AN EVOLVING MAKERSPACE FOR TEACHER EDUCATION

Tonia A. Dousay, *University of Wyoming*

If you could design a makerspace, what would it look like and whom would it serve? How does location fit into your planning? What about expertise? How will you sustain your facility? Last, but certainly not least, how will you staff the makerspace and how does programming or mission impact staffing? At the University of Wyoming, conversations about the maker movement became a reality when we opened a makerspace for teacher education in the College of Education. From initial design to the funding of the space and our teacher education mission, this design case chronicles the processes, considerations, and decisions we faced that may help others who find themselves in a similar situation.

Tonia A. Dousay is an Assistant Professor in the School of Counseling, Leadership, Advocacy, and Design at the University of Wyoming. She is the director of the WyoMakers makerspace on campus and serves on the larger maker education planning committee for the University. Her scholarly and teaching interests focus on instructional and multimedia design, teacher education, learners as designers, and design-based learning.

WHY A MAKERSPACE FOR TEACHER EDUCATION?

Now in their ninth year, *MAKE* magazine created the flagship Maker Faires in 2006 as a mechanism for celebrating the do-it-yourself (DIY) mindset and movement that had begun to take shape in communities. Three flagship faires now occur every year in San Francisco, CA (Bay Area); Chicago, IL; and New York, NY (World) with other featured faires occurring in Newcastle, UK; Cairo, Egypt; Miami, FL; and Sachsen, Germany (MAKE, 2017). In the midst of this growing movement, faculty members in an instructional technology graduate program that also serves teacher education began discussing what impact the maker movement might have

on formal learning and in PK12 classrooms. Conversations considered to what extent schools might adopt the philosophies emerging from makerspaces and what this might mean as we serve preservice teachers. Steeped in constructionism (Papert & Harel, 1991) and tapping into intrinsic motivation (Kurti, Kurti, & Fleming, 2014b), makerspaces now number in the thousands across the United States and the world (Hackerspaces, 2016; MakerDirectory, 2016; Makerspace Network, 2016). Would schools try to replicate the activities and events that occur in a community makerspace? Could teachers find ways to work maker activities--based primarily on informal learning strategies--into rigid instructional plans designed to align with standardized testing? What tools common in makerspaces would appear in a school-based makerspace, and how would this impact our technology integration course for preservice teachers? With educational policy discussions swirling in the nation's capital that would eventually become the *Every Student Succeeds Act* (U.S. Department of Education, 2016), we anticipated another shift in the innovative education landscape. The decision was made in 2013 to prepare a proposal that would lead to the establishment of a makerspace with the explicit purpose of supporting teacher education. The WyoMakers facility opened in October 2014, and this design case chronicles how the author--an assistant professor of instructional technology--designed the space and activities that take place in the makerspace as well as how this effort has influenced the maker movement across campus.

CONTEXT

It should be noted that the University of Wyoming (UW) is the only public, four-year university in the state, and the majority of teachers in the state are graduates of our university and teacher education program. With this unique characteristic in mind, the College of Education currently houses approximately 60 full-time faculty members divided into four departments: Elementary and Early Childhood Education (EECE), Secondary Education (SE), Educational Studies, and Professional Studies. Instructional technology faculty are organized in the Department of Professional Studies as a graduate-degree granting program that also supports teacher candidates in the EECE and SE departments by offering undergraduate-level courses in technology integration.

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The Mary Garland Early Career Fellowship, an opportunity provided through the John P. Ellbogen Foundation, helps new tenure-track faculty at UW by providing funds to help establish a research agenda. While the early conversations about how we might integrate maker education within the college did include another faculty member, the fellowship opportunity requires working individually. Other faculty members, both in instructional technology and teacher education at large, have provided and continue to provide encouragement, feedback, and intermittent support related to space and activity planning. The majority of faculty and administrators in the college expressed little to no knowledge about—or experience with—maker education despite a strong desire to expand into this area of education. As a result, my intent with the fellowship proposal was to combine the design- and student-created media components of my research agenda with a service opportunity that closely aligned with the Ellbogen Foundation's mission of statewide education impact. In the years since proposing and launching the makerspace, more faculty in the college (and university at large) now engage in maker education activities, either within the context of WyoMakers or independently.

INITIAL DESIGN CONSIDERATIONS

When setting out to draft the fellowship proposal, I began with examining the landscape of making within the state of Wyoming as well as the similarities and differences between community-based makerspaces and PK12 school spaces. The following questions guided this information gathering phase:

1. Where is the facility located?
2. Who staffs the facility?
3. How do they pay for supplies?
4. What equipment does the facility use?

Results from this analysis generated ideas about (a) placement of the space, recognizing that we would be bound by the available space on our campus; (b) staffing ideas, taking into consideration funding for student workers and/or volunteer staffing; (c) funding options, considering crowd-sourcing/grant sources as well as using pay-to-access models; and (d) equipment lists. Three overarching priority themes helped with organizing research notes, drafting the proposal, and making final decisions:

1. Ensuring a priority on teacher education.
2. Focusing on digital making due to known building constraints.
3. Reviewing how space and design activities carried out might help or hinder my research, teaching, and service agendas.

First and foremost, the priority of the makerspace had to revolve around teacher education. The John P. Ellbogen

Foundation (2012) supports teaching and leadership with a specific emphasis on statewide impact. Therefore, from proposal to implementation, any sort of making facility must align with this mission. Thus, the proposal briefly explored existing makerspaces in the state with particular attention to a new makerspace housed in a large school district that sometimes accepts our university's preservice teachers for residency experience. A component of outreach programming also made up a small portion of the proposal to address how the makerspace might serve inservice teacher professional development and engage PK12 students in on-campus activities. The other primary component of the proposal focused on the budget and potential equipment list. Ultimately, the proposal was funded and I set out to establish WyoMakers in Fall 2014.

Location

Having the initial proposal approved, the first step taken before making any actual purchasing or staffing decisions involved the location. A quick web and literature search at the time revealed that libraries were emerging as a likely home for makerspace facilities (Bowler, 2014; Halverson & Sheridan, 2014; Kurti, Kurti, & Fleming, 2014a). While established connections and partnerships with some of the university libraries staff did exist, my primary concern with a library placement was that doing so might obscure the teacher education priority due to lack of proximity. Thus, I began by requesting a room from the College of Education. After a preliminary review of available space, our associate dean responsible for space allocation offered a former office located in one of the college's three dedicated buildings.

At approximately 14 feet by 14 feet in dimension, or 200 square feet, and located in one of the oldest buildings on campus, the room was not well aligned with its intended purpose but presented surprising benefits. First, being in an older building, we struggled with wireless internet access, and the wired ethernet in the building does not conform to current standards. To mitigate this issue, some of the fellowship funds were spent purchasing a wireless network extender. Even with additional infrastructure, careful planning determined how and when to conduct significant software updates so as not to interrupt daytime use and internet traffic. Second, the building primarily houses faculty and administrative offices, which meant that the makerspace was not in the general path of students—a concern that required continuous efforts to relocate the space as soon as possible. Lastly, while not directly related to the purpose of the space, the building's history of being the university's original athletics dorm lent an unexpected quality to the environment. Specifically, the office was formerly the dorm's common room and has a fireplace in the corner that now holds a set of electric fireplace logs. The presence of the fireplace posed an interesting design conundrum in determining whether or not to conceal the fireplace with furniture or highlight

the corner with other furniture. Keeping in mind what equipment might be purchased, immediate considerations focused on how to place furniture in the makerspace and work with the size and infrastructure constraints.

During initial space set-up, a retired faculty member stopped in to discuss the purpose and goal of the space. After learning about the teacher education and outreach goals, the faculty member donated an old, leather chair to the makerspace that is original to the building. In considering how the chair might fit with the purpose of the room, the gratefully accepted donation became a centerpiece of the makerspace. As a “maker” and maker educator, I made the blanket depicted in Figure 1 to both complement the chair and reinforce the idea of *making* or using personal interest in knowledge and skills to build the makerspace. In the end, the chair found a home next to the fireplace and has come to be known affectionately as “the thinking chair.”

Staffing

After answering the question of location, the next step involved staffing the makerspace. During the review of makerspace profiles, I visited dozens of websites for both community and school-based makerspaces. A small sample of makerspaces consulted include:

PK12

- Jackson Hole High School (Wyoming) Digital Fabrication Lab <http://www.jhhsfablab.com>
- Lewis and Clark Elementary (Missouri) MakerSpace <https://lc-lps-ca.schoolloop.com/MakerSpace>

UNIVERSITY

- Texas A&M University Engineering Innovation Center <http://engineering.tamu.edu/easa/areas/enrichment/eic>
- University of Nevada, Reno Innevation Center <https://www.unr.edu/innevation>

COMMUNITY

- Chicago Public Library *Maker Lab* <http://www.chipublib.org/maker-lab>
- Geek Group <http://thegeekgroup.org>

FIGURE 1. The “thinking chair” in its current location of WyoMakers.

For PK12 school-based facilities, staffing more often than not connects directly to specific faculty who take ownership of the facility such as libraries or transformed classrooms. University-based makerspaces use various staffing models that include paid student workers, volunteer student staffers, and/or paid staff members to direct or manage a space. Similarly, community-based makerspaces use a variety of staffing models, but more often rely on volunteers than paid workers. However, community spaces that charge membership or workshop fees also sometimes have paid staff. Likewise, community spaces in public libraries sometimes leverage existing paid staff.

Taking all of the models into consideration while conversing with college leadership, we decided that I would serve as the facility coordinator and we would use the paid/volunteer student staffing concept based primarily on budget constraints. I should note that serving as the space coordinator does not come with a monetary benefit or reduction in traditional faculty responsibilities. In other words, I do not receive course buy-outs for my oversight of the facility. Rather, my coordinator duties serve as an integrated approach to my existing teaching, research, and service obligation. With this consideration in mind, I developed a staffing model that would allow for general open hours, private sessions, and outreach events primarily served by students who qualify for work-study employment through the student financial aid office. Through the work-study program, we offer employment to three students each semester at no direct cost to the space, the college, or the university. Instead, the students’ salaries are paid through federal financial aid disbursements,

and we monitor working hours closely to prevent accidentally exceeding the maximum allowable hours worked per week. Students majoring in education are encouraged to apply for the positions, and two of the three current student employees are elementary education majors. When programming needs conflict with student worker availability, I distribute calls for volunteers through targeted invitations to preservice teachers who have previously taken courses that I teach. Additionally, I am able to address more long-term, repeated staffing needs through independent study credit in cooperation with our EECE and SE departments. Now into the second full year of staffing, the hybrid paid/volunteer/credit approach functions well enough to maintain open hours during the day as well as support occasional after hours and weekend events.

Equipment, Funding, and Budget

As previously noted, a fellowship program provided the initial funding for establishing the makerspace. In total, \$25,000 was provided across two years as a start-up initiative. The initial proposed budget for the makerspace appears in Table 1.

The bulk of the budget in the proposal focused on equipment, with some consideration for software, supplies, and travel to promote makerspace activities. Missing from my preliminary research and notes was a consideration for marketing materials such as giveaway items, branding banners, and informational cards. Thankfully, the fellowship guidelines allowed for flexibility in deviating from a proposed budget, especially that some of the budgeted items were available at zero cost. When the need for other funding priorities became apparent, I began looking for efficiencies and applying the constraints of other decisions, such as the location. For example, the size of the room granted to the makerspace

ITEM	PRICE	QTY	TOTAL
MakerBot Replicator 2	\$2,200	1	\$2,200
3D Printer Filament	\$50	20	\$1,000
Adobe Creative Cloud	\$250	4	\$1,000
AutoCAD Inventor Suite	\$1,200	2	\$2,400
Google SketchUp EDU	\$0	4	\$0
GorillaPod Stand	\$30	10	\$300
GorillaPod Micro	\$25	4	\$100
PC Workstation	\$1,500	2	\$3,000
iMac Workstation	\$2,500	2	\$5,000
Nexus 7 tablet	\$250	5	\$1,250
Surface RT2	\$450	5	\$2,250
Conference & Research Travel	\$6,500	1	\$6,500

TABLE 1. Initial makerspace budget.

only allowed for two computer workstations (PC and/or Mac). Additionally, I learned that the AutoCAD Inventor Suite from AutoDesk was available free of charge to educational institutions. Further, I was able to reduce travel expenses by partnering with other offices on campus to collaborate on projects and presentations. Savings from travel were applied to the other areas of the budget as I moved forward with making purchases.

An additional \$2,500 was received from the Department of Professional Studies in recognition of a successful first year of the fellowship and showing progress towards the proposal goals. A broadly categorized breakdown of the total \$27,500 appears in Table 2.

Examples of each expense category include:

EQUIPMENT

- 1-PC/1 Mac workstation
- 2-3D printers
- 1-laser printer
- 6-Sphero SPRK robot kits
- 1-3Doodler EDU bundle
- 1-wireless network extender
- 5-Nexus 7 Android tablets
- 1-iPad Mini
- 2-green screen kits

SOFTWARE

- Adobe Creative Cloud Suite
- Shutterstock image subscription
- Adobe Captivate license

SUPPLIES

- 3D printing filament
- acetone
- markers
- paint
- adhesives
- toolkits

MARKETING

- branded lanyards
- wall decorations
- banners/posters
- postcards/flyers
- t-shirts
- sponsored giveaways

TRAVEL

- International Society for Technology in Education (ISTE) conference registration

EXPENSE	BUDGETED AMOUNT	% OF PROPOSED BUDGET	AMOUNT SPENT	% OF ACTUAL EXPENSE	% CHANGE
Equipment	\$14,100	56.4%	\$17,823	64.8%	8.4%
Software	\$3,400	13.6%	\$3,554	12.9%	-0.7%
Supplies	\$1,000	4.0%	\$1,403	5.0%	1.0%
Marketing	\$0	0%	\$2,864	10.4%	10.4%
Travel	\$6,500	26.0%	\$1,831	6.7%	-19.3%

TABLE 2. Makerspace expenses and budget comparison.

- Society for Information Technology and Teacher Education (SITE) conference registration & travel
- Educational Technology World Conference (ETWC) travel

Admittedly, once the initial budget became more flexible, spending decisions were based less on preliminary research and more on immediate needs.

The *Sphero SPRK* robot kits illustrate an activity project that arose out of a discussion with other faculty and a desire to offer an after-school club at the campus preparatory lab school. Anticipating reduced travel expenses, we purchased the technology with the intent of supporting the immediate need and building the capacity for supporting future projects. Given that the robots have since been used extensively for more than a half a dozen campus-based workshops and were featured at the WyoMakers maker table during the 2016 National Maker Faire in Washington, D.C., this decision proved wise. Of note, the latter activity garnered two editor's choice awards from the editors of *MAKE* magazine during the event. The *MAKE* magazine editors attend the flagship Maker Faires and distribute ribbons intended to recognize creative, innovative, and/or diverse maker activities (MAKE, 2015). Additionally, the marketing materials now serve as a conversation piece as community members visiting the makerspace for the first time mention seeing a banner, being given a postcard, or notice someone wearing a lanyard or t-shirt. These expense decisions at the time seemed frivolous, but now prove useful as the maker movement expands across campus and the state. As we seek to expand the influence of the makerspace or establish new partnerships, the makerspace brand has provided the first line of familiarity and introduction.

Aside from offsetting travel expenses, equipment purchasing decisions changed the most between the proposed budget and final expenses. Initial activity consideration focused heavily on digital makings, such as 3D design, application and software development, mobile photography and videography, and 3D printing. As illustrated in the similarities and differences between the budgeted expenses in Table 1 and the actual equipment purchases, the inherent activity concepts did not change. Rather, specific applications and equipment necessary for the activities expanded. For

example, the physical location did not have room for four workstations, two PC and two Mac. This change meant having an extra \$4,000 available in the budget to purchase the Sphero SPRK robot kits, 3Doodler EDU bundle, and green screen kits. The benefit of a flexible budget allowed for a dynamic and more complete planning of activities. I was able to redirect budgeted funds from no longer necessary equipment, such as the Surface RT 2 tablets, towards other needed expenses, such as the wireless network extender and laser printer. In the case of the Surface RT tablets, feedback from information technology professionals on the lack of long-term sustainability helped inform the decision not to purchase this equipment. Ultimately, being less certain and more flexible allowed for the makerspace to evolve rapidly, adapting to meet our needs.

Sustainability

Initial funding for the makerspace was provided by way of the start-up fellowship. However, active planning for long-term sustainability includes both research-based grant opportunities and community donations as well as a subsidized funding model. A partnership with the UW Foundation, the nonprofit charitable unit of the University, allows private donors to give tax-deductible donations designated for use by WyoMakers as a subunit of the College of Education. Further, we participate in the crowdfunding component available to faculty through the Foundation, YouFund. Through YouFund, we are able to create project campaigns similar to those currently found on Kickstarter.com or DonorsChoose.org. These project campaigns promote specific projects planned for the future and attract donors willing to support a particular need, such as soldering stations or sewing machines for an expansion of makerspace programming. Through planned grant applications to support research projects, more funding has also become available to fund supplies and equipment. Lastly, we are implementing a funding model that uses hobby or personal projects to subsidize academic or course-based projects. Whether a visitor wants to use paint or filament to 3D print an object, a formula to calculate actual supplies expense plus 20% helps inform how much to charge. Examples of hobby or personal projects include the graduate student who designed and 3D printed components of a live-action role play (LARP) costume he

used for an event. The proceeds from his project supported paying for the cost of materials used by the student group who designed and 3D printed components for their rover entered into a NASA competition as part of their senior design project in engineering. Combined, all of these funding mechanisms help support the makerspace as it continues to evolve and meet the needs of our campus community.

EVOLUTION OF THE SPACE

Reflecting on the process of establishing the makerspace, more time was spent on researching equipment and layout of the environment rather than the activities that occurred in it. Well-documented guidance places the environment and activities at the top of the list of considerations (see also Kurti et al., 2014b). However, *knowing a thing* and *engaging in a thing* are often two different endeavors. A shifting economic climate on campus combined with the fellowship guidelines clouded my judgment, and I failed to fully consider the learners, culture, and activities as these components make a whole. This reflection occurred early in the second year of

operating the space, and subsequent activity planning has highlighted the inherent weakness in the early approach. More specifically, “there is no amount of bright, shiny new technology that can take the place of inspiration, and inspiration is a direct result of the environment created by the space” (Kurti et al., 2014a, p. 9). The first year of the makerspace felt very unstructured as a result of my emphasis to purchase initial equipment and supplies. Another way to consider the situation might be a comparison to the 1989 Kevin Costner film *Field of Dreams*. Essentially, I had built it, but no one was coming to use the makerspace. Without planned activities, the unintended consequence was a staffed room full of new purchases without any activities or programming in place to use the equipment. While the branding efforts helped in bringing awareness to the facility, I still needed to find other ways to attract visitors, encourage the utilization of the space by other faculty members, incorporate the makerspace into my own teaching activities for preservice teachers, and connect with similar facilities in the area and state.

FIGURE 2. WyoMakers makerspace at the University of Wyoming. Reprinted from “Defining and differentiating the makerspace,” by T. Dousay, 2017, *Educational Technology*, 57(2), 69-74.

FIGURE 3. Exterior marketing banner.

Location

The initial location provided by the College of Education placed the makerspace in a building primarily intended for administrative offices. This location not only placed constraints on size and capacity, but it also restricted visibility and access to students. Figure 2 depicts the initial space with furnishings and equipment. As visible in the pictures, once all the furniture was arranged, very little room remained for seating or actual activity work. While we could have removed the large circular table in the center of the room, this would have eliminated a space for collaboration or project planning. We also considered removing the wing-back chairs or futon placed below the windows, but these design choices reinforced the desire for a makerspace to be comfortable and inviting (Brahms, 2014). When hosting activities in the location, we found that we were limited to no more than 12 people, but fewer than 8 worked best. From a physical space perspective, more than 12 adolescents and adults required individuals to crowd one another or stand in the doorway or on furniture in order to see demonstrations. When actively working, only two to three individuals could sit at the table holding the computers and only four to five individuals could sit around the large circular table. Once everyone was seated and tables moved to accommodate movement around the room, anyone attempting to sit on the futon or in the wingback chairs could not easily walk around the room. Conversely, small groups of two to five people actively working on a project found the room comfortable for collaborating, planning, and building. For example, a pair of computer science graduate students used

the makerspace to plan, design, and build a remote sensor system and corresponding mobile app to control the system. The students could easily shift between the computers when researching, purchasing additional supplies, or making changes to the app program or turn to the circular table to assemble or modify the remote sensor casing. Unfortunately, when groups needed to store projects, the location failed to provide adequate room for storing or cataloging multiple projects beyond the lower shelf beneath the two 3D printers (see bottom right picture of Figure 3). This aspect forced students to bring their project and all related supplies with them and then take these with them when leaving.

If the primary purpose of the makerspace was to attract students to use the facility for class projects and help education majors consider how to use similar spaces as a teaching tool, we had failed miserably in terms of location. Even with a horizontal banner 4 feet wide by 2 feet tall hanging above the main entrance to the building (see Figure 4), few students or visitors knew where to find the makerspace. In the first two years of operation, the most common comments received via email or through our Facebook page entailed some form of inquiring about the location, asking for explicit directions or expressing concern over not being able to find the building when walking on campus.

At the end of the second year in the initial location, I was able to successfully petition the college for relocation. I enlisted the assistance of another instructional technology

FIGURE 4. Makerspace location. The initial location is marked in red, and the new location is marked in green.

faculty member, the associate dean, and an office assistant to brainstorm possibilities. The colleagues recommended co-locating the makerspace with the PC computer lab located in the college, possibly allowing us to more closely align the facility with the preservice technology integration coursework. However, other college staff expressed discontent with the idea citing noise concerns and a general disruption to the college's information technology current practices. Further discussion revealed a possible location in the college's classroom annex building, repurposing an under-utilized room that housed vending machines and study tables. Benefits of this new location included placing the facility directly into the path of students as two classrooms flank either side of the room. In addition, the room possesses a large picture window to the right of the locking door, allowing passersby to view activities occurring in the space or projects currently in progress. To help illustrate the location differences, Figure 4 depicts a campus map with the original location marked in red and the new location marked in green; both locations are within the blue box. While the two locations are relatively close together, the primary difference lies in the path or flow of student traffic. McWhinnie Hall's proximity on the edge of the primary green space and administrative purposing means that few students or visitors venture near the building's entrance unless planning to visit a faculty member's office. Conversely, the Education

Classroom & Literacy Center, or annex, primarily serves as a classroom building, housing the dual-functioning Literacy Research Center and Clinic in the basement.

Layout

The relocation in Fall 2016 brought about a need to reconsider general room layout. Figure 5 illustrates the general set-up where we situate the two 3D printers on a steel table at one end of the room. We also use a repurposed photography lighting stand to hold filament for the printers. The updated infrastructure of the building supports making use of modern wireless networks as well as multiple ethernet ports available around the room. This allows us to consolidate and group equipment more effectively as well as the flexibility to move equipment around based on individual project needs. Additionally, emerging research on fumes from 3D printing (Azimi, Zhao, Pouzet, Crain, & Stephens, 2016) brought about a new concern for safety and ventilation. While we still look for more research on the topic and better ways to ventilate the 3D printers, the new room has the advantage of being in a building with a high-efficiency particulate air (HEPA) heating, ventilation, and cooling system coupled with placement near a window. Student workers and project designers are instructed to open the window when completing large prints to help reduce the likelihood of fumes

FIGURE 5. New makerspace arrangement.

from accumulating in the room. With more square footage in the new room--approximately 14 feet by 20 feet--we take advantage of the open layout for setting up equipment such as a green screen kit or convening groups for instruction near the printers or workstations. Rather than the large circular table in the original location, we now have two smaller, rectangular tables that visitors can easily move and rearrange based on activity needs. It is common to enter the makerspace twice in any given week and find the furniture has been rearranged. The larger dimensions combined with easily moved furniture allow--and even encourage--students to take control over the environment and customize it based on current needs. For example, students working on mobile photography projects often set up lighting from the green screen kit on the tables--keeping the two together in a large square. Alternately, a group of students working on a 3D model prefer separating the two tables and moving the 3D printers to set one on each and a gap in the middle to allow for easily monitoring progress or working on the printers to troubleshoot issues. Lastly, the new room includes a chair rail wiring system for both electricity and ethernet ports making working from anywhere in the room easier regardless of project type or equipment needs.

TEACHER EDUCATION INTEGRATION

Preservice Teacher Education

The teacher education focus represents the singularly stable component of the WyoMakers makerspace. Regardless of physical location, staffing, or equipment, helping preservice teachers takes priority over all other activity planning. Once the initial space opened, an informational update was

provided to all departments within the College of Education. This overview provided targeted handouts and details regarding what activities the space could already support, what plans were underway, and how the departments might consider using the space. As a result of this effort, many faculty members and graduate students now schedule the makerspace for guest lectures during methods instruction or reserve available equipment for use with preservice teachers in lesson and activity planning. For example, the agricultural education methods instructor first reserved the makerspace in Fall 2015 for two hours to help introduce 3D printing to students and demonstrate proper use and safety with the equipment. The lesson developed for these students generated a Pinterest board of 3D printing applications in the agriculture industry as well as lesson plan concepts the teacher candidates might consider for future lessons. Based on student feedback and successes demonstrated during teaching residency, the same instructor reserved WyoMakers for two separate two-hour blocks in Fall 2016. During the first block, students received similar instruction as the previous year. During the second block, students completed individual tasks related to designing teaching aids in the space and practiced parts of their lesson plans that might make use of the technologies.

This early experimentation has resulted in the space being directly integrated with two secondary education programs: agricultural education and science education. These two programs now follow the two-block plan described earlier as part of methods instruction every fall semester. The integration situates the space within the context of unit planning and encourages preservice teachers to explore innovative

lessons and activities as they prepare for student teaching residency. Students initially visit the makerspace with their class to see the facility and demonstrations on the various technologies available followed by individual consulting visits to discuss with either the work-study student workers or myself to brainstorm activities. Other secondary education subject areas are considering how they might also take advantage of the facility.

Within the curriculum and instruction program, which serves both preservice teachers enrolled in undergraduate study and inservice teachers enrolled in graduate study, individual courses have taken a similar approach to integration. For example, the *Literature for Young Adults* course now reserves the makerspace to introduce students to digital video production. Through multiple scheduled visits, students learn about the green screen tools available, explore stop-motion animation creation, and delve into copyright issues as these concepts apply to creating a book trailer--a required assignment for the course. New requests are received each semester as more teacher education faculty seek similar ways to take advantage of the facility, whether to introduce students to technologies for in-class activities and assignments or to require students integrate the available technologies into the lesson plans they design.

As previously noted, I also invite education majors to serve as facilitators for workshops or drop-in activities hosted in the space. For example, two art education majors who previously completed the introductory technology integration course with me volunteered an hour each week for six weeks in 2015 when WyoMakers sponsored a design elective course for middle grades students enrolled in the campus preparatory lab school. These two volunteers assisted with the weekly class meetings, gaining practical experience to help inform their residency experiences as preservice teachers. One of these students later led a day-long rotating workshop for the 2016 Wyoming Latina Youth Conference by designing an activity using the 3D printing pens we have in the space. He spent two weeks preparing for the activity: designing a paper-based template for the girls to use as they learned 3D drawing, and planning the outcomes of the activity. Under his direction, we re-arranged the tables to allow for four girls to sit at each one, supplying a *3Doodler* pen and copy of the template for each girl. During each session of the workshop, he instructed the girls on how to heat up the pens, use the template to get accustomed to 3D drawing, and progress towards drawing a free-standing tree or plant--blending science with art instruction. When a preservice teacher leads a makerspace activity, they are asked to write a brief reflection on the experience, which is then shared to our public website along with photos of the event. This purposeful closure to the volunteer service is intended to help the student provide documentation to future employers regarding their extracurricular practical experiences.

The aforementioned independent study courses also represent a pilot effort coordinated by myself and current college leadership. The EECE department is actively exploring new concentration areas targeting science, technology, engineering, and mathematics (STEM) experiences. Given the ease of implementing these types of activities in a makerspace, we are considering how hybrid practical experiences (HPEs) (Zeichner, 2010, 2012) might help better prepare preservice teachers for the current PK12 environment. For example, WyoMakers helps support the Laramie Robotics Club, and I, as both the space coordinator and an education faculty member, provide supervision for undergraduate education majors who serve as mentors in the club. These students work two hours each, assisting 6-12th-grade students in the club and maintain a journal of their experiences as mentors. As we look to fully implement HPEs, such an experience might be conducted as a scheduled, semester-long or condensed summer course and require preservice teachers to act as facilitators or mentors for weekly workshops and clubs delivered in the makerspace. Conversations with the associate dean for undergraduate education in the college also include investigating how these experiences might count towards required practicum hours that must be completed prior to teaching residency.

Inservice Teacher Professional Development

Tangential to the preservice teacher priority and as the sole educator preparation program (EPP) in the state, we also incorporate inservice teacher professional development. Through partnerships with faculty in the college already conducting active teacher professional development programs, WyoMakers provides an opportunity for teachers to experience emerging technologies such as virtual reality, robotics, and 3D drawing. Some examples include participating in grant-funded teacher professional development programs to provide instructional support or access to emerging technologies (see also Burrows et al., 2016). Other activities occur through outreach such as hosting demonstrations for PK12 students and teachers. Even teachers visiting as chaperones of student visits find value in being exposed to technologies not available at their school. During demonstrations, we allow time for individual discussion with the chaperoning teacher(s) and/or administrator(s) to explore how the technology might be used in their context and how they might secure funding for the equipment.

Additionally, through coordinated efforts with the state International Society for Technology in Education (ISTE) affiliate, Wyoming Technology-Engagement-Curriculum Connection (WyTECC), and the Wyoming Department of Education (WDE), we also host remote professional teacher development through targeted sessions at statewide conferences. For example, I delivered a "cardboard pinball machine" session at the 2016 WyTECC conference where teachers and administrators actively designed and created

their own cardboard pinball machines using pizza boxes donated by the local Papa John's Pizza, marbles, springs, foam shapes, cardboard tubes, pipe cleaners, and other miscellaneous supplies from the makerspace. The session began with introducing the participants to Caine's Arcade (Interconnected, 2017), the story of a young boy's adventure in creating a complete arcade out of cardboard games in east Los Angeles. Discussion during the hands-on building included the science standards addressed by the activity and how different grade levels might use the activity to keep students engaged during the final weeks of the school year. Another example of inservice professional development includes "pop-up makerspaces" where I and some of our volunteers bring some of the equipment available in the space and source local materials to take over an open area at an event to engage visitors in station-based activities. In both of these examples, inservice teachers are able to receive state-approved professional credit for engaging in professional development, and the teachers are able to explore maker education.

To help facilitate networking and collaboration efforts among PK12 makerspaces around the state, I also established the Wyoming School-Based Makerspace Network (University of Wyoming, 2016): a virtual directory where schools can submit a profile of their facility, and anyone can view these profiles. This network serves to help educators and administrators connect with those more experienced in the maker education framework or identify potential partners when planning activities and professional development on their own.

COLLABORATING ACROSS CAMPUS

Approximately one year after WyoMakers opened, other maker education initiatives launched across the UW campus. A faculty member in the Visual Art program, Mr. Brandon Gellis, established the *3-D ArtScience and STEM Maker Laboratory* with support from grants related to integrating art and science. Much like how WyoMakers exists primarily to serve teacher education, the 3-D ArtSci lab directly targets students in the fine arts degree programs. A few months later, the College of Engineering and Applied Science (CAES) began to finalize plans for a large student innovation center (SIC) focused on making and tinkering in a new building still under design. Recognizing a need for internal expertise, CAES faculty invited my participation in early needs analysis and equipment discussions. Together, Brandon, myself, and the CAES associate dean, Dr. Steve Barrett, are working with a Libraries faculty member and the UW Information Technology (UWIT) office to design the SIC. We meet regularly to work through all of the same design questions faced while creating and establishing WyoMakers. While each makerspace on campus will target a primary student population based on coordinating or sponsoring faculty

members, all of the facilities promote movement between the spaces depending upon an individual learner or project teams' needs for equipment and/or expertise. Additionally, as a broader campus maker network becomes more established, we plan to offer joint workshops and events around interdisciplinary learning themes.

REFLECTIONS ON THE DESIGN

Location

Perhaps the most important lesson learned in this endeavor is that of location. None of my prior research on creating a makerspace really addressed the location component. Library- and classroom-based makerspaces do not necessarily grapple with the location as students will most always have cause to be in the area. Community-based makerspaces usually lease space or locate in high traffic areas of the city, and I saw no real discussion about location for university-based spaces. Even when institutions built new structures or repurposed existing facilities, elements of the space itself took precedence in descriptions and profiles. Now that WyoMakers sits in the direct line of student and visitor traffic, requests for usage have increased more than 50%. Thus, I now stress the importance of physical location to both university and community makerspace planners.

Sharing Expertise

Establishing a makerspace does not need to imply that the primary coordinator(s) will have expertise in all activities. Early demonstrations and hosted classes in WyoMakers relied solely on my prior knowledge or willingness to learn a new skill. I had not yet established collaborations and relationships on campus or at other institutions. Part of my outreach activities now include cataloging the expertise of those who use the space and/or lend knowledge and skill to projects. The additional presence of the school-based maker network helps me quickly direct new requests to appropriate individuals or invite guests to speak and conduct activities in the space.

Short- & Long-Term Strategic Planning

While I did take into consideration how to sustain the makerspace once established, early plans lacked a vision to evolve over time. The budget issues that forced flexibility also led me to revisit my research on facilities and eventually conceptualize a framework for defining spaces (Dousay, 2017). Characteristics of individual spaces formed into general themes related to:

LOCATION

- Permanent facility housing a space and all activities
- Mobile framework providing expertise at remote, on demand locations

FIGURE 6. Framework for defining makerspaces. Reprinted from “Defining and differentiating the makerspace,” by T. Dousay, 2017, *Educational Technology*, 57(2), 69-74.

TECHNOLOGY AND TOOLS AVAILABLE

- Industrial arts; mechanical repair and electronics, woodworking and fabrication, cooking and crafting, and computer labs with digital technologies (Sheridan et al., 2014)
- Digital fabrication equipment and software

PERSONNEL

- Paid staffers
- Volunteer staffers

ACCESS

- Open access
 - Membership
 - Per use charge
- Closed access

Figure 6 depicts these themes as a multidimensional framework with each line representing a spectrum. The spectrum

serves to help a space consider both initial operating priorities as well as long-term sustainability and evolution. The spiral shape twisting around the axis represents a multi-dimensional nature. In its current state, WyoMakers might be classified as an open, permanent facility with mostly digital technologies using both paid and volunteer staffers.

Developing the framework helped me not only define the makerspace but also consider how the facility might evolve over time. As awareness of the space and demand for maker activities expands across campus, demands on the makerspace might dictate that I close access to allow only pre-service and inservice teachers access to the tools or priority scheduling. As I might be able to relocate and expand the facility, WyoMakers might shift to offer both industrial arts tools/activities and digital technologies. Should a different funding model become available or the ability to use work-study paid staffers decreases, I might move farther left or right along the personnel spectrum. All of these questions

must be answered based on the lessons learned and the design decisions already made thus far. In the end, the most important guiding question for any changes will always be, "how will this change support teacher education?"

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