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A Review of University Maker Spaces

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A Review of University Maker Spaces

Introduction

As society continues to progress in a globalized world, the necessity for more and better engineers is increasingly apparent. The engineer of the future needs to be able to harness creativity and innovation in order to stay competitive and relevant in an economy with ever growing needs.[1] It is therefore the responsibility of the university to cultivate and grow these skills in their students. It has been seen, though, that the undergraduate curriculum lends itself to diminishing creativity in students.[2] As such, there is opportunity for improvement in the undergraduate experience in order to not only alleviate this effect, but to also improve on vital engineering skills that are currently underdeveloped in graduating engineers. According to the creators of the Conceive-Design-Implement-Operate initiative (CDIO), skills beyond strictly technical knowledge such as interpersonal skills and critical thinking are in high demand in industry.[3,4] This is supported by the recently released ASEE Transforming Undergraduate Education in Engineering (TUEE) Phase I report.[5] Fostering these skills is, however, no easy feat in the already tightly packed engineering curriculum. The current system has a heavy emphasis on theory and mathematical modeling as opposed to a more practice based curricula, which was the standard engineering education approach until the modern approach gained favor in a shift that occurred between 1935 and 1965.[6] As a result of this shift, many engineering students do not spend much of their time engaged in actual design and build processes until late in their degree program.[7]

Maker spaces have an opportunity to revolutionize the current system by providing an extra-curricular means for students to engage in more hands-on projects and develop a large range of the skills that are currently being underdeveloped. Maker spaces go beyond the traditional machine shop environment familiar to the undergraduate curriculum offering access to rapid prototyping equipment and conceptual design spaces coupled with a unique culture that can be transformative to its users.[8] The concept of the university maker space is young, with the first dating back to roughly 2001 at MIT.[9] Consequently, the full effect and impact of these spaces is not yet fully understood. The research presented in this paper is a first step toward doing just that by creating a review of the existing state of university maker spaces found through university website searches. This list will take into account a number of different characteristics, both unique and common, across university maker spaces in order to create a baseline that can be used to discover and capitalize on practices being implemented with the most beneficial results.

Background

In order to fully understand and appreciate the potential of university maker spaces, the concept of a maker space must first be explored. The birth of maker spaces can be traced to the maker movement which began outside of the university system at the turn of the century as the next iteration of the Do-It-Yourself (DIY) culture.[10] Maker spaces started appearing across the country and the world in the form of open spaces where members would pay membership fees for access to the technology inside, which typically includes a variety of types of rapid prototyping equipment such as 3D printers, laser cutters, and traditional hand tools. These spaces enable the users to express themselves creatively and to be innovative.[11] As the price of the technology associated with “making,” such a the cost of 3D printers, declined,[12] it allowed for greater development of maker spaces, and the spaces began to spread into more locations. Maker spaces have begun to appear in public and academic libraries, and universities have started to turn toward maker spaces as a compliment to design courses already being offered. Maker spaces within the university are an attractive avenue for answering the need for more practice-based engineering that compliments the theoretical class structure already in place. The benefits of maker spaces to its users, and in particular, to the engineering curriculum, can be seen in many aspects, but the benefits are primarily focused around two major concepts. These concepts include the benefits of building physical models and the benefits inherent of informal learning environments and community.

Benefits of Building

The central pillar of maker spaces is the actual act of building and making. For example, at the University of Washington, Pennsylvania State University, and the University of Puerto Rico, the use of maker space technologies has influenced a change in the curriculum for design and manufacturing toward what is known as the Learning Factory model.[13] Hands-on prototyping and designing is a key element of the Learning Factory model and is available through any maker space.

Physical modeling and prototyping have been shown to increase the effectiveness and quality of the final design, and both play a key role in the development of students by linking the material covered in the classroom to the real world. Studies have shown that physical representations of concepts can aid designers by helping them to find new design requirements and design features.[14] In a study by Dow and Klemmer, it was found that designers who used physical models in their design iterations outperformed those who did not use physical models.[15] Because of the benefits of building and working with physical models, industries employ prototyping as an integral part of the design process. For example, Toyota uses physical prototyping in their design process in order to avoid manufacturing defective parts.[16]

Physical models and building are also important in the design process as they serve as a means to mitigate design fixation.[17] By building physical models, designers can reduce sunk costs associated with continued development of flawed ideas by discovering these flaws prior to production. In this way, building is shown to be beneficial, not only from an economic standpoint in the reduction of sunk cost, but also from an educational standpoint through reinforcement of adaptive, and creative thinking.

Informal learning environment

There is no standard as to what components constitute a maker space. As a result, the maker spaces in academia, like those available to the public, come in many different shapes and sizes. The very nature of the culture surrounding maker spaces is ever changing and adaptive which is reflected in the start and expansion of many of the current maker spaces. The Invention Studio at Georgia Institute of Technology, for example, has grown out of an underused mailroom. Today the Invention Studio is a 3,000 ft^2 facility that includes $600K of prototyping equipment and tools along with design, assembly, and testing spaces.[8] The Invention Studio, shown in Figure 1, is student-lead, design-build-play space open to all Georgia Tech students. The Invention Studio is operated by a 70-person team, of which 65 are volunteer, undergraduate "Makers Club" student members from a variety of years and engineering/non-engineering majors.

Figure 1: Pictures from the Georgia Institute of Technology maker space, "Invention Studio".

Although differences do exist between the spaces, certain common characteristics are also present in academic implementations including the use of these spaces in classroom settings. A major benefit of these spaces is that the spaces more open environment allows them to be used more freely and interwoven into the class structure for multiple classes without typical classroom scheduling constraints. The Invention Studio at Georgia Institute of Technology, for example, is used in 25 different classes including sophomore and senior level design courses,[8] and the University of Colorado Boulder has used their space in a freshman level design course resulting in a noted positive impact on the students after taking the class.[18] With positive preliminary results from studies like these, this research project is studying the uses of the spaces and the impact of the spaces in the university environment.

Methodology

Collection of information on university maker spaces was a three phase process: (1) discovery, (2) sort, and (3) comparison/organization. These three phases are described in the following subsections.

Phase 1 – Discovery

Baseline data was compiled by first looking at a population of college and universities in the United States. Universities chosen were the top 100 as ranked in the 2014 edition of U.S. News and World Report's *Best Undergraduate Engineering Programs Rankings.*[19] It should be noted that this list of top 100 is actually 127 since some schools were tied in rankings. For example, three schools are ranked #10: Cornell University, Princeton University, and University of Texas—Austin.[19]

Using the list of colleges and universities as a starting point, the research team visited each college and university website. Using the search feature on the website, the team performed keyword searches to potential maker spaces. The keyword list used was: makerspace, maker space, design lab, maker bot, hacker space, innovation space, and solution space. "Makerspace" and "maker space" were both included because the team encountered both spellings frequently. The team also decided, after reading about the uses and equipment available, that maker spaces are also very similar to the design spaces or hacker spaces that also fall under the general category of innovation/solution spaces. The keyword "maker bot" was included in case any schools referenced specific components of a maker space such as a 3D printer. This keyword would allow the team to discover potential maker spaces that might not be formally labeled as such. The list of keywords grew organically through the process beginning with "maker space" and "maker bot". As the team identified additional keywords, searches were repeated on previously searched college and university websites.

Through the process, the team maintained a spreadsheet to capture which colleges and universities were found to have maker spaces and which keywords resulted in positive hits at that college or university. Anytime a keyword resulted in positive result(s), the keyword was recorded along with the name of the maker space (if applicable), the location of the maker space, a link to the article/website, contacts, and any general notes that we had about the maker space. The research team that performed this research consisted of two undergraduate students; one team member started at the bottom of the list, and the other started at the top. Once the two students met in the middle of the list, each team member spot checked the other team member's results for accuracy based on the established search criteria.

Phase 2 – Sort

After this initial discovery phase, the schools on the discovery list were investigated further. Following the captured web links for each of the articles, maker spaces, and press releases identified in Phase 1, each college or university maker space was studied to determine the current status, and if the school did not currently have a maker space (i.e., one was planned), the maker space was removed from the list. Only a few colleges and universities with positive hits in Phase

1 did not actually have a space built yet, and overwhelmingly, these colleges and universities had future plans to build one. The team chose to eliminate these schools because this project's goal is to report on existing spaces. At the completion of Phase 2, the list contained 35 colleges and universities, and of those 35 colleges and universities, three had more than one maker space, so the resultant list of maker spaces to investigate at the completion of Phase 2 contained 40 entries.

Phase 3 – Comparison/Organization

The third phase consisted of detailing information on each of the maker spaces. These categories, along with each maker space, were then put into a spreadsheet(s) to aid in a side-by-side comparison of all maker spaces. General information about the maker spaces included the name of the space, the website for it, and the affiliated university. Categories of information to research and identify included: (1) Location: Off campus, On campus, or Unknown; (2) Membership: University access only, Open to the community, or Unknown; (3) Department Access: Engineering Use Only or For Other Departments; (4) Management: Always Supervised and Student Run, General University Faculty/Staff Run, Specific and/or Outside Staff; and (5) Equipment: 3D printer, Laser Cutter, Wood Shop, Metal Shop, Electronics, Textile work, Computer, and White Board.

Once of the information was captured in the spreadsheet, information was compiled, and further organized by having all schools in a table with the subcategories in each column. It was uncommon to find specific information related to brand of equipment or number of pieces of equipment, so categories were coded "X" in their corresponding row simply representing "Yes, this maker space applies to this category." For example, a snapshot of the "Management" spreadsheet can be seen Table 1.

Table 1: Example table used to collect information related to maker space management.

University	**Always Supervised**	**Student Run**	**Faculty Run**	**Specific Support Staff**
Arizona State				X
Boise State	X	X	X	X
Boston University		X		
University of California, Berkeley		X	X	X

Additional information that is not on the spreadsheets, but that was noted as a unique feature of a maker space, was added to a list of information and is discussed in this paper's discussion. It should also be noted that it was rare to find information about maximum occupancy or physical square footage, but as size is likely an important aspect of design, if there was a specified number, like Georgia Tech's 3,000 ft^2 innovation studio, it was captured.

Results

Results are presented in four tables and one graphic. Table 2 includes the list of 40 different maker spaces identified from the 127 top undergraduate institutions as ranked by *US News & World Report*.[19] The sources where information was collected is provided as well as the name of the maker space if identified. Each maker space has been given a numerical code; this code is used throughout the entire paper for consistency.

Table 2: Maker spaces identified at 35 colleges and universities in the United States and the source where information on the maker space was found. All maker spaces web sources were accessed between October 17, 2014 and December 19, 2014.

Code	University	Maker Space Name	Information Sources
1	Arizona State University	Tech Shop	https://asunews.asu.edu/20140115-asu-chandler-innovation-center
2	Boise State University	The Kitchen Venture Lab	http://cobe.boisestate.edu/ent/thekitchen/; http://cobe.boisestate.edu/ent/your-event-at-the-kitchen/
3	Boston University	BUILDS	http://builds.cc/
4	University of California, Berkeley	SuperNode	http://supernode.berkeley.edu/training/safety-form.pdf http://supernode.berkeley.edu/index.php?title=Main_Page
5	University of California, Davis	Davis Makerspace	http://www.davismakerspace.org/
6	University of California, San Diego	QI Prototyping Lab	http://prototyping.ucsd.edu/
7	California Polytechnic State University	Innovation Sandbox	http://cie.calpoly.edu/programs/innovation-sandbox/c/10.aspx http://www.theinnovationsandbox.com
8	Carnegie Mellon University	IDeATe	http://www.cmu.edu/homepage/creativity/2014/summer/space-for-innovation.shtml
9	Case Western Reserve University	Think[box]	http://engineering.case.edu/thinkbox/
10	Colorado State University		http://cns-eoc.colostate.edu/makerspace.html
11	Columbia University	Columbia Makerspace	http://engineering.columbia.edu/web/newsletter/room_innovation%E2%80%94school_opens_new_makerspace
12A	University of Colorado Boulder	CINC	http://www.colorado.edu/envd/resources/cinc
12B	University of Colorado Boulder	ITLL	http://itll.colorado.edu/about_us
13	Dartmouth College	Unified Projects Laboratory	http://engineering.dartmouth.edu/esc/designlabs/ http://engineering.dartmouth.edu/esc/ https://engineering.dartmouth.edu/safety/ProjectLabEtiquette.pdf
14A	Drexel University	ExCITe Center	http://www.drexel.edu/soe/faculty-research/research-initiatives/rigee/creative-initiatives/
14B	Drexel University	Drexel dLab	http://www.drexel.edu/soe/faculty-

		MakerSpace	research/research-initiatives/rigee/creative-initiatives/
15	Duke University	Duke Co-Lab	https://colab.duke.edu/
16	Georgia Institute of Technology	Invention Studio	http://inventionstudio.gatech.edu/about/
17	Harvard University	Guerilla Maker Space	http://guerrillamakerspace.squarespace.com/#what-is-gms
18	Johns Hopkins University	DMC Makerspace	http://digitalmedia.jhu.edu/resources/dmc-makerspace/
19	Lehigh University		http://www.lehigh.edu/ip3/available_labs_resources.pdf
20	North Carolina State University	Hunt Library Makerspace	http://www.lib.ncsu.edu/spaces/hunt-library-makerspace
21	Northwestern University	Segal Design Institute Prototyping Lab	http://segal.northwestern.edu/about/prototyping-lab-facilities.html
22	Oregon State University		http://eecs.oregonstate.edu/education/3dprinter/index2.php
23	Princeton University	Keller Center Maker Space	http://kellercenter.princeton.edu/create/maker-space/overview/
24	Purdue University	BoilerMaker Lab	https://tech.purdue.edu/facilities/boilermaker-lab
25	Rice University	Oshman Engineering Design Kitchen	http://oedk.rice.edu/
26	Stanford University	Create:Space	https://acomp.stanford.edu/techlounge/createspace
27	Syracuse University	SU Makerspace	http://news.syr.edu/su-makerspace-is-open-for-business-will-host-open-house-oct-10-41663/
28	University of Maryland	John and Stella Graves MakerSpace	http://www.lib.umd.edu/tlc/makerspace
29	University of Michigan, Ann Arbor	Wilson Student Team Project Center	http://teamprojects.engin.umich.edu/about/
30	University of Illinois at Urbana-Champaign	MakerLab	http://makerlab.illinois.edu/
31	University of Nevada	DeLaMare's Makerspace	http://www.unr.edu/nevada-today/news/2014/makerspace
32	University of Texas at Austin	Longhorn Make Studio	http://makerspace.engr.utexas.edu/
33	University of South Florida	X-Labs	http://www.eng.usf.edu/dfx/index.html
34	University of Wisconsin—Milwaukee	Digital Craft Research Lab	http://www.frankieflood.com/dcrl/uwm/home.html
35A	University of Central Florida	Harris Corporation Gathering Lab	http://today.ucf.edu/creativity-bolstered-ucf-new-maker-space-labs/

35B	University of Central Florida	Idea Lab	http://today.ucf.edu/creativity-bolstered-ucf-new-maker-space-labs/
35C	University of Central Florida	Texas Instruments Innovation Lab	http://today.ucf.edu/creativity-bolstered-ucf-new-maker-space-labs/ http://e2e.ti.com/blogs_/b/designproject/archive/2014/09/23/unique-innovation-lab-at-university-of-central-florida-brings-hard-and-soft-sciences-together
35D	University of Central Florida	Manufacturing Lab	http://today.ucf.edu/creativity-bolstered-ucf-new-maker-space-labs/
36	University of Mary Washington	ThinkLab	http://umwthinklab.com/
37	University of North Carolina at Chapel Hill		http://library.unc.edu/makerspace/
38	Vanderbilt University	Vanderbilt Mobile Makerspace	http://www.tennessean.com/story/money/2014/10/24/mobile-makerspace-sparks-imaginations-vanderbilt-childrens-hospital/17812695/
39	Washington State University	Fab Labs	http://sdc.wsu.edu/sdc/our-spaces/fabrication-labs/
40	Yale University	Yale CEID	http://ceid.yale.edu/about-us/what-is-the-ceid/

For each of the maker spaces, information was collected on whether the space was on-campus or off-campus, whether the maker space is designated for campus use or for engineering use only, and if the space allowed for external community use. Table 3 provides this information.

Table 3: Compiled information on the location (on or off campus), department versus campus use limitations, and the allowed membership of maker spaces identified at 35 colleges and universities in the United States.

Code	**University**	**Location**	**Department**	**Membership**
1	Arizona State University	O	O	U
2	Boise State University	O	O	C-Fee
3	Boston University	Y	O	U
4	University of California, Berkeley	Y	O	U
5	University of California, Davis	O	O	U
6	University of California, San Diego	Y	O	U
7	California Polytechnic State University	Y	O	N/A
8	Carnegie Mellon University	Y	O	U
9	Case Western Reserve University	Y	O	C-Alumni
10	Colorado State University	Y	O	U
11	Columbia University	Y	O	U
12A	University of Colorado Boulder	Y	O	U
12B	University of Colorado Boulder	Y	O	U
13	Dartmouth College	Y	E	U

14A	Drexel University	N/A	O	N/A
14B	Drexel University	N/A	N/A	N/A
15	Duke University	N/A	N/A	N/A
16	Georgia Institute of Technology	Y	O	U
17	Harvard University	O	O	U
18	Johns Hopkins University	Y	O	U
19	Lehigh University	Y	O	N/A
20	North Carolina State University	Y	O	C-Affiliates
21	Northwestern University	Y	O	U
22	Oregon State University	Y	E	U
23	Princeton University	Y	O	U
24	Purdue University	Y	O	U
25	Rice University	N/A	E-O when working with Engineering	U
26	Stanford University	Y	O	U
27	Syracuse University	Y	O	U
28	University of Maryland	Y	O	U
29	University of Michigan, Ann Arbor	Y	O	N/A
30	University of Illinois at Urbana-Champaign	N/A	O	C-Area Businesses
31	University of Nevada	N/A	N/A	N/A
32	University of Texas at Austin	Y	E	U
33	University of South Florida	N/A	E	U
34	University of Wisconsin—Milwaukee	Y	O	U
35A	University of Central Florida	Y	O	U
35B	University of Central Florida	Y	O	U
35C	University of Central Florida	Y	O	U
35D	University of Central Florida	Y	O	U
36	University of Mary Washington	Y	O	N/A
37	University of North Carolina at Chapel Hill	Y	O	U
38	Vanderbilt University	O	O	C-Children's Hospital
39	Washington State University	Y	O	U
40	Yale University	N/A	O	N/A
Key: ***(Location)*** *Y: on campus, O: off campus, N/A: Not found & Unknown;* ***(Department)*** *E: Only engineering, O: Other departments/broader Community, N/A: Not found & Unknown;* ***(Membership)*** *U: University Access Only, C: Open to the Community, N/A: Not found & Unknown*				

Building off of access models, the research team also wanted to understand how the different maker spaces were staffed. The research team identified three different models: Faculty Run, Student Run, or Specific Support Staff. The majority of the resources implied mixed models for how the maker spaces were managed, and consequently, the team arrived at the Venn diagram in Figure 2 as the best representation for this information.

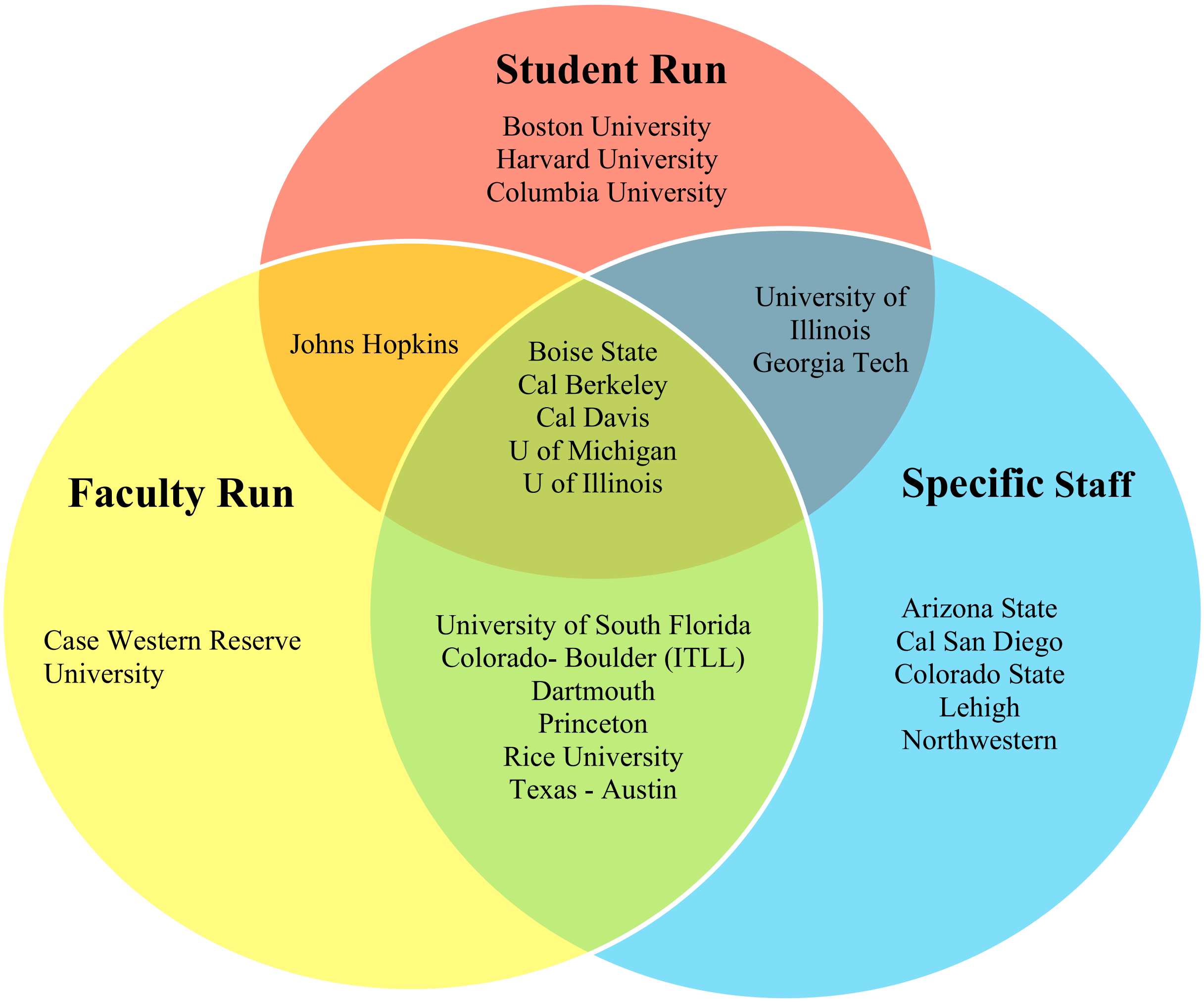

Figure 2: Venn diagram showing identified operational models for maker space management.

Using the search criteria described in the methodology, the team identified equipment access at each of the different university maker spaces. Types of equipment listed included 3D printers, laser cutters, and electronics. Shop access included wood or metal. In some cases, maker spaces included access to textile equipment. White board and computer access were also listed as being included by some of the sources with white boards having the least amount of mentions. The lack of mentions of computers and white boards is hypothesized to be a function of their ubiquitousness rather than their absence.

Table 4: Compiled information on the types of equipment available maker spaces identified at 35 colleges and universities in the United States.

Code	University	3D Printer	Laser Cutter	Wood Shop	Metal Shop	Electronics	Textile	Computer	White Boards
1	Arizona State University				X	X			
2	Boise State University							X	X
3	Boston University								
4	University of California, Berkeley	X				X		X	
5	University of California, Davis	X							
6	University of California, San Diego	X	X	X	X	X		X	
7	California Polytechnic State University	X						X	
8	Carnegie Mellon University	X	X			X		X	
9	Case Western Reserve University	X	X	X		X	X		
10	Colorado State University	X		X		X		X	
11	Columbia University	X	X	X		X	X		
12A	University of Colorado Boulder		X	X	X			X	
12B	University of Colorado Boulder	X	X	X	X				
13	Dartmouth College	X			X	X		X	
14A	Drexel University	X						X	
14B	Drexel University								
15	Duke University	X							
16	Georgia Institute of Technology	X	X	X	X	X		X	
17	Harvard University							X	
18	Johns Hopkins University	X				X		X	
19	Lehigh University	X	X	X	X				
20	North Carolina State University	X	X						
21	Northwestern University	X	X		X	X		X	
22	Oregon State University	X	X						
23	Princeton University	X				X			
24	Purdue University	X						X	X
25	Rice University	X	X	X	X	X		X	X
26	Stanford University	X				X		X	X
27	Syracuse University	X	X		X	X	X	X	
28	University of Maryland	X						X	
29	University of Michigan, Ann Arbor		X	X	X			X	
30	University of Illinois at Urbana-Champaign	X				X		X	
31	University of Nevada	X	X			X		X	
32	University of Texas at Austin	X	X	X	X	X	X		
33	University of South Florida	X	X		X	X		X	X
34	University of Wisconsin—Milwaukee	X	X		X			X	

35A	University of Central Florida							X	X
35B	University of Central Florida							X	X
35C	University of Central Florida	X	X			X			
35D	University of Central Florida				X				
36	University of Mary Washington	X							X
37	University of North Carolina at Chapel Hill	X				X		X	
38	Vanderbilt University	X				X			
39	Washington State University	X	X						
40	Yale University								

Discussion

Review of the data indicates some interesting trends with university maker spaces. For example, the most common equipment identified during the search for maker spaces was the 3D printer, and the most common type of 3D printer seen on university maker space websites was the MakerBot brand 3D printer. This 3D printer was identified so frequently that the team decided to add MakerBot as a keyword during searches, which admittedly may have biased search results. The second most common type of equipment identified was the laser cutter followed by mention of wood working or metal working capabilities. Also frequently noted were electronics and soldering capabilities. Interestingly, while ideation and modeling play an important role in making, the explicit mention of whiteboards and computer stations was less common. It should be noted that the equipment and capabilities were chosen to show breadth; other very common pieces of equipment included: CNC routers, CNC mills, CAD/CAM stations, PCB mills, plasma cutters, vinyl cutters, 3d scanners, and welding.

With respect to maker space staffing, the most common model identified for staffing utilized a combination of student support and specialized staff personnel. For example, at the University of Illinois at Urbana-Champaign, the lab is overseen by an executive director and a director—both University employees—three industry advisors, and six student lab gurus.[20] Some, however, appear to be grassroots, student-driven initiatives. For example, The Makerspace at Columbia University, was "Purely student driven, the idea for the space was brought on by a group of Engineering students who lobbied Dean Mary C. Boyce last fall. The dean recruited a faculty steering committee to work with students on its formation and launch. Now, a leadership committee comprised of ten students is in place and charged with setting the priorities and policies of the new space, and its operational structure." [21] The Makerspace at Columbia is explicitly listed as being open to all students while being housed in the engineering school.[21]

It should be noted as well that of those schools where information on who could use a space was found, only four limited access to just students, faculty, and staff of engineering, and consequently, 32 of the maker spaces were open to all members of the campus community. And of those four where access was limited to engineering students, faculty, and staff, only one mentioned a process through with non-engineering students could gain access.

With respect to access, the overwhelming majority of maker spaces are open to only the campus community—faculty, staff, and students. Just five identified maker spaces explicitly stated policies allowing for use by individuals other than faculty, staff, and students. These included: Boise State University's The Kitchen,[22] Case Western Reserve University's Think[box],[23] North Carolina State University's Hunt Library Makerspace,[24] University of Illinois at Urbana-Champaign's Maker Lab,[20] Vanderbilt University's Mobile Makerspace.[25]

Vanderbilt's Mobile Makerspace is a more traditional spin on the flexibility of space, and echo's the extreme flexibility of space at the Hasso Plattner Institute of Design (or more commonly, the d.school) at Stanford.[26] Only, Vanderbilt's maker space is not for its students; instead, it is for patients at the Monroe Carell Jr. Children's Hospital at Vanderbilt.[25] The maker space which is housed on a cart allows for extreme flexibility and includes equipment and tools such as electronics components, Play-Doh, and a 3D printer.[25]

Perhaps the most common location where maker spaces are housed on college and university campuses is the library. With respect to library placement, Thanassis Rikakis, the vice provost for Design, Arts and Technology at Carnegie Mellon University was quoted as stating, "The placement of the IDeATe facility in Hunt Library is part of an overall plan for the evolution of the library into a 21st century, mediated learning commons" in a press release on the maker space.[27] Carnegie Mellon University has housed their Integrative Design, Arts and Technology (IDeATe) program and its maker spaces in their Hunt Library – becoming IDeATe@Hunt.[27] Similarly, Stanford Univesity has housed Create:Space on the first floor of the Lathrop Library,[28] and the University of Maryland has housed their John and Stella Graves MakerSpace on the second floor of the McKeldin Library.[29] And, both University of North Carolina at Chapel Hill and North Carolina State University have used space in their libraries to house maker spaces.[24,30] At the University of North Carolina at Chapel Hill library, MakNet is listed as a group for Maker-Students, and provides links to other maker sites on the NC Chapel Hill campus and within the region.[30] Placement of a maker space in a library may provide a central location for many campuses trying to encourage multidisciplinary activity through the maker space; interestingly, these three examples are all maker spaces open to the broader campus community.

Such emphasis of structure, space, and rules, may be the antithesis of the maker movement, and at Harvard, the identified Guerrilla Maker Space experiments with a space-less maker space. The Guerrilla Maker Space was the grass roots effort and brainchild of two students, Christan Balch and Saskia Leggett, and the Guerrilla Maker Space website is their final course deliverable.[31] The students experiment with bringing making to people instead of bring people to a space, and on their website state, "We show up at unexpected places with a plastic bucket full of things to make with, two laptops, and a handful of MaKey MaKeys, and we go from there." [31]

While a number of searches resulted in future planned maker spaces; two in particular represent the major shift in how colleges and universities see the maker culture and maker spaces playing a key role in the campus culture. Wichita State University is currently developing an Innovation Campus with facilities such as an Experiential Engineering Building, partnership buildings to serve faculty, staff, students, and companies, and a new business school building among others.[32] To be housed in the Experiential Engineering Building is a $3.75 million maker space that will be open to the public based on membership.[33] At the University of Connecticut, the Board of Trustees have approved the construction of an Innovation Partnership Building that will colocate researchers, innovators, and entrepreneurs together with the hope of fostering entrepreneurial activities and technology transfer at the University of Connecticut.[34]

Conclusion & Future Work

Over the course of the study there was a degree of interpretation needed in collecting the information. This ambiguity represents a key limitation of this study as many of the sources of information were press releases or media publications. Consequently, as the information gathered was in the form of data gathered from the websites of the institute, some degree of interpretation was necessary to help categorize how the maker spaces fit into each category. For example, the management and availability of the spaces are not always explicitly described and as a result some conclusions were drawn. To alleviate the possibility of incorrect information, future phases of the project would involve contacting the maker spaces in order to corroborate the data.

Also, since the search relied on key words entered into college and university websites, colleges and universities known to have maker spaces, such as Pennsylvania State University, did not necessary return any results. This anomaly may be a result of the search terms or the search feature on a particular college or university website. Future work will explore additional search terms, alternative searching approaches, and expansion of the list of universities looked at beyond the 127 originally examined.

Another important aspect looking forward will be identifying the impact that these maker spaces have and why. This effort includes looking at the impact of the spaces on the universities as well as the students themselves. By examining the impact that the spaces have, features and components of the maker spaces can be looked into to see which features correlate with the most impact. These components and features will then be duplicated at other locations in order to determine the strength of the correlation between the components and the impact.

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