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Community College Innovation Centers – Lessons Learned from Works in Progress

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Community College Innovation Centers – Lessons Learned from Current Works in Progress

Abstract

Some argue that the concept of a makerspace has been around since the late 1800s, starting out in public libraries, with the most recent modern, public versions originating around the year 2000. In 2009, MIT formed the Fab Foundation as a way to formalize Fab Labs and Innovation Centers, regarding equipment and capabilities of those lab spaces. Since then, makerspaces, fab labs, innovation centers, and engineering labs have grown exponentially, primarily within colleges and universities, as well as at public libraries, and private companies open to the public. It is only recently that community colleges have started to follow this trend in the creation and use of these types of spaces.

Compared to private companies, as well as 4-year colleges and universities, community colleges are often extremely limited in the technology and capabilities they can offer users of these lab spaces. In many instances, community college innovation centers can barely be considered a makerspace due to limitations of equipment and scope of capabilities, let alone staffing within an environment that focuses on a near one hundred percent off-campus student body. This paper is intended to present a brief history of this up and coming technological space, based on a review of the very small literature base, as well as share suggestions and lessons learned from two collaborative community colleges that jumped into this innovative, yet expensive endeavor, while on an often extremely limited budget, with minimal, or even zero, guidance from others.

Introduction

As four-year colleges and universities, as well as publicly funded libraries and private companies, continue creating or expanding their makerspaces, community colleges have begun this process as well. Two very big differences however, are that community colleges typically have extremely limited funding and their students and faculty are often very different compared to those at universities.

Because of the differences inherent to community colleges, the limited information that is available for reference may not be directly applicable to those in the community colleges who are considering or planning the creation of a makerspace. While more papers related to university makerspaces are getting published compared to just five years ago, there is still little material linked to the community colleges available. Those community colleges that want to create a makerspace can reference lessons learned by universities, private companies, and public libraries, but given the difference between them, those lessons may not be helpful in guiding the community colleges. While university, private, and library information can provide a basic foundation of information, the context and outcomes may not align at all with what community colleges experience.

Since there was a lack of existing information, the methodology of this paper is two-fold. First, the published literature related to the operation of makerspaces at universities and other sources was reviewed, identifying problems experienced and suggested best practices, then focusing on those problems that were noted in the even further limited problems identified by community colleges. The best way to describe this methodology is the quantitative descriptive methodology approach, or purely observational. This was used to determine the next step to take in the process. No hypotheses were started with, and due to the extensive limitations at the colleges, much of what they did was based on outreach with each other, as well as simply asking questions of friends and colleagues who had similar lab space at universities. Published information related to best practices at universities was often reviewed, however, those recommendations were often impossible to follow through on. In the end, suggestions from all sources were compared, and only those that could be done were implemented.

Second, the authors of this paper, who are faculty at two community colleges and are also the makerspace lab coordinators, share the major lessons they have learned in the creation and continuing evolution of their makerspaces. The intent is to highlight problems identified by the larger makerspace population that are common with community colleges, as well as major issues our community colleges have experienced, then to share that information with others who may be interested in facilitating a makerspace at their community college. This provides initial examples that may be used as part of the literature base that can at least be references. This methodology is a qualitative approach, representing both colleges as case studies.

Literature Review

In June 2018, Weiner, Lande, and Jordan [1] presented their research of the existing literature, as it related to makerspaces and engineering education. While the focus of that research was on how makerspaces are used for engineering education, their methodology identified the overall body of makerspace-related literature that existed at that time, and broke the results into 12 primary topics. They also found that, since 2013, only one article related to makerspaces had been published by the Journal of Engineering Education, and 68 had been published as conference proceedings. Furthermore, they also noted that only 26% of the total articles were focused on makerspaces as Engineering Labs, and of the 12 primary topics, only one article focused on the operation of the makerspaces. Of the 12 primary topics they identified in the literature, none were directly related to community colleges using makerspaces.

While there is only a small amount of published information related to the operation and best practices learned from university, public library, and private makerspaces, it is a starting point for those at the community colleges. Because there is very little published regarding operating a makerspace, initially focusing on best practices is a good start for research into operation. While identifying best practices may not provide enough information related to how one could actually do them, it does potentially suggest a path the community colleges could at least consider for operating their makerspaces.

Best Practices Noted at Universities and Public Libraries

While makerspaces, hackerspaces, innovation labs, fab labs, and engineering labs are technically defined with different meanings, in general usage, those terms are considered to be interchangeable [2]. In general, makerspaces are credited with helping to increase diversity and inclusion in the STEM fields. However, the intention of those activities that are encouraged and supported within makerspaces has to inherently encourage that diversity [3]. In other words, the best practices related to diversifying the population of STEM majors may not increase diversity within STEM. But, if the makerspace activities are interesting to a larger population, that may be enough to encourage the potentially diverse, non-engineering population to get involved at the makerspace. Encouraging interdisciplinary activities not only increases usage of the makerspace [4], especially with Entrepreneurial majors, but also increases the diversity of those who use the lab space [3] [4] and their overall interaction [2].

One of the most commonly noted best practices involves the creation of a sense of community and a collaborative culture. This has been noted in multiple articles, including those based on international makerspaces [4] as well. In general, the sense of community often originates from simply allowing the students to participate in the governing and daily operation of the makerspace [4] [2] [5] [6] [7]. Collaborative cultures tend to stem from encouraging collaboration when carrying out daily operations [4], having few restrictions on usage by encouraging academic, extracurricular, and personal projects [2], and having activities that encourage people to work together [8]. Scheduled activities such as training, workshops, and social events also encourages students to interact with each other outside of collaborative projects, which may strengthen the sense of community [2] [7]. It is these types of activities, especially workshops and social events that have been found to be effective in creating a link with community colleges and recruiting their students [8].

If the primary intent is also to simply increase the usage of the space, another suggested best practice is to use the space for teaching courses, particularly those courses that are based on design [2] and/or competition projects [8]. Holding classes in the space will also assist in funding as well [7]. If this is done, it is strongly suggested that the space has flexible, movable boundaries and furniture [7], and that practical engineering skills are taught using the lab equipment [2].

Operation Details Noted at Universities

While best practices may not offer operational details, they do provide potential paths that give ideas of daily operations and abilities. With that said, there are some specific operations that are suggested in the literature by universities and public makerspaces. By far, the most common detail related to operation of the space is related to funding, however, that is a broad consideration. In addition to funding of the actual space and maintenance of the space [9], equipment and tool maintenance is mentioned as being crucial for ensuring success of the space [4] [2] [9]. In general, users expect that the machines and tools will work, and if they do not work, users will stop using the space. Furthermore, the machines and tools must be maintained to ensure their safe operation. This can be a consideration that is very difficult to determine because, while makerspaces do not have a defined list of equipment, most typically include 3D printing, laser cutting, a wood shop, a metal shop, electronics design and testing, a textile work area, access to computers, and white boards [6]. The extent of the equipment in the lab and the level of operation (i.e. beginner, intermediate, expert) are highly influential in determining the maintenance that is needed.

Another operation concern is also related to funding and safe operation. The space must be accessible to disabled participants, and in addition to ensuring their safety, the safety of all users must be taken into account as a funding consideration [9]. This is often difficult to do because, of the university makerspaces, approximately 88% are open to the entire campus, not just the Engineering students, and approximately 15% of the spaces are open to the general public [6]. While there are options for assisting in lab liability protection, ultimately, insurance and protection are also needed for the universities as well.

Finally, again from the perspective of funding, it is strongly suggested that a professional manager run the lab daily, working alongside a lab coordinator, who may be from the faculty or staff. In general, the manager is responsible for maintaining records, especially related to safety, as well as usage to support funding, and providing training for using the equipment. The coordinator would then focus on obtaining funding sources and outreach to create industry relationships and recruit potential students. Record keeping by both the manager and coordinator is crucial because it provides support for funding as well as evidence in the event of a liability issue [7].

Community Colleges

While information related directly to community colleges is sparse and often found within discussions related to interactions with universities, there are some specific considerations that have been found within the literature. In line with what the papers related to university makerspaces indicated, the top problem that community colleges encounter when they make the leap into creating a makerspace is funding. The costs associated with initially creating a community college maker space can typically be as high as $400,000, as well as a yearly cost of $100,000 for lab salaries and maintenance [10]. The fact that initial funding costs are a key consideration was supported by the Ivy Tech Engineering program during a webinar they hosted to discuss this topic [11]. In general, when the primary focus of lab space is for an engineering program, the costs tend to be extremely prohibitive because engineering lab equipment is very expensive. Unfortunately, this is also the case if the focus of the makerspace is an Engineering program, and if the proposed lab space requires renovations or updating, the combined total cost is often too much for a community college to afford [12].

While most of the literature relates to universities and their makerspace operating lessons, as discussed above, some of those details may be applicable to community colleges. Fortunately, one article was discovered that was specifically focused on community college makerspaces. In

2017, a network of 34 California Community Colleges (CCC) was coordinated to establish a multidisciplinary series of makerspaces [13]. The makerspaces were initially created to include manufacturing and machining, however, they expanded, based on the focus of the college itself. The CCC makerspace network now includes culinary art, ceramics, electronics, 3D printing, laser cutting, vinyl cutting, computer access, document printing, and activities for English Language Learners [13]. As noted in the recommendations from universities, and the details that are specifically related to community colleges, funding was also identified as a key consideration [14]. More importantly, however, the CCC provided more details than had previously existed in the literature. While the specific lessons learned fall within the same general categories as what the universities identified, these are quite possibly the first time these details have been identified and shared, specifically for community colleges. This information is consolidated and shown in Table 1, below.

• Create makerspace goals and outcomes that highlight the range of users, including students, families, and ages • Offer activities that foster self-discovery of topics • Identify and advertise curricular paths that foster identities as scientists and artists • Share goals and outcomes with partners, and provide effective communication paths between partners, the lab, students, and college administration	• Have both a manager and a coordinator to operate the space, including setting goals, management, paperwork, and daily operation • Make cross-organizational partnerships with local companies • Create an advisory committee specifically for the lab, consisting of stakeholders • Update and/or create curricula that includes activities that can be performed in the lab, however, do not underestimate the time needed for that to pass through the curriculum process

Table 1. Community College Best Practices Identified by the CCC Network [13]

Finally, while CCC identified and implemented the best practices listed above, they also acknowledged that there were severe challenges that were encountered, which they were still working on. These challenges are highlighted in Table 2 [13]:

Two Community Colleges…Works in Progress

The two community colleges serving as the primary sources of this paper have worked together for the past three years (fall 2016 – spring 2019). While an extensive report that discussed community college makerspace considerations was published in early 2018 [14], by that time, the two colleges were already opening, or were beginning the initial preparation and installation of their labs. In other words, when the two colleges were starting out, there was very little to guide them as they each approached the mountain of issues and concerns that were specific to the environment and their students.

Funding	• Working within the constraints of fiscal budgeting and reimbursement practices • Spending allocated funds within fiscal constraints and purchasing cut-off deadline
Staffing	• Underestimating the amount of dedicated staff required to manage makerspace activities • Faculty and staff learning how to work with interns and students to incorporate them as staff
Human Resources	• The college's slow hiring process resulted in a slower than planned ramping of the project, truncating implementation of the first year

Table 2. Challenges Identified by the CCC Network [13]

The relationship between the two colleges began due to one common connection – the same company donated the initial makerspace equipment to the Engineering program at both of the colleges. The two colleges worked collaboratively by sharing information, attending training sessions together, and an open willingness to guide each other based on their own experiences during the creation and establishment of their Engineering Labs.

Skyline College

Skyline College, located in San Bruno, CA is a member of the California Community College System and is a federally-designated Hispanic-Serving Institution (HSI). During the 2017-2018 academic year, the college enrolled approximately 23,000 students, the majority of whom are from minoritized populations. Of the students at Skyline College, 2.6% are African American, 0.2% are American Indian, 18.2% are Asian, 18.4% are Filipino, 18.8% are Latino, 1.2% are Pacific Islander, 19.3% are White, 19.8% are Multi-Ethnic, and 1.7% are unknown. Like all California Community Colleges, Skyline College is an open-enrollment institution, designed to welcome students of all backgrounds.

Skyline College is part of a three-college district and was the last college of the three to build an Engineering program. Though the college has enrolled and supported engineering students in foundational math and physics courses for a long time, financial and political barriers prevented offering engineering courses, and native Skyline students had to complete their engineering coursework elsewhere in the district, a neighboring district, or worse, transfer without lower division coursework completed. In Fall 2014, the college offered its first and only Engineering course (Introduction to Engineering), developed and taught by an adjunct instructor in their physics department, whose technical background was in engineering. This adjunct professor began to develop a few other engineering courses over 2015, and in Spring 2016 the college was leveraging external grant funds to hire him as a temporary full-time faculty member to begin the development of what was to become the Engineering and Computer Science program at Skyline College.

One of the sticking points to creating a new engineering program was that there was no lab space for engineering lab courses. Fortunately, and in good timing, the college was approached in Summer 2015 by a donor company interested in supplying a maker space to help engage and retain underrepresented students in STEM, while also opening opportunities for community members to access the maker space. The donor company had installed maker spaces at other universities, but this was to be the first installed in a California community college. One of the challenges was that, unlike four-year universities that have ample space to dedicate all-day access to a lab, Skyline College had to repurpose two classrooms to clear real estate for the new maker space. As such, a primary condition in the agreement was that the new maker space would have to be an instructional space as well. While this presented a challenge to offer open-access for students and community members to work on projects, this also paved the way for the space to become the new Engineering lecture and lab space, thereby becoming a primary catalyst in the development of the Engineering program at Skyline College. Demolition of the original two classrooms was done over the winter break in 2015, and construction and lab installation carried out in the early months of 2016. The maker space opened on April 6th, 2016 with a ribbon cutting by the college president, members of the board, and executives of the donor company.

Special emphasis should be given to the importance of the maker space in the development of the Engineering and Computer Science program at Skyline College. The program now has eight Engineering and eight Computer Science courses, most of which are taught in or have projects connected to the maker space. The adjunct faculty that started the program is now tenure track lead of the program. The program faculty consists of one full-time residential faculty member, one adjunct instructor in Engineering, two adjunct instructors in Computer Science, and a full-time laboratory technician who manages the maker space and supports physical science instruction including Engineering, Physics, and Computer Science.

South Mountain Community College

South Mountain Community College (SMCC) is a member of Maricopa Community College District, and is located in Phoenix, AZ. While the district is one of the largest in the nation, South Mountain Community College is the smallest member with just over 10,000 students enrolled, however, this equates to approximately 4,000 full-time students. Compared to other district members, the students at SMCC are slightly younger, with an average age of 24. 70% of the students are part-time, taking an average of 8.4 credits, and 51% of the students intend to continue their studies at a university, however, 71% of the students have never attended a college/university, or have attended some college, but did not graduate. The college is a federally-designated Hispanic Serving Institute (HSI), with 58% of the students identifying as Hispanic, and 72.3% of all enrolled students are first-generation college students.

The service area that the college is located within is one of the most underprivileged in the county and the state, resulting in many students being extremely limited in their financial abilities, particularly their ability to pay tuition and fees. Approximately 92% of the students receive Financial Aid, and 34% of the students receive Pell Grants.

While there are 10 colleges in the district, South Mountain Community College is one of only four that have an Engineering program. Within the district, that Engineering program is the smallest, but it is growing. In Spring 2017 there were 32 students majoring in Engineering, but in Fall 2018, that number had increased to 175. The number of courses offered has expanded from two introductory engineering courses, to a combination of six to eight introductory and advanced engineering courses offered each semester. The program faculty consists of one full-time residential faculty member, and two adjunct instructors.

Prior to Spring 2017 there was no lab space for any of the Engineering courses, and the introductory Engineering Design course was held in a classroom, with minimal supplies and equipment stored in a closet that was shared with another program. The college was initially approached in Summer 2016 by the donor company, however, due to costs, building space, politics, and others issues, the lab space was not ready for equipment installation until December 2017. The lab was finally staffed and fully functional, and opened for the college Engineering students in August 2018. In January 2019, the lab was officially opened to the college and the surrounding community.

Lessons Learned…so Far…by Those Who Have Made the Leap

At the time Skyline and South Mountain Community College began their journeys of creating their lab spaces, there was nothing previously published that was specific to community colleges and these types of lab spaces. Published information related to best practices at universities was often reviewed, however, those recommendations were usually impossible to follow through on. In the end, suggestions from all sources were compared, and only those that could be done were implemented.

Skyline College

Construction of the makerspace was funded by the college district and managed by district-level facilities. While overall vision of the makerspace was provided remotely by the donor company's lab design consultant, the construction team that determined and installed infrastructure was a varied group comprised of Skyline College facilities, Skyline College Information Technology (IT), district-level facilities on project management, outsourced electrical and mechanical contractors, and the full-time engineering faculty to help with vision as an instructional space. Logistic issues arose due to communication gaps between the remote lab design consultant and the other parties, including a lack of clarity on sizing of equipment, electrical power needs, and heating and ventilation requirements for some equipment. The full-time engineering faculty member helped bridge these gaps for all parties involved by developing a floor plan (Figure 1) that detailed equipment location, electrical outlet locations, and power requirements for large items (e.g. laser cutter, large CNC). He was also tasked with finding and selecting student furniture for the space, something he had no prior experience in.

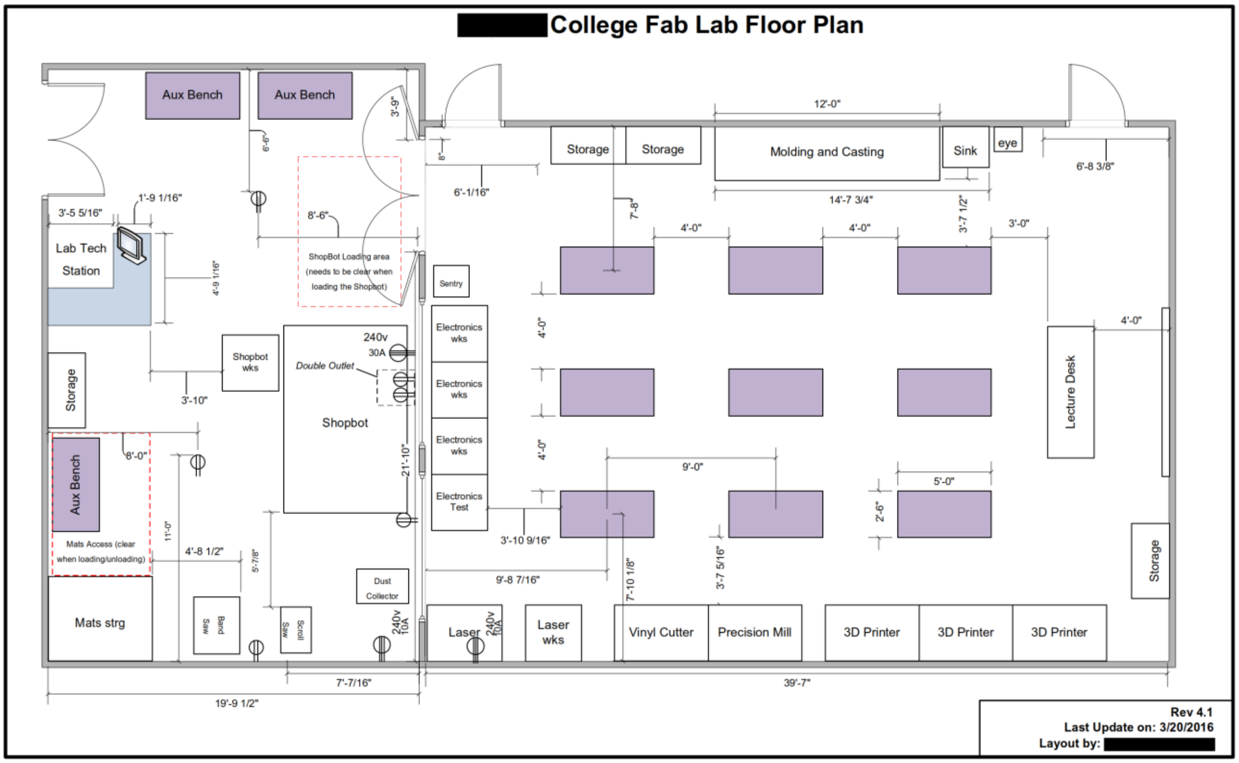

Figure 1 – Skyline College Makerspace (Fab Lab) Layout

A key issue the full-time engineering faculty advocated for, though ultimately was not supported by the college and the district, was the identification and acquisition of an adjacent storage space for the new lab. For all the thought that went into the infrastructure and usage of the lab, the project management team had given little consideration to the storage of materials, tools, and accessories needed for the space to function. The solution proposed and implemented was to install a few relatively small storage cabinets within the makerspace, residing on what little wall space was left after equipment had been positioned (see Figure 1 above). The engineering faculty member had strongly recommended installing a door in a corner of the main room (near the rightmost 3D printer) that would join the makerspace to an unused office space which could have been used for significantly more storage. Unfortunately the project manager responded that the project was already overbudget, in part due to communication gaps on electrical and mechanical infrastructure needs, and the recommendation was not considered.

As the lab is both an instructional room and a makerspace, the cabinet storage space was nearly immediately filled with instructional equipment including electronics test equipment, materials testing tools, various engineering course materials, and makerspace supplies (e.g. 3D printer filament, vinyl rolls, etc.). After almost three years of running the lab, the engineering faculty and makerspace lab technician are desperately out of storage space and are continually searching for innovative solutions to supplement what little space they've already exhausted. For community colleges looking to install a facility under similar constraints of dual instruction+makerspace use, the authors of this paper cannot emphasize strongly enough the need for adequate storage space to support the continued and ever-expanding use of that facility.

Shortly after the space was constructed and installed, the college searched for and hired a full-time laboratory technician to support the makerspace and the physics, engineering and computer science departments. The lab technician is a crucial component to the success of the makerspace: he provides maintenance and support for equipment, trains student assistants to help support the lab during open lab hours, and has been instrumental in engagement within the college and community via instructional workshops and outreach events. Incidentally, he has also become an active co-advisor to the engineering and robotics club and has provided immense support to students in design projects including a solar-powered boat race and various robotics competitions. The lab technician provides routine maintenance and support for the continued successful operation of the makerspace.

One of the last and more difficult pieces to work out in running the makerspace at Skyline College has been developing and implementing a fee structure for the usage of fabrication materials (e.g. 3D printer filament) to support materials replenishment. The engineering and computer science department has committed to pay for materials used in any project that students work on as part of a course assignment. For open access hours, the makerspace is free to use: students, faculty, staff, and community members working on independent projects need only to purchase materials used in the fabrication process. However, charging for these materials has become a logistical issue within the college. The makerspace lab-technician has spent over a year now liaising with various college- and district-level personnel on the initiative to become a "seller entity" on campus (similar to a bookstore), which could charge replenishment fees for materials used. Unfortunately, to this date a solution has still not been adopted, and the engineering department has so far had to subsidize materials used in all student and community projects. The team is working on a webpage, hosted by the college, to implement a PayPal store for selling materials. A primary detail for the site still to be developed is user differentiation between student and community customers.

South Mountain Community College

While they were extremely supportive, initially, the college administration was unable to offer extensive guidance in planning the lab space because it was also new to them. To make matters even more difficult, a major private makerspace that was located locally, went out of business shortly after the initial outreach to them. With minimal guidance, planning for the space became extremely difficult. In order to learn more about makerspace options, the coordinator initially relied on personal interactions and questions presented to contacts at universities and individual companies that could potentially become vendors. While outreach and interaction at conferences was extremely helpful, perhaps the most guidance came from interactions with Skyline College, and the architecture firm that was eventually hired to redesign the building that the lab was installed in. Skyline College suggested equipment based on their experience, and the architecture firm provided potential cost information and space usage based on those suggestions, which ultimately guided SMCC to the equipment and costs associated with preparing the building for it. After that, the process became smoother. The floorplan for the Engineering Lab + Innovation Center is shown in Figure 2.

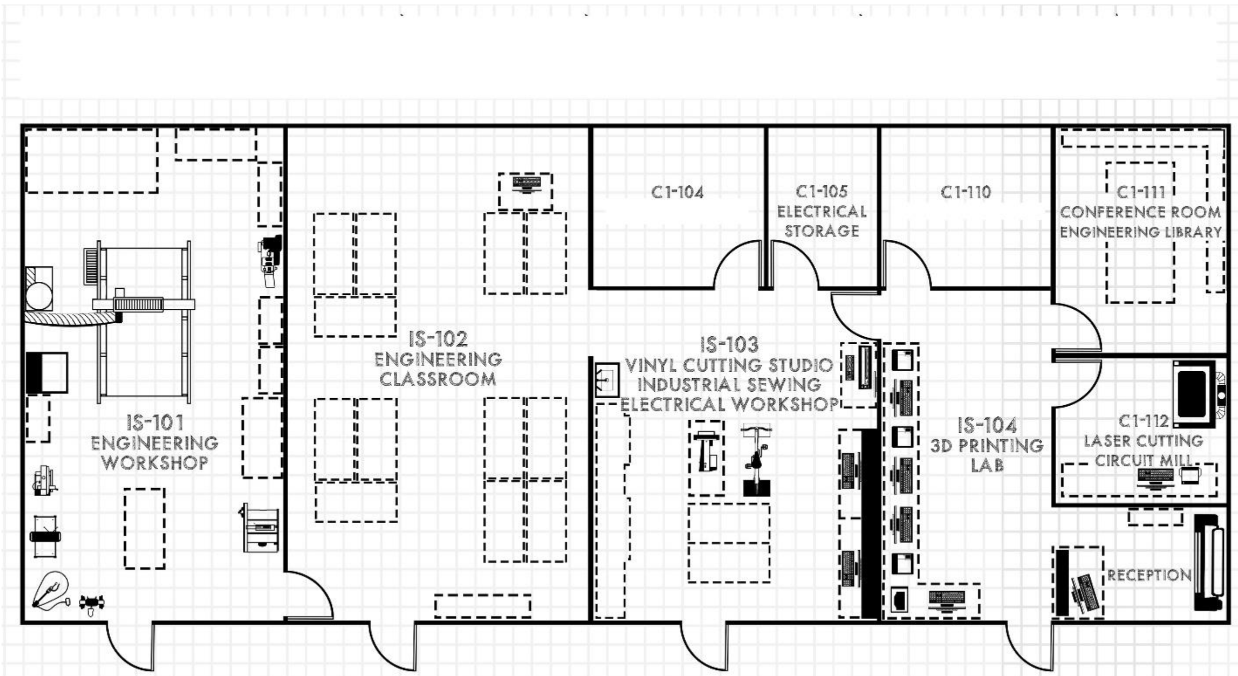

Figure 2. SMCC Engineering Lab + Innovation Center Floorplan

Best practices identified so far, are similar to much learned from the literature, primarily focused on funding, staffing and outreach. While the categories are similar, some of the details within those categories are very different.

Funding

Funding was perhaps the most important category to consider as the space was initially designed, and as it continues to adapt to issues that are identified frequently.   While staffing and outreach often contribute to funding issues, there are several that are specifically related to funding.

During the initial planning stages, the building where the lab would be located had to be renovated. After the final architecture design was chosen, the cost to renovate the building was approximately $130,000. Related to this was a political consideration because the rules within the district indicate that, while the elected Governing Board members do not have to approve expenses that low, it still has to be presented to them. And, regardless of the fact that a company wants to donate, the Board has to give approval for the colleges to receive large donations as well. The retail price of the donated equipment was approximately $250,000. When the proposed donated equipment was initially presented to the Governing Board, it was rejected because of Board members' personal opinions related to the term, "makerspace". As the proposal was resubmitted to address the costs to renovate the building, the term was changed to

"Innovation Center", and it was still rejected due to personal opinions that the "Innovation Center" was the same thing as a "makerspace". When the proposal was presented for the third time, the Engineering Lab Coordinator gave extensive history of the terms that were rejected, and indicated that the space was going to be called an "Engineering Lab and Innovation Center", and explained the difference between the terms and the equipment that is typically included in each. It was only then that the building renovation and receipt of the equipment was approved. While terminology is not a funding issue, ultimately, the rules related to receiving donated equipment and providing background of the needed renovation required clear explanation of the terminology before the project was allowed to start.

Once the project was started, in an effort to reduce some of the expenses, the decision was made to delay the upgrade of the heating and air conditioning (HVAC) system. When the system was upgraded later that year, it was at peak summer, and the heating system could not be fully tested. When cold weather arrived in the winter, the heating system did not work properly, affecting those who were in the space. Repairs took several days to complete, and while the repairs did not cost extra due to system warranty, the initial intent to save costs during building renovation resulted in an extremely uncomfortable environment for the users until it was repaired.

The layout of the space was discussed in great detail from the initial design to the final design. One of the most common topics that was brought up during conversations with Skyline College was storage and the ability to inventory stock. This was one detail, even though it was frequently considered, that was ultimately still underestimated. As the space started to be used, storage space for in-process projects and oversized objects, such as planks of wood, was insufficient. Even though it was part of extensive conversations and planning, this is an issue that is still being addressed, and unfortunately, has to be funded from the program budget. It is recommended that storage for stock, in-process projects, and finished projects be considered multiple times and discussed with others who are in the same situation, then expanded upon after those conversations.

One funding related issue that was very difficult to overcome, and delayed our ability to open the lab outside of Engineering students enrolled in a course that requires a lab fee, was related to accounting. Non-Engineering students did not pay a lab fee, but their potential usage would contribute to the wear and tear of the equipment and would use consumable materials. The problem was creating an account and then linking it to a check-out tool that deposited payments into the account. While this is common in the cafeteria, the bookstore, and tuition cashiering, this had never been done within a program. Establishing an account that is separate from the Engineering program budget, creating that account, and then linking it to a check-out tool that deposited payments into the account took almost one year to officially set up. While we allowed students to use the space, initially, costs were covered from the Engineering program, not students paying for what they used. This is still a problem, however, an approved plan is currently in place, and is being implemented as this paper is being written, and should be in place by summer 2019.

The final funding related issue that was encountered is the general funding source to support the space after it has been operational. When the space was initially opened, it was intended to be supported by the Engineering program budget, however, that budget is a yearly budget and is extremely low. As the equipment started to be used more frequently, repairs and replacement parts had to be made and purchased. It was very quickly identified that the program budget will not be sufficient to fully support the space. Grant funding has been applied for various activities and projects. Projects are evaluated by the Lab Coordinator or Lab Manager prior to their creation, and cost estimates are given, which must be paid before the project is built. Students enrolled in engineering courses with a lab fee do not have to pay for most of their projects as long as their project is directly used in their Engineering class. This is also a current problem, however, an approved plan has been created, and is being implemented as this paper is being written, and should also be ready for implementation in summer 2019.

Staffing

While staffing issues also relate to funding, there were some staffing issues that had to do with timing and availability. When the space first opened, because of scheduling issues, the Program Coordinator could only guarantee six hours per week manning the space to set up equipment, etc. A Work Study student was hired to assist the coordinator, but that was also extremely limited due to Financial Aid requirements. Two adjunct faculty members were hired using separate contracts to assist, and that was sufficient to get the space finalized. After that however, based on legal issues, it was determined that students could not work in the space unless the coordinator, one of the adjunct faculty, or another faculty member who had been trained on the equipment was present. Because of this, the lab hours were limited to Monday through Friday from 8:00 am – 5:00 pm, and the coordinator and faculty had to arrange their schedules to ensure that one was always in the space.

During the second semester, the Lab Manager was hired full time, and additional students were invited to volunteer in the space. This was extremely helpful, however very few of those students were on campus after the typical end time. While the coordinator and manager were able to more easily maintain the schedule, the ability to rely on the students was often affected by exams and other class-related issues. Fortunately, while there were staff timing issues, everyone participates with a "makerspace" mindset and is willing to explore and independently solve problems as they were encountered, then share their findings with others who were present, including other students who were not staff or volunteers. In most instances, if a machine needs routine maintenance or upkeep, several students will work with the Lab Manager or Lab Coordinator so multiple staff and volunteers understand what needs to be done.

Outreach

There are two key outreach recommendations that were experienced at South Mountain Community College, and were also originally identified by the CCC Network. First, outreach to local industry representatives to establish an advisory board was extremely helpful. In the early stages, one did not exist. However, due to early inexperience in establishing this type of space, having an advisory board provided access to outside guidance, and gave clear support for decisions that were made.

The advisory board was also extremely helpful in building student support due to the companies' willingness to explore and offer student internships and part-time jobs. Using their knowledge of the equipment and the training students had access to within the lab and within their courses, the board members were able to clearly understand the potential experiences the students could gain, and then they would identify their company needs as related to that. This resulted in seven paid student internship opportunities the first year, compared to zero, in the previous years.

Finally, also within outreach, a recommendation that was learned is more general, but resulted in several benefits. A willingness to contact individual organizations and reach out established relationships with others that focused on individual areas and pieces of equipment within the lab. Outreach to 3D printing organizations resulted in research opportunities for students. Outreach to companies that provide laser equipment resulted in opportunities for reduced material costs. In general, a willingness to openly discuss the individual pieces of lab equipment often increased student opportunities and reduced costs. In addition to these, it also created relationships with other academics at conferences, and with local high school teachers and students who were usually unfamiliar with the general lab capabilities, but were often familiar with abilities associated with individual pieces of equipment, such as a basic welding system.

Conclusion

Design and implementation of a makerspace at a community college can be a tricky and relatively expensive endeavor, with potential constraints not typically seen at a university. The experiences of the two colleges in this paper have identified constraints in the funding, design, installation, and usage of a makerspace including instructional space limitations, storage space requirements, and operational logistics. While these issues are similar to some of those commonly identified by universities, most of these issues are different magnitudes due to the limits and constraints that are experienced by schools which are very different from universities.

Despite any troubles in getting the makerspace installed and operational, the addition of this resource has been pivotal in catalyzing and supporting the engineering departments at each college. Addition of the makerspace has helped each Engineering program grow, and has created the opportunity for enriched learning activities integrated into the classroom and in personal growth gained through independent projects done by students, engineering clubs, and community members. While this paper is not intended to be a "work in progress", because of the fact that there is little reference literature information available, and this project is continually evolving, our thought is that it may actually be a work in progress, and could perhaps be helpful if a follow-up is written in the near future.

On behalf of the students, faculty, staff, and community members, the authors wish to express their gratitude to the donor company and all those that helped pave the way for the development and installation of fabrication laboratories and makerspaces throughout the country and the world.

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