The Cutting Edge of Informal Learning: Makers, Mobile, and More!

Contributors: Sherry Hsi, Shuchi Grover

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Overview

Cyberlearning spans in-school and out-of-school learning — and these days, a lot of meaningful learning is taking place outside of classrooms. Amateur designers, students, and artists are teaching themselves and each how to make their own electronic toys, program flying robots, or manufacture custom-designed parts with 3D printers and desktop milling machines. Families are doing science together through making backyard instruments to collect local environmental data and share their data online with other global citizen scientists (Anastopoulou et al., 2011; see Cornell Lab of Ornithology). Kindergarteners to senior citizens are combining traditional physical materials like paper, yarn and fabric, together with digital materials like electronics and sensors to create new homespun fashions, to design useful products, and to pursue their interests. (Buechley, Peppler, Eisenberg, & Kafai, 2013; Peppler & Glosson, 2013.) Important learning is also taking place in public libraries where librarians invite youth to author digital stories, produce new media, and publish personally-relevant stories while museums are hosting workshops to reach different audiences (IMLS, 2014; NYSCI, 2013). These learning experiences prove to be highly influential in the choices that youth make about further education, career pathways, and participation as citizens.
In contrast to traditional classroom learning, informal learning is often:

- interest-driven: learners engage based on their interests, not an externally mandated curriculum.
- learner-centric: adults help as guides, facilitators, coaches, and mentors, but the role is to support the learner, rather than to regulate the content, pace, and progress
- playful in approaches: informal experiences tend to engage participant's imagination, encourage exploration, allow tinkering, celebrate teamwork, and take failure in stride, unlike traditional didactic school experiences
- multigenerational: participants often include be children, parents, and senior citizens learning side by side

- intrinsically assessed: outcomes tend to be tangible and readily appreciated by the participants, with less reliance on formal, standardized tests as outcomes

Informal learning institutions like museums with both structured and unstructured activities by themselves don't guarantee a meaningful learning experience. Today's informal learning more often also emphasizes:

- active engagement: the physical space provides unique affordances for doing, not just collections to be viewed
- building materials: the glass between the learner and the artifact is gone, learners are expected to construct not just appreciate
- multiple representations: learners are encouraged to engage with an idea through multiple media, such as storytelling, sketching, constructing, simulating, visualizing, role-playing, discussing socially
- learning trajectories: the informal experience is less contained to a specific space and time, but may span multiple visits or connect to home, to community, or to school.

The movement among "Makers" is one prominent example of today's approach to informal learning and an important arena for cyberlearning advances. Making is "a class of activities focused on designing, building, modifying, and/or repurposing material objects, for playful or useful ends, oriented toward making a ''product'' of some sort that can be used, interacted with, or demonstrated. Making often involves traditional craft and hobby techniques (e.g., sewing, woodworking, etc.), and it often involves the use of digital technologies, either for manufacture (e.g., laser cutters, CNC machines, 3D printers) or within the design (e.g., microcontrollers, LEDs)" (Martin, 2015). Makers are people who openly share tools, knowledge, and materials who value learning and creativity over profit and social capital (Kuznetsov & Paulos, 2010). From creating new artifacts, hacking software, or repurposing objects, makers are highly motivated, interest-driven learners that seek out new experiences and actively share what they learn in a community. Informal settings, such as science museums, increasingly host making experiences and digital technology is frequently used to enhance the opportunities for learning in these experiences. Martin (2015) provides a comprehensive synthesis of making and argues against a tool-centric approach to bringing making into classrooms. He contends that in order to understand the promise of making in education, educators need to appreciate all three interconnected elements of making-"(1) *digital tools*, including rapid prototyping tools and low-cost microcontroller platforms, that characterize many making projects, 2) *community infrastructure*, including online resources and in-person spaces and events, and 3) *the maker mindset*, values, beliefs, and dispositions that are commonplace within the community" (p. 31).

This kind of informal learning aligns well with educational research about authentic, active education that happens in a social community. Education research has shown that meaningful learning is situated in authentic practices using inquiry-based approaches to solve relevant problems, sharing skills in a community of others, and making meaning through activity and action (Wenger, 1998). Whether using physical or digital materials, learning is mediated by multiple media representations and facilitated through direct experiences and interactions mentored by disciplinary experts, more expert peers and novices in a social community of practice (Lave, 1991). Episodic and distributed, learning is interest-driven, serendipitous, sometimes sustained with access to a network of human and technical resources in their community.

Technology is playing a big role in the maker community to enhance informal learning and to better connect informal with formal learning. The maker community leverages online information extensively from using tutorials, online forums, open shared code libraries, social media, and digital video platforms that connect different aged learners to contribute, discuss ideas, share tips, and self-publish instructional videos. Maker communities also use digital fabrication and a network of physical spaces like community workshops, FabLabs, and tech shops, that allow use of shared manufacturing tools to realize their digital imagined and physically implemented projects. These spaces host novice friendly software for programming, computer-aided design, and digital media production. These same tools and software enable control of microprocessors that are used by robotics clubs to get more fluent in coding and learn computer science concepts and computational thinking. Within blended learning environments, smart phones offer digital access to content and limitless knowledge via ubiquitous, wireless access to the Internet while makers meet in physical communities, festivals, and faires to build, experiment, and test their designs. Physical computing devices ranging from programmable maker technologies like Arduino, servo motors, 3D printers, to computer-controlled milling machines help foster new ways to learn through collaborative computer-aided design, online research, and documentation (Halverson & Sheridan, 2014; MakerEd, 2014; Martinez & Stager, 2013).

However, for technology use to reflect cyberlearning ideals, technology must be more than resource in a learning activity: it must enable the design of activities that connect to what we know about how people learn and thus enhance learning. Thus, a cyberlearning approach to maker activities does not over-emphasize the materials used or the thing made. A focus on the materials or things can sometimes lead to cookbook recipes, narrow instruction, and standardized expectations, ending up in an experience not much different from poor schooling. A cyberlearning view emphasizes the transactions among students, materials, and the social setting — and how those transactions provide students opportunities to explore, investigate, test, and refine their knowledge and abilities. Technologies provide more than a resource for building when they enable students to better represent concepts, to gather data and analyze it, to share knowledge with peers, to discuss theories and construct explanations, to critique and suggest improvements, and to reflect on their own learning.

Cyberlearning projects in informal learning can also go beyond maker experiences, too:

- Mobile devices can provide a layer of augmented reality as learners explore an important physical space
- Museum exhibits can invite visitors to learn via new modes of interacting with the setting and visualizing phenomena
- Sensors and cameras can enable citizen science investigations

Several aspects of learning theory are particularly useful to cyberlearning in informal settings for studying and understanding individual learning and learning that happens in a shared, public environment or social community. More specifically:

- **Constructivism and constructionism** provide long-standing ways to conceptualize learning through doing.
- **Identity** is concerned with how learners' sense of who they are and who they can become is shaped through opportunities to explore their interests, values, commitments, and convictions in relation to their participation and engagement with others, new ideas, activities, and phenomena. Further, youth are drawn to expressing identity through new, social media.
- **Embodied cognition** considers how doing and experiencing in a bodily way leads to learning and connects with learning that may later become more de-contextualized and abstract, and can often involve **tangible interfaces**.
- **Collaborative learning** or more broadly, social learning, provides traditions for designing effective learning experiences for groups and for analyzing social interactions for insights about learning

Cyberlearning is poised to contribute to transforming STEM education by using learning theory and technology to enhance powerful grassroots movements in informal learning and develop entirely new informal experiences. Cyberlearning research is needed both to contribute to design, but also to document how people learn in these new experiences and how learning is improved. Further, cyberlearning is well-positioned to connect these informal advances to issues in school learning. For example, schools are looking to the maker community for ideas about how to teach science and design solutions to problem-based challenges. Teachers see making as way as to support inquiry, project-based learning, authentic problem-solving, and deeper discussions (Honey & Kanter, 2013). Educational leaders see the potential to engage greater numbers of underrepresented groups in STEM-related activities including encouraging more girls and women to pursue computer science to help develop a more diverse technological workforce (Fried & Wetsone, 2014).

Issues

Design and theory development. Because making is both a highly collaborative and mobile activity, making opens up new possibilities for exploring how different mobile technologies and apps can be used to support design work and documentation of individual and group projects. Using digital cameras, smart phones, and tablet computers, students self-document their work, monitor their progress, and contribute to online portfolios. New challenges and research opportunities arise in the assessment of design-oriented projects that are collaborative in nature, multi-disciplinary, and process-driven, accomplished intermittently or intensely over weeks and months with the help from multiple peers and educators.

Connections to other Contexts. A great promise of cyberlearning is that learning will be more connected across informal and formal spaces, such as science museums and schools. Much design research is needed to make this promise a reality, as the culture of school and the cultures of informal learning do not easily mix. It is unlikely to be a good idea to require informal spaces into produce standardized outcomes like achieving a particular curricular goal but also unrealistic to expect that schools can become as interest-driven as informal environments are. Considerable challenges of describing and documenting the learning that occurs in each setting in useful ways for other settings are likely to emerge.

Research Methods. Making is also driving changes to what is being researched and how research is accomplished. Researchers are exploring new ways to advance theories of social learning, interest, and motivation. The objects and artifacts created by learners serve as a reflection of their different selves, providing rich avenues for researchers to study identity formation and identities in practice (Ching & Foley, 2013; Tan, Calabrese-Barton, Kang, & O'Neill, 2013). With learning happening in physical, online, and blended learning environments, new research methods are being created to study these complex STEM-rich environments to examine new literacies, representations, dialogue, design-based learning, and collaborative teaming (Halversen, 2013; Ito, 2009; Litts, 2015).

Measurement and Assessment. Making akin to design-based learning is spurring new embedded assessment tools and cyber-enabled research tools to capture moment-to-moment, emergent learning in out-of-school settings. Rather than using high-stakes tests as measures of learning or teacher-graded work, teachers use digital portfolios, scaffolded peer critique, and documentation support to assess project-based learning from collaborative teaming, solving design challenges, and learner-centered making. Learning analytics and online traces are being used to capture multi-modal interactions, online behaviors, participation, and activity over long periods beyond school hours. Digital videos with high storage capabilities archive months and years of video data empowering researchers to conduct longitudinal, ethnographic studies to analyze-in-depth collaborative inquiry, learning conversations, and teaching practices (see Gutwill, Hido, & Sindorf, 2015). Individuals are not only evaluated for changes to their understanding of STEM disciplinary knowledge, but their inquiry processes, empowerment, and resourcefulness (Dixon & Martin, 2014; Brahms, 2014). Other researchers and their developers are exploring how to design better instructional supports, physical computing materials, programming languages, and design tools to support the development of computational thinking, data literacy, and modeling expertise (Blikstein, 2013.)

Professional Development. New models of professional development are needed to prepare peers, coaches, mentors, tutors, facilitators and other adults who support learners in informal spaces — and may be working with cyberlearning technologies in doing their work. Similarly, new approaches to professional development are also needed to meet the needs of teachers who want to learn how to better facilitate maker activities and to assess maker-style projects. For example, MOOCs and web-based video chats can offer mentors and/or teachers a way to join professional learning communities to discuss issues of practice, and learn ways to assess learning that happens in blended learning environments.

Lack of Diversity in the Maker Movement. Making is meant to bring playful designing and fabrication quite literally in the hands of the learner and is believed to be a democratizing force. However, it suffers from a serious lack of diversity, and underrepresentation of women in minorities. While Kneese & Rosenblat (2014) think this issue simply mirrors general Silicon Valley disparities, Lilypad inventor Leah Buechley believes that MAKE magazine has propagated an exclusionary culture in their choice of featured projects (mostly robots and vehicles) and makers (white men/boys). Clearly taking making into all schools and classrooms will help level the playing field.

Challenges Shared with Other Cyberlearning Areas. As learner engagement in spaces is captured digitally, issues about privacy and data security arise, along with new IRB issues. Likewise, as students create their maker artefacts, issues of copyrights, attribution, etc. can arise. Technological barriers to the flow of information across settings can arise (incompatibility between informal settings and school learning management systems, for example). As institutions tend to reflect societal issues, gaps in equity across gender, race, and other demographic characteristics may persist if not addressed.

Projects

Examples of NSF Cyberlearning projects that overlap with topics discussed in this primer (see project tag map).

Making learning tangible

- EXP: BodyVis: Advancing New Science Learning and Inquiry Experiences via Custom Designed Wearable On-Body Sensing and Visualization
- EAGER: Engineering Inquiry for All at Nedlam's Workshop
- EAGER: Paper Mechatronics: Creating High-Low Tech Design Kits to Promote Engineering Education
- RAPID: Learning in the Making: Leveraging Technologies for Impact
- EAGER: Infusing Learning Sciences Research into Digital Fabrication and Making in Education

More posts: making-learning-tangible

Citizen science

- DIP: Next Generation WeatherBlur: Expanding Non-Hierarchical Online Learning Community Models for Citizen Science
- DIP: Collaborative Research: STEM Literacy through Infographics

- DIP: ScienceKit for ScienceEverywhere - A Seamless Scientizing Ecosystem for Raising Scientifically-Minded Children
- DIP: Potential for everyday learning in a virtual community: A design-based investigation
- CAP: Towards Inclusive Design of Serious Games for Learning

More posts: citizen-science

Informal learning

- EAGER: Collaborative Research: Virtual STEM Buddies for Personalized Learning Experiences in Free Choice Informal Learning Settings
- EAGER: Collaborative Research: Designing Digital Rails to Foster Scientific Curiosity around Museum Collections
- CAP: Innovating Data-driven Methodologies for Documenting and Studying Informal Learning
- RAPID: Learning in the Making: Leveraging Technologies for Impact
- Badge-Based STEM Assessment: Current Terrain and the Road Ahead

More posts: informal-learning

Resources

Martin, L. (2015). The Promise of the Maker Movement for Education. Journal of Pre-College Engineering Education Research (J-PEER), 5(1).

Informalscience.org web site, run by the Center for Advancement of Informal Science Education (CAISE)

Maker Ed (The Maker Education Initiative) – Every Child a Maker

Make: Do-it-yourself projects, how-tos, and inspiration.

Exploratorium Tinkering Studio blog

FabLearn conference web site

Community Science Workshop Network

Readings

This section includes references and key readings documenting the thinking behind the concept, important milestones in the work, foundational examples to build from, and summaries along the way.

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Institute of Museum and Library Services. (2012). Talking Points: Museums, Libraries, and Makerspaces.

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Kafai, Y. B. (2006). Constructionism. In K. Sawyer (Ed.), Cambridge handbook of the learning sciences. Cambridge, MA: Cambridge University Press.

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Kafai, Y. B., Peppler, K. A., & Chapman, R. (2009) (Eds.). The Computer Clubhouse: Constructionism and Creativity in the Inner City. New York: Teachers College Press.

Kafai, Y. B., & Peppler, K. A. (2011). Youth, technology, and DIY: Developing participatory competencies in creative media production. Review of Research in Education, 35(1), 89-119.

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Recent Dissertations on Making

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