary knowledge standards and then projects those standards into an organized set of curricular activities and formal assessment instruments and media; traditional curricula are built as standardized packages that are significantly monolithic, minimally revisable, expensive, and largely indifferent to individual student interests. Our design approach is fundamentally modular and evolutionary, in which challenges are dynamically created, positioned, repositioned, revised, and discarded in relation to other challenges that precede them that have proven successful. The crucible of participant engagement, as measured by persistence in working to achieve challenges, has been and will remain central to our design approach. A similar logic organizes our approach to designing distinct sequences; we design new sequences if we find we are not engaging a segment of the youth population. For example, in response to a desire to better engage female participants, we introduced a jewelry design challenge using a 3D printer. This challenge sequence markedly increased the percentage of female participants engaging in 3D design challenges and remains among our most popular challenge sequences.

We use the data from our website to determine which challenges appear to be sticking points for participants. How they are sticking points cannot be determined from the analytics; we use the analytics data to guide us to where to look in our field data (i.e., video recordings) to determine how and why challenges are problematic. Challenges may be uninteresting, have instructions that are hard to follow, lack sufficient scaffolding, or increase the level of difficulty from prior challenges too quickly. We then revise challenges and sequences on the basis of what we find from field observations. For example, in our Robot Obstacle Course sequence, we saw a drop-off in engagement after level 2. In-room observations and interviews revealed that the introduction of a required sensor was too big a step between levels 2 and 3. In response, we inserted a new level 3 so participants could understand how the sensor worked before requiring them to integrate the sensor into a complex program (now moved to level 4). We regard this approach as a generative way to use a learning analytics perspective without falling into the naïve view that analytics data alone can provide meaningful and specific guidance for design iteration (Stevens, 2013). For that, we need to look 'beyond the interface' directly at participant activity. The design based research (Design-Based Research Collective, 2003) approach we employ is a significantly new one, in that iteration is rapid and informed in a very direct way by participant experiences; iterations are initiated not by tests of sequestered disciplinary knowledge but by evidence of ongoing, interest-driven participation and engagement in challenge sequences.

Conclusions

To instantiate FUSE as an alternative infrastructure for learning, and to do so in a scalable manner, requires that our website help mediate and structure participant activity and learning. This paper highlighted a number of specific functions served by the FUSE website in doing so:

- **Enabling personalized choices based on interests.** Participants use the website to explore available challenge sequences and to select those that interest them.
- **Providing pathways to deeper expertise.** Initial challenge levels are relatively easy, but increase in difficulty. The leveling up sequence is communicated by the website and provides participants with a clear indication of where they can go next if they choose.
- **Enabling dynamic arrangements for learning.** FUSE enables more dynamic and flexible arrangements of participants in the room—arrangements that are mediated by the participants themselves and not the teacher.
- **Redefining the role of the teacher.** By shifting the primary content expertise and scaffolding burden away from the teacher, the website transforms his or her role to that of facilitator and guide, allowing a focus on process coaching and nurturing peer learning interactions.
- **Documenting learning outcomes.** The website also shifts the 'assessment' burden away from the teacher and to the individual participants by having them upload evidence of their completed challenges.
- **Supporting peer collaboration.** By disseminating information about which challenges peers are currently working on or have already completed, the website facilitates a rich set of peer collaboration and helping behaviors.
- **Capturing user data to support iterative refinement of challenges.** Analyzing patterns of participant engagement with the set of FUSE challenges provides an important lens into which challenges are appealing, to whom, and which may need refinement.
- **Providing a research platform.** Finally, by mediating learning activity on the website, we are able to study young people's interest-driven learning, problem solving, and collaboration activity at scale and with a level of granularity that would not be otherwise possible.

These shifts in the material organization of learning in school are often initially intimidating to the teachers who facilitate FUSE in their classrooms. However, with time, teachers begin to embrace these shifts and, in interviews, have indicated that they are using some of these elements in their "regular" classes as well. One grade 7-8 science teacher commented:

> Students enter the program with little to no background knowledge and quickly start developing skills in computer-aided design, electronics, and robotics. The enthusiasm students feel when they accomplish levels is contagious and because of the program's thoughtful design, students feel safe and secure with continuing to try new challenges that they previously thought too difficult. Students are instantly hooked and love progressing through the challenges, which are academically rigorous, but also insanely fun, exciting and teen-focused.

As we have highlighted here, the FUSE website is an essential element in the successful implementation of FUSE Studios. It provides both a tool for scaling up to a growing number of implementation sites as well as a research tool for studying learning in an interest-driven context. Most critically, the website demonstrates that technology, when thoughtfully designed and implemented, can in fact "re-mediate" learning in ways that productively transform rather than reinforce the practices of current education systems.

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