Makerspaces in Libraries: Technology as Catalyst for Better Learning, Better Teaching

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Abstract. Across disciplines, the practice of education continues to evolve; supporting organizations such as the library are responding by reworking existing and developing new practices. With roots grounded deeply in constructivist learning theory, the emerging practice of makerspaces in libraries is proving an effective step in that evolution. Examples of associated active learning activity at one such library, an early adopter and first mover among academic libraries in adopting and integrating makerspace in libraries, are presented. The product of leveraging technology as catalyst for active learning and engagement within and beyond the physical commons of the library, a blending of formal and informal learning, accented by increased innovation and entrepreneurship across disciplinary and organizational boundaries, appears a natural result.

Keywords: Active Learning · Learning · Makerspace · Maker Space · Libraries · Future of Libraries · Constructivism · Engagement · Innovation · Emerging Technology

1 Introduction

Informal learning happens anytime, anywhere. Increasingly, the learning associated with formal academic programs is taking place outside of the classroom, driving an ongoing transformation across the educational landscape.[1] As educational practice continues to move toward a model more appropriate for the post-Industrial Age,[2] librarians and the commons of library are becoming ever more integral to the learning and teaching lives of the communities they support. Blending traditional roles of content provision with support of active and collaborative learning, makerspaces in libraries is a relatively recent phenomenon – a natural adjunct that crosses disciplinary boundaries of educational innovation, integration of formal and informal learning, Science, Technology, Engineering, and Math (STEM) outreach and engagement. Combined with the Arts (STEAM), the resulting overlapping confluence of interest can drive innovation and entrepreneurship across the supported communities.

This paper presents examples of activity from one of the first movers of the makerspaces in libraries movement, the first academic library in the United States to offer 3D printing and scanning as a library service available to all.[3] In addition to presenting examples of both self-directed and collaborative learning, specific actions are detailed that have enabled the organization to more closely realize institutional and administrative goals. Rather than merely supporting learning by rote, in a makerspace learning is driven directly by curiosity and engagement on the part of the end-user, with a resulting integration of formal and informal contexts across learning styles. In such an active learning environment the role of librarian is more akin to the view of learning expressed by Plutarch nearly two thousand years ago: "the mind is not a vessel to be filled, but a fire to be kindled."[4] The pages following will offer insight into the changing roles of librarians and the library as it further joins forces across the educational enterprise to kindle and nurture the flames of Plutarch's fire in the minds of learners of today.

2 Literature Review

At its heart, the fundamental philosophy connecting makerspace activity with learning is constructivist learning theory. Halverson & Sheridan[5] frame the role of makerspaces in education as simply a natural evolution of constructivist thought, from Dewey and Piaget through Seymour Papert's Constructionism. Ellis & Philips[1] further note that recent decades have witnessed the practice of education evolving away from the traditional teacher-focused "transmission-style of teaching and learning, which were teacher focused, to a variety of *constructivist perspectives which focus on how the learner constructs meaning through active and social learning and personal context* [emphasis added]." Beyond traditional roles of of selecting and providing access to shared resources, libraries are increasingly moving toward playing more central roles in the teaching and learning lives of their communities.

Whether in support of active learning on the part of the student, or co-curricular development with teaching faculty, the development and support of the constructivist learning environment is key to effective institutional support of learning. Jonassen[6] articulates design principles and lays the groundwork; Stripling & Hughes-Hassel[7] detail the beginnings of more widespread library adoption and support in the introduction of the more formalized concept of inquiry-based learning and the support of collaborative learning communities. In addition to a thorough backgrounding, Woodard[8] frames library support as a function of teaching information literacy skills — importantly, recognizing that *technology can serve as catalyst* triggering learning, changed teaching practices, and different roles for educators themselves. Tracing the natural evolution, Levy & Roberts[9] recognize the changing roles of librarians in the practice of education, and document the emerging roles of librarian as educator and active partner in educational development.

The introduction and rapid adoption of the Framework for 21st Century Learning[10] consolidated the approach and growing support for constructivist and/or problem-based learning approaches by libraries. With mastery of key subjects, such as reading and languages, arts, mathematics, and sciences, at the core, the framework was designed with a vision of ensuring "student success in a world where change is constant and learning never stops." With interdisciplinary themes woven throughout, the framework identifies overarching support for "Learning and Innovation Skills," "Information, Media, and Technology skills," with "Life and Career Skills." Recognizing the role of librarians as vital partners and agents in support of 21st century learners, Kuhlthau[11] recognizes the active hybridization of roles in support of inquiry-based learning with constructivist models of learning. Booth[12] established the foundation for the development of library instructors around deeply constructivist roots, providing a legitimate platform for the use of technologies, emerging and otherwise, into standard library practice, with Beagle[13] recognizing constructivist learning support as emergent in the information commons of the academic library.

With growing library adoption and support of constructivist learning, branded variously as "creative collaboration," "cultivating curiosity," or "21st century learning," such active learning behavior began to be recognized as "maker" activity. Over the same timeframe, associated makerspaces in libraries began to proliferate to meet the needs of "fundamentally experiential learners, actively engaged and solving problems, posing questions, and making decisions."[14] Resources including Beetham & Sharpe[15] began to arrive on the scene, establishing the connections between formal pedagogy and the types of 21st century learning being adopted and supported in libraries worldwide; indeed, a global survey of libraries conducted near the end of 2013 found that fully *seventy-eight percent of respondents either already provide makerspace or were planning to do do in the near future*[16] [emphasis added].

Grounded in learning theory, appropriately framed in terms of 21st century learning, and with growing adoption worldwide, there is growing recognition that makerspace in libraries offers an environment in which formal and informal learning can blend naturally. Driven by self-interest, spontaneous and collaborative engagement in makerspace activity can enable members of communities of practice to develop and hone competencies associated with formal academic programs.

3 Active Learning in Practice

Across education, it is widely accepted that much of the learning by students enrolled in academic programs takes place outside of the formal classroom. Even with recent innovations such as flipped classrooms, it is when the learner actively engages with the materials to be learned, whether or not as "home" work, that learning happens. In practice, for a majority of students significant amounts of learning is taking place in a collaborative fashion as students actively engage with one another around the topic of study. Whether school library in K-12, an academic library in higher education, or public library where boundaries cross, the library is one of a small number of places ideal for the activity. Rather than the formality of the classroom, or the informality and relative solitude of home, the library is a "third place;" [17] intrinsically neutral, and dedicated to values of equal access to all, it is a place where learners gather.

Technology has always been a catalyst for learning in the library. Consider the book itself, or codex, a technology that only came into existence in the fifteenth century; prior to that library technology included papyrus scrolls or even stone tablets. Over recent decades, that technology has expanded to include photocopier machines, ICT such as personal computers and laser printers. In a makerspace technology typically expands further, and might range from pipe cleaners and glue guns to 3D printers and laser cutters.

a. Active Learning

In any examination of library technology that directly supports teaching and learning across disciplines, obvious things like collaborative study areas are too easily overlooked; conversation areas are powerful tools in support of collaborative learning. The library can leverage and encourage such informal learning behavior simply with the arrangement of furniture and ready availability of resources. In the case of the DeLaMare Science & Engineering Library, non-traditional library technology introduced included whiteboards and markers. In combination with an active encouragement of conversation, and availability of study tables that also lent themselves to use as whiteboard surfaces, ad-hoc study groups began to form throughout the library. In 2010 an initial pilot of two rolling whiteboards with a writeable surface four feet in height and eight feet in width was quickly expanded to a total of six. With heavy use, the library continued to expand the availability of ad-hoc collaboration areas throughout the library by painting entire walls with whiteboard paint.[18] By 2013 the library had over 20,000 square feet of whiteboard writeable space – throughout a space that is roughly 22,500 square feet in total – and there are times in the semester when that is still not enough. The library is alive with formal and informal learning behavior; although predominantly student-driven, faculty regularly leverage the space to hold office hours and review sessions with ready access to space to encourage students to engage directly in moderated problem solving.

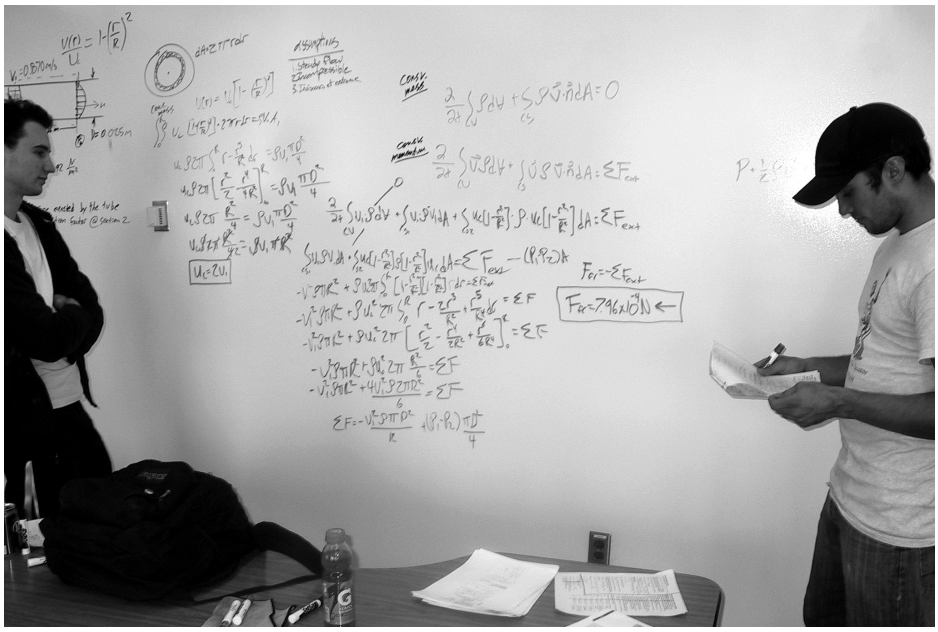

Fig. 1. Ready availability of writeable "whiteboard" surfaces throughout the library seem to greatly improve the formation of ad-hoc collaborations between students attempting to problem solve and learn formal academic course material.

Driven by requests from the communities supported, novel resources and services added by the library in support of active learning range from 3D printers and scanners, a wide range of lendable technology, laser and vinyl cutters, and even a printed circuit board mill: each is information technology that serves to catalyze both self-directed and collaborative active learning. As an example, at the University of Nevada, Reno, all incoming freshman students enrolled in Engineering are required to pass the ENG 100 introductory course. In that course, students are introduced to basic concepts of engineering by means of group projects that include building robotic hovercraft piloted and controlled by LEGO Mindstorms technology and box fans, powered by a hydrogen fuel cell. In support, the library provisions LEGO Mindstorms robotics toolkits that are available for checkout. Custom parts are regularly designed and 3D printed for new designs, and the laser cutter is regularly busy cutting shapes from Styrofoam and other materials to assemble. Fig. 2 shows a snapshot of one such group actively constructing a prototype within the spaces of the library, with ready access to supporting technology.

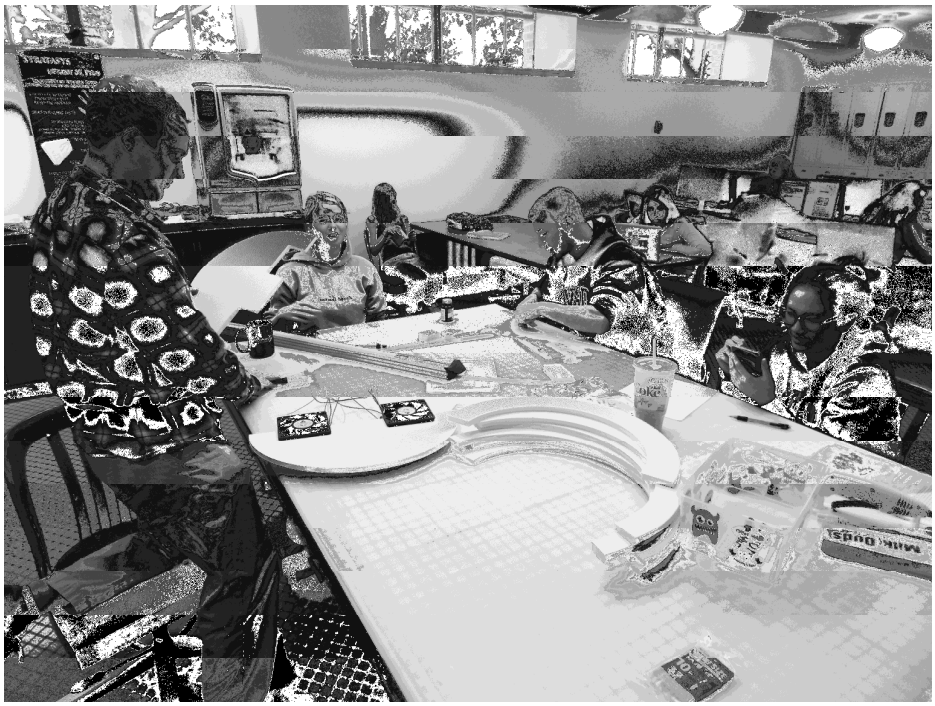

Fig. 2. Students regularly utilize the spaces and rapid prototyping services of the library to collaboratively develop projects; in this case a team of ENG 100 students are actively engaged in assembling the pieces of their custom robotic hovercraft design on the main floor of the library. Note the structural pieces recently cut from a sheet of Styrofoam by means of laser cutter technology provisioned in the library.

Similarly, for advanced courses such as Statics, the laser cutter is regularly used by students to precision cut designs from balsa wood prior to assembly and testing of designs. In a real sense, the laser cutter is simply another type of "printer," producing the precise shapes by cutting away the excess material in a subtractive process. The rationale for implementing such a shared service or resource in the library is simple: libraries are fundamentally about sharing and supporting sometimes expensive technology to the benefit of all. The ability to rapidly prototype and test ideas is on the critical path to learning and the creation of new knowledge, and the library is a natural hub.

Fig. 3. A team of engineering students assembling a real-world model of a truss bridge from balsa wood structural members precision cut to their design specification; successful designs sustain can static loads far in excess of 300 pounds.

b. Innovation and Entrepreneurship

With ready access to rapid prototyping equipment, combined with the creative abrasion and intellectual stimulation that comes about naturally in such an active hub, it is not surprising that innovation and entrepreneurship are natural results. One such example is the *hummingdoc*[19] – a stethoscope adapter for earpods that, combined with a similarly developed smartphone app, can enable the user to listen to and analyze heart and lung sounds. Initially conceived to enable expectant parents to hear their as yet unborn child's heartbeat without needing to go to the doctor's office, the product was prototyped with the 3D printing services of the library and members of the supporting community. The product went on to be a product of a separately created limited liability company, Hummingdoc LLC, with product actively being sold and delivered.

Another example of a product conceived and prototyped with support of the library's makerspace equipment and services is the *InfinitByte* flash drive.[20] Designed around the use of microSD cards, the waterproof and ruggedized drive holds two cards yielding a capacity of up to four terabytes operating at speeds of up to 5Gbps. Its inventor, a retired military Blackhawk helicopter pilot instructor, spent a substantial amount of time working with students at the University to develop the part designs to exacting specifications using 3D modeling software in the library. After an initial Kickstarter crowfunding campaign failed to reach needed funding goals, its designer, and the students he had been working with, learned critical business lessons. In response to feedback from the campaign as to pricing, he reworked his supply manufacturing chain and was able to reduce the anticipated final cost by more than half, to something on the order of a few tens of dollars; a second Kickstarter campaign is currently under development, with an anticipated near-term launch.

Beyond directly enabling innovation and entrepreneurship, the benefit of learning on the part of the students involved in such cases cannot be overstated – the sort of learning that can at best be presented as a theoretical in the classroom environment. Authentic experiential learning, driven by real-world considerations, has repeatedly translated into direct benefit for those involved; beyond knowledge creation, providing skills and experience that is valued in academia as well as in private industry.

c. Engagement Leading to Outreach

The technology of the library is proving to be a key ingredient in outreach and engagement. In addition to K-12 and academic liaison outreach, the availability of a continuum of lendable technology in support of self-directed learning is proving watershed. Consider a crossover example that combines curiosity, building to full engagement, disciplinary, and career choices, leading directly to entrepreneurship. A student, self-described as "flailing and uncertain," and without having declared a major by the end of his sophomore year, borrowed an entry-level micro-programmable from the library. After exhausting interest with the Makey-Makey kit, [21] with its ability to control web-based games by means of simple connections, he returned and checked out the next step: a Sparkfun Arduino Inventor kit[22] with associated how-to documentation.

A few weeks later the student renewed the kit, with its wealth of electronic bits and pieces, stepping up to check out a Raspberry Pi, assorted shields, and a soldering iron kit. The following semester, the author heard directly from a faculty member of the robotics lab on campus about a new student who had "mad skills" – he could program, solder, prototype… it was in fact the very same student. Note that the skills that were most valued by the Engineering faculty member were not those that were being taught in the formal classroom, but those that had been learned by the student on his own with access to appropriate and supporting resources through the library. Fig. 4 is a picture of the student in the robotics lab, where he worked for the remainder of his undergraduate term, proudly showing the forearm of a prototype android he had constructed. Even the 3D printed white ABS plastic structure of the forearm and digits was a direct product of engagement with library resources, as he had printed the pieces with the library's 3D printing and scanning service.

Although one might expect an associated entrepreneurial effort to be associated with robotics, upon graduation this past year the student joined forces with a fellow engineer to create the online company *dringo.org*[23] to connect students with businesses by means of crowdsourcing the search.

Fig. 4. Prototype android arm, controlled by logic assembled on the breadboard circuit in the student's right hand. Note that the structure and enclosure of the forearm and digits is composed of parts fabricated by means of the library's 3D printing service. Photo credit: Nick Crowl.

4 Summary and Conclusion

This paper has touched on only a few of the many examples witnessed in the library over the past year. Reimagined to not only allow for, but encourage active learning, the examples presented in can only hint at the tantalizing possibilities: full engagement with the active learning environment of makerspaces in libraries can be transformative. Motivated by curiosity and self-interest, and supported by the resources of the library, acquisition of 21st century skills ranging from information, media, and technology skills to innovation, life, and career skills are a natural outcome of engagement with the resources of the library. In addition to blending traditional roles of content provision with support of active and collaborative learning, opportunities for engagement and creative abrasion across STEAM disciplines are driving innovation and entrepreneurship across the community.

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