TRANSITING TO A STUDENT-MANAGED MAKER SPACE

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Abstract

Over the past two years, the College of Engineering at New Mexico State University has worked to develop and grow student engagement in the Aggie Innovation Space, a multidisciplinary maker space facility. In fall 2015, the college transitioned management of the facility from a full time staff operations manager to a facility that is fully managed by on-campus Co-Op students. This paper will discuss the adoption of an organizational management structure that supports career-critical skills (finance, marketing, organizational dynamics, technical mentoring, teams, etc.) gained through the Co-Op management structure, and how a student-managed facility has shifted student engagement from traditional course-based projects to more innovative and entrepreneurial initiatives.

Introduction

In 2013, New Mexico State University (NMSU) created the Aggie Innovation Space (AIS) to help students, faculty, and staff move their ideas forward. The AIS is a maker space that encourages creativity and collaboration. It helps its clients (students, faculty, staff, and occasionally members of the community) move their ideas through the initial stages of the engineering design process. The AIS helps clients develop project management plans and create low-to-mid resolution prototypes, as well as providing training and industry collaboration opportunities for students.

Initially, the AIS was managed by a full-time staff employee of NMSU. The staff member was given the title of Operations Manager and possessed experience in project management, mechanical design, and fabrication. The Operations Manager had various responsibilities, including managing student employees, delegating projects to student employees, providing oversight on projects, and reporting activities to the College of Engineering, as well as the traditional administrative duties of ordering supplies and managing the budget.

In mid 2014, the Operations Manager accepted a position in another department, which prompted the exploration of other maker space management models. Given the strong commitment and sense of ownership by the students working in the AIS and support from the administration and several faculty members, a student-managed model was introduced. This model replicated a successful multidisciplinary student-managed program hosted in the Klipsch School of Electrical and Computer Engineering that focused on the highly regarded national nano-satellite program. The AIS also transitioned the student status from student employees to on-campus Co-Op positions. The Co-Op transition required students to assume more responsibility, as they were now able to claim the work experience as cooperative education versus general student employment, similar to Co-Op positions held within industry. Under the Co-Op model, employed students were required to sign a Code of Ethics that included a requirement to maintain student confidentiality where applicable.

Background

The concept of a maker space takes the traditional lab/machine shop atmosphere and turns it into a multidisciplinary environment that fosters innovation by providing the resources for design and prototyping (Barrett, et al. 2015). It is a facility "where students, faculty, and staff from diverse fields can come together to create, learn and work" and where "campus community members can freely tinker, design and prototype their ideas" (Meyer 2015).

While faculty and staff lead some maker spaces, others have adopted a student-run model of management. Student-run management models can help empower students to be responsible for maintenance, management, and ensuring safe practices of the maker space (Morocz, et al. 2015).

Some schools, such as Arizona State University, have maker spaces run by support staff. Other schools, such as Boise State and University of California, Berkeley, are run by a combination of student, faculty, and staff (Barrett, et al. 2015). Schools such as Georgia Tech, MIT, and San Diego State University have student-run facilities.

Georgia Institute of Technology

Georgia Tech runs a multidisciplinary facility that is funded by more than 30 industry partners and is managed and maintained by a group of 80 undergraduate students known as the "Makers Club." Members serve as "Undergraduate Lab Instructors" in four-hour shifts and assist other students with equipment, lead special project sessions, and maintain the equipment and lab space. The Makers Club gives students the benefits of leadership practice and added points for their resumes, as well as enriched the social and cultural atmosphere of the university. Having peer-to-peer activities has also given rise to student-led initiatives in the form of workshops and contests. University staff serves in a support/advisory role to the facility, and are responsible for certain repairs, purchase requests, and some training and fundraising efforts (Forest, et al. 2014).

Massachusetts Institute of Technology

MIT has a series of smaller maker spaces rather than a single centralized facility. One particular facility – the Pappalardo Lab – supports MIT capstone projects and has a design studio, meeting facilities, and a machine shop. This lab has six full-time instructors on staff who assist with training on the lab's equipment. In contrast, the MIT Electronics Research Society (MITERS)-supported lab is run and funded by students and focuses on more personal projects, as opposed to curriculum-based projects (Wilczynski 2015).

San Diego State University

The SDSU student-run maker space uses students known as "Master Builders" who volunteer two hours per week and are given weekly training sessions by the STEM librarian in running the 3D printer, designing, and other engineering concepts. The student volunteers then act as maker space attendants and assist incoming students with the 3D printer and designing their projects. In addition to serving as an initial student trainer, the STEM librarian also serves in the capacity of project advisor. However, it was discovered that the student volunteers were also important in helping with the 3D printer requests and consultations due to the time-intensive nature of the task (Wong-Welch 2015).

Best Practices

In examining the different types of maker space formats, some best practices emerge:

- **Location**: The site should be in a central location that is easily accessible, within public view (Meyer 2015).
- **Facility**: The facility should be open, give visibility to projects, be easily toured by visitors and able to showcase projects,

and have sufficient space so that it won't be quickly outgrown (Meyer 2015).

- **Inclusivity**: A maker space, its tools, and its layout should be accessible to those with disabilities; this might include items such as braille labels, tables that have adjustable height, large print signs, equipment accessible to those who are seated, and easily accessible materials for those who are motor-impaired (University of Washington 2015).
- **Technology and Equipment**: Useful technologies that are commonly found in maker spaces include 3D printers, CNC machines, laser cutters, CAD software, microcontrollers, soldering kits, and augmented reality tools. Provide advanced prototyping equipment that is accessible and free of charge to students (Meyer 2015).
- **Budgeting**: In addition to budgeting for equipment, materials, and overhead, it might be important to budget for any remodeling or furniture changes, though furnishings can possibly be made rather than bought to save money (Maker Media 2013).
- **Infrastructure**: The maker space should be able to support all electrical, safety, and transportation (e.g., loading dock, elevator) needs, and should not violate any zoning ordinances (Maker Media 2013).
- **Materials**: Ensure that a wide array of low-resolution materials (e.g., clay, Styrofoam, paper, foil, glue, pipe cleaners) are available, readily accessible, and stored in an organized and easy-to-find manner (Maker Media 2013).
- **Training**: Provide training for those who use the maker space and its tools and equipment to help prevent accidents (Meyer 2015).
- **Safety**: Ensure the maker space is uncluttered, spacious enough to navigate safely around equipment, well-lit, and well-ventilated; ensure that a safety plan is in place for possibly hazardous activities and equipment (Maker Media 2013).
- **Community**: Provide a common space where students across all disciplines and years are enabled and encouraged to freely meet, share ideas, and collaborate on projects that are curricular and extra-curricular, personal and professional (Forest, et al. 2014).
- **Challenge***:* Students should be encouraged to use the space to work on "open-ended, real world challenges" (Forest, et al. 2014).
- **Autonomy***:* Allow students the freedom to experiment and innovate, and minimize faculty or staff intervention that may prevent this (Educause 2013)
- **Privacy versus Collaboration***:* Ensure that there is room for collaborative group work (such as large, open tables), and also adequate setup for an individual student to work with some privacy (Maker Media 2013).

Transitioning to a Student-Managed Maker Space

Prior to the AIS becoming a student-managed maker space, an Operations Manager ensured it was supporting clients. The Operations Manager primarily helped feed new projects into the pipeline, delegated projects to the student employees, provided oversight on projects, and performed administrative duties like schedules, timesheets, ordering of supplies, budgeting, and reporting. The AIS was not actively seeking to transition to a student-managed maker space, but did so when the Operations Manager took a position in another department.

The transition began by researching other models across the country and within New Mexico State University. Efforts quickly focused on a highly successful student-managed model hosted within the Klipsch School of Electrical and Computer Engineering at NMSU for a national nano-satellite program. That model was developed and implemented by College of Engineering interim dean, Steve Stochaj, and was focused on providing students with leadership skills as well as a strong technical experience. The model was presented to current AIS student employees for input. Initially, there was some resistance. They were leery of the change and afraid of the uncertainty involved. Most, if not all, of the students were very happy with their current roles within the AIS. The proposed changes were perceived as a threat to an environment they had grown fond of, and they were reluctant to step out of their comfort zones. They weren't fully aware of the various administrative responsibilities previously undertaken by the Operations Manager; all they had to do was work on the projects that were assigned to them. Several of the students, however, seized the opportunity to create a peer-to-peer environment and took on leadership roles. The remaining student employees soon embraced their new roles and relished the unbounded opportunity to expand their skills beyond their previous levels, as well as learning new skills.

After the Operations Manager officially transitioned out of his role, the student employees developed their own management and operations team through experimentation. In their previous roles, they were not involved in the process of how projects were introduced to the AIS, how projects were delegated, or what the administrative duties were. They found themselves working through common organizational dynamics experienced in the workplace. They reviewed data on the types of projects that had used the AIS over the past year and categorized them as follows:

- Course project (non-capstone)
- Capstone project
- Individual entrepreneurial endeavors
- Faculty-assisted research projects
- Student organization/competition (SAE baja, concrete canoe, steel bridge, etc.)

They quickly created teams around areas of expertise to ensure clients of the AIS were provided appropriate mentorship. They created an online scheduling system to reserve equipment and to schedule time with a specific technical mentor. They took the initiative to learn new software, create pop-up workshops in areas they felt would help their student peers succeed in the classroom (e.g., tutorial-type workshops on Excel, MatLab, NX), and they identified new equipment that would expand capabilities within the AIS. Of note was their adoption of modified flexible work schedules that ensured regular operational hours of the AIS while recognizing the realities of balancing employment with their respective course loads. The modified flex schedule required each student to commit to a minimum of ten fixed hours of work per week with the opportunity for an additional five hours of flex time per week as needed to address staffing needs for workshops, special projects, tours, or end-of semester demands on the AIS. The fixed hours ensured regular operational hours, while the flex hours allowed the students to cover for each other as needed to ensure they were able to balance their respective course demands. The operational hours were determined based on student needs rather than institutional office hours and extended into the evening. The students quickly gained an appreciation for the art of time management.

In order to better understand the needs of their current and potential clients, they conducted a survey to gauge knowledge about the AIS among engineering students. They found that most clients learned of the AIS through word-of-mouth from other students, faculty sending students with course projects, and, occasionally, a person from the community who had heard about the services provided at the AIS. As projects entered the pipeline, they realized they needed to develop a process for prioritizing them and, subsequently, identifying which student employee would take the lead. They were faced with a challenge of finding a common time for the ten full-time students to meet, thus the meetings were short (15-30 minutes) and well focused. Next, the students began taking ownership of projects based on the required expertise, the level of interest they had in it, and to a lesser extent, their willingness to work on a project they thought the others would prefer not to have. They aligned on deliverables and timelines. They sought input from each other projects so they could more effectively move their clients through the engineering design process. They updated each other via email and brief informal meetings. They agreed that a project concluded only after the client was satisfied with the results. If the client was not satisfied, they understood the need to iterate until client satisfaction was achieved. This process is outlined below in Figure 1.

The administrative duties were also learned through trial and error, as well as a lot of coaching from administration. Although each of the student employees contributes to the various administrative duties, two of the student employees have taken leadership roles in this realm. These two students, both of whom have military backgrounds through ROTC, used their leadership skills to ensure effective administrative functionality of the AIS while mentoring their counterparts along the way.

Collectively, the student employees discovered that through regular communication and respect for each other, they had the skills to manage the AIS facility and the initiative to increase the level of student engagement

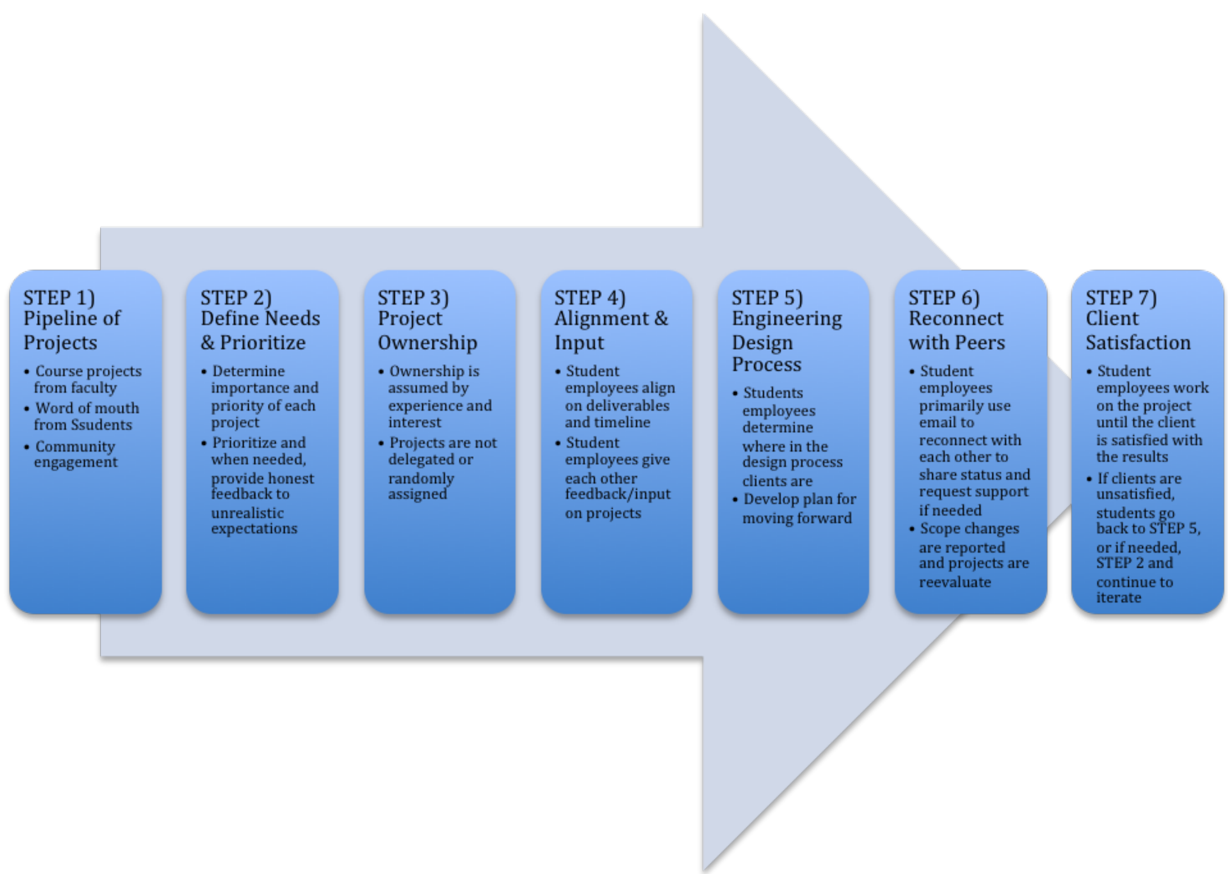

Figure 1. Student-Managed Process for Supporting Client Projects.

across the college. As peer managers of the AIS, they have come to respect their roles and understand the expectations of their positions as mentors and stewards.

Although there are many benefits to having a student-managed maker space, there are acknowledged challenges. In the short term, the student employees lacked confidence, as they no longer had an experienced professional who made sure they were on the right track and was readily available for input on unfamiliar challenges. The students had become accustomed to a hierarchical work environment and were uncertain how to maneuver without an authority figure to make key decisions, act as a single point of contact, and manage emergencies. Lastly, the pace at which each of the Co-Op students rose to the challenge varied, resulting in a lag between the initial transition and full student buy-in. This resulted in a perceived lack of commitment among the student team, and was only resolved following several team meetings and open communication.

Many of these challenges are resulting in long-term gains for the students employed in the AIS Co-Op program. More than a strong sense of pride and ownership, the student employees are developing real-world skills that will help them throughout their careers. They are no longer uncomfortable with uncertainty. They are developing confidence in their ability to solve unfamiliar problems. They are learning to work together efficiently and effectively without external support or pressure. Additionally, this new role assumed by the Co-Op students requires a shift in mindset from one that was reactive to one that is proactive. These Co-Op students have increased their respective levels of engagement while developing capabilities in areas that interest them most.

Professional Development

Leadership skills are invaluable, but not typically gained through traditional student employment experiences. By moving to the new student-managed Co-Op model, the students were required to assume a higher level of responsibility. Under the new model, the students operate as a horizontal organization. This broad and shallow structure provides each of the students the ability to take the lead on different projects, big and small. A team approach is evident in the projects undertaken by the students, and they have become empowered to take initiative.

The Co-Op management structure of the AIS promotes the same skills and knowledge expected of Co-Op students employed in industry. It also promotes a sense of responsibility. The students have savored their successes while learning to take responsibility for their mistakes. They are very conscious of their roles as mentors to their peers and stewards of the AIS and have risen to the challenge.

The AIS Co-Op students are responsible for managing all aspects of the projects that occur within the facility. They are responsible for creating their own timelines and are required to give regular reports on the progress of each major project that is occurring during the semester. They are also responsible for enforcing deadlines when it comes to projects. The bottom line is that the students must and do deliver on their projects, as they are dealing with their peers as clients. They understand that failure to meet deadlines can have serious implications for student grades and course completion. During our first semester, there were no major lapses within the projects that had been scheduled and the students performed very well. Having to face deadlines successfully and having to make do when necessary, the students face the same realities practicing engineers see every day.

The Co-Op management of the AIS strongly emphasizes teamwork and collaboration among the students. The staff of the AIS exhibits a certain camaraderie that is bound by their joint responsibility and pride in the space. They have proven to be outgoing and quick to help each other whenever issues arise. The Co-Op students have also learned to collaborate with different faculty members and student clients to accomplish their particular goals. Several of the Co-Op students are multidisciplinary and encourage the others to be the same. In order to assist some projects, the students have even been willing to learn skills that are not directly related to their major and future discipline.

By working in this type of organizational structure, the Co-Op students have learned to take on responsibility not only for their individual tasks, but also for the priorities and the overall direction of the AIS. By working directly with their clients, this type of work environment also produces an emotional intelligence and maturity that facilitates interactions with co-workers and the general public.

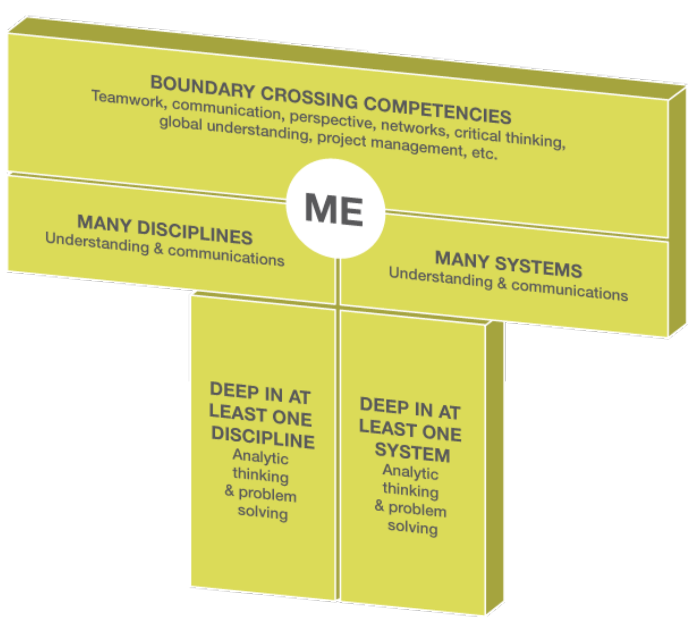

Figure 2.

Work Experience Gained through the AIS Co-Op experience

Managing and working in this university maker space provides on-the-job training for these Co-Op students. There are many different projects and events whereby the students are able to learn new skills and perform tasks valued by engineering employers. In line with the concept of T-shaped individuals, the AIS Co-Op students have gained invaluable depth and breadth. As depicted in Figure 2, T-shaped individuals represent the depth of related skills and expertise in a single field, and the breadth of skills required to collaborate across disciplines and the ability to apply their knowledge in areas of expertise other than their own. As future engineers, AIS Co-Op students are gaining broader attributes such as empathy, communication skills, team building, and the ability to collaborate. As such, the AIS Co-Op model has provided students an opportunity to perform in a real engineering role.

An important job skill learned almost immediately by the students is that of schedule management. The students are responsible for determining the hours of operation and for staffing the maker space during those hours. With the additional constraints of student employees having their own class schedules, this task quickly becomes a problem with multifaceted constraints. The Co-Op students work through these issues and managed to staff the Aggie Innovation Space throughout their first semester. During the semester, the student managers made several schedule changes to better accommodate the student traffic.

Resource management was another skill acquired and practiced by the Co-Op students. They learned to work within a fixed budget to maintain operations and still afford investment in better prototyping technologies. The students kept their employment hours within their assigned budget and did not run out of funds. Overall, the students managed their resources very well. Their ability to deliver results within fiscal constraints is a highly desirable skill that is sought by employers.

Space management was another challenge that the Co-Op students were able to take on with little input from the faculty. The Co-Op students did well at managing workshops, tours, time on highly popular equipment, and providing access to software needed by the clients. The students worked hard to transform the different rooms and facilities to accommodate larger groups for tours and workshops. They also had to contend with unscheduled repairs of the 3D printers, which was especially challenging since they needed to prioritize print jobs and that sometimes frustrated the clients. The students did their best to fix problems promptly. They even worked to find other resources on campus when there were none available at the AIS for the students to use.

As peer managers of the AIS, the Co-Op students also gained experience mentoring fellow students. Peer mentoring is a very important skill to possess, as it demonstrates the ability to transfer technical knowledge and skills to a co-worker. The students spent copious time presenting workshops on modeling tools and maker space equipment usage. There were many one-on-one coaching sessions where the Co-Op students spent time helping other students master the use of prototyping tools and equipment.

The ability to combine and utilize these skills will benefit employers by providing them with extremely capable employees from day one. Students that become Co-Ops within the AIS have learned specific technical engineering skills, but they have also learned the important T-shaped soft skills required in today's workplace. They have learned to work well with other people, how to resolve conflicts, how to meet deadlines, and how to plan for the future. Students that work under this innovative management model become self-starters who can adapt to change and work with others to find practical engineering solutions.

Conclusion

The benefits of having a student-managed maker space are proving to outweigh the cons of not having an experienced manager. The students are developing self-confidence, interpersonal skills, and depth in their areas of interest. In an age of increasing budget cuts, the student-managed model is also more sustainable. It can scale when times are good, but adjust when needed.

A key aspect moving forward with this management model will be to ensure the quality of the AIS management remains high when student leaders graduate. This can be done through extensive cross training of all students. This is already being partially implemented through the shallow organizational structure adopted by the students. Faculty mentors should continue to encourage students to find opportunities to acquire additional responsibilities and competencies.

In our short experience with this new model we have not had to yet deal with any significant cases where the students did not deliver or perform for a client. The students have performed well because they are very communicative and convey concerns for delay to their clients in a straightforward manner. It is imperative that the faculty mentors develop an open dialog with the student managers so that they are comfortable reporting mistakes, both big and small. It is also incumbent upon the faculty to ensure the students do not over commit their time and capabilities so as to avoid a catastrophic fail with their client. To this point the students have thus far done well in gauging their abilities to provide deliverables to their clients.

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