Student-Led Makerspace Workshop Platform

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Abstract:

Makerspaces often introduce educational workshops that demonstrate available tools to build users' skills, while fostering collaboration and creativity in the space. A notable challenge in developing workshops in educational makerspace environments stems from finding instructors who are skillful, passionate, and available to teach frequent workshops; with student-run workshops almost completely depending on the pre-established experiences of the instructors and to operate around their individual availabilities. This paper introduces a framework that uses student employees, robust training programs, and workshop documentation to train student instructors on technical and teaching skills. By following this framework, a safe and effective learning space can be created for staff and attendees that build a diverse and welcoming community within the makerspace, while also providing standardization to workshops, ensuring quality, accessibility, and a rolling training platform so every year new employees can be onboarded. This peer-to-peer learning system encourages communication, understanding, and a balance of power between the students and instructors, understood through quantitative and qualitative data from attendee feedback and employee review.

1 Introduction and Motivation:

Due to the recent Maker Movement, education has seen a significant push towards hands-on-learning both in and out of the classroom. Spaces have and are continuing to be developed with the goals of providing a place for students to learn hands-on. These spaces often accommodate students completing class projects as well as encouraging personal passion projects. They all offer benefits for their users that may include tools, equipment, and educational resources. Educational resources offered in these makerspaces range from required training for use of equipment to informative workshops. Through conversations with other universities, we have found that it is very difficult for many makerspaces, previously including our own, to maintain a system of informative workshops, inspiring the motivation behind this paper. With makerspaces connecting students, faculty, and staff together to bring their ideas into reality, connecting these makerspaces together to share resources and workshops will provide a sense of community for all users.

1.1 Rational:

With hands-on learning and experimentation enabled by makerspaces, students are able to learn from their failures, get exposed to new opportunities, such as the opportunity to see their "ideas come to fruition," and develop new skills they can take with them for future successes (Davis, 2018). The rise of the Maker Movement has inspired more resources and training to be accessible to makerspace users. Resources include equipment guides, specific sessions to learn new valuable skills, and the ability for people to collaborate and create within a single space (Davenport, 2015). Despite the large increase in use across the country in academic makerspaces, there is not a large presence of educational material and workshops that are being output to the student users, and it is more commonly being asked whether "maker activities" can be incorporated "into rigid instructional plans to align with standardized testing" (Dousay, 2017). This paper offers a framework to operate accessible educational hands-on workshops to students, while also presenting a system that can benefit the makerspaces that host these workshops.

1.2 State of the Art:

The Maker Movement originated about two decades ago with the purpose of connecting people with the same interests, whether that be through finding new hobbies, gaining new skills, or encouraging collaboration (Deloitte and Maker Media, 2013). Since then, a significant amount of work has examined the organizational structure behind these spaces, the culture behind connecting these large groups of people, and individuals or groups that have aided in advancing the movement.

Before the Maker Movement, it was very difficult for the general public to access the required tools and information to innovate. As the Maker Movement continued to grow in popularity, a rise in access to both equipment and education has had noticeable impacts on entrepreneurship. One study focused on this impact to entrepreneurship by looking into how it affects business generation and sustainment, through introducing more individuals into creating, forming diverse networks of people who are passionate about innovating, and reducing the costs of prototyping (Holm, 2015).

Another study, which focused on the students using these spaces, discussed the benefits of providing such extra-curricular learning through hands-on projects and opportunities to learn new skills (Barrett et al., 2015). The study broke down how different makerspaces on universities' campuses were staffed, the location of these spaces on those campuses (on-campus or off-campus), and the level of access for students at those universities (university access or open to community) to understand how different spaces are structured operationally. It was found that it is very common for these spaces to be run primarily as a combination of student staff and university staff personnel; with completely student-driven initiatives seen less frequently. Although the study did not look into the benefits of one staffing method over the other, it is

important to understand how other universities decide to staff their space for the benefits of the student users.

Other studies have looked at benefits of student-run makerspaces and impacts on safety (Jariwala et al., 2021), while others have examined the benefits on the culture that can be generated from the peer-to-peer collaboration (Noel et al. 2020). Although it is commonly believed that education should be taught by instructors who have received formal education through universities and courses, the Maker Movement allows for a sense of collaboration between those learning from lessons and those teaching them, rather than having students passively reacting to these lessons in a normal classroom setting. In a study focusing on the Marina Bay School's Makers' Club, it was found that students can actively benefit from a "self-directed journey of discovery and exploration," through the use of student instructors not bound by generic curriculum programs (Tan, 2018).

Despite these widespread benefits that can come from creating and continuing this Maker Movement, it is apparent that those who create makerspaces often face challenges, including operational costs and budget needed to run a space (equipment purchases, maintenance expenditures, consumables), staffing required to keep the space running, and the training required for the staff and users of the space (Curiosity Commons, 2015). This training is often an obstacle for makerspaces as most need to create "workshops, online tutorials, handouts, and overall information" to account for the common "user inexperience" on such technologies (Moorefield-Lang, 2014). Training often takes time, planning, resources, dedication, and consistency to ensure that it successfully educates students to safely use the equipment. In a study looking at similar challenges present in K-12 and college engineering classrooms, it was found that teacher preparation, technology and resource management, and diversity are common concerns to be aware of in the future (Hira et al., 2014). Preparation can include making sure the instructors who are teaching such hands-on curriculum and workshops are knowledgeable on the various subject matter, as well as how to operate and use a variety of materials and equipment. The management of the technology and resources available in these spaces is also a significant concern for these spaces as there may be limited equipment, training or support available at these schools to make a makerspace run effectively. Lastly, diversity is raised as a significant concern as there has been a significant push to include women and underrepresented minorities, as well as people with different levels of experience in these spaces. Focusing on all of these topics in the future will aid in keeping these makerspaces operational and welcoming, while also ensuring that the space has the tools and facilities available for high level projects and work.

Looking towards this future, it is important for groups and organizations continuing this Maker Movement to "identify and share best practices" to best meet the needs of the individuals using the spaces (Wilczynski et al. 2017). These issues of staffing, funding, and training often lead to makerspaces struggling to meet the goals of making these spaces more diverse and

beneficial to its users, thereby not developing the benefits of diverse networks of people passionate about innovating. By focusing on connecting these common spaces across the country, groups and organizations can learn from one another to benefit all users who come to these spaces.

1.3 Approach:

We have developed a unique approach to teaching workshops that has yielded over 300 workshops per year using a student-run team of 15 workshop staff, and a robust documentation and training system. Where most makerspace workshops are volunteer run, our makerspace utilizes federal work-study funding to create a team of paid instructors who are focused on running and developing workshops. We provide all the necessary training and technical development allowing us to hire students based on passion and excitement for learning and teaching which promotes a talented and diverse team. The students on the workshop team split their time between teaching workshops, attending trainings, and working on projects. Projects include prototyping new techniques or processes to improve existing workshops, developing new workshops and the associated materials, and improving or recreating legacy documentation. This approach allows us to offer a wide range of workshops on a variety of topics and provides an opportunity for the staff team to develop technical and leadership skills.

This research introduces a framework for using student employees, robust training programs, and workshop documentation to train student instructors on technical and teaching skills. The framework is based on the idea of standardizing workshop pedagogy and using weekly meetings to train instructors on the workshops as well as topics such as the EDGE method of teaching, promoting accessibility and inclusion, and maintaining documentation and organization. Our approach allows for a diverse range of workshops to be offered and the ability to customize the workshop catalog to match the tools available in a makerspace. It creates a safe and welcoming learning environment for staff and attendees and builds a sense of community within the makerspace. Students attending these workshops can learn valuable skills, discover new hobbies, and make new connections. The peer-to-peer learning system encourages communication and creates a balance of power between students and instructors, making it easier to create new workshops through the exchange of ideas between the attendees and student instructors, generating a sense of fulfillment in the work students complete.

2 Background:

2.1 Makerspace:

The makerspace that we use to host our workshops is located in a central building on campus with main entrances on either side, meaning students frequently use this building as a quick and sheltered way to cross campus. The building has an open format design with enclosed

open format classrooms that facilitate collaboration and group work during lectures. The second floor is primarily an open study space with small tables. The first floor is home to an undergraduate robotics lab, the prototyping lab and the makerspace. Workbenches are arranged throughout the makerspace, providing a place for many students to collaborate and use the available tools. Due to the open format building, many of the workbenches are directly next to the main walkway allowing those passing by to quickly engage with the makerspace.

Figure 1: Open study space on the second floor

Figure 2: Workbenches within the makerspace

Within the makerspace, tools are available to checkout by all students who have completed a "Basic User Training," with tools ranging from hammers, saws, sewing machines, and countless others as seen in Appendix B. This training provides the necessary information to safely use the space and tools. The training gives a student access to hand tools, drills, sewing machines and other basic tools that have little associated risk to the student. For tools that are

more dangerous or complex, additional training is required per tool. Examples of these include the laser cutter, drill press, belt sander, CNC machine, and vinyl cutter. This system of access levels allows students with no prior experience in a makerspace to easily get started using basic tools and advance their skills at their own pace, as comfort and confidence increases. A student employee is on duty during open hours to check out tools and maintain the space. Bigger tools are locked and require a key that can be checked out. Materials such as plywood, acrylic, sandpaper, vinyl sticker material, and jewelry wire, are also available to purchase from the front desk to be used for student projects. This is another aspect of reducing the barrier to entry of using a makerspace: students can acquire materials for a low cost without needing to travel off campus or order materials online, and use student employees for advice on which materials will be best for their use.

2.2 Previous System

Ever since the makerspace's inception back in 2018, our makerspace has offered a range of workshops on a variety of topics. Before the creation of the current team discussed in this paper, the workshop team was primarily staffed by volunteers from departments across the university. In talking with the current manager of the makerspace, we discovered several challenges regarding this format of using a completely volunteer workforce. We found that the faculty who previously ran these workshops would frequently miss workshops, often due to other work being prioritized. Overtime, those teaching the workshops began to withdraw, leading to a reduced capacity for workshops. This jeopardized the sustainability of the program when run exclusively through staff volunteers, which was a major inspiration behind the current workshop system.

The content and timeframe of the current workshops has not deviated too far from what was offered years ago. Workshops were available from the second week of each 7-term to the week prior to finals; with similar topics ranging from Soldering, Laser Cutting, Leather Working, and Sewing. Additionally, similar to how the current workshops are advertised, the previous workshop system published workshops through the Makerspace's Canvas page, as discussed further in Section 3.4. Unlike the current workshop system however, the registration for these workshops was managed through a legacy system developed a decade prior by an external developer. A major reason for changing to what is currently used for registration, is that once the developer left, there was no additional documentation for keeping the system active.

Over a year before the current team discussed in this paper was created, five student volunteers were hired and trained on a few workshops, with the goal of replacing the original university employees who ran the workshops. Unfortunately, due to the pandemic, this system was halted, but the idea behind using student workers was raised, and promised to be an effective method for use in the future.

3 Methods:

3.1 Team:

The student team that operates and runs our workshops consists of workshop instructors and coordinators. Instructors teach the workshops as well as developing new topics to be taught in the future, while coordinators are responsible for managing the team and systems. The coordinators are specifically responsible for each 7-week term's schedule, guiding the direction of the team, developing training for the instructors, and creating partnerships with clubs and organizations on campus. It is important to note that both the instructor and coordinator positions can be federally funded to reduce the operational costs, which was previously noted as a significant difficulty many makerspaces struggle with (Curiosity Commons, 2015). When the team hires new instructors or coordinators, the student coordinators lead the hiring process and communicate with the staff advisor about hiring decisions. Aside from this, the student team is extremely independent from other makerspaces that often use faculty and staff to run the space, which introduces a sense of community within the team and encourages a shared goal of creating and teaching valuable workshops.

The management system we currently employ has four workshop coordinators, typically more senior/experienced students, responsible for most administrative tasks. This allows the workshop instructors to focus on the actual creation and leading of workshops. However, we do not want the position of coordinators to establish a higher position of power over the instructors. We have taken steps to ensure every member of the team knows that their ideas are valuable and encouraged. This was initially not an obvious goal as there are more responsibilities in overseeing the entire workshop program. We try to regularly build connections with the rest of the team not only to create an atmosphere of growth within the job, but also to encourage friendships between all members. Beyond our student coordinators, our program is overseen by two faculty advisors who oversee the makerspace as a whole. At the moment, their roles are Director of [Makerspace] Technical Operations and Advanced Technology & Prototyping Specialist. They handle interaction with internal university systems, like funding and access control for physical resources, but leave the content and management of workshops to the discretion of our student team. This helps to foster a feeling of equality and belonging early on, especially when considering the demographic of our new hires. For our team, as a program only hiring federal work study students, a vast majority of our applicants are first year students looking for a position for the rest of their college careers. The intimidation of starting a new job on top of a whole new lifestyle can be lessened by establishing peer relationships to people that might typically be called managers.

Our method of integrating new members into our team further promotes the type of team environment that has helped the success of our program, while also introducing new types of challenges. We aim to hire and train these team members in groups of primarily first year

students to build a team with an even distribution of class years. A good dynamic between team members has the added benefit of positively impacting attendees of the workshops. The peer-to-peer experience between instructors and attendees contrasts the typical professor-student dynamic that most students experience in daily classes. Specifically, we provide a sense of comfort and direct attention that is tough to match in a classroom environment: many students end up having very limited direct contact with their professor unless they seek it out. They may also feel more intimidated when asking questions of someone they perceive to be an expert, which is reduced by having fellow students teach. We have found that this environment of the workshops allows students to quickly engage with the learning material while having fun and connecting with fellow students.

Our workshop program has evolved over time as we have learned from our successes and challenges and incorporated new ideas. A key element of this evolution is the growth of our team from 9 instructors up to 20 instructors the following year. This growth allowed us to develop many new workshops, strengthen our documentation, and bring improvements to the makerspace outside of the workshops. The increase of people, workshops, and projects required a much more organized leadership and strengthened our team of coordinators. To minimize the divide between the new instructors and returning instructors, workshop staff meetings included everyone.

Growth and evolution are still occurring in our program as it begins its second year. So far, we have hired two groups of instructors. The first group of ten instructors helped found the system along with two coordinators. One instructor then became a coordinator to help with the higher than expected demand of the role and eleven new instructors were hired. Recently, another instructor is transitioning to replace a soon graduating coordinator. The rapid growth of the team presented many growing pains which were resolved by reducing the team of instructors from twenty-one to twelve. This has presented a new set of challenges that were not present in the same way during the first year, mainly revolving around team size and division of responsibility. Unlike the original group, the new members were coming into an established system and team. This resulted in the new members having a sense of uneven power distribution between them and the returning instructors. The perceived imbalance of power and influence hindered the passionate environment of the team and dampened the sense of community. On top of this division between new hires and old, our meetings were originally run by coordinators lecturing the instructors, with no flow of ideas between instructors and coordinators. As we began to notice the separation of these groups, we decided to direct our focus towards creating a close-knit and single team. To achieve this, we have begun running team meetings in a discussion-style, where everyone has the chance to talk and give input on conversation topics. These changes include sitting in a circle, as opposed to our previous lecture-style seating allowing team members to feel more engaged in conversation and comfortable enough to share their thoughts. This dynamic has benefited the team immensely as the coordinators are able to consider instructors' ideas that have proven to be incredibly helpful to improving our program.

3.2 Workshop Structure:

The structure of the workshops are standardized in their appearance as well as teaching styles and learning objectives. Having this consistency between workshops helps with ensuring pedagogical quality for each workshop. To create a consistent appearance between workshops, instructors set up the workshop materials and wear makerspace branded shirts and name tags. We have found that many passing by students will see instructors and request to join a workshop, this helps with advertising and bringing new students into the makerspace. The instructors arrive between five and fifteen minutes early and set up the tools and materials. The capacity for each workshop is between six to eight attendees with two instructors to ensure that each attendee can receive individualized help, and because students must sign-up for the events ahead of time, there is no risk that particular events become overbooked. In the event a particular workshop has no attendees showup for the event, the instructors have the choice to work on their own work separately, or continue building future workshops for the space.

Instructors greet the attendees to the workshop and are trained to make connections and create an environment of collaboration and support. These connections are a major part of the training we implement once instructors are hired, where we demonstrate how to effectively communicate with the attendees and provide a safe atmosphere to learn. Our workshops are taught using the EDGE teaching method as an educational guideline (ScoutSmarts). This method was originally developed by The Boy Scouts of America as a way of teaching scouts valuable leadership skills, but is now implemented into many programs, as a baseline for teaching practices. EDGE is an acronym standing for “Explain, Demonstrate, Guide, Enable”, which are the four stages of teaching a skill. Before the students begin, instructors follow the "Explain" step to discuss what they are teaching, how the students will learn the skill, and why this skill can be valuable. This is often accompanied by images and other visuals and provides the basic understanding of the skill before moving to the next step in the method. The “Demonstrate” step allows the instructor to physically show the attendees how to perform a skill through an example. The instructor will walk through their demonstration, while emphasizing key ideas along with points of safety. Throughout both the “Explain” and “Demonstrate” steps, instructors engage with the attendees by asking and answering questions to ensure both understanding and excitement for the skill. These steps prepare the attendees for the “Guide” stage where the instructors allow the attendees to try the skill themselves. This is typically the longest section of our workshops as a major goal is to give students the chance to practice these skills in a safe and supportive environment. The instructors “float” around the workshop answering questions and giving advice while the attendees practice the skill. The “Enable” step tends to be less obvious and continues past the end of the workshop. It encourages instructors to remind attendees that they have successfully gained a new skill and is signified by the attendees ability and confidence in performing the skill individually. Every workshop is designed for students to leave feeling confident in their ability to repeat the skills on their own and inspired to continue learning and growing skills.

When developing a workshop for our makerspace, we follow a specific process to ensure that it is beneficial, engaging, and informative. First, we determine the goal of the workshop: either specific skill or use of a tool. This can come from student suggestions through a public Microsoft Form, from team observations and discussion, and from available tools that need training for use. Often a new workshop is developed by a small sub-team who will start the development process by advancing their technical skills and knowledge of the topic of the workshop. This includes familiarizing themselves with the required tools, processes and techniques through research and experimentation. When the instructors feel confident, they start to outline the learning outcomes for the workshop, as well as any materials that need preparation. Workshops are designed so that each participant will create something to take home at the end. The goal of this end product is to demonstrate all the desired learning outcomes in an enjoyable way while also maintaining a low cost to reduce load on departmental funding, and is useful or interesting for the attendees. The whole team is involved in an iterative and feedback driven approach through this development. Once this is satisfactory, the sub-team will share the new workshop to the rest of the team and make changes as needed based on feedback. We then create a detailed lesson plan based on the EDGE (Explain, Demonstrate, Guide, Enable) teaching method to ensure that participants will engage and retain the skills from the workshop.

3.3 Training System:

The enforcement of such an organized and high standard was not always the case for the workshop team. Our training systems have evolved dramatically as we have faced challenges and explored possible methods for new workshops and ideas. These challenges were complex and required collaboration among both instructors and coordinators alike. Our current training system has developed in such a way that can be summarized through a series of challenges faced by our team. When the team of students was first formed, it was run by two students who were given a goal of creating workshops in the makerspace, a team of newly hired students, and minimal additional information. This was a difficult task as the coordinators had little experience when it came to running a team and teaching workshops. Training was primarily done through the coordinators running workshops to the instructors whose job was to then replicate the workshop on their own. While this allowed the instructors to gain an understanding of what the workshops entailed, it was challenging for them to teach the workshops independently due to lack of a deeper understanding of the skills. Since the instructors only learned the minimum amount of information to teach the workshops, they lacked the ability to problem solve or answer complex questions. It was challenging for them to teach the workshops independently because they lacked the ability to problem solve or answer complex questions. In addition to this, the team wanted to begin creating new workshops.

A new system for training was developed in which each instructor was assigned to develop a new workshop and then at each meeting, one instructor presented and ran their workshop to the rest of the team. This worked well as collaboration between the instructors

increased and they became a much more close knit team. This greatly increased the amount that the instructors were able to learn because the meetings became more collaborative and hands-on. New workshops were being output to the school community at a steady rate. However, due to the necessary addition of hours required for instructors to create documentation and develop workshops on their own time, many of them were becoming overworked and, at times, responsibilities were unclear. As they ran out of free time to work on workshops due to other academic responsibilities, instructors began to produce poor quality and underwhelming workshops. This problem was further emphasized by a large increase in the team size. The divided knowledge among new and experienced instructors made training meetings difficult to navigate. The coordinators began running meetings by separating the team into sub-groups each with a mix of returning instructors and new instructors who required training on the workshop being discussed. These groups would each go over the workshop and the returning instructors would train the new instructors on the workshop. This system created an inconsistency of knowledge, and pedagogy on how the workshops were being taught. It also did not provide instructors with the depth of knowledge required to feel confident and solve problems outside of the direct scope of the workshop. We found that instructors would teach workshops differently due to the lack of standardization on how each training was conducted. We also found that this training system was not rigorous enough and did not prepare the instructors to confidently teach workshops. New instructors were able to catch up quickly but observations from instructor evaluations highlighted imperfections in the system. By downsizing our team to only 12 instructors, we found a size that worked well for our workshop output.

By introducing the EDGE teaching method as the baseline for every workshop, the team is working towards the goal of standardizing and improving the current workshops. We have developed a long term goal to generate a well-documented and sustainable workshop system. The training system has been updated to incorporate this new standard along with adding an additional hour to each training meeting to ensure the team knows much more about each skill than what is expected to be presented in the workshops.

3.4 Scheduling:

Currently, we offer roughly 12 workshops per week, of which are outlined in Appendix A, starting the first week of each 7-week term and ending the week before finals. We do not offer workshops on days off, to allow both our student employees and the attendees the opportunity to enjoy the day off; however workshops are occasionally offered on weekends based on instructor’s preferences, resulting in over 300 workshops per year. Since student’s schedules are frequently recurring, the workshops vary in times each week to increase the accessibility for our events; where we can reduce the chances a student is unable to attend a workshop due to a conflict. The frequency of each workshop is determined by the demand: workshops such as laser cutting and soldering are offered multiple times each week, as these are skills commonly

required to complete class projects; while workshops on more fine-tuned skills are offered once every other week.

A minimum of two instructors are assigned to teach each workshop, ensuring each participant receives individualized help throughout each lesson. It also guarantees each workshop can be run even after one instructor is unable to make it, whether that be due to a conflict or illness. When an instructor has something come up that prevents them from being able to work, they first attempt to find coverage through "Slack", our primary channel for communication. If this is unsuccessful, the workshop will run with only one instructor. Instructors are scheduled in shuffled pairs so they have the opportunity to work with a diverse group of teammates. For each workshop, we attempt to pair instructors who build off of each other's skills, creating a combined feeling of confidence in teaching the workshop. This sometimes results in two moderately comfortable instructors and sometimes results in one very skilled instructor paired with one who is still learning. This system works in addition to our training system to build the confidence of each of our instructors. Instructors are assigned to a variety of workshops throughout the term so they can continuously practice their skills. At one point we considered assigning instructors to only one or two workshop topics where they would become very skilled at, however, we have found that it is very beneficial to have everyone be adept in each topic we offer. This creates a coherent team of equal members, reducing the stress of finding coverage, and making the job more gratifying as the instructors are able to become well-rounded in many helpful and interesting skills.

When actively developing the workshop schedule for a particular term, the coordinators use a variety of overlapping systems. At least two weeks before the end of each term, every instructor fills out their availability on a scheduling software called "WhenToWork." We primarily use this software to view the instructors' availability when scheduling workshops and to reference when comparing the hours submitted via their timecards, as shown in Figure 3.

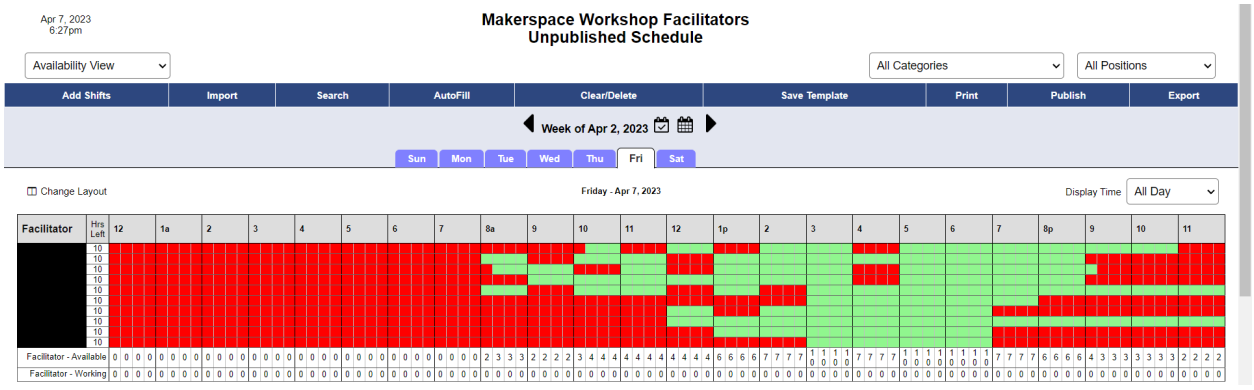


Figure 3: WhenToWork Coordinator view of Instructor Availability on a given day

On a spreadsheet, we create a calendar representing the entire term, making sure to include any days off from classes. Next to each week, we list the workshops we plan to run and assign two instructors to each workshop, as shown in Figure 4. This creates a rough outline with instructor pairings, which may change when comparing instructors' availability for that particular week. By combining the above availability of the instructors with the desired output we hope to see for that week, we can find a time within the usual workshop hours to place each particular workshop. If the availability of the suggested pairings do not work, we simply edit the pairings for that particular workshop.

Week #	Month						
	Sunday Date	Monday Date	Tuesday Date	Wednesday Date	Thursday Date	Friday Date	Saturday Date
08:00							
09:00							
10:00							
11:00							
12:00							
01:00							
02:00							
03:00							
04:00							
05:00							
06:00							
07:00							
08:00							
09:00							

Laser Cutting	Instructor Y, Instructor D
Laser Cutting	Instructor K, Instructor M
Laser Cutting	Instructor I, Instructor S
Soldering	Instructor B, Instructor G
Soldering	Instructor H, Instructor O
Sewing	Instructor J, Instructor Y
Leather Working	Instructor Y, Instructor B
Wire Jewelry Making	Instructor O, Instructor M
Drill Press and Belt Sander	Instructor S, Instructor Y
Vinyl Cutter	Instructor D, Instructor K
Rubber Stamp Making	Instructor G, Instructor H
Vacuum Forming	Instructor B, Instructor D
Basics of Hand Tools	Instructor J, Instructor I

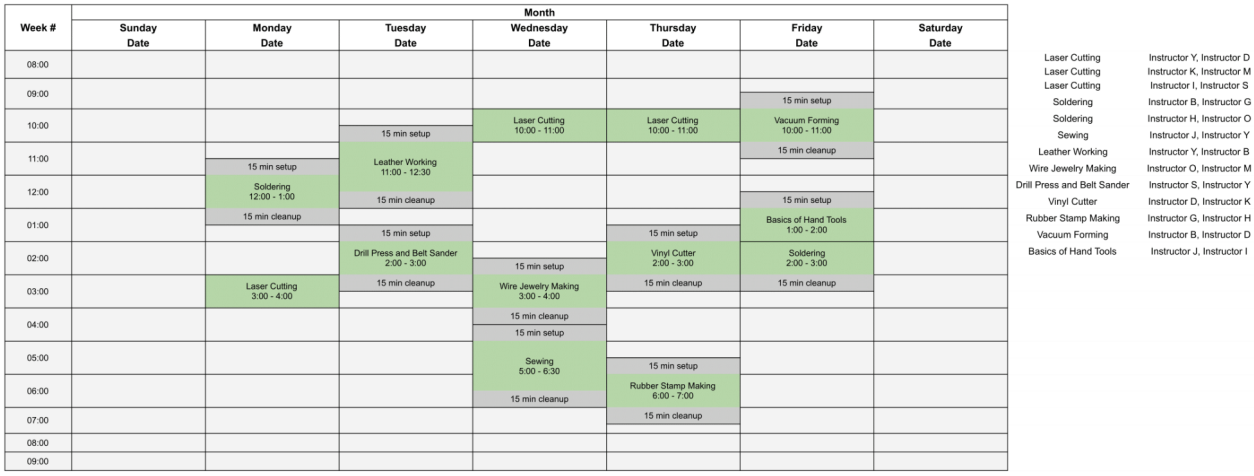
Figure 4: Workshop calendar with list of workshops and assigned instructors

The placement for the workshops in a given week is heavily based on when the same workshop was scheduled for the following and preceding weeks, to make sure workshops are being run on a variety of different days at varying times. At this time, every workshop is highlighted in red to show that the workshop placements must be double checked and entered into our other systems. For each week we finish up to this point, we use a tracking sheet that lists the instructors' names and workshop topics and durations (including setup and cleanup time), as shown in Figure 5. This allows us to make sure every instructor teaches an even variety of each topic, while also keeping track of hours. Further changes to the workshop schedule and pairings can then be made to meet the instructors' total requested hours and an even variety of workshops.

	Laser Cutting	Soldering	Sewing	Leather Working	Basics of Hand Tools	Vinyl Cutting	Rubber Stamp Making	Wood Burning	Wire Jewelry Making	Vacuum Forming	Drill Press and Belt Sander	Needle Felting	Total w/ Meetings
Duration:	1	1.5	2	2	1.5	1	1.5	1.5	1	1	1	1	21
Instructor B	3	2	2	1	1	1	1	0	2	1	1	1	42
Instructor D	3	1	1	1	1	3	1	1	2	0	1	1	41
Instructor G	3	3	1	1	2	1	1	1	1	1	1	0	42.5
Instructor H	3	3	2	1	1	1	1	0	1	1	1	1	42.5
Instructor J	4	3	1	2	1	2	0	0	1	1	1	0	42
Instructor K	4	2	1	1	0	1	1	1	2	1	2	1	42
Instructor M	3	4	2	1	1	1	0	0	1	1	2	0	42.5
Instructor I	5	2	1	1	1	1	1	1	1	0	1	1	41.5
Instructor O	4	5	2	1	0	1	0	1	1	0	1	0	43
Instructor S	4	3	1	1	1	2	0	1	1	0	1	1	41.5
Instructor Y	4	2	2	1	1	1	1	0	1	0	3	0	42

Figure 5: Tracking sheet for instructor's hours and topics

Once all workshops are placed, the entire calendar is double checked in reference to the WhenToWork availability for each instructor, while also ensuring each instructor is meeting their desired number of hours for each week. We also check whether a workshop will require the same space, and make sure these events are not placed at the same time. Included in the listings on the spreadsheet calendar are fifteen minute setup and cleanup times at the beginning and end of workshops that require more equipment, to give instructors more time to prepare. After a workshop is double checked, it is highlighted green and is ready to be added to public calendars, as shown in Figure 6.



Week #	Month						
	Sunday Date	Monday Date	Tuesday Date	Wednesday Date	Thursday Date	Friday Date	Saturday Date
08:00							
09:00						15 min setup	
10:00			15 min setup	Laser Cutting 10:00 - 11:00	Laser Cutting 10:00 - 11:00	Vacuum Forming 10:00 - 11:00	
11:00		15 min setup	Leather Working 11:00 - 12:30			15 min cleanup	
12:00		Soldering 12:00 - 1:00	15 min cleanup			15 min setup	
01:00		15 min cleanup	15 min setup		15 min setup	Basics of Hand Tools 1:00 - 2:00	
02:00			Drill Press and Belt Sander 2:00 - 3:00	15 min setup	Vinyl Cutter 2:00 - 3:00	Soldering 2:00 - 3:00	
03:00		Laser Cutting 3:00 - 4:00	15 min cleanup	Wire Jewelry Making 3:00 - 4:00	15 min cleanup	15 min cleanup	
04:00				15 min cleanup			
05:00				15 min setup Sewing 5:00 - 6:30	15 min setup		
06:00				15 min cleanup	Rubber Stamp Making 6:00 - 7:00		
07:00					15 min cleanup		
08:00							
09:00							

Laser Cutting	Instructor Y, Instructor D
Laser Cutting	Instructor K, Instructor M
Laser Cutting	Instructor I, Instructor S
Soldering	Instructor B, Instructor G
Soldering	Instructor H, Instructor O
Sewing	Instructor J, Instructor Y
Leather Working	Instructor Y, Instructor B
Wire Jewelry Making	Instructor O, Instructor M
Drill Press and Belt Sander	Instructor S, Instructor Y
Vinyl Cutter	Instructor D, Instructor K
Rubber Stamp Making	Instructor G, Instructor H
Vacuum Forming	Instructor B, Instructor D
Basics of Hand Tools	Instructor J, Instructor I

Figure 6: A completed week's schedule

The spreadsheet calendar is used as a main reference for the rest of the scheduling process. Instructor hours are placed into WhenToWork, which sends notifications for instructors to view their schedules, and Microsoft Outlook invitations are sent to the instructor team to provide a convenient way to view schedules alongside personal schedules. The makerspace also uses a system called "LibCal" to reserve certain spaces in the building, which includes certain machines and work benches. Following the Outlook invitations, we reserve the benches and laser cutter for each workshop offering to ensure these spaces will be free at the time of each workshop. Next, we add all the events to a system called "EventBrite," a ticket software that allows the students at the university to sign-up for our workshops. Once all workshops are placed in the EventBrite, we create an email that is sent out to the campus community, which lists all workshops and the scheduled times, alongside links to sign-up through EventBrite. This email is sent at the beginning of every 7-week term to allow students an overview of the events they can attend, along with the specialized collaborations we run with other organizations on campus. The last step in the scheduling process is to add all workshops to the Makerspace's "Canvas" page, the main system the students use at the university for other courses. This page is the current "Hub" for the makerspace, where students can go to find resources, take training quizzes, and sign-up for workshops.

3.5 Feedback

To gain more of an understanding on how to grow the team, feedback meetings are held with the entire instructor team to reflect and discuss the current direction of the workshops and training system. With our goal of creating a positive work environment for all the instructors, we hope to understand how we can make changes to the system to benefit those running the workshops for those who attend them. When developing the new training system discussed earlier in Section 3.3, an internal survey provided more insight on the satisfaction of the training system and how to further provide the instructors with ways to grow in their roles. From these feedback meetings with the team, we also hope to understand how to more effectively meet the desired hours requested from each instructor when scheduling workshops, and how the coordinators could more effectively run the team. This allows the entire team to have a voice and become involved in an iterative and feedback driven system commonly found in industry.

External feedback on workshops is collected via an anonymous form provided to attendees of every workshop. The intent of this is to judge the overall attendee satisfaction with workshops, identify most frequented ones, and measure our inclusivity. Pertinent questions for satisfaction include “How likely are you to recommend this workshop to a friend or attend more workshops?” and (referring to that question) “Why?”. Inclusivity data included gender and racial identity information, which will be compared to overall university statistics. It’s important to consider that this may not represent every student interaction with our workshops. Filling out the form was not required, and furthermore, we have observed a significant number of potential attendees register online but not show up.

4 Results and discussion:

Our system's growth was based primarily on trial and error. Through each challenge, we used discussion and experimentation to find what worked best for our team. This rapid evolution caused instability and created a strain on our workshop staff and an inconsistency in training systems and protocols. Our staff's schedules fluctuated between overworked and underworked as we changed team size and workshop frequency. Many of them were not happy with the inconsistent schedules and repetitive training. We struggled to communicate the latest information and all the changes that we were making, which was identified as the most prominent complaint and one overarching issue with the system development process. Since collecting this feedback, we have settled into a more stable format that we hope to continue next year, consisting of 2 weekly meetings with specific topics: training and projects. The focus with these changes was to ensure time is well spent and goals are clearly laid out. Our current team is passionate about our program and has been extremely patient. This team has been essential to the development of our system.

The evolution of our program has come with an evolution of our goals as well. Originally we set out with the open ended goal to create workshops in the makerspace. As we grew our team and influence within the makerspace, we shifted to the broader goal of reducing the barrier to entry of making within our community. The materials available to purchase have grown to match the materials required for the workshops and we have worked on advertising efforts to get new people into the makerspace. One of the most effective ways we've done this is through outreach with clubs and organizations to foster collaboration and bring them into the makerspace. By showing them the resources available, and how they could benefit from using the space, we promote use and awareness of the space. This has brought people in from groups and communities that would not normally engage with a makerspace. It also benefits the clubs, as on-campus events are a big way for them to gain interest, especially collaborations that expand their reach with new groups.

Feedback from workshop attendees shows very positive results from the workshops. When asked how likely they would suggest this workshop to a friend or attend a different workshop, attendees respond with an average rating of 9.3 out of 10, with 10 being most likely. This average comes from 101 responses of 103 requested. Other responses from attendees have shown us that the workshops are "informative" and "fun" and the instructors are "friendly," "great," and "helpful," supporting the effectiveness of the aforementioned peer-to-peer environment and two-way learning. Students are learning new skills, enjoying a quick and fun break from school work, and integrating into the makerspace. Along with feedback, we collected information on demographics and attendance. Based on the data from this and conversations between instructors and attendees, we have determined that the main reason for attending is to learn how to use specialty tools that are inaccessible in other ways. Prime examples of these are the laser cutter and soldering equipment, our two most popular workshops. This feedback is invaluable in the workshop creation and pruning process, allowing us to prioritize workshops that are expected to be most popular. From the demographics data, we were able to evaluate our success in fostering an inclusive and accessible environment. Based on comparison with the distribution of the university, we have a decent representation of the total student population in attendance, with gender and racial percentages roughly matching. In fact, we saw a skew towards female and nonbinary students being more prevalent in workshop attendance than in the student population, indicating we have had some success in involving traditionally underrepresented groups.

Although this system creates successful and engaging workshops, there are many aspects of the process that are rough and in need of work. The systems and team have undergone numerous changes and many more are to come. Notably, the tools and processes we use to create the schedule are in need of a full redesign. The current process uses seven different softwares to create and advertise the schedule. This often causes errors and discontinuities between softwares due to manual entry in each. Training new coordinators to use and navigate all these systems is

also a large task and often causes confusion and mistakes. Moving forward, we plan to redesign this system to decrease the steps in creating a schedule and streamline and automate the process.

When looking at the format and structure of the makerspace to identify additional barriers to entry for new users, we identified that the tool checkout system does not give students knowledge of the tools available to check out. The tools are stored in drawers behind the front desk and are only accessed by the student employee on duty. Moving forward, we plan to make our inventory list more accessible and interactive, as demonstrated in Appendix B, and possibly adjust the storage methods of our tools. A new system being designed with advice from this paper should keep this type of interaction in mind.

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Appendix:

Appendix A: Workshops Offered

Basics of Hand Tools	Sewing
Drill Press and Belt Sander	Soldering
Laser Cutting	Vacuum Forming
Leather Working	Vinyl Cutting
Needle Felting	Wire Jewelry Making
Rubber Stamp Making	Wood Burning

Appendix B: Tools Available

Name	Description
Calipers	A measuring instrument having two usually adjustable arms, legs, or jaws used especially to measure diameter or thickness.
Center Punch	Perfect for creating dimples in wood and metal prior to drilling, this punch features a lightweight aluminum body and a hardened steel point.
6 inch / 4 inch C-Clamp	The C-Clamp is easy to operate and ideal for DIY or household clamping. The steel construction provides strength and durability, and threads roll smoothly.
4 ¼ inch, 6 inch, 12 inch Quick Clamp	The Quick Clamp can be operated with ease with its trigger design. The rubber helps for a tighter and safer hold on your surface.
Spring Clamp	Spring Clamp features vinyl tips to help protect your work surface from damage. The clamp has small holes in the handle for hanging clamped objects. The clamp has a heavy-duty steel construction for durability.
Clay Picks	Clay pick set includes 11 Double Sided Pieces with 21 different tools for clay carving, sculpting, and jewelry making. These picks can be helpful during post processing of FDM printed parts.
Compass	Professional Compass/Divider for math, geometry, art, drafting and drawing, creates circles up to 9 Inches in diameter.
Cutting Mat	Grey self-healing cutting mat with non-slip bottom and 1" grid pattern for accuracy when cutting. The special surface and core work together to minimize the effects of cutting.

Degassing Chamber	A small vacuum chamber for studio or lab use in de-airing materials such as mold rubbers and resins.
Rotary Tool (Dremel)	1.2 Amp Variable Speed Corded Rotary Tool Kit for cutting, sanding, grinding, polishing, carving and more
Hand Drill	18-Volt LXT Lithium-Ion Compact Brushless Cordless 1/2-inch Driver-Drill Mechanical 2-speed transmission (0-400 and 0-1,550 RPM) for a wide range of drilling and fastening applications BL Brushless motor delivers 530 in. lbs. of Max Torque.
Steel Contractor Bit Set	The Makita Steel Contractor-Grade Bit Set includes 38 high-speed and durable steel drill and driver bits that include the most widely used screwdriver and nut driver sizes. Drill Bits in inches.
Drill Bit Set	The Drill Bit Set offers an assortment of straight shank bits for use in metal, wood, and masonry materials. Available in 18 piece standard and 21 piece metric.
Small File Kit	A set of 10 files are made from alloy steel and machined into distinctive shapes for different small-scale and finishing applications.
File Set	A large set of files constructed of hardened alloy steel for strength and durability.
Mini Fume Hood	Confines airborne material by diluting it with a large amount of air.
Rapid Heat Ceramic Glue Gun	This Glue Gun comes with a sturdy fold-out stand and handle base to prevent mishaps.
Mini Hot Glue Gun	A Glue Gun for smaller jobs, when you need a smaller drop of glue.
Ball Peen Hammer	A ball-peen hammer, also known as a machinist's hammer, is a type of peening hammer used in metalworking. It is distinguished by having a hemispherical head. It is commonly used as a tool for metalworking.
Framing Hammer	This 28 oz milled-face hammer features a bonded and molded shock reduction grip that reduces shock up to 70% and will not come off, while the long handle and heavy head make it ideal for driving large common nails.
Rubber Mallet	The hickory handle is extremely hard, dense and shock resistant, while the rubber head offers sturdy control, accurate strikes and great results.
Hot Air Gun	This portable hot air gun heats up in seconds and quickly gets temperatures up to 200 C / 390 F. It's great for heat-shrink, melting things, and even very basic low temp rework.
Hot Pen Styrofoam Cutter	This Styrofoam cutter is a professional model that heats up to 400°F within 10 seconds. It easily cuts, shapes and sculpts styrofoam smooth and fast. Seals edges clean and leaves no debris! You can cut the form board or foam block from any angle and craft into your desired shape.

Tabletop Hot Wire Cutter	The large table with 15-11/32-Inch by 11-Inch ensures smooth and easy movement of the workpiece. The holder and wire coil may be shifted and adjusted along the over arm to enable miter cutting.
Iron and Mat	Iron has controls to change both steam level and temperature, enabling the perfect amount of steam and heat for each fabric type to remove wrinkles and flatten Ironing Mat turns any flat surface into a place to iron
Level	A device for establishing a horizontal plane.
Multimeter	A multimeter or a multitester, also known as a VOM (volt-ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance.
Olfa Knife	This knife can be used in place of a box cutter for cutting various types of materials.
Plier Set	6-Piece Utility Set features 6 different utility pliers with non-slip ergonomic handles for a secure comfortable grip. Chrome plated finish provides durability and protection from abrasion and corrosion.
Rotary Protractor Angle Ruler	This rotary protractor measures both angle and length of workpiece. The gauge can measure 0-180 degree, 0-10cm in metric reading. Laser engraving clearly marked for good visibility, and will not rub off
Safe Cutting Ruler	A ruler made to protect fingers and hands from your cutting tools. The incorporated metric scale makes it possible to measure and cut at the same time.
Coping Saw	A 6.5 inch Deep Cut Coping Saw made from heavy duty steel and includes a rust resistant coating. The extra-deep 6 in. clearance is designed for angled and curved cuts in hard to reach areas.
Hacksaw	A fine-tooth saw with a blade under tension in a frame used for cutting hard materials like metals, but can also cut other materials, such as plastic and wood.
Hand Saw	Used in woodworking and carpentry to cut pieces of wood.
Jab Saw	This 6 in. Fixed Jab Saw uniquely integrates rasping holes along the side of the blade to rapidly expand holes or smooth rough edges of sheetrock after a cut has been made. The saw cuts plaster, drywall and other materials with ease, perfect for contractors and builders.
Corner Sander	A sander that is able to reach crevices a normal sander can’t get to such as corners, and tight spaces.
Orbital Sander	A power tool used to smooth surfaces with sandpaper by vibrating in small circles.
Sheet Sander	A power tool used to smooth surfaces with sandpaper.

Scale	This scale can measure up to 10 kg, has TARE functionality, with weights available in grams, ounces, pounds, and millimeters.
130 Stitch Computerized Sewing Machine	Reliable, lightweight, and versatile, the CS7130 features 130 unique built-in utility and decorative stitches. The kit includes one spool of polyester thread, a bobbin, fabric scissors, a seam ripper, needle threader and magnetic pin cushion.
Soldering Iron Station	The Hakko FX-888D 70-Watt Digital Soldering Iron has an adjustable temperature control soldering station with a digital display and a temperature range of 120 to 899° Fahrenheit. The solder kit includes a desolder pump and wire strippers.
Metal Body Desoldering Pump	This high quality desoldering pump, featuring an anti-static tip is ideal for any soldering project. The body is made of high-strength, durable aluminum. Included in the Solder Iron kit.
Square	This rafter square is made of a very durable plastic material that will stand up to everyday use. It has a 12 in. frame that makes marking and cutting wider boards easy. It has molded conversation tables and easy to see graduations on both sides.
Carpenters Square	This tool allows for measurement and creation of right angles. Often used by carpenters to create the perfect right angle.
Staple Gun	This staple gun is ideal for home or professional use. The grip handle resists slipping for comfortable, easy operation. It features a jam-resistant mechanism for reliable performance.
Staple Remover	Staple Puller featuring a strong ergonomic handle to easily remove all staples.
Tape Measure	A tape measure is a flexible ruler and used to measure distance. It consists of a ribbon of cloth, plastic, fiberglass, or metal strip with linear-measurement markings.
Tin Snips	The Milwaukee Straight Scissors have a 4 inch Iron Carbide cutting edge with ruler markings on the front of the blade for added precision.
Tool Kit	The 64 Bit Driver Kit includes iFixit's 4 mm aluminum screwdriver handle with magnetic bit sockets, knurled grips, and swivel tops—plus 64 precision driver bits and a flexible extension.
T-Square	36-inch length Aluminum T-square, 2-Inch wide x 2.3mm thick extruded aluminum blade. Has both Inch and Centimeter measurements.
Adjustable Wrench	A tool used to loosen or tighten a nut or bolt with an adjustable jaw to fit a variety of nuts and bolts.
Allen Wrenches	Stored in a folding case, with high-visibility size markings for fast size selection. The set offers the most common inch and metric hex wrench sizes.

Combination Wrench	Each wrench has an open-end for access to fasteners in tight spaces and a 12-point box-end to get a secure grip on fasteners when added torque is needed.
Socket Wrench	This kit is made from Hardened treated Chrome Vanadium steel alloy. A sturdy plastic organizing case is included.Both Metric and English sizes are included. 3/8” Reversible Ratchet is included.
Self-Adjusting Wire Stripper and Cutter	This Self-Adjusting Wire Stripper and Cutter has an adjustable stopper to control the length of the core strip and a tensioning thumb screw allows for precise stripping of smaller gauge wire. It also has a convenient wire cutter in the handle.
X-Acto Cutting Knife	4-3/4 in. aluminum handles with 4-Slot point chuck for easy blade release. Includes a super sharp #11 blade and a high impact safety cap. Used for precision cutting, forming and stripping of paper, plastic, wood, cloth and film.
18-Volt Pivoting Hand Vac	This powerful 18 Volt, lightweight compact design allows for maximum portability and folds in half for storage. The cyclonic action keeps dirt away from the filter for greater suction power and longer battery life.
Protective Gloves	Premium Latex Palm-Coated Knit Gloves offer cut and liquid protection. A seamless knit shell with a latex coating provides moderate cut and excellent abrasion resistance. Palm coating protects grip even in wet, greasy or oily conditions. Machine washable.
Nitrile Gloves	A disposable glove with the strength of nitrile, balanced with excellent dexterity for lighter-duty applications. Latex-free, powder-free, and chlorinated for easy changing.
Hair Ties	Hair ties are available to secure long hair while working in the Makerspace.
Safety Glasses	Safety glasses are durably constructed to provide an excellent level of protection. Lightweight design enhances comfort for enjoyable, all-day wear. Molded nosepiece sits comfortably on your face to prevent slippage.
Aprons	Shop apron is made with durable cotton fabric for comfort and flexibility. The adjustable waist and neck ties are held on with grommets for a long-lasting secure fit, while the apron itself provides great protection for shop or home use.
Protective Mask	Masks are intended to use for protection against solid particulates, such as dust and powders. They are extremely durable but come with a soft and comfortable inner surface at the same time.
Lamp	This lamp provides great lighting on your project so we can work safely on your project. With a built-in magnifying glass, you're able to look extra closely at what you're doing.