Scaling Up: Challenges and Lessons Learned During Implementation of Phase Two of an Academic Makerspace

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Abstract: In 2017, the University of Wyoming (UW) College of Engineering and Applied Science, together with the UW Libraries and the UW IT department, unveiled a temporary experiential learning makerspace in the largest campus library. This Coe Student Innovation Center (CSIC) makerspace — the first phase of a broader makerspace initiative at UW – was designed to explore student and community interest in a budding maker movement in southeast Wyoming, and to gauge whether such a center would be a useful and regularly utilized addition to campus. Almost two years on, and with more than 6,500 visitors to date, 224 events hosted, and a 155% rise in usage from year to year, the CSIC has proven very successful, enabling the University to not only green-light the planned transition of the makerspace from its temporary location to a permanent home in the new Engineering Education & Research Building, but also to maintain the current CSIC space as a K-14 outreach facility and introductory makerspace. This paper sets out to provide a useful guide to other makerspaces or experiential learning centers as they prepare to transition from Phase I (inception and early development) to Phase II (significant growth and development of established policies, protocols, usage, and instruction). The paper discusses the challenges and lessons learned during the planning and build-out of a campus-wide makerspace network, and lays out the steps necessary to enable both facilities to expand in scope, maintain active, engaged userbases, share policy and ideas, and collaborate together effectively.

INTRODUCTION

The Student Innovation Center (SIC) network at the University of Wyoming (UW) is made up of two complementary makerspace facilities: the Coe Student Innovation Center (CSIC), aimed at K-14 STEAM outreach and offering introductory equipment, and the Engineering Education and Research Building (EERB) Student Innovation Center (EERB SIC), geared towards advanced use and offering a wider array of state-of-the-art desktop, benchtop, and industrial equipment.

The development and evolution of the SIC makerspace network falls into three phases: (I) inception and early development; (II) development of established policies, protocols, usage, and instruction; and (III) optimization and further expansion [1]. To date, Phase I objectives have been met through introduction and operation of the CSIC.

It is the intent of this paper to serve as a guide for other academic makerspaces seeking to expand the scope and impact of their active learning centers by sharing our lessons learned, challenges encountered, and recommended practices identified during the SIC network's transition from Phase I to Phase II. The paper also outlines the goals, expected outcomes, and challenges of Phase II as the University transitions to two collaborative makerspace facilities.

BACKGROUND

Within academia, makerspaces provide hands-on, collaborative, creative ways to encourage campus community makers to design, invent, and experiment as they engage in interdisciplinary STEAM subject matter typically related to classes, research, or personal entrepreneurial projects.

Although the SIC makerspaces are not the first of their kind on the UW campus, they are the first large-scale, multidisciplinary facilities at the University to provide accessible, dedicated space for all students to create, collaborate, and innovate. As part of an initiative in 2012, a makerspace (the EERB SIC) was planned to be incorporated in a new Engineering Education and Research Building (EERB) scheduled to open in Fall 2019. In the interim, a temporary makerspace (the CSIC) officially opened during Fall 2017 in the largest campus library in order to assess community response, to chronicle the lessons learned, and to assess the equipment needed to run the EERB SIC. Construction on the EERB was completed in Spring 2019. Located on the building's first floor, the EERB SIC includes a makerspace, wood shop, and a reconfigurable student project center. The overwhelmingly positive responses from both the UW community and from constituencies in southeast Wyoming led to the decision to keep the CSIC space as a sister facility to the EERB SIC.

Since its inception, the CSIC makerspace has welcomed 6,500 unique visitors, with the busiest month attracting 810 total visitors and the slowest drawing 113. There have been approximately 361 visitors a month, of whom about 75% are drops-ins with interests in using equipment, and the remainder are typically tours groups wishing to engage in directed activities. Of all the activities and equipment offered at the CSIC, 3D printing, 3D scanning, virtual reality, and use of the K-12 stations (Lego, Lego Mindstorms, littleBits snap circuitry, Ozobot robots, and MakeyMakey circuitry kits) are the four most frequently requested stations, in order.

The CSIC has also scored well as a forum for events, tours, and activities. The 224 events hosted serve to foster interest in the wide-ranging academic and personal applications that a makerspace provides; encourage faculty and staff to consider how the space might be used in their curricula or research; and motivate use by community members in personal, research, or entrepreneurial projects. Of these events, 92 have been informational tours and 132 have been directed activities.

Broadly, the two SIC makerspaces exist to help champion a rich, user-driven maker culture at the University, and to celebrate innovation, creativity, empowerment, experimentation, accessibility, and exploration. UW's campus makerspaces serve to promote educational applications, research endeavors, real-world skill development, and to ready students for employment opportunities.

Specifically, the goal of the SIC is to provide complementary experiential active learning environments across the University of Wyoming campus to foster student innovation, creativity, curiosity, and entrepreneurship through state-of-the-art technology and interdisciplinary collaboration.

PHASES OF MAKERSPACE DEVELOPMENT

In order to best serve the community, address further opportunities, and find solutions for the challenges detailed in this paper, the SIC must continually improve its performance. According to Foertsch [1], there are three phases of makerspace development:

Phase I covers inception and early growth, and involves research, strategy, and initial planning. Phase I might include a committee defining questions such as scope and programming. During this phase, a makerspace might address issues concerning initial location and equipment, legal structure, budgeting, and membership requirements. For the SIC, Phase I was considered complete after expectations for student and community usage were met; that sufficient introductory protocol, instruction, and practices were established; that a five-year comprehensive strategic plan was drafted; and that the EERB SIC was approved for development.

Phase II includes in-depth implementation, strategy, and operations. Phase II makerspaces are those that are more established, and have a firm grasp on their identity, vision, mission, permanent location, and membership base. Milestones during this phase might include establishing longer-term facilities, prioritizing creative functions that determine necessary equipment, creating and maintaining policies and procedures, and establishing educational programming and events [1]. The SIC makerspaces are currently considered in Phase II.

Phase III makerspaces are those that are networking effectively with other existing groups to create mutual advantage. A makerspace might be considered in Phase III when it begins to expand further, create adjunct makerspaces or companies, and establish governance and leadership succession. During Phase III, a makerspace might refine the quality of the makerspace experience and optimize its size and function [1].

CLASSIFYING MAKERSPACES

Makerspaces are becoming increasingly common in higher education. Research by the SIC found that 164 out of the 311 universities (52.7%) across the United States listed by the 2018 U.S. News & World Report National University Rankings [2] offer some form of active learning makerspace environment. And yet the term "makerspace" can be ambiguous, and might refer to a wide array of different types of facilities.

As such, there is a need to standardize the means by which these makerspaces can be compared. Wilczynski [3] proposes that all higher education makerspaces follow a standardized classification system that assigns numerical ratings to five indices: scope (S); accessibility (A); user base (U); footprint (F); and management/staffing (M). In addition to drafting a strategic plan and assessing phases of development, the SIC strongly encourages using this classification system as a third means by which to assess Phase II makerspace progress. For Phase I makerspaces, such rankings can help identify closest academic makerspace peers or potential collaborators, as well next tier influential spaces that a facility might aspire to emulate.

The SIC conducted an internal ranking of all 164 recognized makerspaces and identified the University of Idaho and the University of Southern Mississippi as the most similar to our own, with a shared ranking of S-1, A-4-P, U-1, F-2, M-3.

CHALLENGES FACED AND LESSONS LEARNED DURING PHASE I

As part of the strategic planning report, the SIC conducted a SWOT analysis and made the results available on our website, https://www.uwyo.edu/sic/. The analysis identified four critical challenges:

Challenge 1: Increasing user base and user retention

In the first months of the CSIC's operation, SIC staff focused almost entirely on development of the space, staff training, and visitor feedback to determine what resources and instruction to offer. Publicity was largely word-of-mouth. During the second and third semesters of operation, focus turned to hosting monthly workshops and to awareness advertising campaigns as well as information booths in high-traffic areas that attracted 990 student visitors over eight days. Since the launch of the awareness campaign, there has been an average monthly rise in usage of 155% from prior-year visitor counts, with the highest growth (285% from September 2017 to 2018) matching the four most popular information booth dates (567 students).

The SIC is also addressing the longer-term challenges of visitor and volunteer retention—challenges cited frequently by academic makerspaces [4]–[8]. Specifically, SIC students have established a student organization (the Association of Wyoming Student Makers, "AWSM") that is tasked with helping to maintain the space and equipment and train visitors. In exchange, AWSM members get discounted or free access to materials, unrestricted access during open hours to develop projects, and the ability to vote on important makerspace policies. A student-run organization that can participate in many levels of decision-making has been found to help facilities be more successful [6], [9], [10]. This community-centered approach provides students with a level of accountability to run the space and guide its growth [11]–[16]. Students develop a greater sense of ownership and seek to participate and voice suggestions more readily [17]–[20].

According to Burke [21], community "is the defining element of the maker movement." To encourage this sense of community, collaboration, and ownership, the SIC has set up a "Maker" volunteer program that currently has 18 student volunteers and four participants under 18 years old. These Makers and Junior Makers are expected to track hours and help improve the spaces. The SIC developed a badge rank and reward system to support these two programs, with 12 categories ranging from safety training to 3D printing and 3D modeling. Program incentives include new volunteer titles, ranks and authority, and discounted access to equipment materials.

Challenge 2: Expanding workshops and training

To address the paramount issue of user safety and effective training, the SIC developed an online interactive safety training course hosted on the University e-learning website. Visitors must pass the course before being allowed to use equipment or be in the space unsupervised. To this end, SIC staff are developing a series of interactive online training modules for all remaining equipment. The development of flexible, self-driven online content, in addition to an increase in in-house weekly workshops, is expected to boost the number of active makerspace participants.

Challenge 3: Breaking down barriers, promoting resources, and fostering relationships

Studies suggest that the most successful makerspaces are those that empower students to "learn by doing" [22]–[27]. SIC makers are taught the skills necessary to run machines safely, and then given the autonomy to use the space without direct supervision. This self-reliant, open-ended atmosphere can instill in users a greater sense of confidence and accountability [13], [23], [28].

Student-centered inquiry and experimentation can drive innovation. Through this trial-and-error approach, makers can be encouraged to embrace a "right to fail." Martinez and Stager suggest that when students are encouraged to take risks, experiment, and explore ideas, they are more likely to view their ideas as both valuable and achievable [29].

There is also a persistent misconception that makerspaces are exclusive to engineers or technologically-savvy users. Some visitors have expressed worry that they lack the experience necessary to use the SIC. One way to correct such misperceptions is to significantly increase our active user base, including outreach to underrepresented groups [4], [30], [31].

Likewise, university departments may not immediately see how their students could benefit from using makerspace resources. It is important for fledgling academic makerspaces to promote interdisciplinary collaboration and to engage faculty and research staff. The SIC's response has been to host workshops and open-houses designed specifically to appeal to those constituencies. Of the 224 events the SIC has hosted, 25% have involved informational tours or open-houses designed to break down barriers and encourage use by specific academic groups.

At the same time, the SIC has sought to strengthen ties to the local community. Such connections can also help align with the state's innovative and economic goals. The relatively small number of community-focused informational events (5%) hosted to-date suggests that the SIC should seek to increase its presence in the community through additional outreach events.

Finally, the SIC sees heavy use from K-12 educators and classroom visits, most often through directed activities. Of the events hosted, 12% have involved informational tours or open-houses aimed at K-12 educators interested in facility tours and information on how to use the makerspaces in primary and secondary educational applications.

The SIC has finalized most of the policy, procedure, and protocols necessary for staff to run the makerspace effectively but has not yet made these publicly available. To encourage communication across creative communities, SIC has begun compiling an online database of all known Wyoming makerspaces and what they offer. For new makerspaces, a central site that enables members and visitors to access, edit, and add content (such as a wiki) can be useful to disseminate information among academic makerspace peers. The site will soon also enable visitors to participate in peer forums, view equipment status, request access, download lesson plans, show accreditation, and view campus facilities and equipment locations.

Challenge 4: Collecting data and benchmarking academic makerspace trends
Another important goal is the continued benchmarking of improvements and growth. Wilczynski's classification system can help makerspaces find and reach out to other facilities that most closely align with their own in terms of progress and policy, and enable makerspaces that are similar in scope or phase to establish direct partnerships.

Data collection and usage statistics are crucial to ongoing support for new makerspaces, and are essential when applying for grants or appealing to donors. The SIC staff are developing an inexpensive, RFID and Arduino-based visitor counter that can distinguish between demographic groups. Digitizing usage statistics can allow for more accurate data collection and reliably quantitative measurements than manual head counts.

GOALS OF PHASE II

According to the SWOT analysis and data gained from comparisons to similarly ranked institutions, the SIC's next steps within Phase II should be to 1) continue making students and community members aware of the facilities; 2) increase the frequency, accessibility, and availability of training and workshops; 3) continue to build our returning user base and enable them to use equipment unaided; and 4) digitize SIC visitor and usage statistics.

The decision to maintain both the CSIC and the EERB SIC as sister spaces requires that goals laid out in the original strategic plan be revisited. The SIC advisory committee has determined that the CSIC will be run by an on-site specialist directed by both Information Technology and Library staff, whereas the EERB SIC will be maintained by an on-site specialist under the College of Engineering and Applied Science. Importantly, both spaces, despite being under separate management and funded by separate departments, must still work together effectively, evolve as a unit toward the goals outlined below, promote interdisciplinary use, and share policy and ideas freely. The four Phase II goals necessary for the SIC to maintain momentum toward Phase III are detailed below.

Goal 1: Increase data collection
Justification for grant funding often depends on access to robust data sets describing use of facilities or equipment. The SIC seeks to increase its efforts to digitize and automate a number of these data sets in order to gather more robust data on user demographics.

Two institutions—MIT and Georgia Tech—use smartphone apps in addition to card reader systems [32], [33]. MIT's "Mobius" program addresses information accessibility and gives users a single platform with which makers can check in, show credentials, and find all information needed to access the MIT makerspace resources [34]. Georgia Tech's "Invention Studio" works in similar ways but also includes forums; a means to report problems with machines, service, and staff; and real-time push notifications regarding equipment and project status.

Goal 2: Continue to reduce barriers to student engagement
The SIC is exploring use of key card readers to provide after-hours access using existing University IDs. User pairs who have undergone sufficient and rigorous training [9], [13] would be allowed in to the space at any time during building operation. This may enable makers to work on projects during more convenient or during quieter periods. Such a system can also produce a digital record of after-hours use [35].

Trust, communication and sufficient training should be central to any effort to empower students to work unsupervised. Mylon et al. [13] suggests that when a makerspace supervisor makes all the decisions, students abdicate responsibility and feel less ownership and responsibility for maintaining a space. Morris [36] suggests that "students thrive in a space where they can freely develop new ideas in an unconstrained manner. They want to be able to go from ideation to creation without a high barrier to entry."

Another key to driving engagement is to allow student members to help decide makerspace policy and purchases. The SIC has given the Association of Wyoming Student Makers the right to vote on issues. Recently, student staff and RSO members have proposed ideas for and voted on operating hours, tour protocol, significant equipment purchases, and space layout. This is influenced by MIT's model, which permits students to vote for and make minor purchases of replacement parts, equipment, and general supplies [10].

Goal 3: Reinforce public relations, community support, and outreach
A Phase II makerspace should work well with all entities, from local community through the state and national level, where applicable. Thus, the SIC aims to foster a greater sense of community among Wyoming makers by sharing information via its website and Wikipedia server by end of 2019. The SIC also intends to establish stronger roots in the community to address the gaps in progress identified by Wilczynski's classification system. To this end, the SIC intends to host two major annual events beyond its regular monthly programming: a maker competition proposed and run by AWSM, and a Maker Faire for southeast Wyoming.

Goal 4: Maintain partnerships across all SIC facilities

For the University of Wyoming's CSIC and EERB SIC to be successful, they must work well together when it comes to protocol and policy. The CSIC is meant as an introductory space for students and community members interested in making. After sufficient training, visitors might be shepherded to other advanced spaces on campus that might suit a specific need or interest.

There is still a need to determine the scope, identity, and role that both SIC spaces will play to complement the other. To address this, the SIC intends to establish the "Makerspace Community Subcommittee," comprised of campus community members. A democratic, community-driven approach to decision-making is common across academic makerspaces, and helps promote a sense of ownership, leadership, and autonomy among students and community makers.

CONCLUSIONS

In its first two years of operation, the Student Innovation Center makerspace network at the University of Wyoming delivered on its Phase I goals by developing and expanding an experiential learning makerspace located in the largest library on the campus. As the makerspace evolved to meet the growing needs of its early participants and to accommodate rapid growth in new user communities, so too did the need to extend the network to include a second, advanced-use makerspace. This paper explains how the University of Wyoming makerspace network addressed the challenges identified during this expansion. Specifically, the paper discusses two metrics from existing literature that can be effective for benchmarking the development of an academic makerspace and for identifying its development phase. The paper highlights the hurdles involved with building up and retaining a community, increasing engagement, and empowering users. It also describes what the SIC had to do to augment its workshop database, break down barriers to broader access for the campus community, promote the network's capabilities and resources, and better collect and analyze data on attendance and usage of the makerspace facilities and services. Lastly, the paper details the SIC's approach to setting and communicating the long-term goals necessary for new makerspaces to maintain momentum as they move into Phase II of their development – goals that include widening access for new potential users, as well as forging partnerships with other makerspaces and extending outreach to local communities.

We hope that the challenges outlined here can help new makerspaces to grow and expand more effectively by providing guidelines and lessons learned during our own development.
This paper and the lessons learned, recommended practices, and research detailed here can serve as a useful, effective guide to other academic makerspaces currently seeking to expand in scope and impact from Phase I (inception and early development) to Phase II (significant growth and development of established policies, protocols, usage, and instruction).

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