Work-in-Progress: Lessons Learned Supporting First-Year Students in an Academic Makerspace

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Abstract

All students in the first-year course, Introduction to Engineering and Design, are required to attend the makerspace orientation training, which includes a tour, safety information, and training to operate the entry level 3D printers. Attendance at this training is required before participating in any other machine training sessions for all students. The training structure for first-year students has gone through several iterations. When the makerspace first opened, faculty from the first-year program worked with the makerspace manager to require training during one of the regular lab sessions. These lab sessions are three hours long, offered once per week for each class section of 12-18 students, and three of the sections have lab concurrently. This method continued throughout Fall 2016 - Fall 2018, but several issues arose with negotiating time for the rest of the lab activities and consistent quality across all training sessions with large groups attending at once. Over the past academic year, faculty, staff, and TAs experimented with the structure of lab activities and now require this training as part of a pre-lab assignment.

Based on feedback from makerspace student staff and first-year students, the size of these pre-lab training sessions has been limited and they are available to first-year students only. This allows students to participate with others in their cohort, and makerspace student staff also emphasize opportunities for use of the space, machines, and that technical and design workshops are available through the space. A survey has been developed and was sent out to the Fall 2019 first-year cohort to assess student confidence in their training experience, whether they have participated in any additional training or follow up events, as well as two open ended response questions. Survey data from Fall 2019 is presented and further iterations for the Spring 2020 semester discussed.

Introduction

This work in progress paper details the evolution of an academic makerspace training system for first-year students. The makerspace in a large northeastern university opened three and a half years ago. It is housed in the school of engineering but open to all university students, staff, and faculty. The space is 10,000 sq-ft, with a large open floor plan and typical maker equipment as well as advanced machining and testing, such as 3D printers (FDM, SLA), CNC routing and milling, soldering, PCB milling and testing, laser cutting, and waterjet cutting. There is a workshop area with a large screen for presentations within the space itself. The makerspace is managed by three full-time staff members and a large group of paid undergraduate and graduate student staff, who lead the introductory training and workshops.

The first-year cornerstone course, Introduction to Engineering and Design, is a single semester 3-credit hour course required for all engineering majors. The course has weekly joint lectures, held in the school's auditorium, 3-hour lab sessions, and 1.5-hour recitation sessions. The size of each

section varies per semester but is usually 12-15 students, and students are in the same cohort for lab and recitation.

Since opening the makerspace, the full-time management staff have worked with faculty in the first-year engineering program to introduce all students in the course to the space through required introductory training. Students are thus able to enter the space as a cohort, reducing the barrier to entry and scaffolding their participation. This training has evolved over the past three years based on student and faculty feedback.

For the first two years, students attended the training during part of a lab session. However, because several lab sessions run concurrently, each lab group went to the makerspace at different times within the lab session, disrupting the required lab activity. The number of students in each lab section varied, so the quality of the training session also varied: larger cohorts received less attention and hands-on time to practice 3D print setup. Over the 2018-2019 academic year, these first-year student only training sessions became a required pre-lab activity. The structure and support for this pre-lab training is described below.

The curriculum of the first-year course has also evolved over the past four years. Before the makerspace opened, there was no required 3D printing or prototyping training. A short Computer Aided Design (CAD) keychain design activity was introduced in 2016; this started as a simplified first week lab activity. In Fall 2018, it was redesigned as a full lab activity and moved to the fourth week of the class. Students now must learn both Fusion 360 and Autodesk Revit and then complete a short design activity using each software.

The primary semester-long design project for the course has been also developed over the past three years to allow a combination of the original highly structured, robotic projects and given prompt-based and student-initiated concept open-ended design challenges [1]. As the fabrication of the less strictly defined projects can necessitate a more diverse range of skills, the course has now included mandatory basic use training on tools in the makerspace and held a series of workshops on skills commonly used in previous student projects. The first-year teaching assistants (TAs) now work with the makerspace to host introductory workshops within the space itself on technical and design skills to continue the scaffolding of first-year use. As the initial exposure to the makerspace and prototyping equipment for many students, the environment presented during the first-year course introductory training and workshops can shape the experience of courses and assignments throughout their engineering education.

This paper analyses the data presented in response to an end-of-semester survey on the impact of the makerspace training and course integration. The responses reflect the familiarity with makerspace equipment and learning process allowing completion of both coursework and extracurricular and personal projects.

Background

Project-based courses and learning continue to increase in engineering programs and degrees, as universities seek to overhaul their curriculum, support different methods of teaching and learning, and satisfy new ABET criteria [2]. To support these courses, new curricular programs

have been developed such as the service design program, EPICS, at Purdue, and the Vertically Integrated Projects (VIP) program, started at Georgia Tech [3, 4]. These programs seek to support project-based learning from the cornerstone, first-year project to the capstone, senior design class. Alongside these programs, new campus facilities and academic makerspaces have been developed to satisfy the need for rapid prototyping tools and support both extracurricular and curricular project-based learning [5, 6].

Use of these makerspaces can be intimidating for first-year students as they enter the university. And, though there is a growing presence of these spaces at most schools, many students still do not know that they exist or, if they do, how to attend training and start utilizing the available resources [7]. To address this, first-year engineering programs are embedding use of the makerspace within course activities [1, 8-11].

For the first-year program at Northeastern, a new "Learning Center" was developed in 2013 with access to project work space, various hand tools, and 3D printers [9]. When it initially opened, some of the student population did not utilize, either because they did not know it existed or because they did not think it would be useful. The percentage of students who did not utilize dropped over time as information about the resources and training available was increased, and students were able to accomplish more advanced projects within the first-year because of this space [9]. At Drexel University, labs are taught within the makerspace itself, with two of the lab modules utilizing rapid prototyping resources such as Arduino, laser cutting, CNC milling, and 3D printing [10]. Student response demonstrated an overall increase in satisfaction with the support provided for these lab activities [10]. NJIT has recently opened an academic makerspace. To support use of this space, faculty in the first-year engineering program have experimented with embedding makerspace use at the end of the semester with two short design challenges around 3D printing [11]. These experiences reflect different components and challenges of the program outlined in this paper.

Methods

All introductory engineering course students are required to attend the makerspace safety orientation, covering basic safety rules and introductory 3D printer use, during a session scheduled independently of orientations offered to other university users. The safety orientations are reserved for course students only and attended during the first month of the course; it must be completed before the lab session in the fourth week of class, which now includes an introduction to two different CAD programs and a design challenge.

The course only training sessions are run 2-3 times per week day during the second and third week of the course. They are only run by a select group of junior or senior undergraduate makerspace staff. The university uses OrgSync, an online student engagement management system, for all clubs and student affairs sponsored activities. The makerspace has an OrgSync portal, and the course students are required to sign up for a specific training session through that portal. The attendees for each first-year training session were limited to 12 students in Fall 2019 and 10 students in Spring 2020 based on feedback from students requesting sessions with fewer attendees to improve hearing and individual engagement in an often loud and distracting

environment. Regular training sessions (for any user) are listed on a public Google calendar and do not require prior sign up.

Throughout the semester, workshops were offered to first-year students by course TAs on technical skills expected to be useful in the design and fabrication of the cornerstone design projects and were collectively titled "First-Year Series" workshops. In Fall 2019 the workshops offered were:

- Intro to Circuits
- Intro to Soldering
- Intro to Arduino
- Intro to Raspberry Pi
- Advanced Arduino

Advanced Arduino covered connection to a Bluetooth module and wireless servo motor control. Introductory trainings on makerspace equipment not covered during the safety orientation, as well as workshops on a broader range of engineering and design-based skills, were offered by the makerspace independently of the intro course and open to all university students and affiliates.

The anonymous survey was created in Google Forms and sent to students in the 12th week of the course. The survey distributed asked participants about:

- Previous use of similar fabrication spaces
- Orientation they attended (if attended for other reasons or before participation in the course)
- Use of makerspace equipment for either course-related or personal projects
- Confidence in ability to set up a 3D print without further instruction
- Level of comfort asking for assistance from the makerspace student staff
- Further equipment trainings or workshops attended
- Number of people present in the training group

In addition, there were two open ended responses for recommendations to improve the space. The data collection survey was distributed during class near the culmination of the semester long design project, and survey text has been included in the Appendix.

Preliminary Results

In Fall 2019, 288 students were enrolled in the course, and 203 student responses to the survey were received. The majority of those students, 171 (84%), attended the orientation training because they were required to do so for their pre-lab. The remaining students indicated that they had attended the training during welcome week events, before they were required to do so, or as part of a summer STEM program. Of all respondents, 76 (37%) had previously used a makerspace or similar fabrication facility. Following the required safety orientation, 122 students indicated that they continued to use the makerspace for their course project and 82 that they had

since used the space and tools for a personal project. These combined responses of continued use after training are shown in Figure 1.

Of the respondents, 59 (29%) responded that they had attended additional makerspace training. These trainings were listed on the general training calendar and did not require prior sign up. A summary of what they choose to attend is shown in Figure 2.

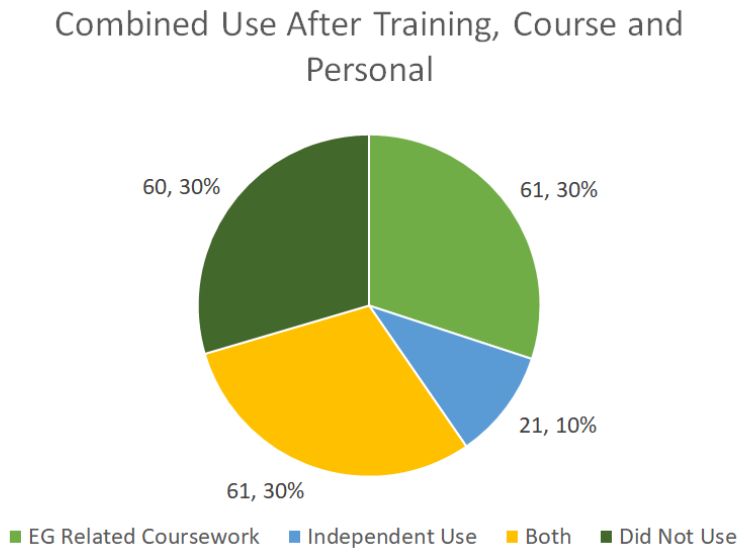

Figure 1: Combined Response of Makerspace Use After Training

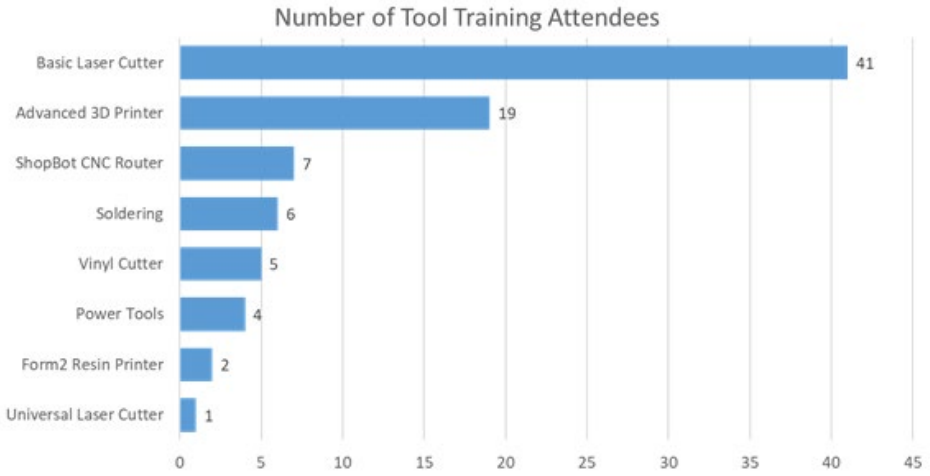

Figure 2: Additional Training Attended After Course Orientation

In addition, 58 students (29% of respondents) attended at least one first-year course workshop following their safety orientation. Of those, 26 (13% of all respondents) attended both first-year course and independent makerspace workshops, and 23 (11% of total) attended only independent makerspace hosted workshops.

Next, the survey asked students how many attendees had been in their specific training session. Group size had been an issue with the first-year training sessions before the switch to the current pre-lab training model, as students found it hard to hear or pay attention in larger groups. As seen in Figure 3, there were still 36 students who indicated that more than 12 students were in their session. This is discussed in more detail below.

To better understand group training size issues, Figure 4 shows the number of attendees in the respondent's specific training session for the two subsets of students who indicated that they did not yet feel comfortable setting up a 3D print and for those who did not feel comfortable asking the makerspace student staff for help. Figure 5 summarizes the open-ended survey responses (grouped by subject for clarity), with text size corresponding to frequency of suggestion occurrence.

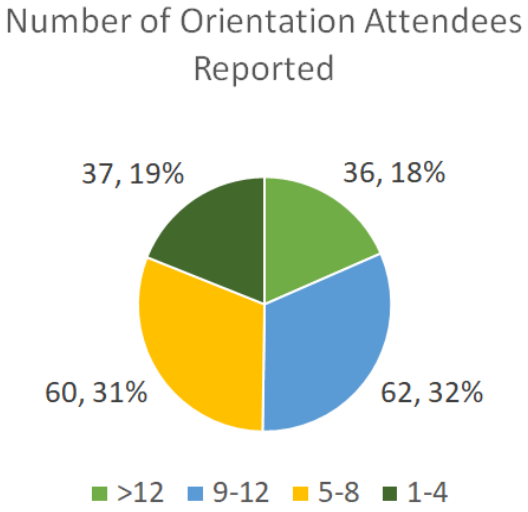

Figure 3: Number of Attendees Reported in Student's Attended Orientation Session

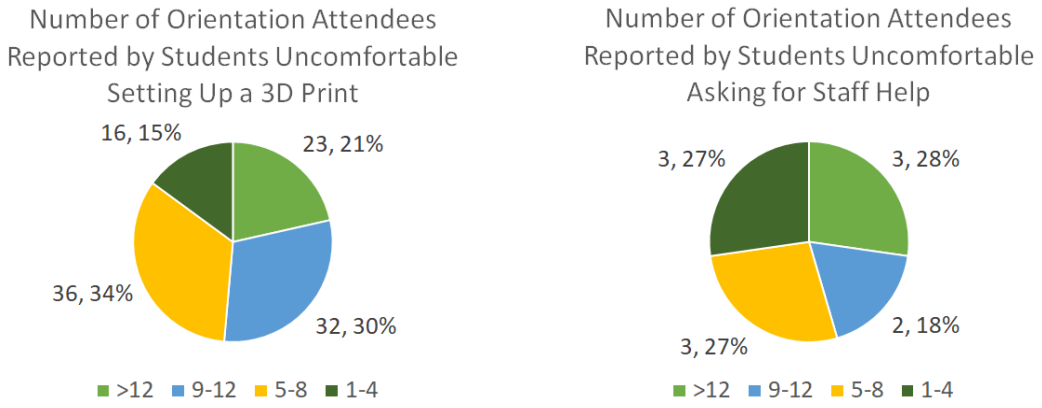

Figure 4: Number of Orientation Attendees Reported by Subset Issue

Figure 5: Summary of Open-Ended Responses

Discussion

A new system to control group size with dedicated time for first-year students to attend makerspace training was developed in Spring – Fall 2019. Additional workshops focusing on technical skills useful for first-year projects were hosted throughout each semester. These workshops, along with continued redevelopment of the first-year labs and projects, have helped to foster and support repeated usage of the makerspace by first-year students. This can be seen from Figure 1, with 70% of the respondents indicating that they used the space for course or personal projects after the required training.

As can be seen in the data from Figure 3, there were still some make up training sessions that had a large group size. Students also requested smaller groups and training be held more often in the open-ended responses. After the two weeks of scheduled training for both previous semesters, there were still about 30-40 students who requested training at the last minute. Because a small cohort of makerspace student staff run these trainings, the make up sessions had large groups and were offered ad hoc. To address this, in Spring 2020, any additional trainings needed will be scheduled by the end of the second week of class so that students can still register for them through the OrgSync portal.

A crucial development for this system of first-year training has been communication between the makerspace management and student staff and the first-year program. Previously, communication with the first-year program was sent through faculty. There was confusion between both the course TAs and students about how to register for the training. This semester, first-year course TAs will now all go over the sign-up system in their recitation and lab trainings, so everyone involved with the course should be able to help students register and be aware of the system.

The makerspace student staff who lead training and the scheduling of the training sessions for the past three semesters has been organized by someone who works for both programs. They are able to act as a liaison between either program and support communication between staff and faculty. This student liaison is invested in the success of both programs.

In summary, the steps that have been successful so far in creating a clear training system between the two programs and support for continued first-year use are:

- Communication between programs – all faculty, staff, and TAs
- Having liaison TAs, who work for both the makerspace and the course
- Very small training groups: 10 students or less
- Tie-in to required lab activities and semester long design project to build and apply skills
- Scaffold and support additional participation through continued introductory workshops

Future Work

Data will again be collected in Spring 2020. The training sessions have been restricted to ten students per session, and there is a plan to add any additional needed training to the OrgSync page. The course enrollment for spring semesters is generally lower than for fall semester: for Spring 2020 there are 260 students enrolled. Student experience and survey response this semester will show if the attendance limitations, scheduling, and communication plan has improved. Feedback will be collected from liaison TAs and orientation session instructors regarding student engagement following the implemented changes. The first-year course is also continuing to expand the number of open-ended projects that are offered to students and will again offer the first-year series workshops.

The impact of makerspace training and collaborative workshops on introductory engineering courses can best be measured using data sets collected over time, including differences correlated to changes made in the program in response to previous feedback. In order to provide the greatest benefit to users, the qualitative survey feedback can be used to develop better ways to integrate the course with the space. Further feedback in future semesters can be compared to already collected data to determine the positive and negative effects of any changes made. Future work is also planned to look at longitudinal data of students who use the makerspace in their first-year and follow them through all four years of undergraduate work.

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Appendix

MakerSpace x EG Safety Feedback Form

Please fill out the following form. You will not be graded in any way, we just want to make sure everyone knows the resources available, and that we can improve the space as much as possible!

1. When did you first attend a MakerSpace safety orientation?

   Mark only one oval.

   - ◯ Required EG prelab
   - ◯ Welcome Week
   - ◯ Did not attend
   - ◯ Other: _____

2. Have you previously used a MakerSpace or other fabrication facility?

   Mark only one oval.

   - ◯ Yes
   - ◯ No

3. Since your safety orientation, have you used MakerSpace equipment for EG-related coursework?

   Mark only one oval.

   - ◯ Yes
   - ◯ No

4. Since your safety orientation, have you used MakerSpace equipment for non-EG related coursework or personal projects?

   Mark only one oval.

   - ◯ Yes
   - ◯ No

5. Do you feel confident setting up a 3D print?

   Mark only one oval.

   - ◯ Yes
   - ◯ No
   - ◯ Maybe

6. Do you feel comfortable asking MakerSpace staff for assistance?

   Mark only one oval.

   - ◯ Yes
   - ◯ No
   - ◯ Other: _____

7. Have you attended any equipment trainings since safety orientation?

   Mark only one oval.

   - ◯ Yes
   - ◯ No

8. If so, which ones?

Check all that apply.

- [ ] Laser cutter
- [ ] Advanced 3D printer
- [ ] Form2 resin printer
- [ ] Sewing machine
- [ ] Othermill
- [ ] Vinyl cutter
- [ ] ShopBot

Other: [ ] _____

9. About how many people attended your safety orientation?

Mark only one oval.

- ◯ 1-4
- ◯ 5-8
- ◯ 9-12
- ◯ >12

10. Have you attended any EG MakerSpace-hosted workshops?

Mark only one oval.

- ◯ Yes
- ◯ No

11. Have you attended any non-EG MakerSpace-hosted workshops?

Mark only one oval.

- ◯ Yes
- ◯ No

12. Do you have any suggestions for how we could improve the space or the trainings?

_____

13. What would make you more/less likely to use the space?

_____