Student Input on the Design of the Foisie Innovation Studio

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science Submitted

on May 2, 2016

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Abstract

The Foisie Innovation Studio (FIS) will be a student-centric building and thus, the students' voices should be represented in its planning. The team did so throughout the design phase by homing in on three main sections of the building: the makerspace, the collaboration space, and the global impact space. Recommendations were developed for each of these and for the FIS as a whole. These recommendations include some aspects of the design of the building, and also capture how the students will be using the space and programs that will help bring students into the building.

Executive Summary

Worcester Polytechnic Institute was founded on the two principles of theory and practice, represented by the towers on Washburn Shops and Boynton Hall. Now, 150 years later, it is time to add another tower: impact. The impact on our community, and even the world as a whole, comes from innovation. The Foisie Innovation Studio (FIS) will be the home for innovation. Our team uses the motto: "Inspire. Invent. Innovate." This mindset is the most important foundation for the FIS as it encourages students to be creative in their research and project work. In the FIS, students will inspire each other to pursue projects. Students will invent in the makerspace, taking their inspiration from an idea to a prototype. Inspiration and invention together promote innovation. By encouraging students to be innovative throughout their education, they will become entrepreneurs and industry leaders.

Our team focused on the functions of three spaces in the FIS: the makerspace, the collaboration space, and the global impact space. We visited other makerspaces and business incubators including the University of Massachusetts Amherst, Yale University, Massachusetts Institute of Technology, Artisan's Asylum, Olin College of Engineering, and 1776 Business Incubator in Washington, D.C. We conducted 42 interviews with students, faculty, trustees, and managers of other innovation spaces. We conducted four experiments involving student groups in order to understand how their environment and resources affected the way they work. We inventoried seven shops on campus to understand what capabilities WPI currently possesses and to whom they are available. We analyzed 25 years of project titles to understand the areas of studies students are involved in. We delivered seven presentations outlining our findings. Finally, we developed 45 programs to be hosted in the FIS. All of our research culminated in a total of 18 recommendations for the makerspace, collaboration space, global impact space, and the FIS as a whole.

When developing proposals for the makerspace, we focused on how the FIS makerspace will interact with the other machine shops on campus, how it can support student group and personal projects, and how we can promote the maker culture at WPI. We developed seven recommendations for the makerspace:

1. Serve as the central hub with the existing shops on campus as its satellites.
2. Hire a passionate and approachable manager supported by involved student volunteers.
3. Conduct extensive training sessions to ensure the safety of the students.
4. Have a store for buying materials and components.
5. Provide storage for extended project work.
6. Support a variety of events that promote the maker culture.
7. Design a flexible makerspace that can adapt to the needs of future projects and students.

Students will come to the collaboration space in the FIS to work on projects and socialize. We needed to consider how a single space could successfully serve both purposes. Through all of our efforts and research we developed four recommendations:

1. Provide organizational tools for the conception of ideas and the continuation of project work.
2. Opt for modular and unconventional furniture to make the space flexible and adaptable.
3. Utilize visual tools and modify the mood within the space to encourage creativity and collaboration.
4. Provide a co-working office and host events to promote the entrepreneurial mindset.

One of the most unique aspects of WPI's academic project-based curriculum is its global programs. The Global Impact Space (GIS) in the FIS will allow students to continue their projects by offering programs to extend project work, opportunities to work alongside others with similar passions, and network with professionals. These ideas led to three recommendations for the GIS:

1. Enhance global communications during project work through the implementation of video conferencing.
2. Expose students to past projects through a curated collection of presentations and related media.
3. Program events in all FIS spaces that connect with important themes for global awareness.

In addition to the recommendations specific to each of the three spaces, we developed four recommendations for the FIS as a whole. These proposals are based on commonalities among all three spaces:

1. All students should have 24/7 access to the FIS.
2. Create an open atmosphere with few walls, glass, and mobile dividers.
3. Provide a kitchenette for 24 hour food access and for the stimulation of social interactions.
4. Promote the FIS as a social hub on campus through programmed events.

All of these recommendations combined will ensure the FIS satisfies student needs and promotes the building as WPI's third tower: impact.

Acknowledgments

Our team would like to express our sincere gratitude to the following individuals and groups for supporting us throughout the completion of this project:

Our Advisor, Professor Diran Apelian, for believing in the importance of the student voice and supporting this project from its conception. He gave our team his heart and trust from day one and we will be forever grateful for his artisnal mentorship.

Our Co-Advisor, Dean Arthur Heinricher, for continuously showing confidence in our project while keeping us grounded. His steady guidance was imperative to the success of our work.

President Laurie Leshin for recognizing the need of the student perspective in the design of the Foisie Innovation Studio. Without her, this project would not have come into existence.

The architects at Gensler: Alex Fernandez, Ken Fisher, and Keller Roughton for their genuine interest in working with our student team and integrating our recommendations into the designs of the FIS.

Dean Michael Ginzberg and Professor Kristin Boudreau for providing their insights and visions on the global and entrepreneurial impacts of the Foisie Innovation Studio.

Provost Bruce Bursten, Dean Philip Clay, Fred DiMauro, and Jeff Solomon for being phenomenal supporters of our work and for seeking forums in which to share our findings.

Professor Curtis Abel for contributing his energy and time to our off-campus visits and brainstorming sessions.

Trustee James Baum and Trustee Mike Aspinwall who provided us with insight and support from the beginning to the end.

The WPI Board of Trustees for their support and endorsement of our project recommendations.

David Privitera, a founding member of IDEO Boston, for challenging us to think outside the box and reconceptualize the future uses of the Foisie Innovation Studio.

Amy Loomis '13 (MIT), Baird Soules (UMass Amherst), Meagan Riley (1776), and Deputy Dean Vince Wilczynski (Yale), for welcoming us to their campuses and providing us with valuable insights on university makerspaces.

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1 Introduction

Discussions to build a one-of-a-kind "innovation studio" at Worcester Polytechnic Institute began in the early 2000's. The concept of innovation studios has become a unique identifying factor for a number of elite schools that provide their students with a place to effectively work on projects and turn their ideas into a reality. Schools such as Yale, MIT, and Harvard have integrated makerspaces, digital labs, and collaboration spaces into their campuses.

After 15 years a plan to renovate the gym had been developed. In the end, the decision was made to demolish Alumni Gym and build a new building in its place. This decision ultimately opened a new opportunity: a chance to put a beautiful new building into the heart of WPI's 150 year old campus. Due to the potential that this building held, a variety of stakeholders immediately leapt at the opportunity to provide their opinions about the design of the building. Although many ideas were considered, it was important to ensure the students' voices were heard because the Foisie Innovation Studio was described to be a building by the students, for the students. Providing the students' voices in such a high-stakes investment was not something to be taken lightly and thus this Interactive Qualifying Project (IQP) was formed to provide the voice of the students in the design phases of the Foisie Innovation Studio.

1.1 Framing the Problem

Supporting Project Work

One of the main aspects of WPI's curriculum that makes it so special is project work. All students do significant project work in their MQP and IQP. Many projects are associated with a class such as the Great Problem Seminars and software engineering. In Addition, WPI students are involved in many non-academic projects such as Engineers Without Borders, the mural club "We Art Good", the Test Kitchen, or The CollabLab. Despite this wide range of on campus projects, WPI does not have dedicated space for project teams to meet and work. Furthermore, stock materials, storage, and lab access are also challenges students face.

Possibly the most important support needed for project work is a place to meet and work. As we discovered over the course of our IQP, there are phenomenal labs and shops at WPI for all kinds of projects. The issue, however, is that most students are either unaware of or denied access to these resources. Communication to students about their rights and responsibilities needs improvement. Beyond needing lab space, many project teams need collaborative workspace to communicate ideas.

Many projects need stock material like metals, plastics, foams, glues, or fasteners. One of the takeaways from our research is that groups spend a great deal of time and effort acquiring stock. With seven week terms and fast approaching deadlines, stock must be ordered well in advance. Local sources like Home Depot or Lowe's are often sufficient, but many underclassmen groups do not own cars, rendering those stores useless.

The simple rule of project storage, as described by nearly every school, makerspace, and shop we've spoken to is that you can never have too much. Throughout our interviews with students, and our personal experiences, we know of MQPs, GPSs, and club groups of every size that don't have a space for their projects. Another key issue with storing projects at WPI is that most spaces are owned by professors and departments. While this is a useful method for allocating space, it means that unaffiliated projects will not have access to resources.

Another important factor in supporting project work is helping students find the right shop and machinery for their specific project needs. The simplest examples include the manufacturing labs, like Washburn Shops. Despite having some very advanced machining capabilities, low-tech making is not supported. There is a need for more low-tech making, and better communication between shops and students.

Storage, stock, and access are all areas where the FIS can help. Beyond this, it can also serve as a building you can point to where real engineering is happening. Given how proud WPI is of pioneering project-based learning, it would be unfortunate not to take this opportunity to show off all of our hands-on work in one place. Alongside this, tours and other admissions programs will benefit from having central location for project work at WPI.

Encouraging Entrepreneurship

WPI is known for its project-based curriculum, but there is more to project work than designing and making your product. Laurie Leshin, WPI's 16th president and a strong supporter of innovation and entrepreneurship, stated during her Inaugural Address, "we will take our distinctive undergraduate programs to the next level of value and impact, by striving for more integration across disciplines and across the curriculum, exploring innovative ways to enable our students to achieve more during their time here, and incorporating technology into the teaching and learning experience while always seeking to measure and understand how new approaches enhance learning and understanding." President Leshin has a vision for increasing the impact of the WPI curriculum.

Glenn Gaudette, a professor of Biomedical Engineering, served on the Innovation Pillar Committee for the 2015 Strategic Plan. Professor Gaudette sees the need for an entrepreneurship incubation space. He argues that an entrepreneurship space is a way to keep alumni connected to the school, as well as a means for them to give back to WPI. Currently, we have small innovative solutions. However, we need to anticipate market opportunities and customer needs. By doing so, we can come up with huge innovative solutions with a large impact.

In one scenario, a student graduates from WPI, starts a company, and then comes back to mentor current students with their business ideas. In another scenario, entrepreneurship is encouraged while a student works on his Great Problem Seminar project. As a result, he starts to look at his project as a business venture. He then continues to work on and develop that project further as a part of his Interactive Qualifying Project. By senior year, during the Major Qualifying Project, the student is able to perfect the concept, put a patent on the design, and turn that project into a business. As Professor Gaudette said, WPI students

have the skills to come up with impactful solutions to problems.

Entrepreneurship has been advertised as critical to the modern higher education experience by many, including President Obama. In 2014, the Obama administration launched an effort to support the "Maker Movement". The main goal was to promote a community of makers, entrepreneurs, and creative thinkers within the nation in order to innovate in various industries. One major goal was to combine theory with practice. One result of this movement was a Maker Faire to show off the projects and ideas that embody this movement. Hundreds of universities responded by creating innovation spaces on their campuses, with detailed descriptions of their goals and functions. As President Obama said: "every company, every college, every community, every citizen joins us as we lift up makers and builders and doers across the country."[1]

Strengthening the Connection between Theory and Practice

The third overall challenge we identified was strengthening the connection between theory and practice. This is WPI's motto, and as such it deserves to be protected. Strengthening this connection is a trend not only at WPI but is part of a larger movement in higher education. WPI has a proud history of creating practically trained engineers in their fields. For instance, while an electrical engineer may focus heavily on communication and signaling, understanding how their circuit boards are manufactured is also useful background. Improving the connection between theory and practice both prepares students for industry, and improves the quality of class projects. Furthermore, there is a whole body of students who either desperately seek more ways to apply classwork to their projects, or who struggle to care about or digest lecture information without an application. Having a space that connects theory and practice is essential. In essence, while WPI has made great steps towards bridging theory and practice, there is much more to do.

Some of the successful makerspaces we visited strive to connect engineering theory to application. Yale has a classroom connected and completely open to a lab where students have the lecture portion of their design courses. One of the rooms in the electrical engineering space at UMass Amherst, called M5, is also dedicated to a freshman electrical engineering course. Students at these universities learn and build in the same location, whereas at WPI students have lectures in classrooms and then build in separate labs. Since theory and practice are the principles WPI prides itself on, the FIS will connect these ideas.

The Scope of our IQP

The FIS has a multitude of spaces and concepts that define it. Although the entirety of the FIS includes student space, offices, classrooms and residences, this IQP focused on three main, student-centric areas: the makerspace, the collaboration space, and the global impact space. A number of recommendations were developed for each of the three spaces along with programming concepts for

1. The White House, "A Nation of Makers," 2014, accessed March 4, 2016, `https://www.whitehouse.gov/nation-of-makers`.

the FIS. The aspect of programming is important in this type of project since we are not architects or designers, nor do we claim to be. Providing programming recommendations is a way to give the architects an idea of how students at WPI actually work and how they will use these spaces on a day-to-day basis. Ultimately, the programming will help connect all aspects of the FIS to create an enriching environment that will become a unique community for WPI members to be inspired, invent, and to innovate.

2 Proposals for the Makerspace

The three main questions that our IQP strove to answer in regards to the makerspace are the following:

1. How will the makerspace interact with the other machine shops on campus?
2. How can the makerspace support student group and personal projects?
3. How can we promote the maker culture at WPI?

Applying these questions on our visits to other makerspaces served as a starting point, however we also needed to look internally to fully understand what the WPI makerspace will encompass. An inventory of the shops on campus gave insight on how the makerspace will fit in with and stand apart from them. From our visits we learned that hosting a variety of events is the best way to promote a maker culture. Speaking with different club presidents and looking at makerspace calendars from the universities we visited helped us develop a calendar of our own. Through our efforts and research, we came up with seven recommendations for the makerspace:

1. Serve as the central hub with the existing shops on campus as its satellites.
2. Hire a passionate and approachable manager supported by involved student volunteers.
3. Conduct extensive training sessions to ensure the safety of the students.
4. Have a store for buying materials and components.
5. Provide storage for extended project work.
6. Support a variety of events that promote the maker culture.
7. Design a flexible makerspace that can adapt to the needs of future projects and students.

The next sections describe each of the recommendations in greater detail.

2.1 Serve as the center of the satellite model

WPI has eight shops on campus, many of which have similar tools and machinery. In order to avoid duplicating capabilities and equipment, we propose adopting a satellite model for sharing the resources of existing shops on campus. In the satellite model, the makerspace is a contact point and first-stop. The satellite system reduces the pressure to put advanced machinery in the makerspace.

WPI Shop Inventory

We created an inventory of all WPI machine shops. The list includes shops in Higgins, Olin, Goddard, Atwater-Kent, Kaven, and Washburn. Higgins and Washburn are both under the Mechanical Engineering Department and are together known as the Manufacturing Engineering (MFE) Labs. At each shop we documented the machines and hand tools present using the brand and model number when possible. During the inventory process, we also spoke with the lab managers to determine how their shop was run and their opinions about the new makerspace. The table below summarizes the information gathered.

Table 1: WPI Shop Inventory

Room Number	Lab Manager	Access	Capabilities
AK 112	Bill Appleyard	Ask lab manager before use	Light machining and metal work
HL 005	Student Managed	Open to all students whenever a lab monitor is present.	Light wood and plastic work, soldering, and 3D printing
GD 007	Tom Partington	Ask lab manager before use. Primarily for chemical engineering, chemistry, and biomedical projects.	Light machining and metal work
HL 004	Kevin Arruda	Ask lab manager before use and a machine online.	CNC Machining and metal work
KH 002	Russ Lang	Ask lab manager before use.	3D printing and metal work
OL 005	Fredrick Hudson	Ask lab manager before use.	Light machining and metal work
WB 108	Torbjorn Berstrom	Register project on mfelabs.org and reserve time on a machine	CNC Machining, metal work, assembly, 3D Printing, welding, and laser cutting.

The primary goal of the inventory was to enumerate the resources that WPI already has. Jeff Solomon, WPI's CFO, and Fred DiMauro, WPI's Vice President of Facilities, expressed interest in a master-inventory of the labs and shops as it would help them better manage requests for new machinery. This inventory illustrates that there is a significant amount of duplication among the shops. Goddard, Higgins, Kaven, and Olin shops all have a manual mill with digital readout (for measuring cuts), so putting more mills in the makerspace would be superfluous. It would be a better use of resources to allow students to use the shop that best matches their needs.

Beyond seeing just how well-equipped our shops, we also saw their limitations. For instance, Washburn is over-crowded during MQP season in late C term. On the other hand, some shops, such as Olin and Atwater-Kent, serve very few students. Overall, the inconsistent use of the shops on campus can be attributed to a lack of communication. Many students are not aware they have access to shops, or the capabilities of each shop. When talking to the lab managers, we found that, with the exception of Washburn, most shops are only known to students who hear things from their peers. For example, a member of CollabLab might walk passed the Higgins shop and asked if they could use the shop.

Other than this, they would have no way of knowing about the Higgins machine shop. Students may request to work in the shop, but there is no official training or reservation. Washburn, on the other hand, requires different levels of training for specific areas of the shop and has an online reservation system for its tools. The shop managers also differ in how willing they are to help students. For some, that is their major objective, but others are too busy taking inventory, helping faculty, or with professional development to work one-on-one with students. Some staff members in certain shops have a reputation of being unhelpful or unfriendly to students.

Creating a Satellite Model

The satellite model requires a new organizational structure, participation of lab managers, and clear communication between shops and the students. This paragraph describes a few suggestions on how to implement the satellite model. First, there could be someone in the makerspace to direct students to the shop that has the resources necessary for their project. Alternatively, students could look at some well-known website housing the inventory to determine which shop has the desired equipment. If a student is sent to another shop, there will be some acknowledgment or confirmation. This way, the student is both expected by the shop, and the shop is prepared. Depending on how often this occurs, there may need to be an electronic system for coordination, or it could simply be someone at the makerspace calling up the shop and giving them some notice. The electronic system could consist of a student checking the weekly availability of the desired shop on a computer. When the student finds a suitable time slot, they could reserve it by providing their name, email, and a description of what they need to do. All of this information would be sent to the lab manager. Shortly after they make the reservation, the lab manager could send a confirmation email so the student knows they are expected.

Management in a Satellite Model

The satellite model will dictate some aspects of how the makerspace and other shops on campus will be managed. The most important point Professor Bergstrom made was that a satellite system with the makerspace as the central hub will require that the lab managers across campus work together. For instance, if students are being told about all the shops they can use, it would be necessary for lab managers to communicate with each other, and make sure students can smoothly switch between different shops. Currently, the shops are operated completely separately making it difficult to use more than one shop over the course of a project. We asked each lab manager how they would feel if the new makerspace sent student to their shop to make parts. When we spoke with the the smaller machine shop owners, they made it clear that they were not prepared to support more students than they currently do. For the FIS makerspace, this means that if a distributed model is adopted, more man-power will have to be allocated to those satellite shops. We suggest that each shop would have one or two student workers depending on the size of the shop. The workers job is to coordinate with students

who want to use the shop and provide help if necessary. It is unclear what their exact responsibilities may be, but preliminary ones include teaching students how to use machines and setting up meetings with individuals who want to use the shop.

2.2 Hire a passionate and approachable manager aided by students

The second component of our proposal concerns the management of the makerspace. Overall, we suggest that a dedicated staff member manage the equipment and functions of the space, with students acting as lab monitors. The lab manager, or a student lab monitor, serves as a concierge for the whole makerspace - available there to answer any questions or requests that makers may have about the space. Some examples are informing students on which machine to use for a given task, explaining to students the rules and policies of the makerspace, or being the first adult to contact in the case of an emergency or injury.

Examples from WPI

There are several spaces within WPI where well loved and dedicated staff members are responsible for running the space. One such person is Joe St. Germain, the lab manager for the Undergraduate Robotics Engineering Lab. Among the robotics students, he is known as the "patron saint of RBE". His responsibilities include from keeping the lab clean, designing hardware for courses, ordering supplies, and running lab sections. Joe is loved by students, and that relationship is important. It causes students to be more respectful to the lab, since they know that Joe will be the one responsible for any messes or accidents. Another example is Tom Partington. We met Tom when while taking inventory of Goddard. As the manager for the Goddard Machine Shop, he mostly serves students in chemistry, chemical engineering, and biology. When asked about access to his shop, he said "my door is always open", and that he works with students who come in not knowing exactly how to make their parts.

While there are a few examples of lovable lab managers and staff, there is a stigma surrounding some machine shops at WPI where inexperienced students are not welcome. For example, even the lab monitors of Washburn and Higgins believe these shops are unwelcoming. The makerspace needs to change this perception. Who ever is working in the makerspace must have a passion for helping students. They must be approachable, passionate, and knowledgeable. They must put safety first, but accessibility a close second. The students involved with its management must be willing to help others who are lost or confused.

Passionate Managers at Yale and University of Massachusetts Amherst

Baird Solues is a senior lecturer at UMASS in the electrical engineering department. In addition to lecturing, Professor Soules also manages the university's Electrical and Computer Engineering (ECE) studio space called M5. During our visit to M5, Professor Soules brought us on a tour. Throughout it, we observed

how students interacted with him. He was approachable, and casual around the students. We walked through the lounge, where students were sleeping, laughing, and socializing. Unlike some professors or faculty, whose presence might deter such an atmosphere, he was welcomed by students. We saw similar interactions with Vincent Wilczynski, the Deputy Dean of Yale School of Engineering & Applied Science & James S. Tyler Director of the Center for Engineering Innovation & Design (CIED). Dean Wilczynski was enthusiastic and approachable, and seemed right at home in the CIED. Dean Wilczynski has an office with glass walls that looks down into the makerspace. He told us that his door is nearly always open and students know when he is there. We envision the makerspace manager's office will be visible in the makerspace so that they are easy to find.

Student Involvment at Other Schools

We spoke with two seniors at UMASS Amherst who started the Mechanical Engineering Department's makerspace. The makerspace began because they felt that the machine shop was not accessible to students. In contrast, students have access to the makerspace any time one of the student managers is present. The space is run entirely by a registered student organization and having the space run by their peers makes working there very comfortable. The two seniors argued that a space run by students is more inviting than one run by staff members. M5 operates differently than the mechanical engineering makerspace. Professor Soules is the manager of the space, but enlists students to help with operations. Students serve primarily as machine shop monitors, with many of these positions qualifying for work study. Student machine shop monitors are able to use the 3D printer and machine shop, and can supervise other students while they work.

Student involvement in a WPI Makerspace

In addition to the workers in the satellite shops and the lab manager, there should be student volunteers in the makerspace to help students. These students would be responsible for helping keep the makerspace clean and safe. They ought to be distinguishable from the rest of the users by some means, such as T-shirts, wristbands, or hats. This program would be similar to the NINJAs (Need Information Now? Just Ask) at Olin College. The student volunteers would serve as aids to users and help them whenever needed. They would assist in training programs and workshops as lab monitors do in Washburn. Although we hope the sense of community and responsibility will encourage students to keep the makerspace neat and organized, as it does at Yale, the volunteers will ensure the space remains organized and clean.

This idea was borne out of the mission and experiences of the CollabLab. CollabLab is a student run makerspace located in HL005, supervised by Professor Ken Stafford. We conducted interviews with several members of the CollabLab. These students feel very strongly that the student body should have a say in how the makerspace is run, and that their help is essential to its success. By allowing students to be involved in the management of the makerspace, they will develop a sense of ownership and respect for the space. Training new students,

coordinating events, supervising the use of certain tools, running the materials store, and managing storage are all examples of roles well suited to student lab volunteers.

Example from Artisan's Asylum

Aaron Grossman is a member of Artisan's Asylum, a community makerspace in Somerville, Massachusetts. From Aaron, we learned that the best way to find creative and reliable staff is to hold free events that offer some incentive to come visit the makerspace. This incentive could be help with projects or meeting other makers. Artisan's Asylum has experimented with many different ways of managing their space and members. Artistan's Aslyum is a public space with very limited resources, so the studio has taken a community driven trust-based approach. Currently, they have a board of directors, president, treasurer, secretary, wardens, and "deskies". Wardens are trusted and experienced members, who help others use tools and become involved with the community. Deskies are volunteers who give tours and introduce people to the space. We will face many of the same challenges in the FIS, such as trying to find motivated student volunteers. From this community-driven trust-based model, we learned that giving members power and trusting them creates a sense of ownership, which in turn creates respect and care for the space.

2.3 Conduct Training Sessions

In order to keep students safe, and to keep the makerspace open to everyone as much as possible, extensive hands-on training must be held frequently. Frequent training sessions will ensure that students are able to use the space safely.

Training in Washburn Shops and Other Shops on Campus

Currently, Washburn only holds two or three training courses each term that are advertised only through the MFE Labs email alias. During the training, a lab monitor will read descriptions and instructions for each machine to a group of 10 to 20 students. The students do not use the machines at all during the training. The training students receive in Washburn also allows them to use the labs in Higgins. This training is infrequent, poorly advertised, and does not provide necessary hands-on experience to ensure students are ready to use the machinery.

No other shops on campus provide formal training sessions. Some lab managers, like Tom Partington in Goddard, will train students on a few of the machines in the shop as needed. Since there is no formal training, he does not allow students to use some of the more complex machines such as the manual lathes. In Atwater-Kent, Bill Appleyard does not have the time or staff support to train students who use the lab. Therefore, access to the lab is limited to students that Bill trusts and knows are trained.

Safety and Training at Other Schools

Yale offers an orientation training program for the CEID every Wednesday during the academic year. At Yale, Dean Wilczynski emphasized the importance of keeping all areas of the makerspace visible, and open where possible, so the managers and lab monitors can see everything that is going on in the makerspace.

A similar point about visibility was made by Professor Bergstrom in the MFE Labs. He mentioned that before he took over as operations manager, Washburn was split into two shops, with two separate labs. The two rooms were small, and contained the same equipment. In addition to be a waste of human resources, it also made it harder to use both shops, since students would have to deal with two separate managers.

Of all the schools we visited, Olin College had the most innovative approach to training and safety. First, it is worth noting that despite its small student body, Olin has equipment nearly has large and advanced as WPI. Olin has categorizes their tools into three groups: red, yellow, and green. The green tools are easy and safe, and yellow and red tools are progressively more advanced. The list below outlines how the tools are categorized.
Green Tools

1. Power sanders
2. Hand tools
3. Drill Press

Yellow Tools

1. Basic Mill operations (drilling, facing, end milling)
2. Basic Lathe operations (turning, drilling, facing)

Red Tools

1. Advanced CNC Milling
2. Advanced CNC Lathe turning
3. Welding
4. Water-Jet and Laser cutter

As freshman, every Olin student is encouraged to become certified on three "green" tools. A database of which student is certified on which machine is kept by the shop. Furthermore, each machine in the shop is labeled with it's name and color, making it easy for students and staff to keep track of which tools should be used. On our visit to Olin, we asked students about access to their shops. Students at Olin have the freedom to work on projects whenever the schedule allows due to the 24 hour access of the shops. The honor system at Olin requires that students will always have a partner with them in the shops. This is similar to the policy of having a partner when operating machines at

Washburn. Ultimately, we propose a similar model for the makerspace, where tools are categories and students are certified for each category. In order to manage this, we also propose that lab monitors are certified on all tools in order to train students on any machine. On the spot certification makes this granular certification model possible. Furthermore, we would like to see how WPI ID card readers could be used to control access to machines.

Another interesting model for certification was suggested by a WPI student and employee of MassChallenge, a startup accelerator working with technology and medical device. Since MassChallenge has some very expensive equipment and members are allowed to work at any time of day or night, they have developed a unique model for keeping everyone safe. Training is provided one-on-one when a member wants to use a new tool. Most of the tools are kept under electronic lockout, and can only be unlocked by a MassChallenge mentor. If no employee is present and a member wants to use the tool, they must call or message one of the mentors, who will verify that they have been trained and then respond with the electronic code. This electronic code changes daily. In this scenario, the benefit is that they must always get permission before using machinery. All in all, a simple, granular, hands-on, and electronically recorded method for training and certification makes the most sense for the FIS Makerspace.

Safety and Training in the FIS Makerspace

We suggest small training sessions every week, in addition to on-the-spot training by lab monitors. This is the model used by the CollabLab for training students on small machines like grinders and drills. More frequent training sessions with fewer students would allow for thorough hands-on training ensuring that students fully understand the equipment. There needs to be an online calendar detailing all of the events for the makerspace. This calendar should also be displayed on a TV screen near the entrance to the makerspace. Yale has a TV monitor outside of the makerspace displaying the calendar for the week and the which lab monitor is on duty, as seen in Figure 1. Furthermore, training in other shops on campus should carry over to the makerspace. Allowing students to accredit training to different shops will prevent them from having to take several very similar training sessions.

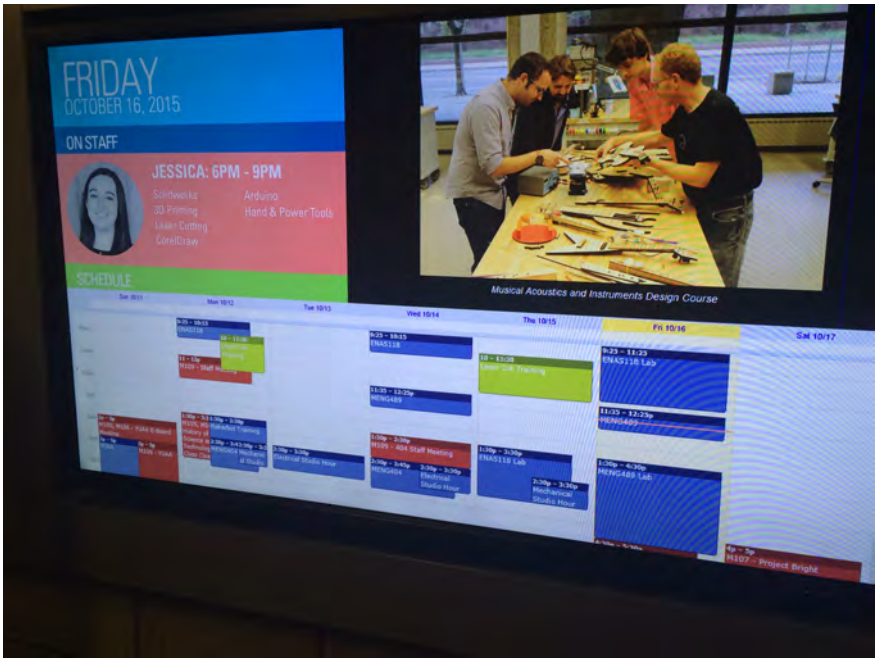

Figure 1: Screen displaying makerspace calendar and lab monitor, CEID, Yale

Method to Distinguish Usage Rights

We discussed the various systems Washburn has had for authorizing users, and in the end we agreed that some tiered system where a user's level of training is indicated on their person helps keep students safe and held accountable. If there are varying levels of usage rights for the makerspace (as there is for Washburn Shops), there needs to be a simple way to distinguish which certification someone has while they are in the makerspace. We spoke at length with Professor Bergstrom about the different methods they have used in the past. One of the more successful methods was printing name tags that outlined usage rights. Every time they entered Washburn they would swipe their ID and a name tag with their picture and access level was printed for them to wear. At Olin College, students had different color armbands to indicate their access level.

2.4 Have a Store for Materials and Components

Stock is a fundamental element of building and making something. Therefore, creating a stock store in the makerspace is essential. This store would be available to all students for personal, class, and extra-curricular projects. The stock store would include materials such as acrylic, plywood, sheet metal, cardboard, foam, fasteners, and more. Having stock readily available on campus will allow students to dive right into projects as soon as they want to. It will also allow for uninterrupted work flow.

Student Opinion on Stock Availability

Many of the students we interviewed complained that obtaining stock is difficult. The nearest Home Depot is a mile and a half away from campus and Lowe's is even farther away at three miles from campus. Walking to either store is unsafe. For some students, driving is an option. Students without cars, however, need to ask people for rides or pay for a taxi. Ordering stock online is not ideal since shipping can significantly delay a seven week project. All 13 students we interviewed were very excited about the idea of available stock on campus. One student suggested the store could coordinate large group orders from websites like McMaster-Carr to reduce shipping costs.

Stock Stores at Other Schools

The Pappalardo Lab at MIT has a stock store where students could purchase materials for their design course that takes place in the lab. The store is composed of shelving filled with stock lining one of the walls of the shop. The shelving units are in a recces in the wall, as seen in Figure 2. The store includes materials such as foam boards, cardboard, wooden dowels, and plywood, all of which can be seen stacked on the shelves. The plastic bins visible in the image contain hardware, motors, wires, and adhesives. The stock store supports eight project teams each semester.

Figure 2: Pappalardo Lab Stock Store, MIT

The store uses an electronic self-check-out system, shown in Figure 3, compatible with student ID cards. By making the stock store compatible with the IDs, students do not have to worry about having cash or credit cards to buy stock. The Pappalardo Lab inspired the idea that the FIS stock store should be compatible with Goatbucks. The convenience of Goatbucks will encourage students to use the shop, and therefore get involved in the space. The departments on campus could utilize the electronic system as well to fund student projects for classes. For example, one member on our team recently took a mechanical engineering course involving prototyping. The Mechanical Engineering Department reimbursed them for all of the parts and materials. Students enrolled in such classes eligible for department funding could be added to a list along with the amount of money the department would provide to them. When the student goes to check out at the computer, they would scan their ID. If the student is on the list, an option to pay with department funding would appear. If the student goes over the allotted funding, they would pay the difference with cash or GoatBucks. Instead of charging a student and then reimbursing them, the department would cover the cost directly. This eliminates the need for students to wait for reimbursement. The option for department funding would only appear at the makerspace stock store when the student is on the list, eliminating the possibility of students inappropriately using department funds.

Figure 3: Pappalardo Lab Stock Store Electronic Check-Out System, MIT

Inspiration from the ECE Shop and CollabLab

In addition to stock, basic consumables must be freely available, with some limits, for all projects. The idea for free consumables came from WPI's ECE Shop located in Atwater-Kent. A short list of consumables includes screws, nails, hot glue, solder, resistors, tape, etc. Trying to provide free hardware to all students at all times will get expensive. The idea of free hardware should at least be tried with costs tracked carefully. Should the system prove to be too expensive, another model should be implemented. Having these items on hand at all times means that a student never has to interrupt his or her work-flow because a trivial part is missing.

Another important source of material should be free scrap. Most small projects can be done completely from the scrap of other projects. The CollabLab gets a lot of great components by "dumpster diving" in the ATC scrap or the Fuller loading docks, so making that officially available as scrap would be a valuable free resource for students.

2.5 Provide Storage for Extended Project Work

Storage is sparse on campus for academic, personal, and club projects alike. There needs to be space dedicated for safe storage so students on teams can

access the project whenever they need to. Storage on campus will also encourage students to use the shops more often, since they will not need to bring their project back and forth between a shop and their room.

Examples of Storage Needs for Academic Projects

A variety of courses offered at WPI require students to build prototypes for their projects.In the Mechanical Engineering department, the course Introduction to Engineering Design requires students to make a prototype. The class is offered B, C, and D term and allows for 40 students to enroll each term. The students divide into groups of four so there are about ten groups each of the three terms. One member of the team recently took the class. Their project was a wheelchair attachment made out of PVC piping to help handicapped students play soccer. The prototype was about 3' by 4' by 3' and required ample room for storing the uncut ten foot PVC pipes. The group stored some items in the professor's MQP lab, however the space had very little room for additional projects. There was also no way to ensure their items were protected and they often found their products moved around and tampered with. Any storage available in the makerspace should have locks to ensure students are not stealing parts and materials. This is especially important for students involved in projects with electronics. Not all of the projects made for the design course were that large. One of the other groups modified a baby walker with sensors and speakers to help blind children learn to walk. This group's project only would have required a 2' by 1' by 2' space.

We interviewed a group of three Biomedical Engineers that built a microscope out of plywood that is compatible with the camera on a cell phone for one of their classes. The microscope is rather small and only requires a cubic foot of space for storage. The class is now over, but the group received funding to continue to work on the microscope. They no longer have a place to store the microscope, so it is in one of their apartments leaving it inaccessible to the rest of the group.

Examples of Storage Needs for Clubs at WPI

The president of Engineers Without Borders (EWB) explained that the prototype and materials for their PVC water collection system for a project in Guatemala was kept in her apartment, therefore it was inaccessible for the other members for the majority of the time. This is inefficient and unproductive. Furthermore, anytime they wanted to work on the project someone needed to transport the system and materials up to campus which is cumbersome. For all of EWB's technical equipment (prototypes, materials, and tools), the president believes, "we could easily fill 40 square feet (5' by 8'). . . So something like a small closet would be ideal for us"

Another example of an extracurricular project in need of storage is the Robotic's Club's autonomous sailboat. The boat has a three foot long hull and a five foot mast. The boat was kept in a Professor's office, therefore, the students were only able to access it when he was there. Keeping such a large project in a small dorm room or apartment would not be ideal due to size limitations and

transportation issues. It would be much more convenient to store the large boat in the same location it will be worked on.

While many clubs are lacking storage space, some do have the luxury of providing their members with some. Currently, CollabLab provides a small amount of storage to each member who requests it. CollabLab has about 40 active members. In total, they currently support storage for 33 small (under 1' by 1' by 2') projects, six medium (under 3' by 1' by 2') projects, and six large (under 3' by 2' by 2') projects. There are typically one or two lockers unoccupied at any given time. The members of the club are able to request a locker for the duration of their project. Once they are done with the project they remove their stuff from the locker so that another person can use it. The benefit of this system is that it is need based. It attempts to avoid giving lockers to people who will not be using them.

CollabLab is able to provide some storage for its members, however the large scale projects cannot be stored in any of their lockers. For example, a group of about 17 students are working on a battle rocket. The battle rocket is about nine feet tall and has several components. It is currently being stored in the American Society of Mechanical Engineers (ASME) office on the third floor of Higgins Labs. However, CollabLab is in the basement of Higgins Labs forcing the students to transport the rockets every time they want to work on them.

Examples of Storage Needs for Personal Projects at WPI

Beyond academic and club projects, students partake in personal projects either individually or in small groups. Students have been increasingly involved in local and on-campus combat robotic competitions. The robots for such competitions can weigh up to 12 pounds, but most WPI students compete in the three pound weight class due to cost constraints. According to one student who consistently participates in the competitions, a 2' by 2' by 2' space would be sufficient for storage of the robot and extra parts and materials. Five student teams participated in WPI's first on-campus combat robot competition held on January 23, 2016. Prior to the event, these groups of students would store their robots in the Robotics Lab storage room where ever they could find some space. While convenient to keep the robot in the Robotics Lab, there was minimal space in the storage room for personal projects. The event will likely gain more popularity and participants if it becomes a well established event on campus.

Other personal projects are smaller and more temporary, such as gifts. Many students use the laser cutter to engrave gifts for their significant others, to make paddles for a fraternity, or sorority crafting. These are examples of the kinds of project that should be stored in the makerspace.

Storage Solutions at Other Schools

Nearly all of the places we visited had some form of storage for their students or members. The hallway leading into the CEID is lined with lockers. There are 20 lockers total. Ten lockers are three feet tall, three feet wide, and two and a half feet deep. The remaining ten lockers are a half a foot shorter. The

lockers are first assigned to student groups enrolled in a design course requiring the production of a prototype. Then lockers are given to clubs that heavily utilize the makerspace. Usually one or two lockers remain each semester for students working on personal projects.

One team member visited Dartmouth and was intrigued by their storage solutions. The lockers at Dartmouth were much smaller than they ones we saw at other universities. They were only about 8" by 10" by 12". However, as seen in Figure 4, the lockers are clear. Clear lockers would be preferred since they allow students to see projects happening on campus. All of the students we interviewed about the makerspace agreed that seeing what people are making inspires people to start their own projects.

Figure 4: Clear storage lockers at Dartmouth

Recommended Implementation

Throughout the section we have provided specific examples of academic, extracurricular, and personal project needs at WPI. We certainly did not capture all of the projects happening on campus at any given time, but hope we conveyed the importance and necessity of ample storage. To accommodate the wide array of project sizes, we recommend a modular storage system. There are many ways to make the storage modular, but they key is to have various sizes of spaces, preferably with some mechanism for locking groups or individual sections. We describe one possible solution here. There could be several wide cabinets with adjustable shelves. There would be many doors, with each shelving section having it's own door. If a student requests more space than one shelf can provide, they

could remove some of the shelves to have a double or triple height shelf. A student with two shelves could then open two doors to access the space. The doors could even interlock to create an appropriate sized door for the desired shelf height or number of shelves. This allows for modular shelving that can still be secure and locked. If the shelving unit described above does not already exist for purchase, WPI students could build them. This idea is inspired from our visit to Olin College. The students actually built most of the tables in their shops. Allowing the students to build the furniture provides them with a sense of ownership of the space.

If the modular storage system cannot be pursued, an alternative is to include various sizes of clear lockers. There should be a total of 150 lockers: 50 lockers should be 3' by 1' by 2', 50 lockers should be 3' by 2' by 2', and the final 50 should be 1' by 1' by 1'. Regardless of the type of storage included in the makerspace, there will be a way to electronically request a storage unit for the duration of a project. Depending on student needs, a certain number of lockers may need to be allocated to academic projects. Not all of the lockers can be designated to academic projects however as it may deter people from pursuing personal and club projects.

Furthermore, there needs to be space dedicated to large projects and for additional storage as WPI continues to grow. As of now the current designs only have half of a basement to accommodate mechanical systems. We strongly encourage the architects and administration to look into expanding it to a full basement. While it may not be used right away, having the full basement would allow for more storage for larger projects as the WPI student body grows.

2.6 Support events and promote maker culture

WPI already has several academic based labs on campus. The makerspace in the Foisie Innovation Studio should have a great deal of programming and an emphasis on the social aspect of the maker culture so that it is not just another shop on campus. An organized set of events will launch this makerspace off the ground. A founder of another school's makerspace noted that "we offered free classes for the first five months, all volunteer time we were able to build a core community of people." Hosting events ensures that the space is well used, well advertised, and will promote a community and culture of makers. There are five types of events:

1. Certification and Training
2. Club
3. Social
4. Outreach
5. Company Sponsored

The wide variety of events will help draw people into the makerspace even if they are not currently involved with a project.

Below is a sample month calendar for the makerspace to give an idea of the frequency and types of events that should be held. The events are categorized and color coded. The first category of events is "Training and Certification" which was described in section 2.3 "Conduct extensive training sessions". The remaining categories of events will be explained in depth in the remainder of this section.

Makerspace Detailed Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	■ 2-3pm Laser Cutter Workshop		■ 1-3pm Certification and Training	■ 1-2pm Makerbot Training		■ Starting 10am -- Hack@WPI
■ -- Until 10pm Hack@WPI		■ 6-7pm Soldering Workshop	■ 1-3pm Certification and Training ■ 6-9pm AEES/AICHE Joint Social			■ 8am-12pm STEM Saturday
	■ 2-3pm Laser Cutter Workshop ■ 8am-12pm Introduce a Girl To Engineering		■ 1-3pm Certification and Training ■ 6-7pm Innovation Challenge	■ 1-2pm Makerbot Training		■ 12-2pm Jewelry Making
			■ 1-3pm Certification and Training	■ 6-7pm PVC 1001		
	■ 2-3pm Laser Cutter Workshop ■ 8-11pm Little Bites and Legos	■ 9am-6pm Stratasys Extreme Redesign	■ 1-3pm Certification and Training	■ 1-2pm Makerbot Training		

Training & Workshops

Social Events

Club Activities

Outreach Events

Company Sponsored

Makerspace Event Descriptions

Certification and Training
- Get certified on the machines and learn how to stay safe in the makerspace

Makerbot Workshop
- Learn how to use the makerbot, and practice designing and printing a sample part

Laser Cutter Workshop
- Learn how to use the laser cutter, and practice designing and cutting a sample part

Soldering Workshop
- Learn how to slice wires, solder pin-hole boards, and other basic soldering techniques

Hack@WPI
- Hack@WPI is a 48 hour event where groups of four students engage in collaborative programming. Build an app, program a robot, or make a website--anything is fair game!

AEES/AICHE Joint Social
- Students in AEES or AICHe are invited to attend the social to network with professors and industry partners

STEM Saturday
- Share your love for STEM with local middle school students! Email Ken at fakeemail@wpi.edu to sign up.

Jewelry Making
- Local artisan Tim Timson will be running an into to brass jewelry making. Don't forget, Valentine's day is coming up!

Introduce a Girl to Engineering
- Help empower the next generation of girls to be leaders in engineering!

Little Bites and Legos
- Stressed out because of midterms? Take a break, play with legos, and nom on little-bite mini muffins.

Stratasys Extreme Redesign
- Stratasys is hosting a 3D printing competition, calling upon students to redesign an existing product or create a new one

PVC 1001
- Engineers without Borders is hosting a PVC workshop for their members and any interested students

Club Events

We looked on 25Live, WPI's room scheduling website, and spoke with some club presidents to determine the potential events clubs could host. We specifically targeted engineering based organizations. Many of these clubs already host student run workshops, general body meetings, and social events in classrooms or meeting rooms on campus. Uniting the locations of those events will also unite the people and ideas that are involved. The first club event listed on the calendar is a joint social between the American Academy of Environmental Engineers and Scientists (AAEES) and the American Institute of Chemical Engineers (AICHE). This is an event we found while looking through 25Live. Although the social may not involve any making, both groups are engineering based. Hosting such socials in the makerspace is an excellent way to ensure students use the makerspace to its full potential.

The second club event listed on the calendar is "PVC 1001", an idea the EWB president came up with during an interview. EWB is very receptive to the idea of conducting workshops open to all students. They believe it would not only be helpful, but also excellent advertisement for the club itself. In this unique workshop members of EWB would share their experience with working with PVC pipes. Furthermore, EWB is in desperate need of a better space to work on their projects. Prototyping is extremely important for this organization as they need to test their ideas before traveling to another country to implement them. Members have tried building prototypes in Washburn, but found the experience to be very disappointing. The president is a lab monitor, but described Washburn as inaccessible, very proprietary, and not a very good workspace due to its lack of storage and work benches. EWB imagines conducting their weekly general body meetings in the makerspace. This would allow members to work on prototyping during their meetings instead of having to schedule even more time outside of the meeting to construct them.

We spoke with several other clubs about events not listed on the sample calendar. CollabLab supports students participating in national and regional competitions, such as SmartMouse, a maze solving robot competition, and Battle of rockets, a rocketry competition. These competitions, occurring three or four times a year, require a lot of group work and manufacturing, which is ideal for the makerspace. The CollabLab also hosts Open Lab night every Friday, where members are encouraged to socialize and work on their projects. This event typically attracts eight to 12 students and is well suited to the makerspace as it ties in both technical and social elements. These club projects are also a great way to spark interest in making. Joining one of these projects would be an easy way to get involved in the Makerspace.

Social Events

Technical events are important for a makerspace, however, it is also essential to host social events to make the space more inviting to people who may not have a project to work on. This one of the key points made by Baird Soules, senior lecturer at UMass Amherst and manager of the M5 Makerspace, as well as Dean Wilczynski. To Baird, this meant hosting casual events on Saturdays.

The highlight of the discussion was to "[...] not forget the people who aren't making anything." In other words, if this space is to be a place for all of the WPI Community, it must be a fun location to simply hang out or to study, as well as work. Dean emphasized that Yale frequently hosts a variety of social events in the CEID including themed study breaks for their students close to the end of the semester. Our team looked closely at their calendar when we were developing our own calendars. One great example of a social event Yale hosted was a "Milk and Cookies Study Break". The extensive programming at the CEID ranging from technical workshops to social events for students and staff promotes a community and culture of making. Inspired by this, we came up with "Little Bites and Legos", where students could snack on miniature desserts and play with Legos. The other two social events on the calendar are the Innovation Challenger and a jewelry making workshop. Curtis Abel has been conducting Innovation Challenges throughout the year in the Rubin Campus Center. During the challenges student teams compete against a faculty team to build something out of simple materials. There is certainly an aspect of making to these events making them well suited for the makerspace. Yet, these Innovation Challenges are also just a really fun event loved by the students. For the jewelry making event, we envision teachers from the Worcester Craft Center coming to WPI with some tools and materials to conduct the class. Similar to the Innovation Challenges, there is some technical aspect to the event, but it would be a more relaxed workshop and an opportunity for students to hang out with friends and try something new. WPI could even form a partnership with the Worcester Craft Center and add it as one of the makerspace's satellite locations. All in all, having events less focused on technical skills in the makerspace is a requirement for a vibrant maker community and a successful makerspace.

Outreach Events

Beyond just serving WPI's student body, the makerspace could support the numerous outreach events the university hosts. Two outreach events that already happen at WPI and are listed on the calendar are STEM Saturday and Introduce a Girl to Engineering Day. The goal of outreach programs is to inspire students to pursue engineering. These events are often held in the Campus Center and Alden–places where engineering does not really happen. If we want to inspire students to pursue STEM fields we should be hosting these outreach events in the makerspace where WPI students are actually engineering.

To learn more about WPI's outreach efforts, we spoke with Jenna Noel-Grinshteyn, the manager for the outreach program Engineering Ambassadors. The program currently conducts presentations that are accompanied by an engineering activity to middle school students in classrooms and conference rooms around campus. While this situation is working just fine, Jenna believes there is a lot of potential to improve the program if it could utilize the makerspace. The point of Engineering Ambassadors is to excite students about engineering, which can be difficult when they are just sitting in a classroom. Conducting these presentations in the makerspace would not only spark an interest in engineering among the students, but would also allow for more complex activities. As of now, the activities

that accompany the presentations are not very challenging for middle school students since classrooms do not have the resources for them to do very much. Some of the low level prototyping equipment we are envisioning for the space would provide more possibilities for more challenging activities. The possibility of using the makerspace for Engineering Ambassador Programs would depend greatly on how the space is laid out. There would have to be a presenting area with a projector. Furthermore, Jenna is concerned about the liability and safety of the children if unguarded machinery is scattered throughout the room.

Company Sponsored Events

Finally, hosting more company sponsored events will draw many people to the makerspace. These are typically great networking opportunities and a way to showcase the talent of WPI students. We spoke with the president of the Association of Computing Machinery (ACM) aout the Hack@WPI event they hosted in January. ACM was able to recieve sponsorship from Microsoft for the event. While the event does not require physical tools, the space could convert to accommodate the hackathon. Hackathons require a stage, presentation space, tables, and ethernet ports. Most importantly, they stressed having part of the makerspace well equipped with electrical outlets and ethernet ports. Since most CS majors prefer using their personal laptops, ACM noted that having external monitors, mice, and keyboards would be more cost and space effective than desktop computers. The second company event is the Stratasys Extreme Redesign Challenge, which is a 3D printing challenge. This is another event that already occurs at WPI that we found on 25Live. These company sponsored events focused on science and engineering should be hosted in areas where students are applying their knowledge.

Company sponsored events can also encourage manufacturing companies to donate and support their equipment. For instance, we could invite Universal Systems to WPI to run a laser cutter cram session right during the end of MQP season, typically in C term, or when robotics courses are wrapping up. This would not only help handle the huge demand for laser cutters during those times, but also build a mutually beneficial relationship with the company.

Lastly, there is also an opportunity to partner with companies who sell electronics, hardware, and sock materials. One way to lower the costs of the previously mentioned stock store is to partner with retailers like DigiKey or Sparkfun, who can provide their products at a discount price in return for mindshare of the students and loyalty. Mindshare and corporate sponsorship was one of the points made by the WPI student and employee of MassChallenge. They noted that "the Mindshare, having students associate their company with a product, is worth way more to these companies than three units". Another example of a company sponsored event is a Hackathon. In 2015, the very first Hack@WPI occurred in the Odeum, and brought in companies like Microsoft and MITRE Corporation. Over the course of a weekend, students worked in groups aided to develop some technology solution. Students also had the chance to network with companies. In essence, company sponsored events are a great opportunity for WPI and WPI students.

Overprogramming

Despite the importance of events and programming in the makerspace, it is important to remember that all this has a limit. Common sense dictates that if too many events are planned, then students won't be able to work on their unrelated projects. An example of how this can be a problem can be found in Washburn. Washburn is occupied for the majority of it's hours by ME 1800, a class that teaches CAM software and CNC machining. This makes it difficult for other projects to occur during those times. A similar issue could arise in the makerspace if it is too frequently occupied by events. One solution to this challenge could be to run events that don't prevent other students from working. These would be smaller, more social events, where student could feel included simply being in the space and working on their projects.

2.7 Design a flexible makerspace (i.e. do not fill the space)

One of the most important pieces of advice we received from other makerspace leaders is to not fill the space. One such leader is Dennis Montone from Bergen County Academies. Dennis Montone is the superintendent of Math and Science at the Bergen County Academies (BCA), a reputable school district in New Jersey. Dennis discovered that the key aspect is not with the tools, but rather with the makers. The focus on students means that the studio should be stocked with only the tools that are obvious and guaranteed to be needed, while the rest should be a product of what the students are doing. Since the main target audience of the FIS are students, they must be the ones to decide which tools should be bought next.

Another source for this concept came from an interview with Diana Lados. Diana Lados is an associate professor of Mechanical Engineering, as well as a member of the Trustee's Facilities Committee. We spoke with her to understand more about the role of the Facilities Committee as well as to understand her personal view on the FIS. Professor Lados expressed interest in what kind of machines and equipment would be in the makerspace portion of the FIS. What we realized from this discussion is that if a list of tools for the Makerspace was made ahead of time by faculty, there would be implicit bias toward the work of those faculty members. Leaving room in the Makerspace for unanticipated tools and capabilities would mitigate this bias, and ensure the makerspace works for the students.

Examples from Yale and Artisan's Asylum

Dean Wilczynski warned us about not filling the space as well. When creating the CEID they left room for new work stations that could potentially arise in the future. They now have a sewing station since so many students asked for one. They had never considered adding a sewing station when planning the makerspace. Had they completely filled the space they would not have had room for this unforeseen student need. Artisan's Asylum is yet another example of leaving room for unexpected needs. They have an extensive jewelry making shop as one of the communal workshops. They had not planned for the jewelry

shop, but once they realized many of their members enjoyed making their own unique jewelry, they knew they had to include one. Both of these makerspaces had room to grow and satisfy unexpected needs. The FIS makerspace must have this flexibility as well.

Potential Capabilities

Despite not wanting to fill the space entirely, we wanted to identify some basic capabilities. Professor Bergstrom believes this new space could be an entry-level shop. To our surprise, he didn't ask for more CNCs or large machinery, but suggested that the space be limited to small desk top tools and rapid prototyping.

We created a list of capabilities the makerspace should have. The capabilities we identified are:

1. 3D printing
2. soldering and reflow
3. lightweight cutting
4. cardboard and foam prototyping
5. sewing and embroidery
6. wood assembly
7. sheet metal work and bending
8. arts and crafts
9. painting
10. CAD abilities.

In developing this list we considered both low level prototyping and more sophisticated methods. These capabilities stem from the areas we believe WPI is not currently able to fully satisfy, the abilities of other makerspaces we visited, and from discussions with students. After we decided upon the potential capabilities of the makerspace, we listed equipment that is necessary to satisfy each ability.

An important aspect of our list to note, is that the quantity for each item is not included. At this point, we are not able to predict the how many of each tool will be needed. Furthermore, the list is meant to generate a rough estimate for the cost. We do not want our list to be used as a shopping list. One of the important lessons we learned from our visits to nearly all the makerspaces is do not fill the space before it is opened. Our contacts advised us to leave room to add equipment we maybe did not think of, but the students express a want for.

Creating the list of capabilities and equipment was helpful as it allows us to consider the events and programming of the space with more detail. Now that we have a general idea of what could potentially be in the makerspace we are able to further define some of the potential events with more detail. We also

believe the list of capabilities will be extremely useful to the architects as they move forward with their design. If they have a strong handle on what students will be doing in the makerspace, they will be able to successfully design a room conducive to this type of work.

2.8 Conclusion

At the beginning of the section, we posed the following three guiding questions about the makerspace:

1. How will the makerspace interact with the other machine shops on campus?
2. How can the makerspace support student group and personal projects?
3. How can we promote the maker culture at WPI?

The proposed strategy of having the makerspace serve as a central hub with the existing shops as its satellites details how the makerspace will interact with the other shops on campus. The satellite model eliminates the need for duplicating equipment we already have on campus, but will likely require more staffing in the existing shops. The approachable manager and student volunteers in the makerspace will help WPI students complete projects through training and by directing them to the appropriate shops to fulfill tasks. Having stock readily available in the makerspace and space dedicated to storage will make project work more convenient and enjoyable. Flexibility to add new work stations and equipment in the makerspace is crucial to account for future unexpected project needs. Finally, the best way to promote a community and culture of makers on campus is to host a variety of events to encourage people to come to the makerspace even when they do not have a project. All of the recommendations outlined above are critical for the success of the FIS makerspace.

3 Proposals for the Collaboration Space

Students will use the collaboration space in the FIS to work in groups on academic, personal and extracurricular projects. The space will also likely become the gathering place for students to socialize. Our visits to other schools and a business incubator provided models for collaborative work spaces that helped us to provide recommendations for the FIS collaboration space. Interviews with both students and faculty members allowed us to further tailor these models to WPI. We also conducted experiments with student groups to "prototype the space" in order to capture what students physically need to work on group projects in the space. Finally, we considered how the space will be utilized beyond project work.

Through all of our efforts and research we developed four recommendations:

1. Provide organizational tools for the conception of ideas and the continuation of project work.

2. Opt for modular, moveable and unconventional furniture to make the space flexible and adaptable.

3. Utilize visual tools to modify the mood within the space to encourage creativity and collaboration.

4. Provide a co-working office and host events to promote the entrepreneurial mindset.

These recommendations will be analyzed in depth in the following sections.

3.1 Organizational Tools

Students need a way to visually conceive and later save their ideas. Student teams rarely get the opportunity to work together for a long period of time in one sitting because of busy schedules or a time restriction on group-work spaces. They generally have to spread their meetings over the week in one or two hour time slots. Because of this, the team ends up wasting valuable time trying to remember and recreate what was done at the previous meeting. Therefore, if groups do not have a way to stay organized from meeting to meeting, their work will suffer greatly seeing as they will be starting at square one again each meeting. With the implementation of a variety of organizational tools, a team can build on ideas much easier and more effectively, leading to more creative solutions in the end.

Examples from Olin College

Many of the places we visited have tools and methods with which their project teams keep track of ideas. Students at Olin College frequently write on glass walls and use sticky notes to organize their ideas as seen in Figure 5. These tactics help students put all of their ideas down on paper and connect the dots to create a framework for their projects. This type of visual organization also allows

a group to break up their project into smaller, more simple subsections. Although this is a great tactic for the organization of ideas, Olin College enrolls fewer than 400 students, compared to WPI's 5000 full time students. Because of this, Olin students can leave their sticky notes on the walls for the duration of their project. WPI could implement this strategy by encouraging students to keep track of their ideas on sticky notes on the wall during meetings, and then remove and save the sticky notes for the next meeting.

Figure 5: Sticky Notes and designs posted to a wall at Olin College.

Examples from Yale University

Yale's CEID made heavy use of whiteboards on wheels, as seen in Figure 6. Students often write notes and draw diagrams on the whiteboards to map out their projects and to prepare for presentations. Since the whiteboards are left in the space at all times, everyone who comes to the space can see the work in progress. Many students at Yale also utilized the whiteboards to save their ideas. The main users of the rolling whiteboards were student groups doing academic course work who were assigned a single whiteboard for the entire duration of their course/project. On top of this, we saw several whiteboards with pictures taped onto them so that students did not have to search for these pictures and ideas each time they met.

In the FIS collaboration space, we hope to see similar solutions for saving ideas. Since we will be catering to a student body that is made up of over 5000 people, we can not assign every project team their own individual whiteboard. We can, however, create a system in which we have 50 whiteboards available at the start of every term, and project teams can reserve a board for the term. If the project runs for more than one term, like many IQPs or MQPs, the team can be given the option to request to renew their whiteboard for the coming term. The whiteboards will have to be tucked away in different areas of the space when they are not being used, but having some whiteboards out at all times is not a bad thing because those whiteboards will show what work is in progress and can inspire others. Additionally, when a team is not using their whiteboard, the

whiteboards can be used as space dividers for teams to modify the existing space to meet their needs.

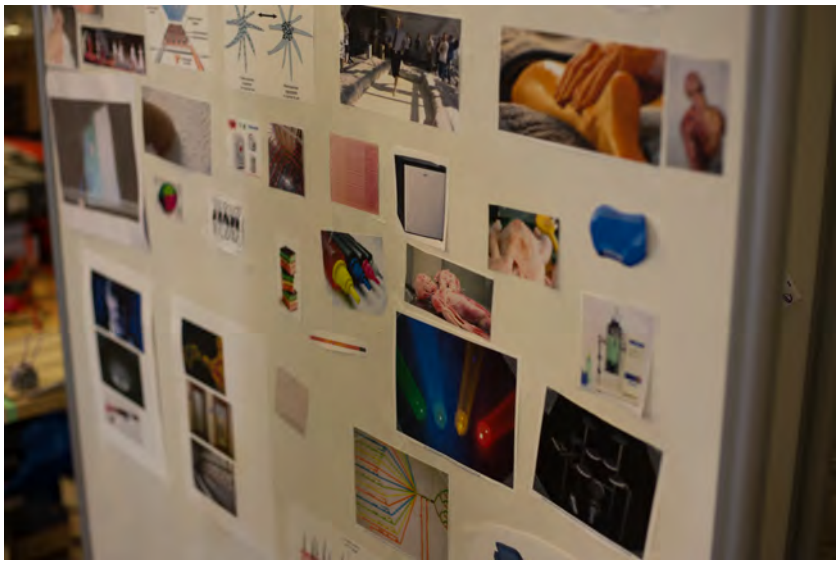

Figure 6: Pictures taped to a movable whiteboard in the CEID at Yale.

Prototyping the Space for WPI

During our interview with David Privitera, the former President of the Cambridge branch of IDEO and a WPI alum, we came up with an idea about how to learn more about how the space students work in affects them. We decided to run an experiment where WPI students were tasked with a simple engineering challenge in a variety of work environments while we observed them.

The idea to prototype a space is presented in *Make Space: How to set the stage for creative collaboration.*[2] However, the book suggests that you prototype by actually building within the space you have. In this process, the designer builds, sees how people react, thinks about what has been learned, and then repeats the process again. One uses iterative cycles of building, testing, and reflecting to make decisions and then progress. Since we do not have a building yet, our prototyping the space experiment was done in the campus center.

When we ran the experiment, three teams had three members and one team had four. During the experiment, each group had 30-60 minutes to design and create a transportation system for a ball, as shown in Figure 7. The teams had to create a system that could move a ball 10 feet from the start and land inside a plastic container using only the supplies provided. The kit that the teams received included only:

- one ping pong ball
- one package of aluminum foil

2. Scott Doorley and Scott Witthoft, *Make Space: How to Set the Stage for Creative Collaboration*, 2nd (Wiley, 2012).

- three plastic containers
- two cardboard boxes
- two rolls of toilet paper
- four soup cans

The teams were allowed to use only the supplies in the kit. They also were not allowed to use any other resources in the room, including chairs, tables, whiteboards, etc. The only instruction we provided was the end goal. In other words, we did not tell them how to create the system or give them any hints.

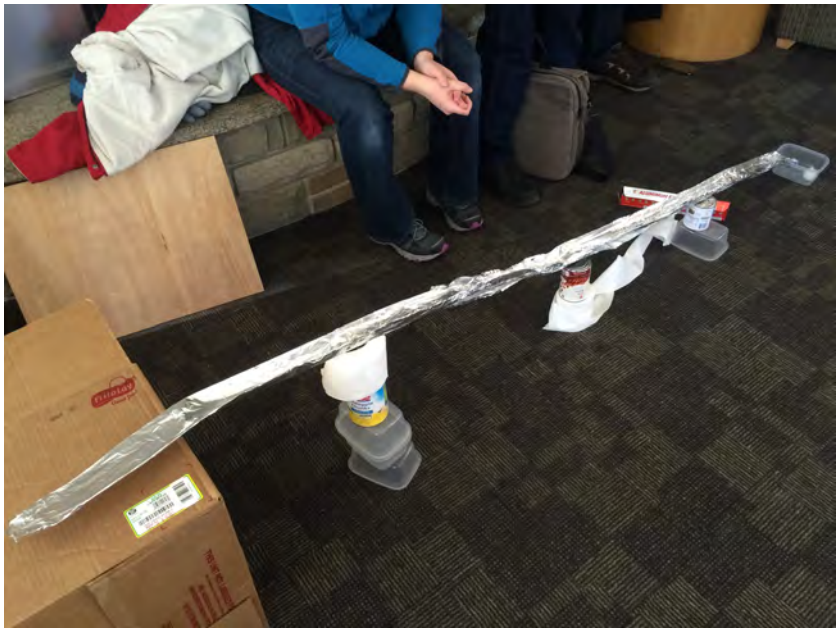

Figure 7: An example of one of the team's Rube Goldberg machines from the prototyping the space exercise.

Our goal was to learn what resources each team felt they lacked while completing the task. As the teams worked, we observed how the team members communicated with each other as well. Once the experiment was complete, we hosted a focus group with the individual teams to discuss how they felt their team worked together as well as what resources should be in the FIS collaboration space. We know that conference rooms, whiteboards, and computers are good resources, but we wanted to see what specific resources the teams were lacking in order to come up with ideas to make the collaboration space better for fostering creative and engaging culture.

Since we did not provide the students with any physical tools in which to organize their thoughts and ideas, it was not a surprise that one of the less successful groups jumped straight into building with very little planning. They rushed through discussions and were unable to keep their ideas straight. The team was inefficient but eventually got the task done. In the discussions that we had with them afterwards, the team admitted they did not really have an

organizational process. The group that created the most reliable and creative configuration took the most amount of time because they spent so much time planning. The results of our experiment suggest that WPI student groups work best when provided an environment that supports the organization of ideas.

3.2 Modular and Unconventional Furniture

The collaboration space should have modular and unconventional furniture to allow a broader variety of project teams to use the collaboration space. With modular furniture, a team of two people can set up a small desk, where a team of ten can move chairs and tables around to meet their needs. Team members need to be able to create and define their group's work space to meet their needs, otherwise the team will be distracted and inefficient. Unconventional furniture will provide a creative place for students to collaborate and socialize, encouraging them to approach problems differently.

WPI Student Needs for Modular and Unconventional Furniture

The main motivation for using modular furniture is to attempt to accommodate a large number of WPI's diverse sizes of project teams. Some project teams have three members, while other teams have 12. One software engineering group that we interviewed explained that they usually meet with the whole group of 12 and then split into smaller groups. They have a difficult time finding a space that allows them all to work both as the whole team and in smaller groups. Modular furniture would allow for an adaptable space to accommodate large project teams such as this. For example, if foam building blocks were accessible in the collaboration space, the software engineering team could build their own room around a table that would fit them all. Figure 8 shows an example of foam blocks from the book *Make Space: How to set the stage for creative collaboration*.[3] In addition to the student groups we interviewed, individual students expressed a desire for movable furniture, particularly mobile whiteboards.

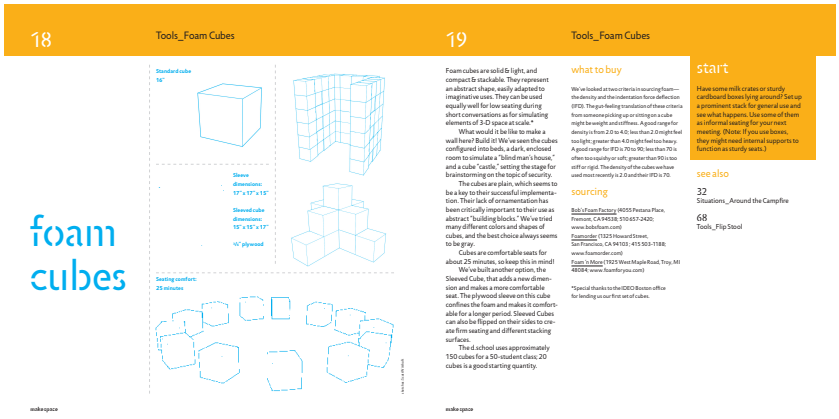

Figure 8: Unconventional furniture: foam cubes.

3. Doorley and Witthoft, *Make Space: How to Set the Stage for Creative Collaboration*.

Ambiance and Orientation

Make Space: How to set the stage for creative collaboration[4] has a section devoted to the ideas of ambiance and orientation. Ambiance is the mood within a space whereas orientation is the actual set up of furniture and tools. Simply being able to change how a room is set up allows for work of many different natures to be done. Therefore, it is important to design the FIS collaboration space with multiple situations in mind. The orientation should be influenced by the event that is taking place within the space at a given time. So if there is a large group discussion taking place, for example, seating should be arranged in a circle. For example, low intensity lighting shifts the mood from active to reflective and opening windows allows for an energizing flow of air. Furthermore, a bit of background noise raises student energy and awareness of surroundings.

Open space inspires innovation. It provides intersections and interactions that keep people inspired and in sync with one another. At the same time however, walls are great for display surfaces. Evidence of work inspires others, and through that inspiration, discovery and synthesis. Walls can also help bind or separate activities depending on their arrangement. They serve as a way to mark changes in mood, tempo or subject matter. This would be advantageous if two very different events were taking place within the collaboration space at the same time, for example, if a local business was giving a presentation in one area of the collaboration space while movable walls (figure 9) would allow for student project teams were to hold a design review in another area.

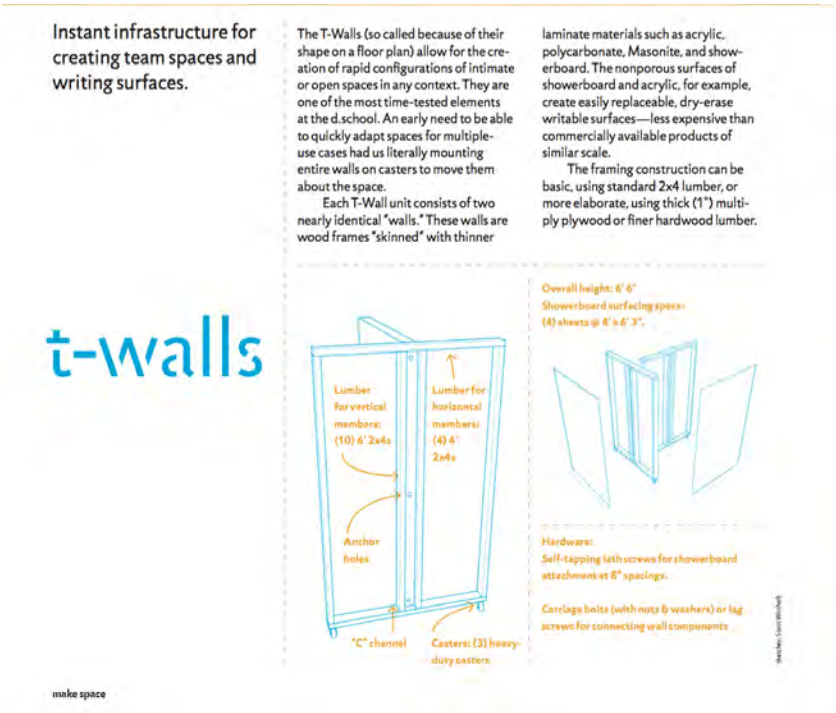

Figure 9: Moveable wall dividers

4. Doorley and Witthoft, *Make Space: How to Set the Stage for Creative Collaboration.*

Examples of Modular and Unconventional Furniture

Many of the schools we visited had some types of modular and/or unconventional furniture. Both Olin and Yale have wooden tables with wheels attached to the bottom of the legs. The wheels can be locked to ensure the tables will not move when they need to remain stationary.

Upon recommendation from Michael Ginzberg, Dean of the Foisie School of Business, we traveled to 1776, a business incubator in Washington, D.C. One of the most interesting elements of 1776 is its unconventional furniture. For example, high walled couches are common throughout the space. The couches provide a comfortable and semi-private place to work. Their members feel a sense of security when working in these "couch-icles", shown below in figure 10.

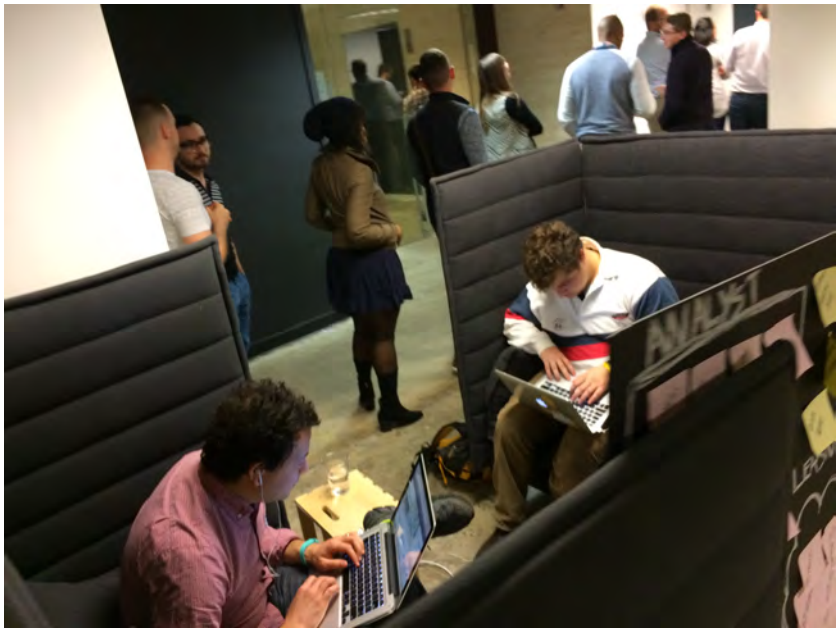

Figure 10: Members of 1776 working in their "couch-icles"

One suggestion from the book[5] is to build mobile project walls as they allow people to create expandable team spaces. A lower shelf can be added to the walls if a project team needs a workbench or storage space. Another piece of furniture the writers mention is the "Periodic Table", as seen in Figure 11. It consists of three parts that can be removed and put back together. There is a square top, box section, and legs with casters that can be stacked. Without the box section inserted, the desk stands at 29 inches tall. With the box section, the desk is 39 inches tall. The dimensions are deliberately designed to help people transition from sitting to standing to encourage movement. The Periodic tables were constructed by OneWorkplace and Stan Heick at HCSI Manufacturing in California.

Another suggestion from the book is the use of bleacher blocks which were conceptualized by Rob Bell at Zomadic, LLC in San Francisco, CA. They are human sized LEGO©blocks that provide the ability to sit, stand, and climb.

5. Doorley and Witthoft, *Make Space: How to Set the Stage for Creative Collaboration.*

Figure 11: Periodic Table

These blocks can be adapted to support highly varied activities. They work well as tables, rooms partitions, storage and shelving units.

The book also suggests the use of storage towers. The towers they describe were constructed by OneWorkplace and Stan Heick at HCSI Manufacturing in California. Storage towers allows for moving storage of personal possessions or communal resources. A localized shelving unit creates an anchor within a space. The storage towers have adjustable shelving, omnidirectional casters, and removable or lockable doors. They stand 36 inches wide by 36 inches deep by 60 inches tall.

3.3 Encouraging Creativity and Collaboration Using Visual and Social Tools

Visible signs of use and activity encourage others to participate in creativity and collaboration. Office Snapshots[6] is a website that focuses on inspiring office design. One article we found particularly interesting was *Tips to Help You Plan and Design for Collaboration*. The article emphasized how the density of people within a space can change the environment drastically. One can use the natural energy created by a large amount of people in a space. In a more crowded

6. Office Snapshots, "Tips to Help You Plan and Design for Collaboration - Office Snapshots," 2012, accessed March 4, 2016, `http://officesnapshots.com/articles/tips-to-help-you-plan-and-design-for-collaboration/`.

space, will see and hear what others are working on and be inspired.

While a high-density of people within a space has its benefits, it is also important to make sure there is some space that is quiet for high stress events where intense focus is required or for a conference call with a professor or fellow student. Within the collaboration space, we recommend that the amount of private space is kept to a minimum in order to maintain the high amount of interaction intended to occur between project groups.

Allowing people the ability to work in different areas and surround themselves with different individuals on a regular basis encourages new conversations and networking. We saw in our prototyping experiment that social interactions and playful behavior inspire people. The most successful teams worked in a relaxed, social space inside the Rubin Campus Center. The team that worked by themselves in a classroom were the slowest team and the least creative in their design.

Similar to the prototyping the space idea presented in the book, *Make Space: How to set the stage for creative collaboration*,[7] it is suggested that different furniture be tested in the collaboration space. The best way to gauge how students will work with the furniture is to give it to them. The furniture in the space can be changed each term for the first year, or even more frequently if required. Students who use the space should be interviewed and/or surveyed after each variation is tested. At the end of the year, there should be another round of interviews and/or surveys in which the students are asked to comment on which setup they liked best, and what aspects they did or did not like in any of the variations.

Tools for Rolling Collaboration Within Groups

Rolling collaboration,[8] a team's ability to continue a single thought process across multiple meetings, encourages dynamic exchanges. In rolling collaboration, visual tools are needed to share and build ideas. This concept was observed in our prototyping the space exercise. A team needs tools to keep track of their ideas and progress.

Smart boards are a high tech solution for recording and keeping ideas. In addition, media displays that teams can plug their laptops into allow them to display their work on a large screen for everyone to see. A less technologically advanced approach would be to create a system in which teams can rent out a white board on wheels for the term. This way a team can use the whiteboard during a meeting, put it away with the notes still on it, and then check it back out again the next time they meet. Ultimately, these visual tools allow teams to save their work between meetings. These tools also allow other students to see ongoing work within the collaboration space.

Social Lounge at Massachusetts Institute of Technology

Massachusetts Institute of Technology's Media Lab is a good example of a co-working space that is connected to a social space, as seen in Figure 12. The

7. Doorley and Witthoft, *Make Space: How to Set the Stage for Creative Collaboration*.
8. Office Snapshots, "Tips to Help You Plan and Design for Collaboration - Office Snapshots."

Media Lab is a a six floor building with approximately 163,000 square feet of space. Our guide told us that different organizations hold events in the lobby, everything from social gatherings to project presentations. There is one main social area with seats, tables, couches, ping pong tables, and media displays where people can congregate. In addition, there is a small kitchenette. Most of these spaces look into labs through glass walls, so people can watch the work that is being done. This social lounge seems to be the central point of the Media Lab that pulls all of the labs together.

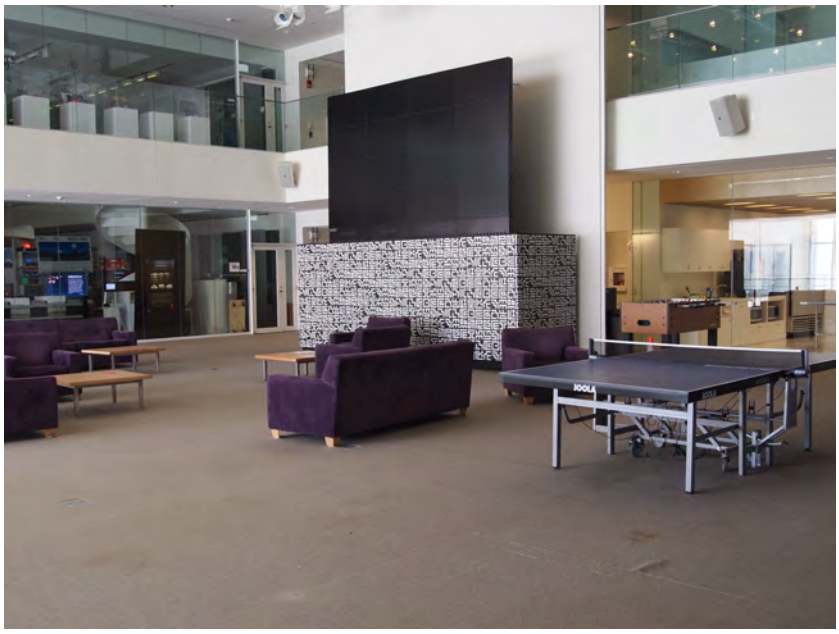

Figure 12: A social space in the MIT Media Lab that has couches, a flat screen TV, game tables, and a kitchen.

3.4 Promoting the Entrepreneurial Mindset

[9][10] Entrepreneurship is usually thought of as starting businesses. The entrepreneurial mindset is an approach to education that focuses on the impact of innovation. Curtis R. Carlson defines innovation as: "Creation and delivery of surprising new knowledge with sustainable value for society." Babson College, a leader in entrepreneurial education, states the following on the curriculum page of their website: "The Entrepreneurship Concentration focuses on the creation of social and economic value by developing core capabilities of idea generation, opportunity recognition, resource acquisition and entrepreneurial management." President Leshin has identified impact as the third tower. Taking theory to practice to impact is what entrepreneurship is all about at WPI.

Rotational Occupancy Office

An office for rotating inhabitants will help foster entrepreneurship in the FIS. These offices should be adjacent to the collaborative work spaces as well as the Global Impact Space. Twice a week, an in-residence entrepreneur or non-government organization (NGO) will be there. Another two days a week, Todd Keiller, the Director of Intellectual Property and Innovation at WPI, will be in the office offering help and information on intellectual property. The last day of the work week, a company will occupy it, whether this be a company looking to partner with WPI, a successful start up, or an innovative venture. Having people readily accessible to answer questions about intellectual property and entrepreneurship will help students elevate the impact of their projects.

Getting the Community Involved

When we visited 1776, Meagan Riley, the Strategic Partnership Manager, emphasized the need to involve the community. She suggested we tap into companies in the area who want to help build the local entrepreneurial ecosystem. In order to accomplish this, we need to look for potential resources unique to our areas of interest and then have people come in to mentor, teach workshops, and give speeches. Producing start-ups requires a laundry list of resources, such as help creating a business plan, a budget, a self discipline plan, tuning your social skills, and gaining physical resources such as money. There are several groups in Worcester that would be extremely helpful in filling the gaps WPI has in order to fulfill the needs of a start-up. Technocopia and Worcester Clean Tech Incubator are two examples of these that would help connect WPI to the city's community. Technocopia is a makerspace that hosts different events in an effort to help get individuals interested in making and inventing. Worcester Clean Tech Incubator is a business incubator that rents out space and resources to start-up companies to help them grow. Working with these two organizations can help with properly planning out the best way to utilize our resources. Having gone through the test

9. Curtis R. Carlson and William W. Wilmot, *Innovation*, First (Crown Publishing, 2006).

10. Babson, "Babson College Entrepreneurship Curriculum," accessed February 8, 2016, `http://www.babson.edu/Academics/divisions/entrepreneurship/curriculum/Pages/home.aspx`.

of time, these two resources know what is required to host events similar to what we are proposing.

3.5 Programming and Calendars

After recognizing that programming in the collaboration space can inspire entrepreneurship among students, we developed three categories of events that will take place in the collaboration space: innovation workshops, a speaker series, and school supported events. The programming of the space is designed to ensure students make the most out of the space and tie together the different areas of the FIS.

Innovation Workshops

The innovation workshops will include improv. workshops and innovation challenges. These workshops allow students to step outside of their comfort zones. Students will practice their presentation skills by working with different WPI improv. that can help them think better on their feet. These will also include events such as Innovation Challenges hosted by Professor Curtis Abel. In these challenges, students and faculty receive a challenge, such as dropping an egg off of a 15 foot balcony without it breaking, or shooting a marshmallow across a room to hit a target. Each challenge is 60 minutes and requires full team focus on the task at hand. These different events will put students in situations that require them to think outside the box.

Speaker Series

The speaker series will be lectures hosted by WPI Alumni, successful business owners, professors, and students. These lectures will be used to inspire, motivate, and answer questions students have about how they can achieve their goals.

School Supported Events

School supported events will include events such as Shark Tank Pitch Competitions and Tech Advisers Network (TAN) meetings. For example, the FIS could host a start-up competition and invite other Worcester colleges to come participate. This will help make the Foisie Innovation Studio the convening place on campus. The Tech Advisers Network can hold their monthly meetings in the collaboration space as well. With 60 members, they would benefit from both the open space and smaller breakout rooms. The active learning classrooms can be used to have the group come together, along with the use of the open concept area and meeting rooms. Since the collaboration space will be much larger than what the TAN has to work with currently, the monthly meetings could be opened up to the general campus and get more exposure. These are just two examples of the many events that could be held to benefit the WPI community.

3.6 Conclusion

The collaboration space in the FIS will be an incredible asset that will help strengthen the connection between students as well as inspire creativity and spark interest in new projects. The following are our four recommendations for the collaboration space:

1. Provide organizational tools for the conception of ideas and the continuation of project work.

2. Opt for modular, moveable and unconventional furniture to make the space flexible and adaptable.

3. Utilize visual tools to modify the mood within the space to encourage creativity and collaboration.

4. Provide a co-working office and host events to promote the entrepreneurial mindset.

All of these recommendations will help transform a large open space for teams to meet into an inspirational and incubation space that all of campus would be able to utilize effectively. Providing organizational tools will help keep students focused and help them have a more streamline way to work. Unconventional furniture creates a space that teams of different sizes could arrange into the best possible fit for them. Visual tools will play a large roll in helping fuel creativity and collaboration. A welcoming space will help create a natural energy that students can feed off of. Lastly, having a co-working office will expose students to new human resources that will help promote an entrepreneurial mindset. All of these recommendations, if properly implemented, will create a functional and inspirational collaboration space in the FIS.

4 Proposals for the Global Impact Space

One of the most unique aspects of WPI's academic project curriculum is its global program: 65% of students complete at least one project at an off-campus location and it is critical for the university to support such a large network. The key difference between programs abroad at WPI and other universities is that students receive academic credit for completing real world projects with direct local impact while being sponsored by organizations like NGOs, governments, or other universities. Since project sponsors are often halfway around the world in different time zones, communication can be extremely difficult. Strong communication is not only important during projects, but also before they start, when teams are preparing for the work ahead. Having reliable communication methods from the beginning can clear up concerns about the project or misunderstandings on either party's end. Mutually beneficial collaboration with sponsors is essential for WPI in the long run since students will be able to develop their projects even further: from ones that simply satisfy major requirements to ones that change the world. The Global Impact Space (GIS) in the FIS will allow students to continue their projects by offering programs to extend their work, work alongside others with similar passions, and to network with professionals. From these ideas, we developed three recommendations for the GIS:

1. Enhance global communications through the implementation of a video conference room.

2. Expose students to past projects through their active presentation and related media.

3. Program events in all FIS spaces that fall under a certain theme for global awareness.

4.1 Enhancing Global Communications

Modern technology can make communication more difficult as it can become over complicated and is often only text based. This is due to the fact that there are no verbal tones or natural facial expressions involved which often leads to miscommunications. These miscommunications can be detrimental to project work, especially at WPI, as the teams are often trying to complete projects in a tight time frame due to the academic terms. An example of this was made evident by a WPI student during an interview about her IQP work. She spoke highly of the IQP at WPI including the statement of: "The IQP is really effective...it's what real life is about." Despite this, she did have difficulties throughout her project experience, especially with clear communications. Looking at this situation from the other side, project miscommunications and such difficulties are a part of real-life projects.

Another major challenge that is often described with global project work has had to do with being able to communicate with sponsors. Students have described issues such as, "time zones come into play - even basic communication becomes harder with all of your project sponsors" or as one student put it: "we

would usually meet in the campus center, in the library or in empty classrooms. It didn't feel right." In order for global project work to continue to grow at WPI, resources need to be provided so that students aren't "in SL104 at 3AM practicing our presentation" because it was the only free space and time they could find. The students of WPI deserve to have a place to feel like they can expertly communicate with their sponsors. This will enable said students to represent the university in a professional setting. The issue of space and professionalism will be solved by a networked conference room available in the FIS. This room will be able to fit approximately 25 people, as this is likely the maximum size needed for a few IQP teams going to the same site to meet with their advisers. Along with the long conference table and rolling chairs, there will be a large screen situated at the front of the room that will allow everybody to see the caller on the other end. Spaced evenly throughout the room will be microphone systems so that everybody can be heard clearly.

In order to keep issues like the previous ones from arising in the future, the FIS will be equipped with videoconferencing technology that will be accessible to all WPI students 24/7 in order for them to communicate with a variety of stakeholders. By having virtual meetings on a regular basis, project sponsors will be able to effectively communicate objectives to the teams allowing projects to flow more seamlessly. With this implementation, students will not need to be as worried about finding a space on campus in which to communicate with sponsors during off hours.

Global projects also add the challenge of working cross culturally. As a student put it, "[it can be] interesting to be in a space and work with people who have not worked with someone of your culture...some people on my IQP, be it sponsors or whoever, have not worked with people outside of their culture, their age or their experiences/community...there will be language and cultural barriers, obviously." By having a GIS in the FIS, students will have further access to resources outside of the sessions with their advisers prior to starting IQP that will help them understand diversity and the culture they are entering. This access doesn't have to just be from an academic sense, however. WPI is the home to over 1,000 international students from 70 countries. Many of these students are extremely proud of their cultures and are already sharing it on college through dozens of cultural organizations. The GIS will be the home to not only global project work, but to cultural programs as well.

Ultimately, the WPI students put it into words the best: "A central place for all of this work would be great...[WPI needs to provide] the resources to keep up with project work. The can provide the space and they should."

4.2 Cataloging Project Work

The WPI Plan created several projects required by students for graduation. After their completion, however, the reports are put away in the library and mostly never looked at again. One of the goals of the FIS would be to expose these reports to interested students and make them more accessible. When introduced in 1970, the WPI Plan added IQP, MQP, the Social Science requirement, and the Humanities and Arts Practicum. The IQP is typically completed

during the junior year. IQPs often do not relate to the student's major but must have a connection to both STEM and humanities or social science. IQP teams are unique because they are almost always comprised of students from different educational backgrounds. MQPs, on the other hand, are a capstone to student's major and are often completed in teams where members share a common area of study. Since WPI believes in the value of having well-rounded students, a third project is required. The third project, commonly known as the inquiry seminar, is done within the humanities and arts department. By completing this project outside of STEM related fields, WPI students are able to obtain a better understanding of the world at large.The humanities requirements at WPI can be fulfilled in a variety of subjects decided upon by the students themselves. Within the six course requirement, students study multiple subjects, some in a deep capacity, known as the depth, and one or two others in a different subject, known as the breadth requirement.

All three of the required WPI projects can be completed on campus or at global locations. Approximately 65% of WPI students complete at least one of their three projects at an off-campus location and approximately 50% of all the WPI students complete one overseas. With a few minor exceptions, the majority of the WPI Plan[11] was to not only require, but also to encourage project work. The implementation of said project work in the classrooms was expanded in 2007 with the introduction of the Great Problem Seminars (GPS). The deliverables across all of these requirements are often similar. For example, the projects give final presentations through a variety of mediums, one of which is a poster presentation. There are established days in which students present their posters to the public, while judges evaluate them.

Since these three projects are completed by all WPI students, there is a plethora of research and information obtained, analyzed, and presented each year. After the final report or project is due, it is sent to the library where it is put into archives for WPI community members or people throughout the world to access. Although these projects are accessed over one million times annually, very few of those people are WPI project teams continuing a previous project or scoping out projects that are of similar nature to theirs. Much of this is due to the fact that the information from the project is simply compiled into a scholarly writing which is often times over 100 pages in length. In order for students to be able to quickly access information that is relevant to them, a new system will be built and integrated for the FIS. This system will further parse project work by a multitude of categories and subjects so that it is more easily search-able and user-friendly. By creating this system, students who may not have knowledge of previous projects, can still find projects that are of interest to them and will inspire them.

Although the database described above would be more convenient for student use, it is also important to make the higher-level information readily accessible to the public. In order to inspire current projects through past research, media will be developed which showcases the impact of projects in an easily con-

11. Worcester Polytechnic Institute, "WPI: The WPI Plan," 1970, accessed March 4, 2016, `https://www.wpi.edu/academics/catalogs/ugrad/wpiplan.html`.

sumable manner. The Global Impact Space will feature space for media display screens to be implemented so that sideshows of images and videos can be constantly shown. Not only will these displays be engaging, they will give the viewers information on how to further access student work. By doing so, projects will not just disappear from future students in the archives, but instead, they can continue to live on which is essential to continuing project work at WPI.

Featuring project work is not only helpful to research, but will also allow the opportunity for students of similar interests and passions to contact one another. When WPI students were asked what they thought about the concept of displaying project work in an open manner, they were thrilled at the prospect, and many stated that they may have had an initial interest in certain subjects sooner in their WPI experience had they seen the opportunities that are out there. As one student put it: "You could meet all of the [past] teams and learn about the country's culture [ahead of time]. Setting up an archive would be cool in the FIS - having a physical copy of the IQPs from several years back as a resource would be nice."

It is very important that students have the resources to electronically capture their project work. In order to successfully tell the story of a project, media would need to be collected before and during the project process. The equipment to record the media will be a further extension of WPI's ATC service where students can check out technology and take it abroad with them. Upon return, students would have the opportunity to enroll in a course that would aid them in creating visual content that fully displays the impact of their project work.

In order to make this happen, the FIS will have a devoted space, equipment, and software for photo and video editing. Some examples of the included software may be Final Cut, Adobe Illustrator, and PhotoShop. The concept of students continuing project work when they return to campus is not new with the FIS. There have been discussions for many years of giving students the option to earn academic credit when they return. These discussions have taken place because many students over the years have expressed interest in continuing their projects since they became sincerely passionate about their work. By allowing students to continue their project work, WPI will not only be encouraging them to follow their passion and to learn more, but they will also be allowing a generation of mentors to be created. It is possible for upperclassmen to help their younger peers as they prepare for their projects as well. It is the sense of peer mentorship that has helped build the WPI community into the support network that it is today, and it will help build the sense of the community in the FIS in the future as well.

4.3 Thematic Programming

The FIS will not be a building that contains separate groups, passions, and spaces. It is instead the physical incarnation of WPI's two towers: theory and practice. As previously discussed, project work is essential to the WPI curriculum and to students as well. Students will use the FIS for a wide variety of academic and personal projects that will require the use of multiple facets of the building. Therefore, it is important to see the different spaces of the studio as steps in the

project process that students will use throughout time. In order to further tie the different subsections together, the concept of thematic programming was conceived. In this instance, thematic programming is the idea that all programming within the studio can be interrelated by a set of themes.

We extracted common themes from 25 years of IQPs and MQPs. In efforts to find areas of interest to WPI students, the project titles were compiled and broken down by word frequency. Figure 13 displays the most frequently used words in the titles of WPI student projects. What we found was that common project themes linked to GPS Projects, as seen in the list presented below. As a result, we decided that the themes associated with the studio would be of similar nature.

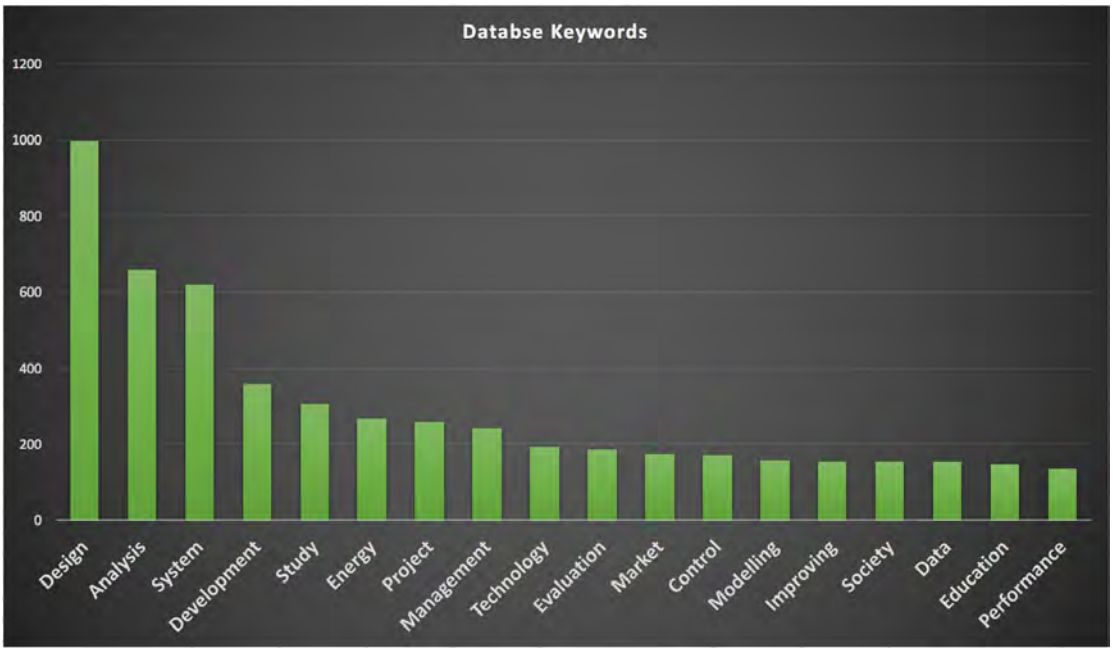

Figure 13: Project database keywords

- Heal the World
- The World's Water
- Biosphere, Atmosphere, and Human Fears
- Livable Cities
- Ignorance is Not Bliss
- Recycle the World
- Culture, Technology, and Human Rights (new for 2015-16)
- Food Sustainability
- Power the World

By doing so, if a specific theme interests a student, they will be able to take part in social events, networking, fora, and workshops that relate to that specified theme.

Specific programming is outside of the scope of this project, however, a sample environmental sustainability theme was created for mock up purposes. It is also important to know, that not all programming developed for the FIS directly relates to the theme that is taking place that semester. This is to accommodate the fact that not all students will be interested in the same concepts and programming should be provided to all of those involved in the community. In the sample booklet that can be found in Appendix A1, the programming options directly related to the theme have small leaf symbols next to them, denoting that they are directly relevant.

The following sections of social events, project networking, fora, and interactive workshops apply to all of the potential themes and it is only the specific programs listed in the sections that vary by topic.

Social Events

Social Events would be informal events during which students can socialize with not only one another, but with attending faculty as well. This may be a type of informal networking.

Project Networking

With the thematic programming in the FIS, students will be able to showcase their projects over numerous years, dependent on the themes. This allows for more cross collaboration of projects in certain categories, allowing students with similar interests to become better networked. Not only do these types of events allow students who have already completed project work the opportunity to continue it in the future, but they can also inspire their younger peers. This peer-to-peer inspiration through presentations can also be evident in project work that isn't required for degree requirements. For example, there are a plethora of robotics engineering students that build robots for personal use. Projects are not all technical, however. For example, there are numerous WPI students that are adopting the entrepreneurial spirit by applying for patents and by starting companies. Having presentations in the FIS would allow students to showcase many different types of work and further allow them to network, communicate and collaborate.

Fora

Fora can be seen as large question and answer sessions between students from different project teams, WPI faculty members, as well as professionals from their fields of expertise. Through these events, students will be able to receive specialized advice from various sources with the main goal of improving their projects and gaining real world experience at the same time.

Interactive Workshops

Faculty, as well as professionals in the field (mainly linking to the semester's theme), may come in and give advice to students. Instead of simple lectures, interactive workshops will have a larger hands-on role in the way the information is presented. This way, students will be able to see, first hand, how something works.

Introducing students to overarching themes early is essential for WPI as they roll out strategic planning related to "major with a mission". Major with a mission is WPI's way of describing students as they cannot be individually defined by their gender, race, activities, area of study or whatever other three letter acronym you can think of. There is much more to the WPI student than just a major. By encouraging students to think about what their mission in life is, they are challenged to think of interests and passions outside of their direct area of study that could influence them, their project work, and most importantly, their futures.

5 The Life of the FIS

Overall, our research and proposals for the FIS have spanned areas such as design, tools, management, and events. All proposals thus far have been specific to certain areas of the building. While each of the three spaces have separate goals, functions, and challenges, there are four recommendations that apply to the building as a whole:

1. All students should have 24 hour access to the FIS.
2. Create an open atmosphere through few walls, glass and mobile dividers.
3. Provide a kitchenette for 24 hour food access and to stimulate social interactions.
4. Promote the FIS as a social hub on campus through programmed events.

Each of these recommendations will be discussed in the following sections

5.1 Give students 24/7 access to the FIS

Students are interested in having the FIS open 24 hours a day. Some students frequently work until 3:00 AM, while others begin their days at 6:00 AM. Nearly all of the shops on campus have hours of 8:00 AM or 9:00 AM to 5:00 PM or 6:00 PM. The library is open until 1:00 AM on weekdays with restricted hours on the weekends. If a group of students wants to meet to work on a project early on a Sunday morning, they have to wait until the library opens at 11:00 AM. It is challenging for students to find a common time to work because of Varying class schedules, sports, and extracurricular activities. Ensuring the FIS is open at all times will accommodate the work habits and schedules of students and encourage them to use the space.

Allowing students to have access to the building at all times instills a feeling of ownership and respect for the space. The strong sense of community here at WPI invokes a sense of civic duty to respect each other and the spaces we all use. We witnessed these two factors on our visit to Yale. The CEID is accessible to students 24/7, whether or not there is a staff member in the building. The members are expected to keep things in order and handle the equipment with care. If there is any issue, their access will be taken away, but this is a very rare occurrence. Dean Wilczynski asserted that this system is successful due to the strong sense of community present at the CEID. In the robotics labs at WPI, there are rarely issues of robots being tampered with, equipment being stolen or misused, or the lab being left a mess. The robotics students understand the space is for everyone to use and everyone must respect each other and the lab itself.

If the administration does not feel comfortable with 24 hour access to the building, then we suggest adopting a student building manager model similar to the one utilized in the Rubin Campus Center. The building managers would work late hours in the night to monitor activity in the building. We suggest hiring students for this position as well as the fact that students are more likely to be willing to work at night.

5.2 Create an open atmosphere

One of our main hopes for the FIS is that students will come to work in the building and be inspired by each other. Through all of our interviews and visits we learned that the main way people become inspired is through seeing what other students are working on. Therefore, it is critical that the FIS has an open atmosphere with good visibility to promote the sharing of ideas.

Each school took different approaches to creating openness in their space. At Yale, the glass windows dividing the machine shops from the main area, and the ability to look down into the makerspace from above encouraged people to stop and observe the work going on. The Media Lab at MIT has a large open atrium at its center. All of the lab spaces are divided by tech glass to create visibility throughout the building. M5 at UMass was built in an existing building, so they were not able to pick where the walls were. Despite having 14 different rooms, the doors were all open helping to create an open atmosphere. At Artisan's Asylum, all of the private work spaces are separated by half walls to maintain visibility throughout the space. They also used thick plastic curtains to separate various wood and metal shops which kept the space visible but also safe.

In the FIS we envision achieving the open atmosphere in a few different ways. The first is by having very few walls. The building will likely be loud as there will be few barriers to damp the noise. However, the FIS is supposed to be very lively and energetic. We have been thinking of the FIS as the complement to the library. If students want a quieter place to study they will go to the library. If they do not mind the extra noise, they can work in the FIS. Everyones needs are still catered to somewhere on campus. When barriers are needed, we suggest using glass walls as these provide a certain level of division, without decreasing visibility.

There will be times when students want to adjust the amount of privacy they have while working in the FIS. To maintain the open atmosphere, we recommend using mobile dividers. These dividers could be as simple as whiteboards on wheels so that students can create cubicles for themselves. One WPI student we interviewed suggested using table-top dividers to separate work space on the tables in the makerspace. The walls of the active learning classrooms should have removable dividers, such as the ones found in the dance studios in the recreation center. The removable wall dividers allow the classrooms to be separate during the day, but open at night providing more flexibility for students.

We assume students will be constantly moving in this building. A group of students could be working in a collaborative work space when they realize they need to go quickly prototype something in the makerspace, and then decide they need to move to a space with whiteboards. Within the time frame of just one meeting a groups needs could change. Having few walls enables students to move around the building with ease and allows them to quickly find open work areas.

5.3 Incorporate a kitchenette into the FIS

Kitchens are social spaces that help promote a sense of community. After visiting UMASS Amhersts M5 and Artisan Asylum, we saw that snack

shops and kitchenettes helped bring a social aspect that connected people without distracting them from their work. One benefit of having a kitchenette as opposed to a full cafe is that it would provide students with 24 hour access to food. As stated before, they key is to allow students to use the space in a way that fits their schedules and preferences. The Studio could have a stocked refrigerator, and the users of the space would be asked to make small donations. This approach is already used on campus in the IEEE lounge and has seen much success. We can also have the students bring their own food and store it in the refrigerator. Both of these options would require a large refrigerator, microwave, sink, cupboard, coffee maker, and plastic cutlery. In essence, food is important to the social life of the space, and a kitchenette or pantry would be a flexible and effective implementation.

Both of these approaches give the students a feeling of ownership for the space. This is important because it encourages students to help keep the pantry clean. It is important to give students responsibility for the space. Providing nearby tables will help bring out the FIS as a social environment.

We suggest that the cafe is run by someone other than Chartwells to offer a variety of food on campus and to help bring more individuals into the space. We recommend asking local businesses such as the Bean Counter or Nu Cafe to open another location in the FIS. Students love both of these eateries and the variety of food they can offer would encourage faculty and students to eat in the FIS cafe.

5.4 Promote the FIS as a social hub on campus

The FIS will be located in the middle of campus. As a result, it should not only be an area where students will work on their projects, but also serve as a social hub. People who are not working on any project should still be allowed to stop by the space and socialize with the students bringing their projects to life. This interaction creates a two way social street - the workers will be able to show off their projects and socialize, and the visitors may be inspired by the activity in the space.

The ability to participate in the space without actively working on a project is key to the success of the building. If the FIS becomes a social hub on campus, similar to the campus center, then more people will come to it and engage in new projects. One makerspace founder we interviewed explained that the FIS is first and foremost about the people. Every school we visited incorporated some casual lounge space adjacent to the workshops and collaborative work areas.

The Rubin Campus Center naturally became a social hub on campus because the building was intended to be the center of student life. To promote the FIS as both an academic and social space, the building needs extensive programming. In chapters 2, 3, and 4 we discussed programming for each individual space, and thematic programming for the building as a whole. While each distinct space will conduct different events, all of the spaces will support some events focusing more on socializing than on any technical subject. For example in the makerspace, alongside Hackathons, Maker Faires and networking events, social events like "Little Bites and Legos" during finals week can help bring the WPI community together in the new building. The same concept applies to the collab-

oration space as well. The improv workshops aim to promote innovative thinking among students, but will also be a fun way for students to get to know each other. Thematic programming organized by the Global Impact Space will incorporate social events, such as a Kick Off Party for the opening of the building. The social events in all areas of the building, will bring students and faculty into the FIS promoting a social atmosphere.

In order for these events to be successful, flexibility is critical. This includes tables on wheels, movable dividers, and collapsible walls. For example, at the Kick Off Party, a completely open layout would be ideal to accommodate all of the people in attendance and so that everyone can see what is going on in all parts of the building. On the other hand, the improv workshops would require a closed off space, such as one of the classrooms, as to not disturb the activity going on in the rest of the building. The workshops would also need all the tables pushed to the perimeter to provide room for movement.

The example of the improv workshops brings up a key aspect about programming: the space must still be usable. If there is an event happening in only one area of the building, students working in other parts should not be disrupted by the event. This was an issue we witnessed at the CEID at Yale. There is no wall separating the classroom from the rest of the makerspace. Therefore, if there is a class going on students in the makerspace must talk quietly and cannot use power tools. In all of the designs for the FIS that we have seen, there is an amphitheater on one side of the diagonal corridor and a large screen for presenting on the other side, known as "The Hive." While it is an interesting idea to have presentation space for events in the heart of the building and open to all of the spaces, this may be a problem since it is a major pathway through the building.

5.5 Conclusion

Despite the specializations of the individual spaces in the FIS, the Studio as a whole will promote project work on campus. Collaboration in the FIS will be promoted through the following actions: provide students with 24 hour access to the FIS, create an open atmosphere through mobile dividers and glass walls, provide food in a kitchenette, host social programs that connect and use all spaces in the studio. The building will require staffing, including a building manager and student workers, to support all of these recommendations.

6 Additional Products

Throughout this IQP, we have developed deliverable materials, including an inventory Wiki, Visit Annotations, Makerspace Calendar, Maker Archetypes, and Thematic Programming Pamphlet. These materials, found in the Appendices, should serve as reference for the administration and architects as they move forward with the design. These additional products are a means for the student voice to be heard as the process continues. A brief description of each and their purpose is found in the following sections.

Inventory Wiki

All of the information about capabilities, training, and access obtained from our inventory of the shops here at WPI was transferred to a wiki style website. The purpose of the wiki is to show how all shop information should be available online to all students. Having the information publicly available will help remedy the lack of communication currently present and inform students where to go to perform necessary tasks for their projects. The current version of the wiki is not a final solution, but rather an example of how the information should be conveyed. We chose a wiki because it is editable, so shop managers and students can contribute and keep the information up to date. A more robust online source should be developed and shared with the students of WPI. The final output of the inventory is available at `http://fis.wpi.edu`. The wiki enables the architects and administration to see what machinery WPI already has on campus in order to avoid duplicating too many capabilities in the new makerspace.

Visit Annotations

During each visit we took many pictures and considered how some of the key aspects of their design would work at WPI. The pictures were used to create annotated PowerPoint slides highlighting both successful and unsuccessful elements of each space. These PowerPoints can be found in Appendix A4.The Visit annotations are relevant to all three of the spaces in the FIS. For instance, many of these annotations show that the building needs to balance open work space and quiet work space. The PowerPoints will serve as a reference sheet to remember what we as students liked about the different spaces we visited.

Makerspace Calendar

The detailed month calendar, which can be found in appendix A2 displays the amount of activity and training suitable for the makerspace. We relied heavily on Yale's calendar to get a sense of how much activity is appropriate so that the makerspace is usable, but not completely empty during the day. The calendar is color coordinated based on the type of activity. Brief descriptions of each of the activities accompanies the calendar. For the architects the calendar shows what kind of events will take place, which may affect the layout of the space. The calendar also provides the administration and idea of the usage of the space during the day, and illustrates just how important this space will be.

Collaboration Space Calendar

The year-long calendar for the collaboration space, which can be found in appendix A2 displays the frequency of the different types of events throughout the year. The calendar is color coordinated based on the type of activity. Detailed descriptions of the types of events listed on the calendar are found in Chapter 3.5. Similar to the makerspace calendar, the collaboration space calendar highlights the types of events and frequency of events for the architects and administration. The calendar emphasizes how lively the collaboration space will be throughout the year.

Maker Archetypes

We conducted several interviews with students specifically about the makerspace. The main goal of the interviews was to determine how students work and what kind of projects people are doing on campus. During the interviews we asked a few direct questions about what they would like to see in the Foisie Innovation Studio, but we mostly focused on how these students operate. We wanted to learn how students work, where they work, and what they believe can be done to promote the maker culture at WPI. For instance, we asked questions such as "Where do you get ideas for projects, and what is your first step?". As we learned from our interview with David Privitera of IDEO Boston, this information is more valuable to the architects than just suggestions about what should be in the makerspace.

Following all of the interviews, we analyzed the notes and developed six maker archetypes. The archetypes summarize commonalities between the students and give an idea of the different types of makers on campus. A deliverable containing brief descriptions of the archetypes and pictures was created for the architects. This document is a reference for them to remember key points about how students work on campus.

Thematic Programming Pamphlet

As a part of the Thematic Programming concept introduced as a feature of the GIS, We developed a booklet outlining the sample theme, Environmental Sustainability, for the Fall of 2018. The events are organized based on the four categories of events. Next to some of the events is a small green leaf indicating that particular event relates to the semester long theme. The end of the booklet contains the theme for the next semester as well as major events to look forward to. The booklet provides some examples of events to encourage the students to use the space. The architects will find it helpful since they will better understand the type of programming the FIS needs to accommodate. The administration will understand how WPI students hope the space will be utilized. To see this booklet, please refer to Appendix A1.

7 Outreach and Communications

During our project, the team communicated our findings in a multitude of venues: meetings with President Laurie Leshin, a faculty meeting, Foisie Dean's Council Strategic Meeting, meetings with the Architects and Facilities, the Trustees' meeting in Florida, and to the University Advancement Office. Through each presentation we saw how we were making a lasting impression and shifting the mindsets of other project stakeholders.

7.1 Communications with President Leshin

First and foremost, this IQP would not be in existence if it were not for President Laurie Leshin's unwavering support. In June of 2015, President Leshin was approached with the concept of this IQP by a team member. It was from there that our advisor, Diran Apelian, was introduced as he was the lead of the makerspace initiative for the FIS. From there, the team was assembled and Dean Arthur Heinricher was brought on as the co-advisor. Although President Leshin did not directly oversee the team throughout this process, we met with her individually to keep her updated on our progress. Our individual meeting with President Leshin took place in B-Term of 2015. At the meeting, the team presented her with a booklet of initial concepts and ideas that showed the scope of the IQP as a whole. She was very pleased with our initial research and decisions and supported us to continue our research. Ultimately, our project would not have come into existence or grown to the magnitude of consideration that it has without her backing and support. Our team is very grateful for all that she has done.

7.2 Faculty Meeting

At the faculty meeting, we discussed our preliminary ideas for how each space should function, and how it will serve the WPI community. Dean Michael Ginzberg and Professor Kristin Boudreau first introduced their ideas about the entrepreneurial and global aspects of the building, respectively. When Diran Apelian was asked to speak about the makerspace, he introduced our team to give a brief presentation about our preliminary ideas for the building. Our greatest take-away from this meeting was that most of the faculty had no clue what the FIS is about, or what needs it should fulfill. The impact of this presentation was that the faculty were made aware that students are interested in the FIS, and that the discussion of this building involves everyone.

7.3 Foisie Dean's Council Strategic Meeting

Furthermore, we spoke at Foisie Dean's Council Strategic Meeting in which several Trustees such as Andrew Aberdale, James Baum, Michael Aspinwall, and Henry Fitzgerald attended. This presentation also focused on the function and life of the three spaces. The questions which followed from the committee members focused heavily on the social life of the space, rather than details like

which tools would the makerspace have. The Trustees were extremely impressed by our work. They cared about what we had to say and were enthusiastic about our passion for the project. One of the trustees immediately emailed Diran Apelian, the project advisor, attesting to the level of excellence we showcased at the council meeting. The Trustees' overwhelming excitement about our project was a major contributing factor in convincing the administration to let us present in Florida at the Trustees' meeting.

7.4 Meeting with Architects and Facilities

We have met with the architects, Fred DiMauro, Jeff Solomon, and Jim Bedard a few times through out the course of the project. The goal of these meetings was to share our proposals for the makerspace, collaborative space, and global impact lab. We wanted to see how closely our ideas aligned to the plan the architects had drawn, and to discuss how to bring the two even closer. We saw that some of our important ideas were captured in the architect's designs. However, there was still room for improvement. Our major concern with the designs they showed us in this meeting was that they had very little space dedicated to purely collaborative work. There was also no stock store and a cafe instead of a kitchenette. Moreover, the high quality of our presentation further encouraged the administration to invite us to the Trustees' meeting in Florida to present our work.

7.5 Trustees' Meeting in Florida

At the Trustees' meeting in Florida, we presented our final proposals for the three spaces of the building. We provided insight about how the building would best serve the students and what functions it needs to support. Since we presented before the architects revealed their plans for the building, everyone present looked at the plans critically to ensure what the architects proposed aligned with our recommendations. It was very evident that the architects, Trustees, faculty, and administration truly cared about our suggestions and recommendations for the FIS. During the architects' presentation we learned that they incorporated some of our suggestions from our last meeting. There is more space dedicated to a collaboration area and they added a student pantry. They even spoke about using the vinyl curtains from Artisan's Asylum that we suggested to them to potentially divide some areas in the makerspace. While they are still missing some of our proposed ideas, they are moving in the right direction and really listening to what we have to say. Furthermore, during discussions following the architects' presentations, President Leshin and the Trustees referenced our work to support their claims. We were also able to share our opinions about the FIS with the Trustees over lunch ensuring our voice was being heard. The presentation at the Trustees' retreat was an overwhelming success.

7.6 University Advancement Meeting

Following our presentation in Florida, we were asked by William J. McAvoy, Vice President of University Advancement, to present at the University Advancement's quarterly meeting. The presentation was filmed to be sent to Robert Foisie and to Professor Gaudette to use to apply for grants. We delivered the same presentation as in Florida and received the same reaction: a standing ovation. The audience asked some interesting questions that we had never been asked before. They really focused on how the students are reacting to the change on campus. They wanted to know if they were excited even though they will never use the building. One woman asked, "If we could tell the donors one thing what would it be?" We took this as an opportunity to push for the full basement. The current designs only have half of a basement for mechanical systems. We encouraged the Division to seek funds to support a full basement because WPI will inevitably become pressed for space in the future. The basement will provide flexibility and room to grow as WPI project needs change.

8 Conclusion

The WPI Plan put an emphasis on project-based learning. Despite the strong emphasis on project work, there is no dedicated space on campus to support group work. Currently, resources needed to bring a project from a concept to completion are inadequate. These resources include labs, shops, tech suites, and other meeting spaces that are either inaccessible or overbooked. The FIS will help remedy these issues through the unification of project work in one place on campus. Students should play a significant role in the operation and management of the space to promote a welcoming environment.

The Studio will include three spaces: the makerspace, collaboration space, and global impact space. In one location, project work, an entrepreneurial mindset and global insight will be fostered on campus. Our team looked at schools like Yale, MIT and Olin School of Engineering with already established innovation studios. Through their expertise and a lot of student input, the team came up with a number of recommendations for each of the spaces. For the makerspace:

1. Serve as the central hub with the existing shops on campus as its satellites.
2. Hire a passionate and approachable manager supported by involved student volunteers.
3. Conduct extensive training sessions to ensure the safety of the students.
4. Have a store for buying materials and components.
5. Provide storage for extended project work.
6. Support a variety of events that promote the maker culture.
7. Design a flexible makerspace that can adapt to the needs of future projects and students.

For the collaboration space:

1. Provide organizational tools for the conception of ideas and the continuation of project work.
2. Opt for modular and unconventional furniture to make the space flexible and adaptable.
3. Utilize visual tools and modify the mood within the space to encourage creativity and collaboration.
4. Provide a co-working office and host events to promote the entrepreneurial mindset.

For the global impact space:

1. Enhance global communications through the implementation of a video conference room.

2. Expose students to past projects through their active presentation and related media.

3. Program events in all FIS spaces that fall under a certain theme for global awareness.

All of these recommendations are designed to bring students into the FIS and support their work while there. This space will provide a safe environment to explore disruptive ideas.

9 Recommendations for Future Work

This IQP has done a lot of work to identify the function and programming of the FIS, and make many recommendations as to how it should be designed and used. However, there is a great deal more that can be done. Throughout our IQP, we came across a questions that we simply didn't have time or the resources to answer. These questions may serve as a starting point to future IQPs.

Three questions still remain for the makerspace. The first question is: How could a student organization help run the makerspace? For example, the officers of the CollabLab could be involved in the management of the makerspace. The second question is: How should the training and certification sessions be managed? Finally, the third question is: How do lab monitors know who is certified to use each machine.

The main goal of the collaboration space is to support project work at WPI. The collaboration space should accommodate projects of all sizes, with the ability to change configuration according to a project team's needs. We collected some information about furniture for the collaboration space. However, the question still remains: What is the best furniture to support flexible project work? Another interesting question is: What happens when the collaboration space becomes too crowded? This concern stems from our experiments, which indicated that when the space becomes crowded the quality of work might decrease.

Finally, there are several aspects of the building that were largely unexplored by this IQP, but which may be interesting subjects for future work. Most importantly: By whom and how should the space be managed? How will the residence hall above interact with the Innovation Studio? How should the student pantry and cafe be stocked and managed? How will "The Hive" support programming in the building? Lastly, who should be in the offices on the second floor of the building to best serve the students?

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A1 Presentations

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Fall Semester
2018

FOISIE
INNOVATION
STUDIO

ENVIRONMENTAL SUSTAINABILITY

“Our theme for this semester is environmental sustainability. From the water that covers over 70% of our planet to the air we breathe - we are surrounded by an environment that we are destroying every day. Ever since the industrial revolution we have left a huge footprint on the planet. With this increase, we must find new ways to sustain our environment and ensure favorable conditions for many generations to come."

- Arthur Heinricher, Dean of Undegraduate Studies

“From all of us here at the FIS, we hope that this theme will stimulate your interest in the matter and you will create something wonderful throughout the semester. Just like you don't walk into a restaurant to eat - you go there for drama, for excitement, you don't enter the FIS just to satisfy a project requirement. You come here to inspire, invent and innovate."

- Diran Apelian, MPI

Improv

Aug 30th

Working with one of the WPI Improv to improve presentation skills.

Elevator Pitch Competition

Sep 9th

This Elevator Pitch contest is to see who can come up with the best 60-second elevator pitch that is randomly assigned to you.

Curtis Innovation Challenge

Oct 10th

This challenge, hosted by Curtis Abel, is a hour long challenge to try to create a container to house an egg that will be dropped from a height of 30 ft. Work with your team to try to save the egg!

IDEO Method Card Game

Nov 17th

A thrilling night of fun and innovation. Sit down with some friends and play the IDEO Method Card Game!

Project Portfolio Workshop

Dec 11th

Have projects you want to showcase to employers? Come learn how to create effective digital portfolios.

Interactive Workshops

Makerspace NSO

Aug 28th Come learn about the capabilities of the Makerspace, and how to get certified on the equipment. Ask questions, share project ideas, and get to know some of the lab monitors.

Tech Advisory Network

Sep 4th The Tech Advisors Network turns research and ideas into an entrepreneur's dream. A group of more than 60 entrepreneurs, investors, and business leaders advise students, faculty, and alumni who hope to turn ideas and research into commercial ventures.

Project Presentations

Oct 15th Students present their IQP, MQP, and GPS projects for the whole school to see, come check out the awesome work your classmates have been doing!

Shark Tank

Oct 20th Give your best pitch to our panel of judges, aiming for the prize as the newest WPI endorsed company!

WPI Test Kitchen

Nov 29st Check out what's cooking in the WPI test kitchen!

Undergraduate Research Presentations

Dec 14th Students present their IQP, MQP, and GPS projects for the whole school to see, come check out the awesome work your classmates have been doing!

Project Networking

WPI Innovator of the Year

Sep 8th — 2015 WPI Innovator of the Year Jeremy Hitchcock gives his take on innovation at WPI and inspires you to reach your true potential!

Martin Burt

Sep 9th — Martin Burt will be giving his talk on environmental engineering in a non-environmental age.

Local Business Owners

Sep 31st — Local success story Wachusett Brewery has two WPI Alums come back and talk about their path to success!

Club and Greek Life Presidents

Oct 9th — Several Club and Greek Life Presidents sit down for a discussion about balancing schoolwork and Extracurriculars.

Diran Apelian

Oct 17th — Materials Department Head Diran Apelian talks about how to make the most of your life, let this inspiring man takes you down the path of success!

Successful Undergraduates

Nov 7th — WPI has a lot of very successful students, come listen to several WPI Student Business Owners about how they reach for success!

Fora

Kick Off Party

Sep 8th — Celebrate the addition of the newest building on campus! Dinner will be provided, and dress casually. Come with friends and see what the makerspace is all about.

Toy Design Competition

Sep 9th — Have a knack for designing? Love playing with toys? Come down to our Toy Design Competition hosted by The Foisie Innovation Studio.

MASSdestruction

Sep 31st — Artisan's Asylum is proud to partner with WPI for our MASSdestruction event. Enter a robot for the 1 or 3 pound weight classes.

Cardboard Construct-a-thon

Nov 9th — Several Club and Greek Life Presidents sit down for a discussion about balancing schoolwork and Extracurriculars.

Turbine Challenge

Nov 16th — Work with a small group to design and build a wind turbine to power a calculator. Materials will be provided. The best turbine will be showcased.

Little Bites and Legos

Dec 12th — Stressed out because of finals? Take a break, play with legos, and nom on little-bite mini muffins.

Social Events

Future Themes

Agricultural Development

Spring Semester
2018

Materials Engineering

Fall Semester
2019

With events to look forward to like

Hackathon

Maker Faire

Graduation cap decorating

A2 Calendars

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Makerspace Detailed Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	■ 2-3pm Laser Cutter Workshop		■ 1-3pm Certification and Training	■ 1-2pm Makerbot Training		■ Starting 10am -- Hack@WPI
■ -- Until 10pm Hack@WPI		■ 6-7pm Soldering Workshop	■ 1-3pm Certification and Training ■ 6-9pm AEES/AICHE Joint Social			■ 8am-12pm STEM Saturday
	■ 2-3pm Laser Cutter Workshop ■ 8am-12pm Introduce a Girl To Engineering		■ 1-3pm Certification and Training ■ 6-7pm Innovation Challenge	■ 1-2pm Makerbot Training		■ 12-2pm Jewelry Making
			■ 1-3pm Certification and Training	■ 6-7pm PVC 1001		
	■ 2-3pm Laser Cutter Workshop ■ 8-11pm Little Bites and Legos	■ 9am-6pm Stratasys Extreme Redesign	■ 1-3pm Certification and Training	■ 1-2pm Makerbot Training		

Training & Workshops

Social Events

Club Activities

Outreach Events

Company Sponsored

Makerspace Event Descriptions

Certification and Training
- Get certified on the machines and learn how to stay safe in the makerspace

Makerbot Workshop
- Learn how to use the makerbot, and practice designing and printing a sample part

Laser Cutter Workshop
- Learn how to use the laser cutter, and practice designing and cutting a sample part

Soldering Workshop
- Learn how to slice wires, solder pin-hole boards, and other basic soldering techniques

Hack@WPI
- Hack@WPI is a 48 hour event where groups of four students engage in collaborative programming. Build an app, program a robot, or make a website--anything is fair game!

AEES/AICHE Joint Social
- Students in AEES or AICHe are invited to attend the social to network with professors and industry partners

STEM Saturday
- Share your love for STEM with local middle school students! Email Ken at fakeemail@wpi.edu to sign up.

Jewelry Making
- Local artisan Tim Timson will be running an into to brass jewelry making. Don't forget, Valentine's day is coming up!

Introduce a Girl to Engineering
- Help empower the next generation of girls to be leaders in engineering!

Little Bites and Legos
- Stressed out because of midterms? Take a break, play with legos, and nom on little-bite mini muffins.

Stratasys Extreme Redesign
- Stratasys is hosting a 3D printing competition, calling upon students to redesign an existing product or create a new one

PVC 1001
- Engineers without Borders is hosting a PVC workshop for their members and any interested students

Collaboration Space

CALENDAR

2015-2016

		S	M	T	W	R	F	S
		19	20	21	22	23	24	25
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		16	17	18	19	20	21	22
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		30	**31**	**1**	**2**	**3**	**4**	5
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		20	**21**	**22**	**23**	**24**	**25**	26
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		4	**5**	**6**	**7**	**8**	**9**	10
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		18	19	20	21	22	23	24
		25	26	**27**	**28**	**29**	**30**	31
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		15	**16**	**17**	**18**	**19**	**20**	21
		22	**23**	**24**	25	26	27	28
		29	**30**	**1**	**2**	**3**	**4**	5
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		10	**11**	**12**	**13**	**14**	**15**	16
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		1	**2**	**3**	4	**5**	**6**	7
	MAY	8	9	10	11	12	13	**14**

D

Graduation

Innovation Workshops

Improv - Sept 11th
Elevator Pitch Competition - Oct 9th
Curtis Challenge (ie egg drop) - Nov 13th
Techtakedown - Dec 11th
IDEO Method Card Game - Jan 22nd
Toy Design Competition - Feb 19th
Lego Buildings - March 18th
Curtis Challenge (ie Rube Goldberg Competition) - April 15th

Speaker Series

WPI Innovator of the Year (ie 2015 Jeremy Hitchcock) - Sept 8th
Local Business Owners (Wachusett Brewery) - Oct 6th
Successful Alumni (Paul Ventimiglia) - Nov 10th
Professors/Faculty (Diran Apelian) - Dec 8th
Motivational Speakers - Jan 19th
Successful Undergraduate Students - Feb 16th
Club and Greek Life Presidents - Mar 15th
Student Presentation on Internship Experiences - April 12th

School Events

Shark Tank (Two Dates, Nov 14th and March 19th)
Tech Advisory Network - Second Thursday of every months
Project Presentations (Two Dates, Oct 9th and Feb 11th)

A3 Archetypes

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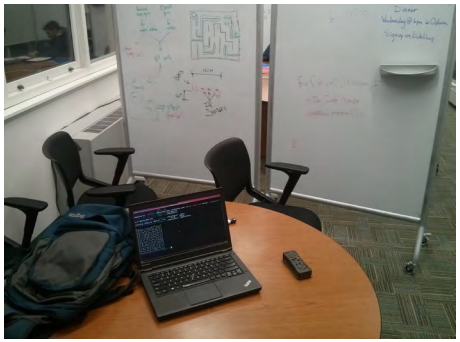
Rapid Digital Prototyper

Rapid Digital Prototypers recognize a problem, develop a solution, and then quickly execute the solution. They prefer materials and tools that are multi-purpose and easily accessible. Such tools and materials include laser cutters, 3D printers, and cardboard. These students rely on CAD software since their equipment require these types of files. Many of their projects are short term, small scale, and involve electronics, mechatronics, or robotics.

Planner

The Planner works carefully and meticulously. This type of maker begins their projects by drawing out sketches on paper and whiteboards. They are not keen on taking shortcuts, and if they can't find what they need, they may give up on the project. They require a clean and organized workspace. The prefer to work in a private, or at least temporarily private, space. Many group projects follow this archetype, since many students working collaboratively requires organization and planning.

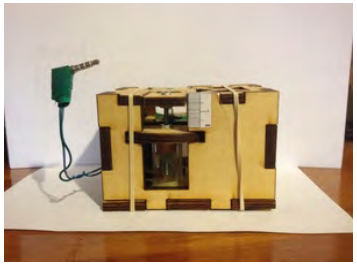


Hacker

Some students make with whatever they have, whenever they can. Hackers are often working on a whim, and make do with whatever materials are lying around. They work on projects that push the limits of their spaces.These kinds of makers are often working alone, and late at night. They like seeing how things work, and thrive on tearing down and rebuilding. Their workbenches are messy, but can easily be cleaned off and stored away when they're done.

Academic Maker

Some students make for research, or for a class. Academic Makers are often working on a deadline, and need 24/7 access. They also may need private storage so that their work isn't damaged by more casual projects. These kinds of makers are often working in groups and may need a larger or modular space to accommodate everyone. Academic Makers may also be working on projects for clubs. These projects are generally long-term, with larger projects, and a larger team.

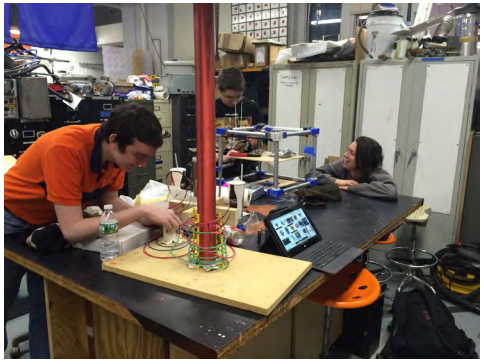


Wishful Maker

Some students want to make, but don't know where to start. The Wishful Maker has ideas, but does not execute them. They may not know how to start, do not have enough people, or are unfamiliar with the necessary tools. They have a strong desire to make, but are unsure of where to get help, or intimidated by the maker community on campus. The Wishful Maker is inspired by seeing other people's projects. These are the students whom we hope will finally become involved in this new space.

Sideline Maker

Some students just want to watch people make. The Sideline Maker is not necessarily personally interested in making. They are often familiar with the maker movement if they have friends heavily involved. They may enjoy watching other people make, attending maker events, and just hanging out in or near the makerspace. Some Sideline Makers may not have a need to make due to their major. They often are lacking the skills necessary, and wouldn't spend very much time in the space.



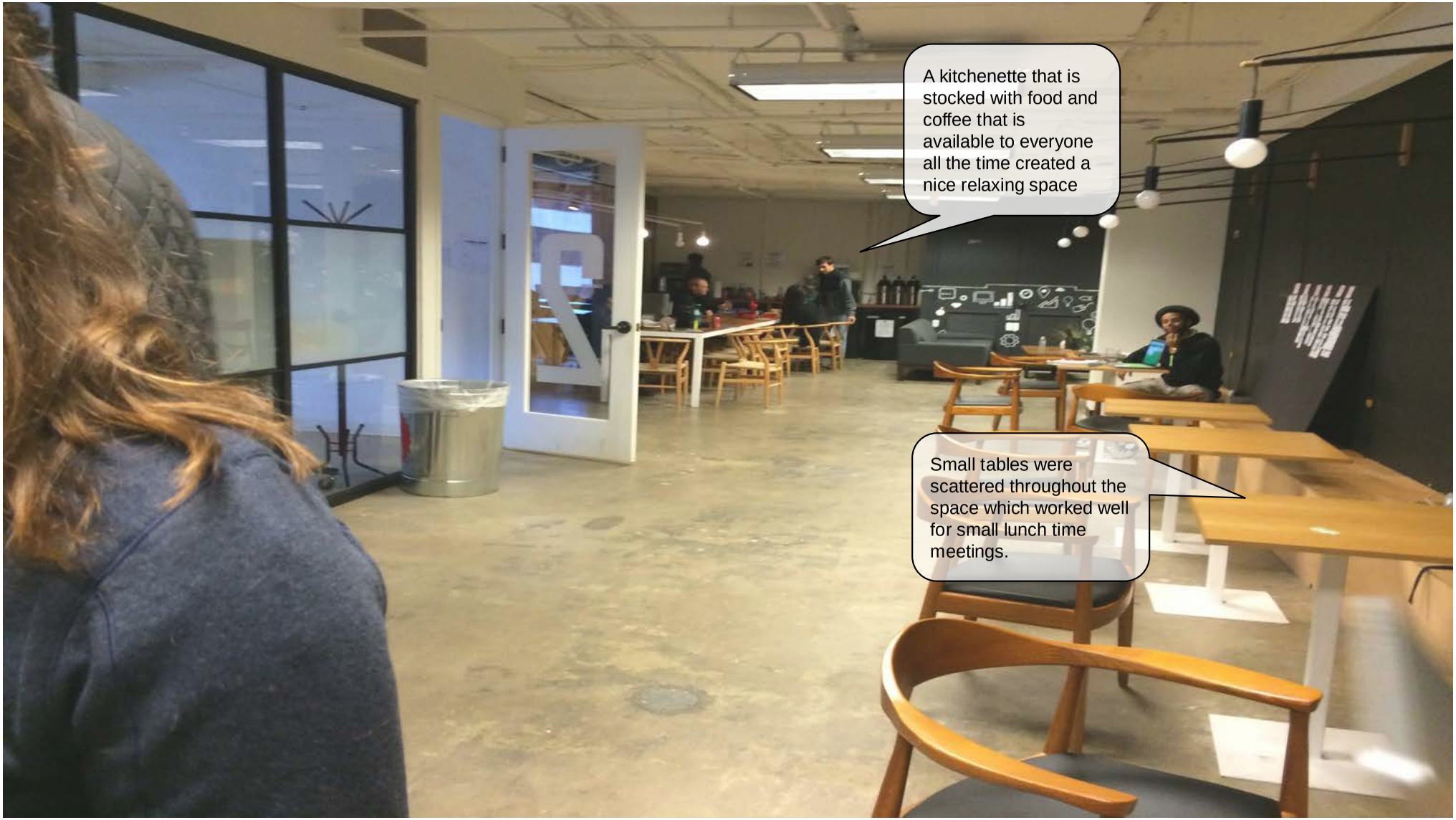
A4 Visit Annotations

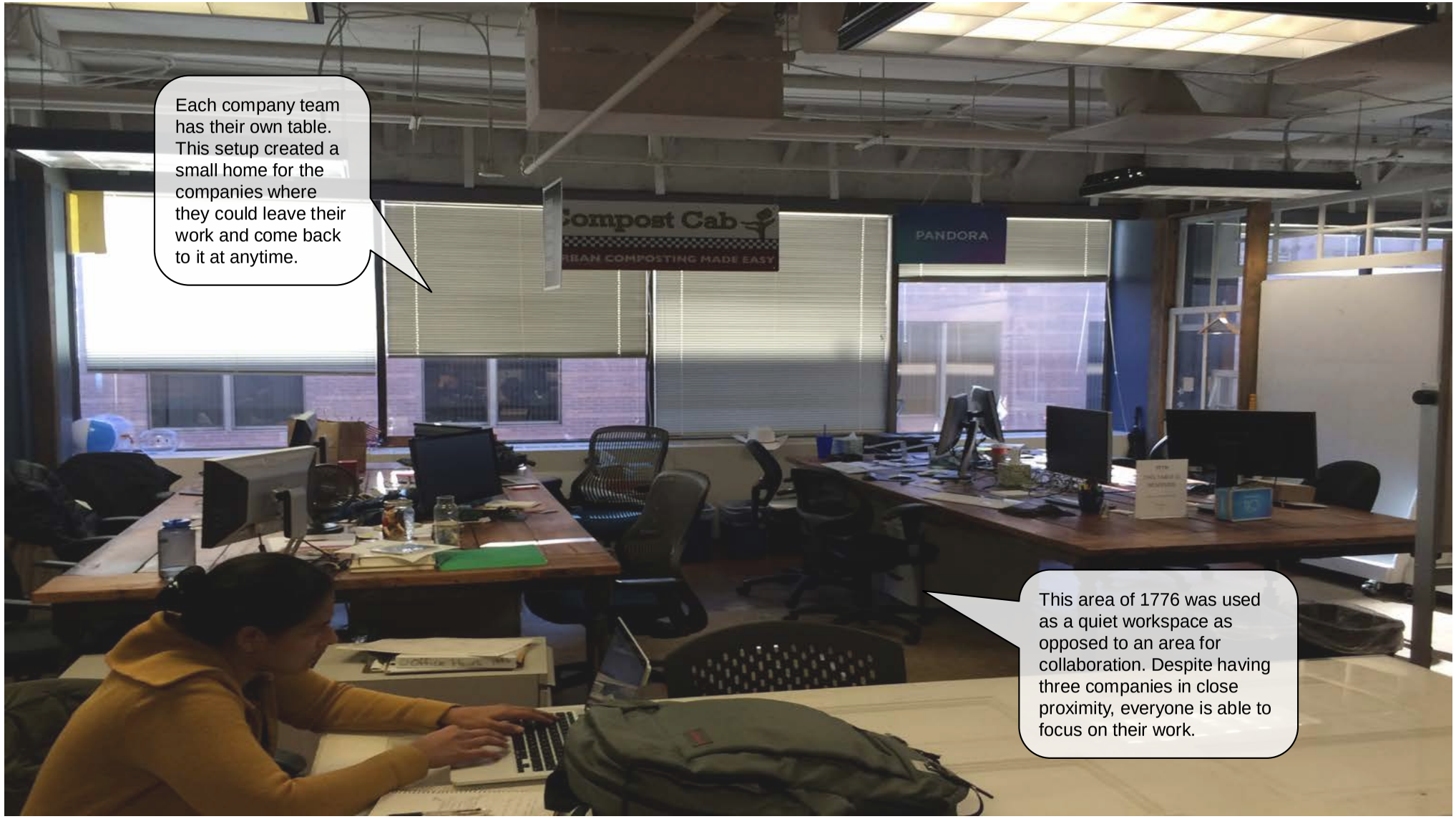
1776 BUSINESS INCUBATOR

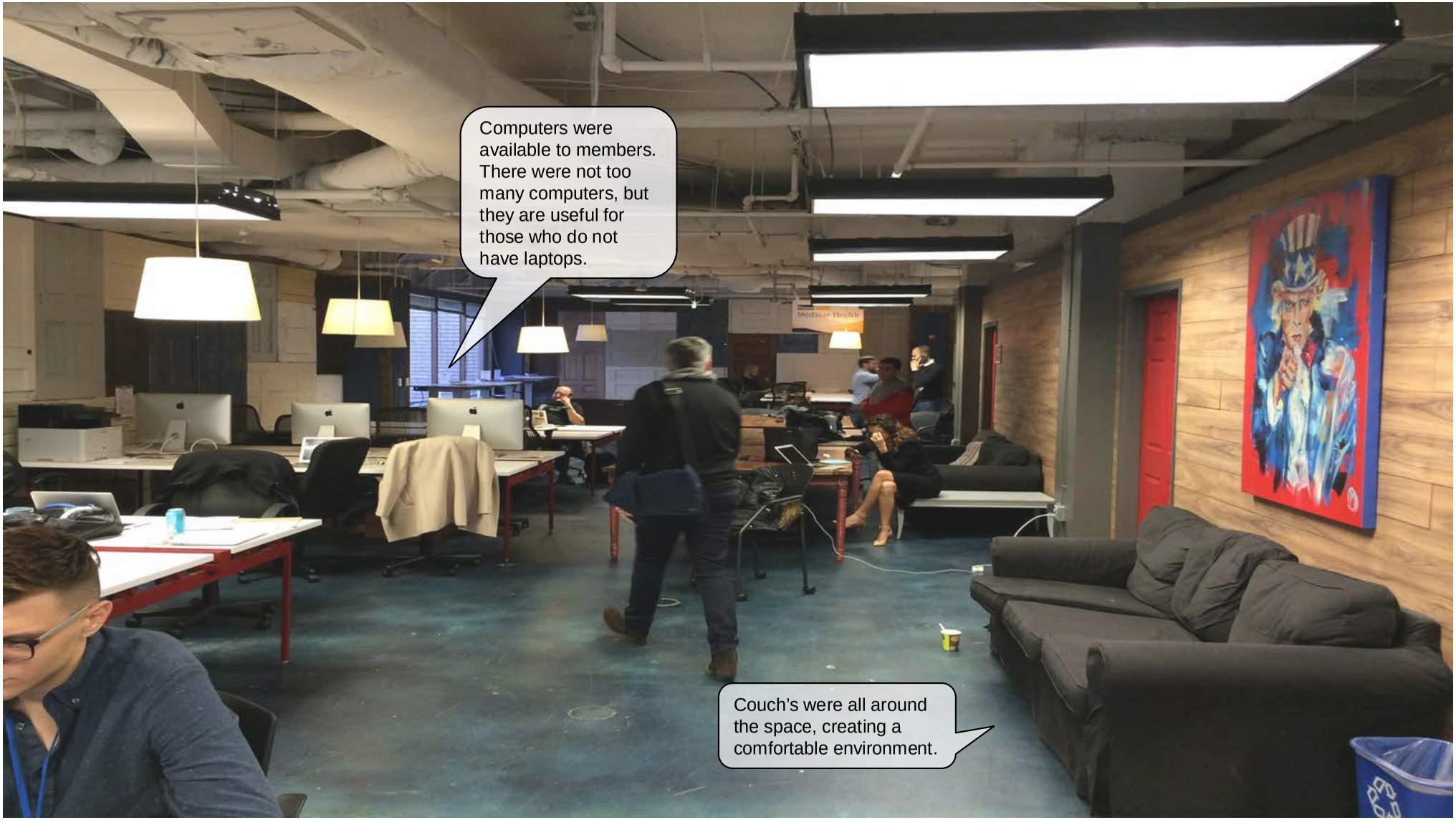
1133 15TH ST NW

WASHINGTON, DC


Small secluded, “cubbies” were situated throughout the space. These high walled couches gave a new, comfortable spin on the traditional cubical.
An abundance of outlets and power strips accommodates everyone’s electrical needs.


A kitchenette that is stocked with food and coffee that is available to everyone all the time created a nice relaxing space
Small tables were scattered throughout the space which worked well for small lunch time meetings.


Each company team has their own table. This setup created a small home for the companies where they could leave their work and come back to it at anytime.
Compost Cab
URBAN COMPOSTING MADE EASY
PANDORA
This area of 1776 was used as a quiet workspace as opposed to an area for collaboration. Despite having three companies in close proximity, everyone is able to focus on their work.


Computers were available to members. There were not too many computers, but they are useful for those who do not have laptops.
Couch's were all around the space, creating a comfortable environment.

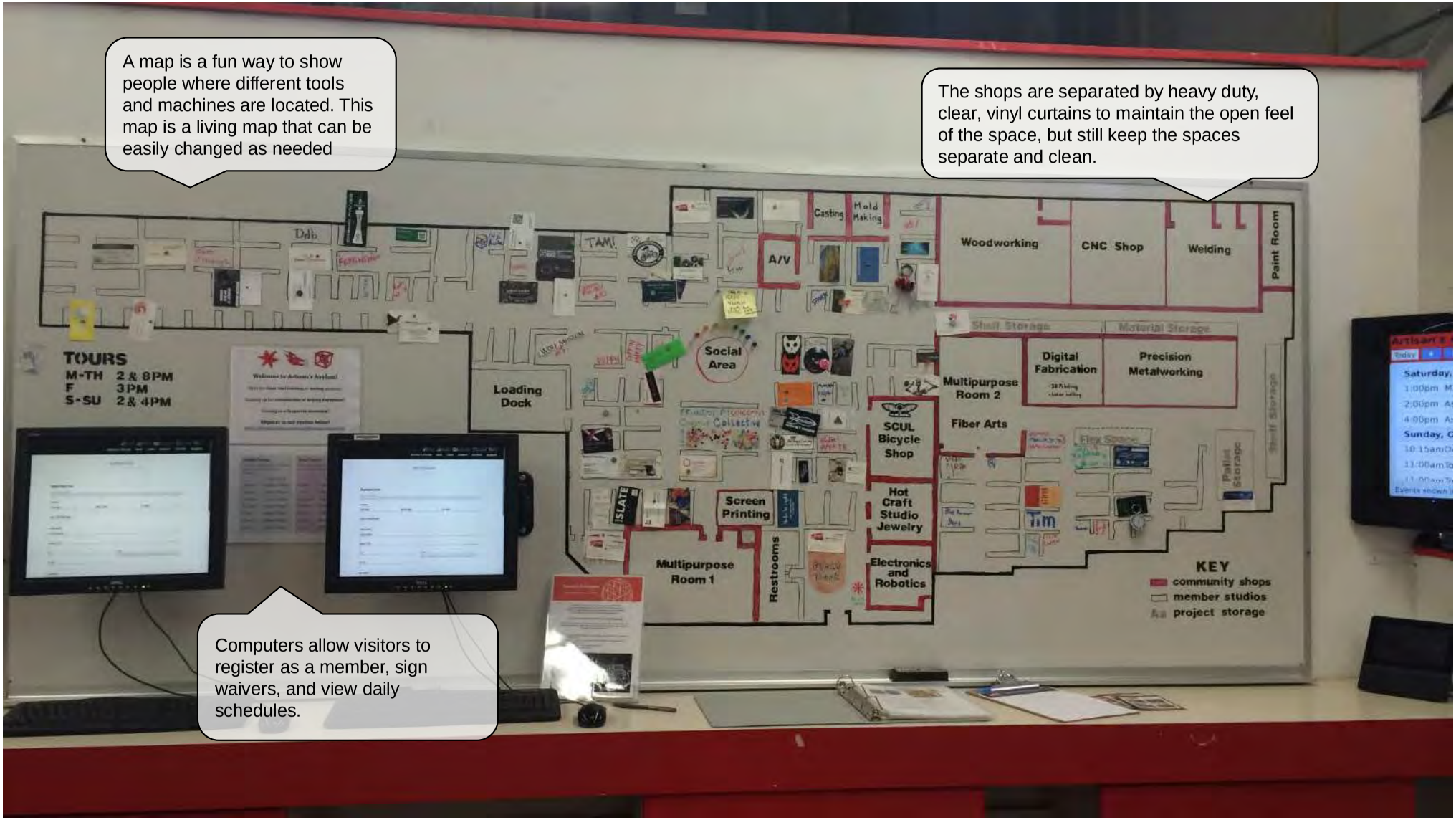

Jobs Room
1776
Jefferson1776-12
Conference rooms that sat 5-12 people lined the sides of the office. This space was particularly useful for meetings with sponsors or other guests.
At WPI, this translates to IQP, MQP, GPS, and other project team meetings with sponsors or advisors.

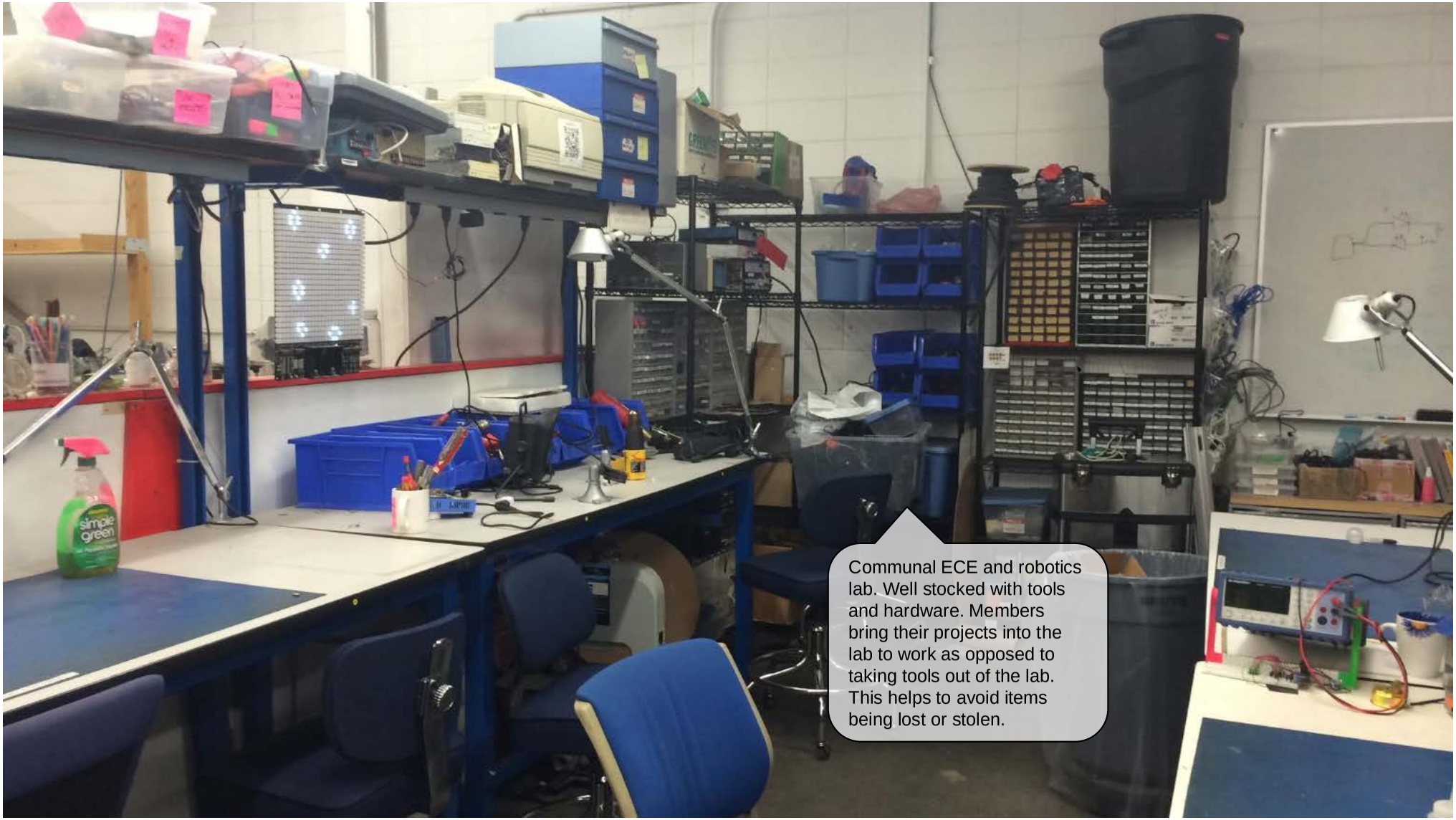

UNIVERSITY of VIRGINIA
DARDEN SCHOOL OF BUSINESS
batten
INSTITUTE
VERSITY of VIRGINIA
AMERICAN UNIVERSITY
split
Banners were hung all around the space, depicting who owned what space, while still maintaining an open environment.
Different schools and companies had spaces reserved for their teams. They were free to use the space as they pleased.

ARTISAN'S ASYLUM

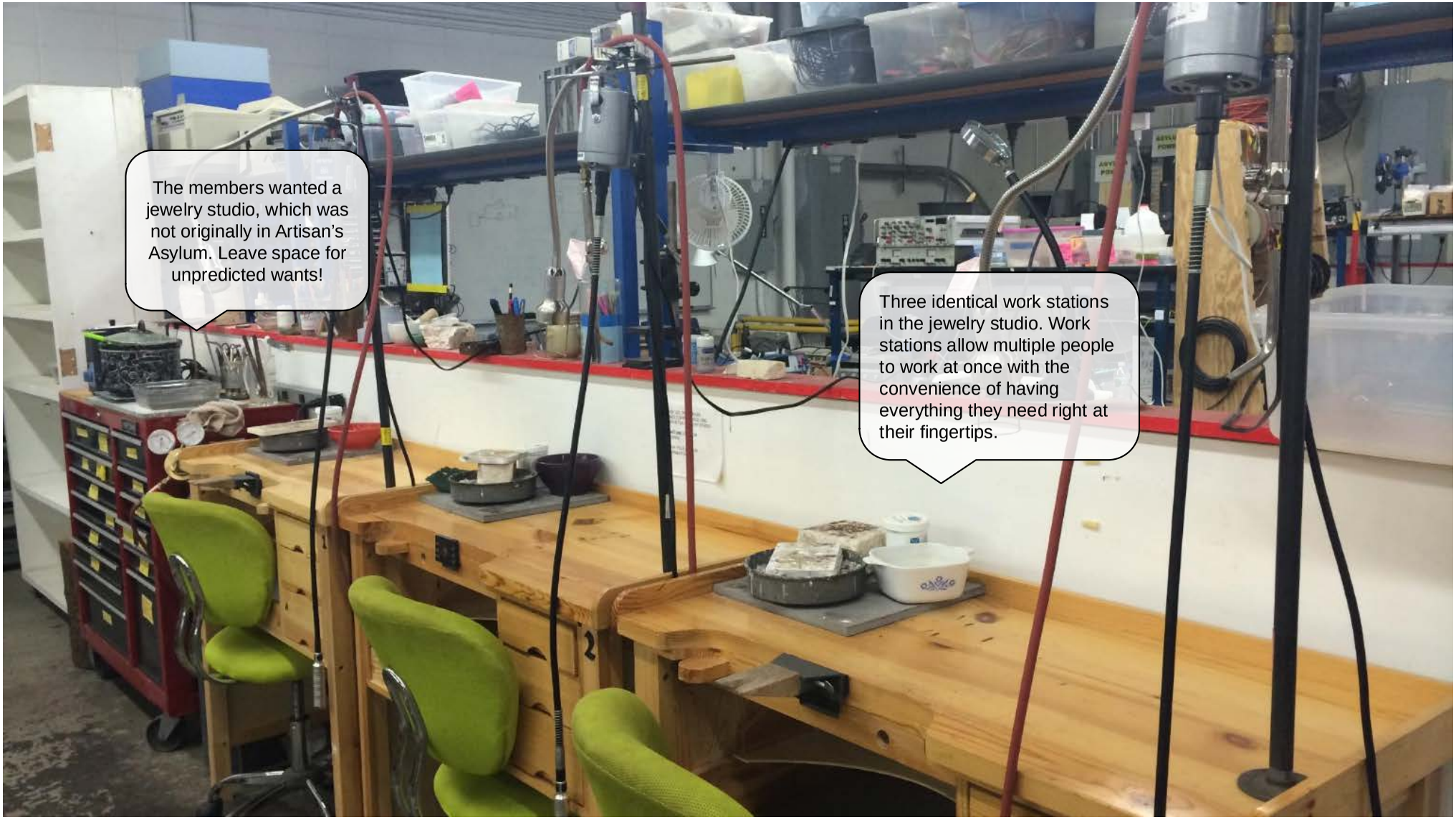
SOMERVILLE, MA

Front desk at Artisan's Asylum staffed with a volunteer to welcome people. Some kind of front desk in the FIS makerspace would be helpful to inform students of the resources available to them.


A map is a fun way to show people where different tools and machines are located. This map is a living map that can be easily changed as needed
The shops are separated by heavy duty, clear, vinyl curtains to maintain the open feel of the space, but still keep the spaces separate and clean.
Computers allow visitors to register as a member, sign waivers, and view daily schedules.
TOURS
M-TH 2 & 8PM
F 3PM
S-SU 2 & 4PM
Casting
Mold Making
A/V
Woodworking
CNC Shop
Welding
Paint Room
Social Area
Loading Dock
Digital Fabrication
Precision Metalworking
Multipurpose Room 2
Fiber Arts
SCUL Bicycle Shop
Hot Craft Studio Jewelry
Screen Printing
Restrooms
Multipurpose Room 1
Electronics and Robotics
KEY
community shops
member studios
project storage



Communal ECE and robotics lab. Well stocked with tools and hardware. Members bring their projects into the lab to work as opposed to taking tools out of the lab. This helps to avoid items being lost or stolen.

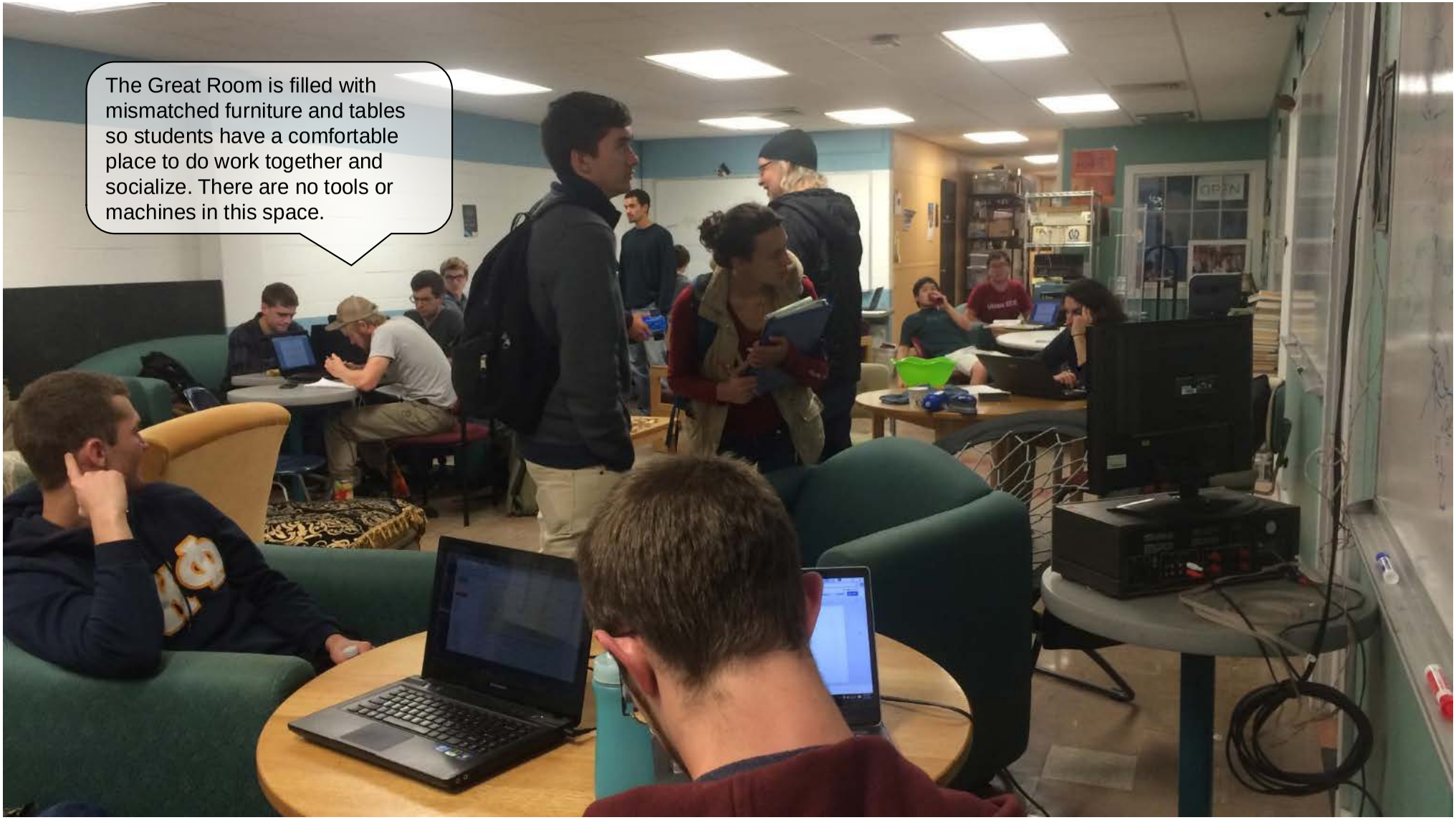

The members wanted a jewelry studio, which was not originally in Artisan's Asylum. Leave space for unpredicted wants!
Three identical work stations in the jewelry studio. Work stations allow multiple people to work at once with the convenience of having everything they need right at their fingertips.

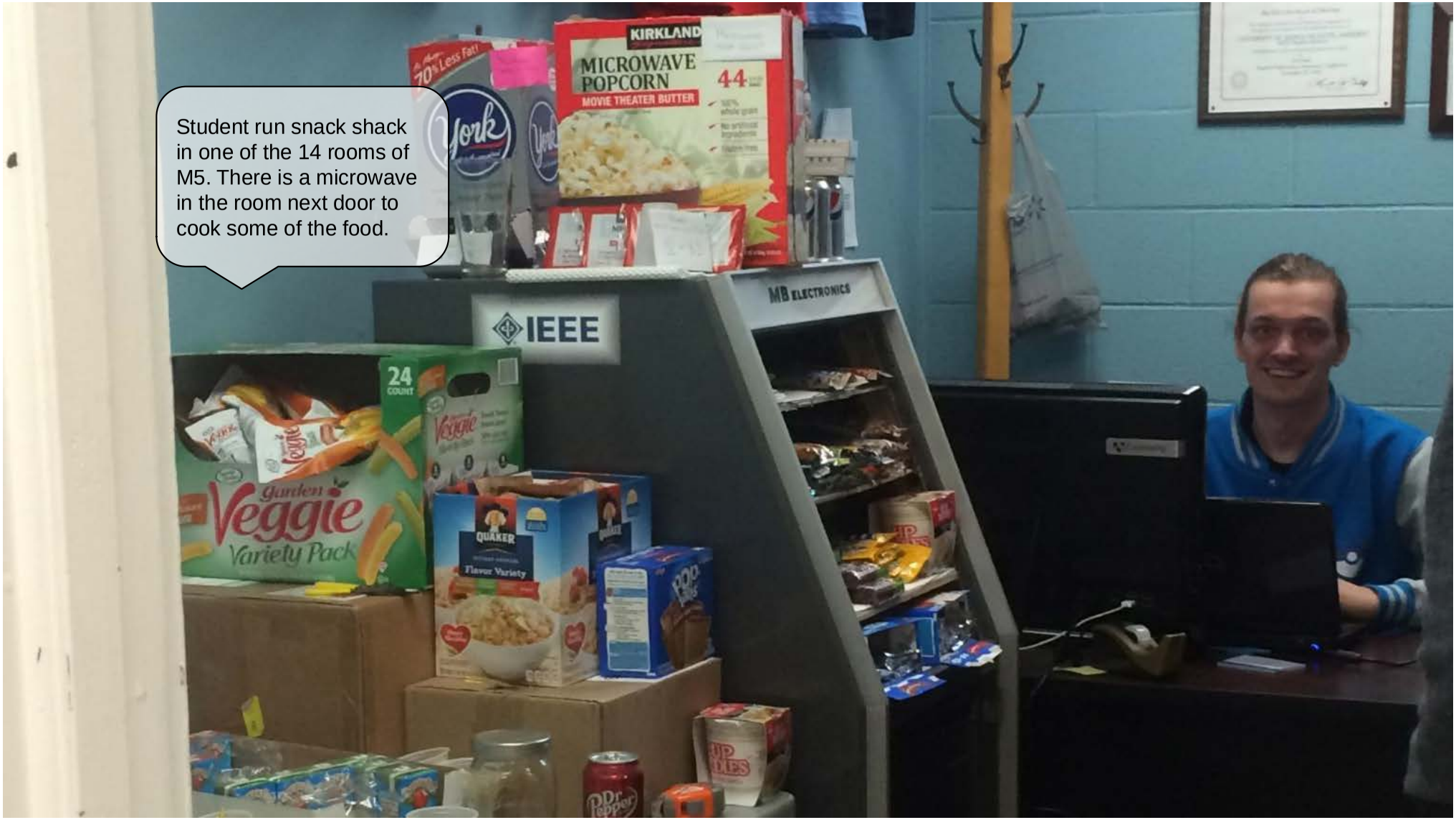

Dividing the space in creative ways keeps it quieter and more personal.
Half walls are used to divide much of Artisan's Asylum. Individual work spaces are private but maintain an open layout.
Members will often display their work along with business cards. Other members are able to view projects and contact the people creating them. This is a very cool concept that might help promote collaboration at WPI.
PG-13

M5

University of Massachusetts Amherst

Amherst, MA


The Great Room is filled with mismatched furniture and tables so students have a comfortable place to do work together and socialize. There are no tools or machines in this space.


Student run snack shack in one of the 14 rooms of M5. There is a microwave in the room next door to cook some of the food.
KIRKLAND
MICROWAVE POPCORN
MOVIE THEATER BUTTER
44
IEEE
MB ELECTRONICS
24 COUNT
Garden Veggie
Variety Pack
QUAKER
Flavor Variety


Wall of storage bins for small electronic parts and hardware.
Please help keep the M5 parts wall stocked!
If you notice an empty or extremely low bin, please place a yellow card in the bin!
Thank you!
-Josh "Mr. Vain" Lowe
Yellow Cards
M5 also has a simple, yet effective, way to ensure stock is maintained
Part of a mural painted on a wall by the students. The paint glows in the dark. Students at M5 are able to make the space feel like their own.
M5


Freshman electrical engineering class that takes place in M5. Conducting classes in M5 makes students aware of the space and its capabilities very early on in their college career


Small sound/music studio in one of the rooms of M5. Here students work on electrical projects involving instruments and sound.
pacific
M5
It is also often a quieter place to study than the great room. This room provides students with the necessary equipment to work on unique projects

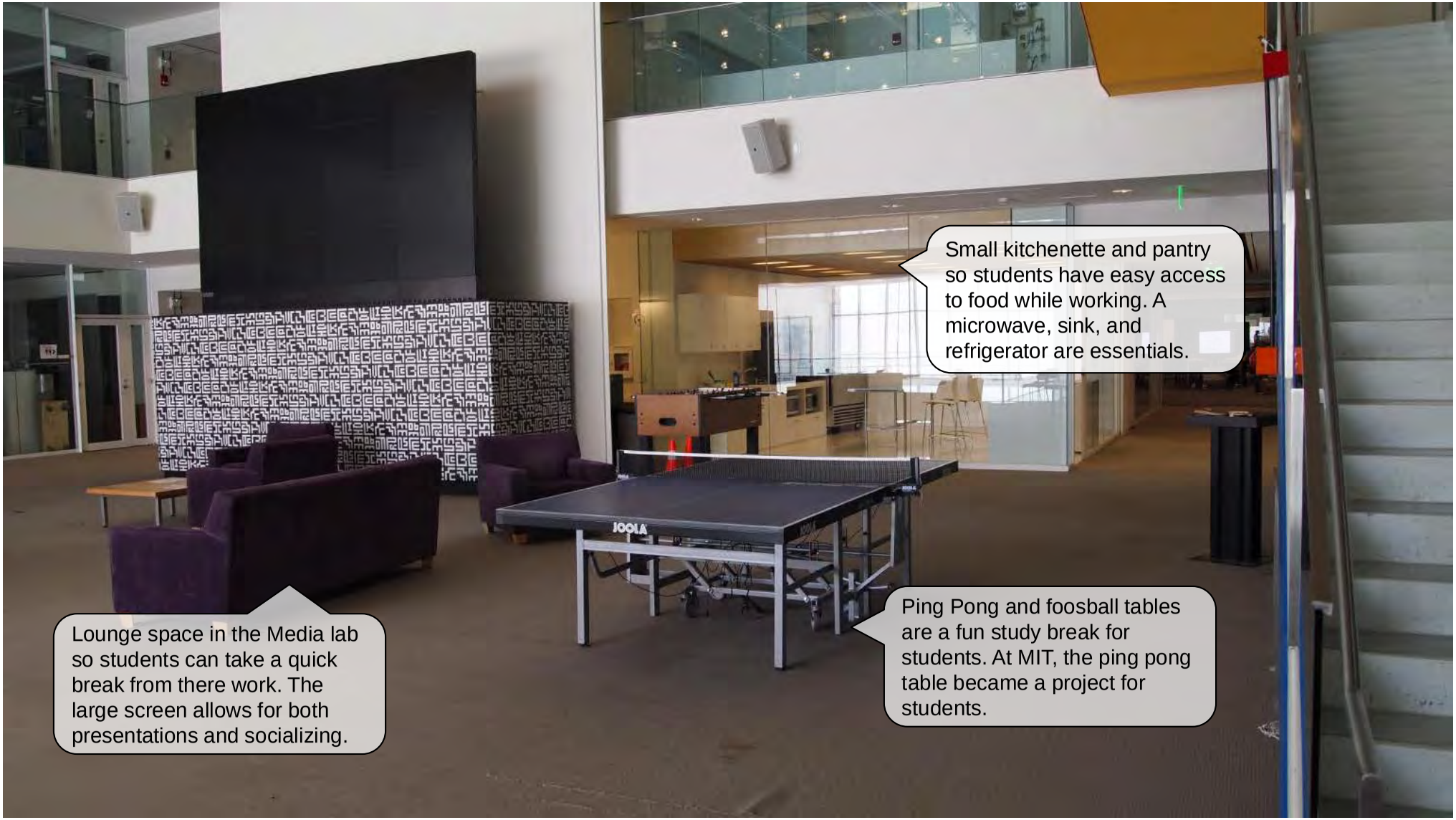
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

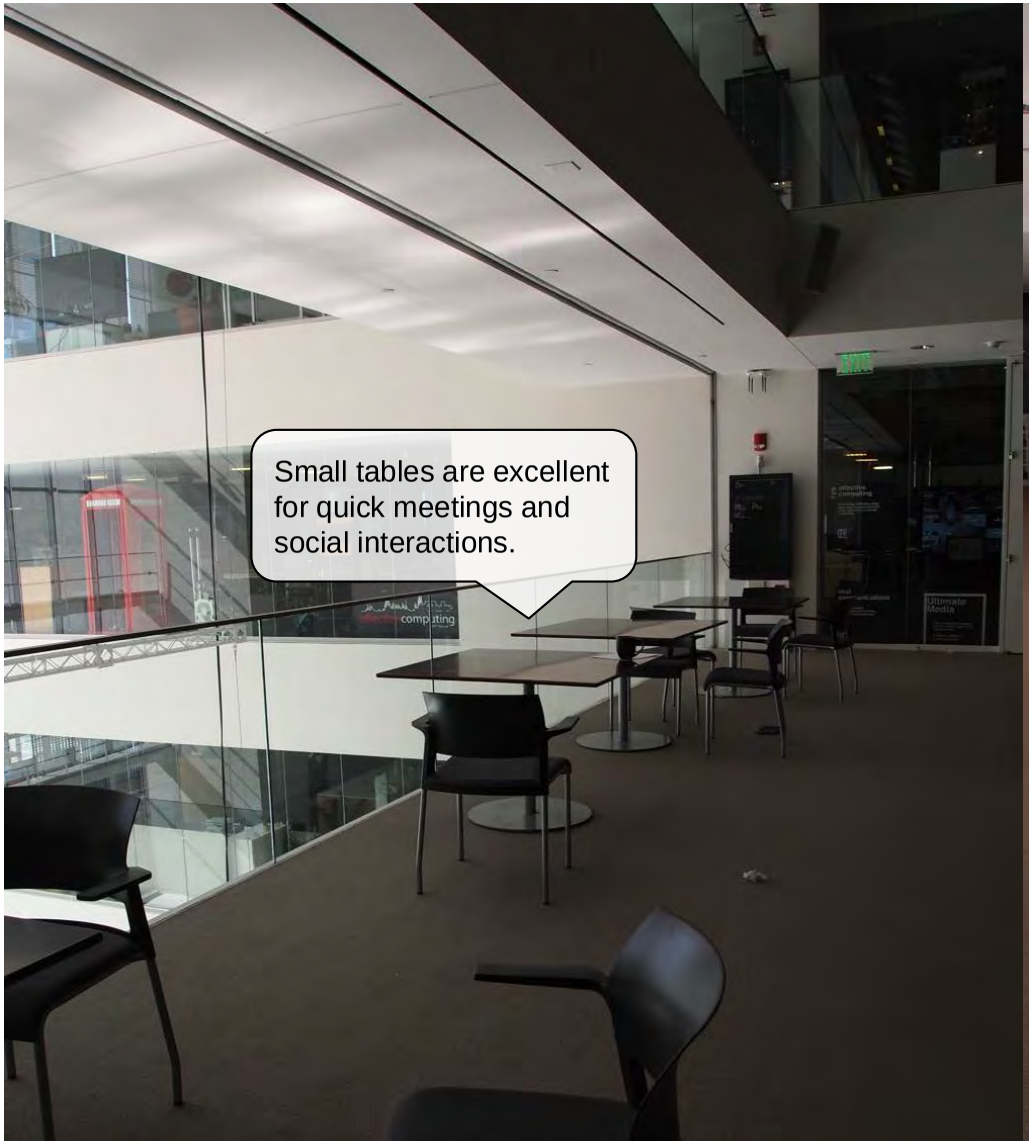
CAMBRIDGE, MA


Consumables available to the students in the Toy Design class. The parts are clearly organized and labeled.
Paint booth ensures students are not spray painting in places they shouldn't be.
googly eyes
office supplies
pushpins
center punches
sewing
paint brushes
THE HOOD

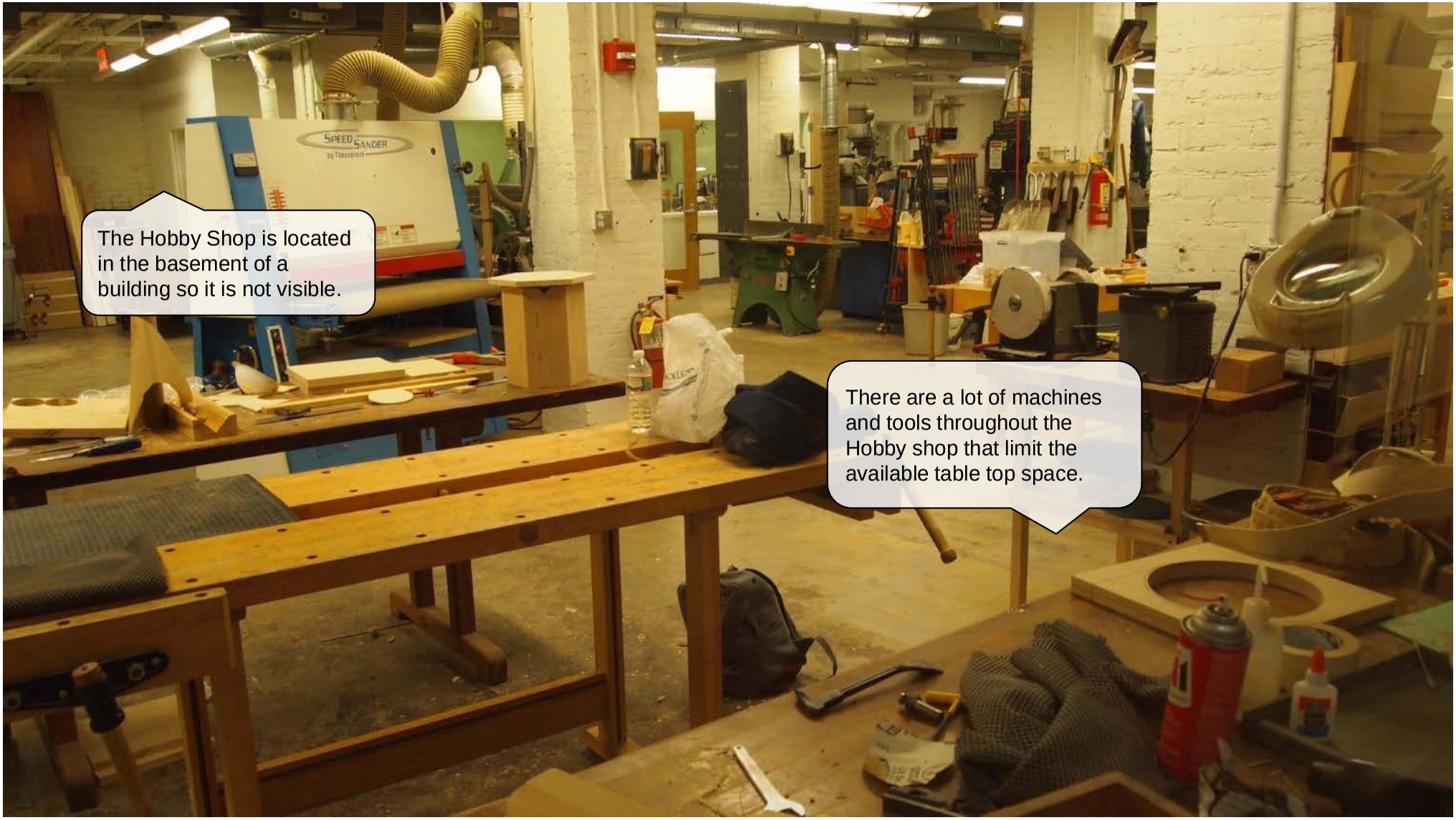

Removable table-top
hot wire cutter.
Flexible work spaces
better accommodate
different projects.


Variety of stock and consumables located in the Pappalardo Lab. Having stock readily available prevent workflow from being disrupted.
shelf 4
2.009 Store
Electronic checkout allows for easy payment with student IDs.
Wire Sleeving
Wire
1000
Sticks • Bâtons
WOODSIES
FOAM CORE BOARD
ULINE


Small kitchenette and pantry so students have easy access to food while working. A microwave, sink, and refrigerator are essentials.
Lounge space in the Media lab so students can take a quick break from there work. The large screen allows for both presentations and socializing.
Ping Pong and foosball tables are a fun study break for students. At MIT, the ping pong table became a project for students.
JOOLA

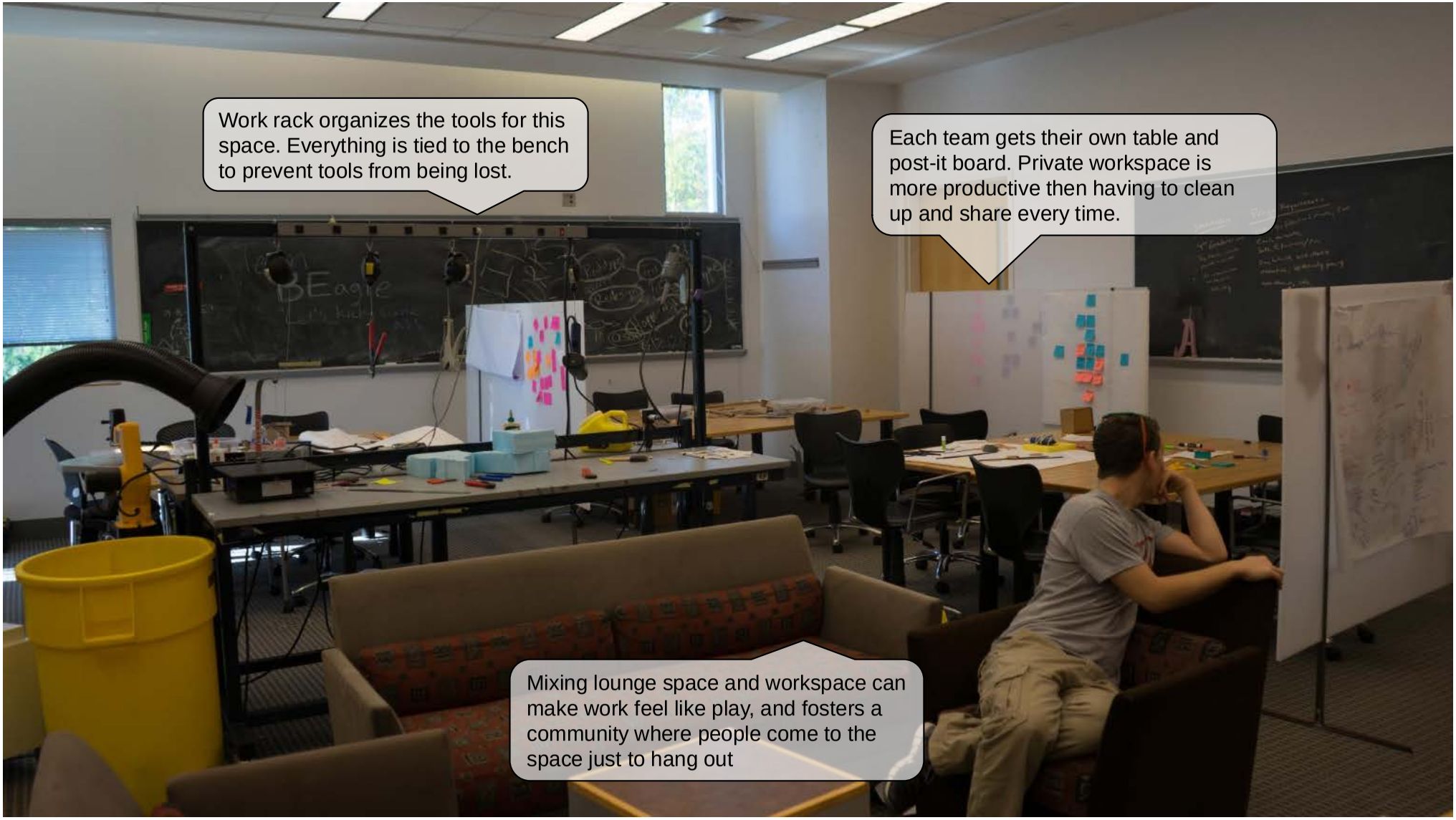

Small tables are excellent for quick meetings and social interactions.


Leftover stock from projects are saved to be used by other students.
Handmade shelving unit by one of the Hobby Shop Lab Managers. Students can store stock and small projects.


SPEED SANDER
The Hobby Shop is located in the basement of a building so it is not visible.
There are a lot of machines and tools throughout the Hobby shop that limit the available table top space.

FRANKLIN W. OLIN COLLEGE OF ENGINEERING

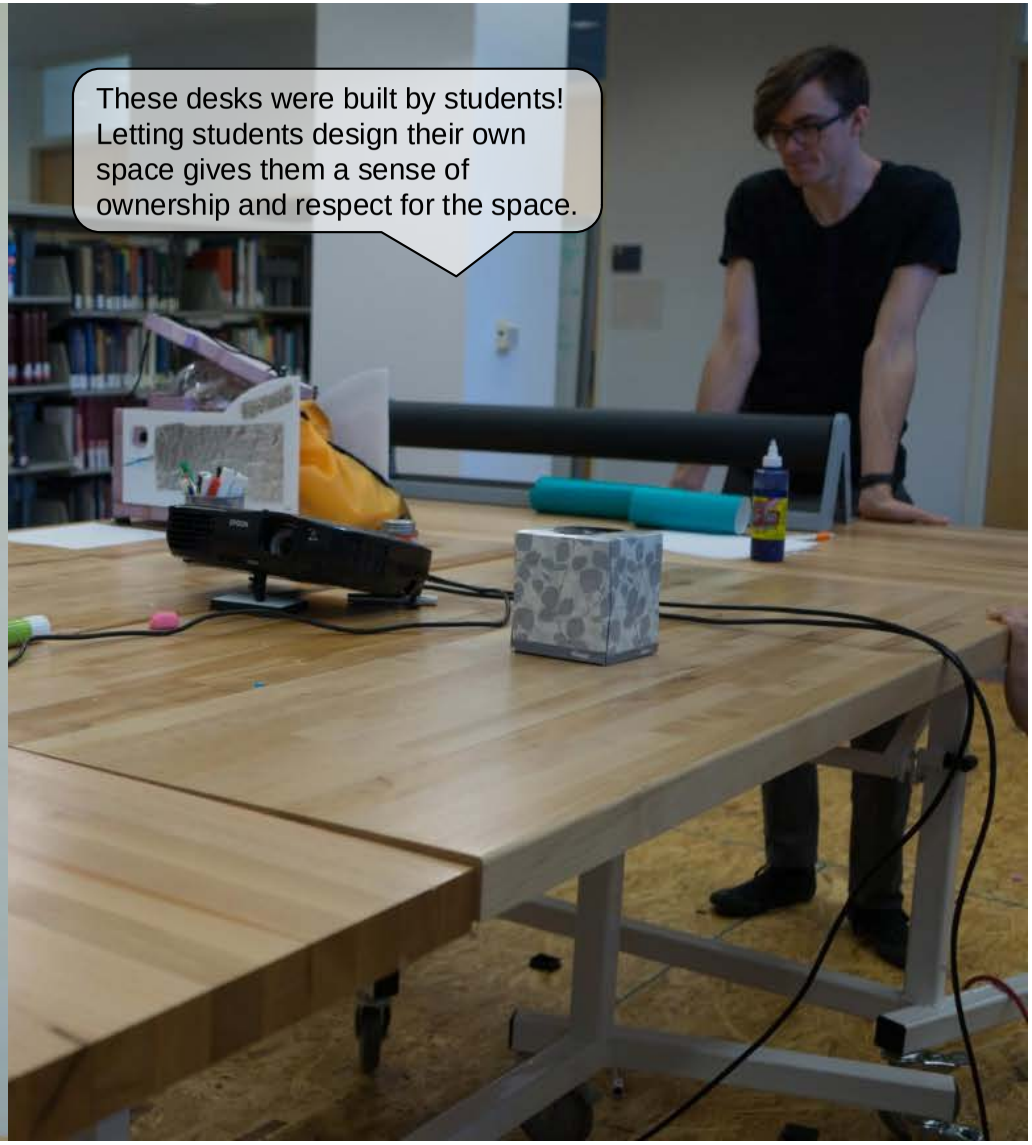
NEEDHAM, MA

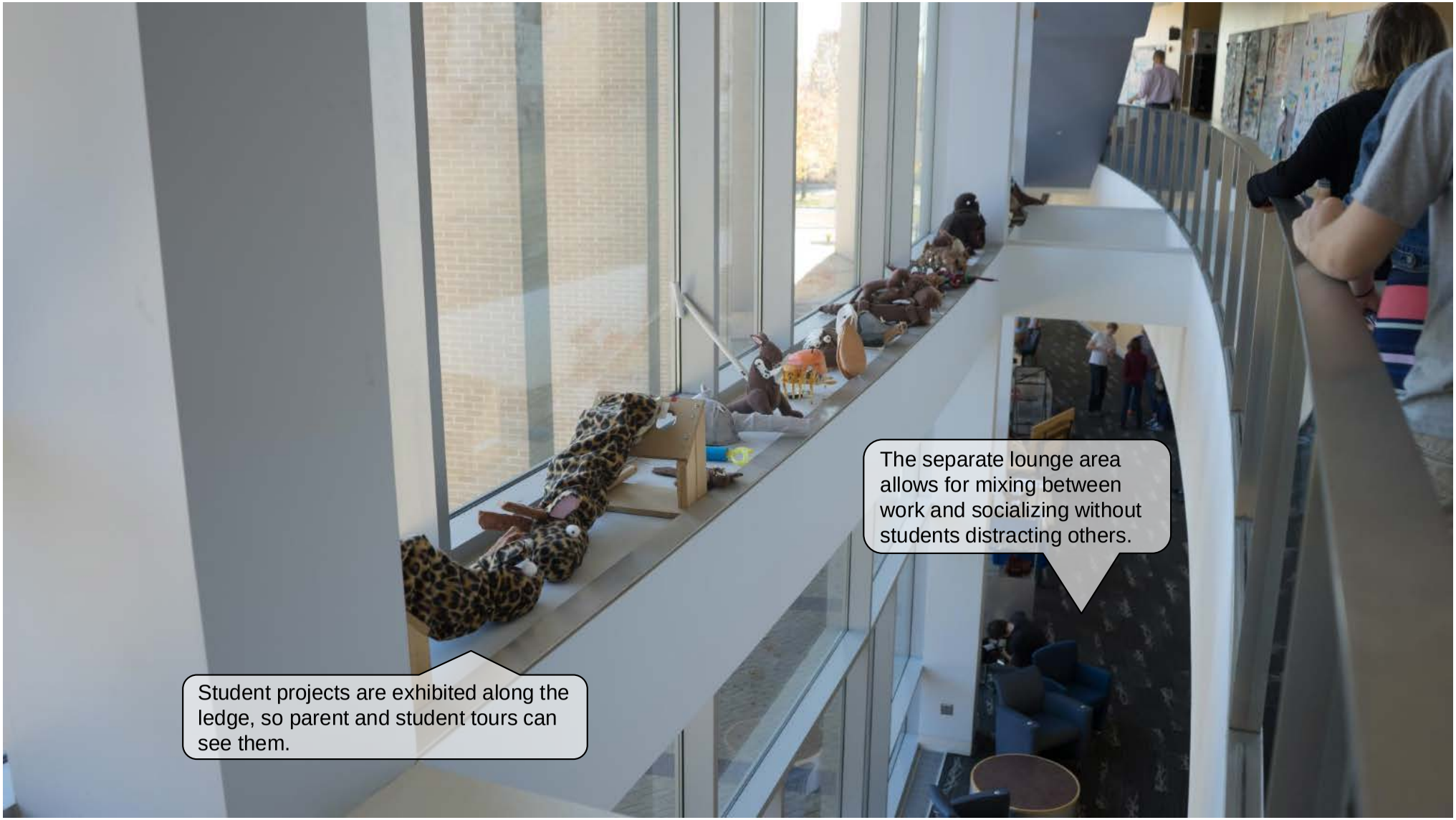

Work rack organizes the tools for this space. Everything is tied to the bench to prevent tools from being lost.
Each team gets their own table and post-it board. Private workspace is more productive then having to clean up and share every time.
Mixing lounge space and workspace can make work feel like play, and fosters a community where people come to the space just to hang out

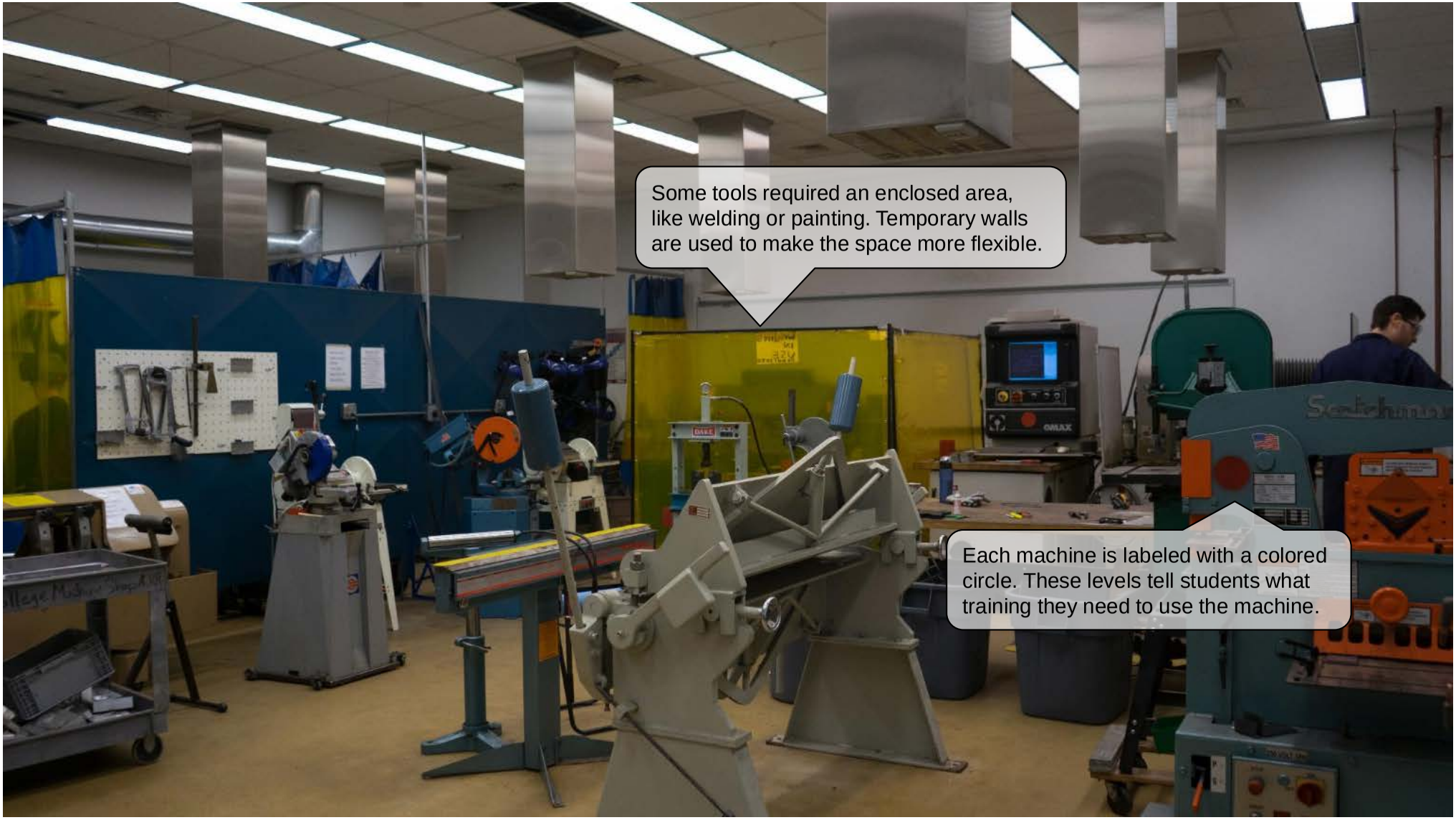

The key here is to have lots of outlets and Ethernet ports, as well as a TV to practice presentations.
The room is divided with a short bookcase creating a semi-secluded area for project teams to focus.
Private group workspaces (tech suites) provide a quieter place for groups to work.


You can **never** have too many post-it notes!!!
Project Storage
WORKSPACES
THE BEST
Central Storage Display
WORKSPACES
Posters and student design work hung all around the room. This is both storage and display, and makes the space feel active even when no one is there


Professional photography show off the projects that students are working on


These desks were built by students! Letting students design their own space gives them a sense of ownership and respect for the space.


The separate lounge area allows for mixing between work and socializing without students distracting others.
Student projects are exhibited along the ledge, so parent and student tours can see them.

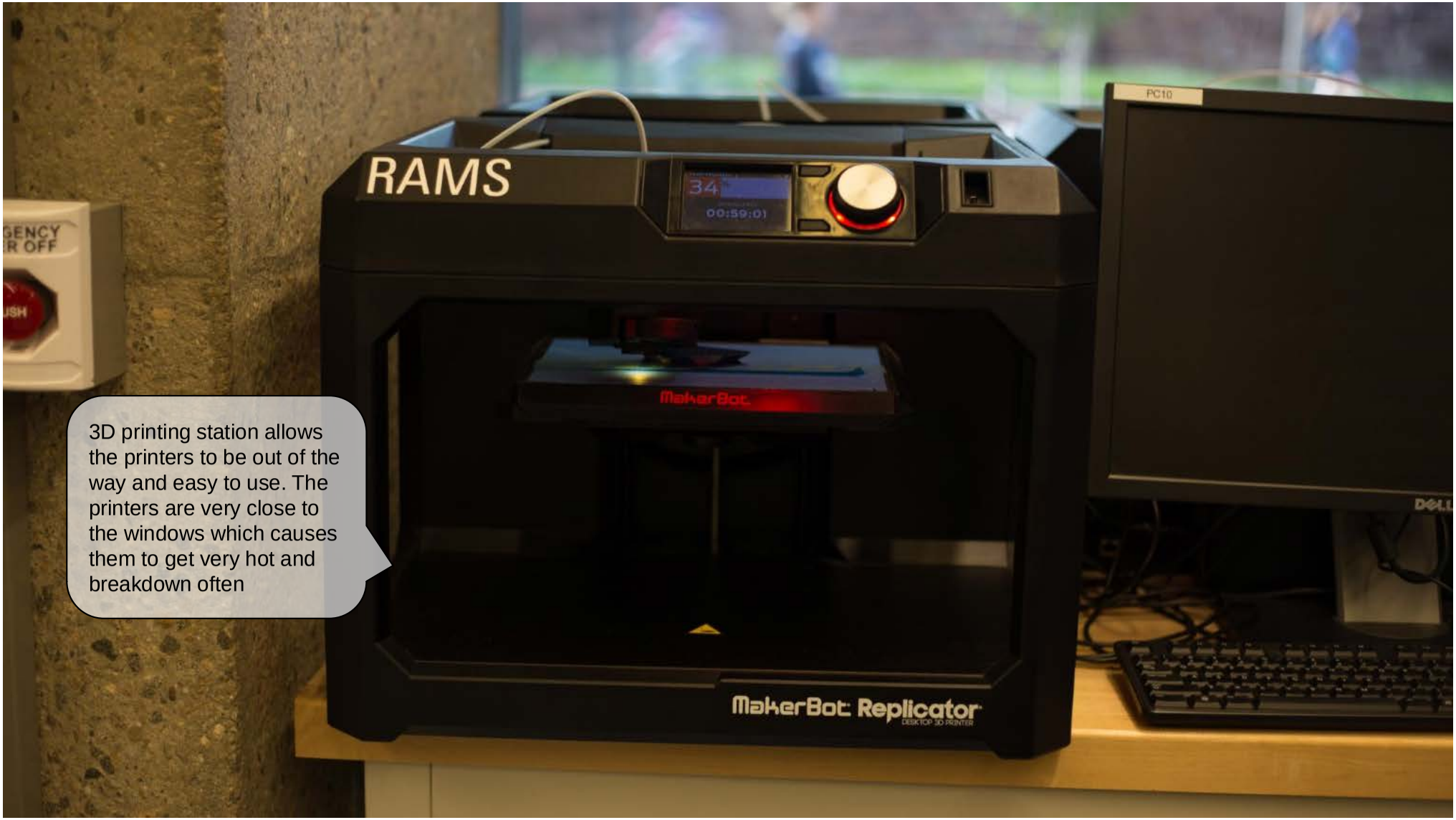

Some tools required an enclosed area, like welding or painting. Temporary walls are used to make the space more flexible.
Each machine is labeled with a colored circle. These levels tell students what training they need to use the machine.

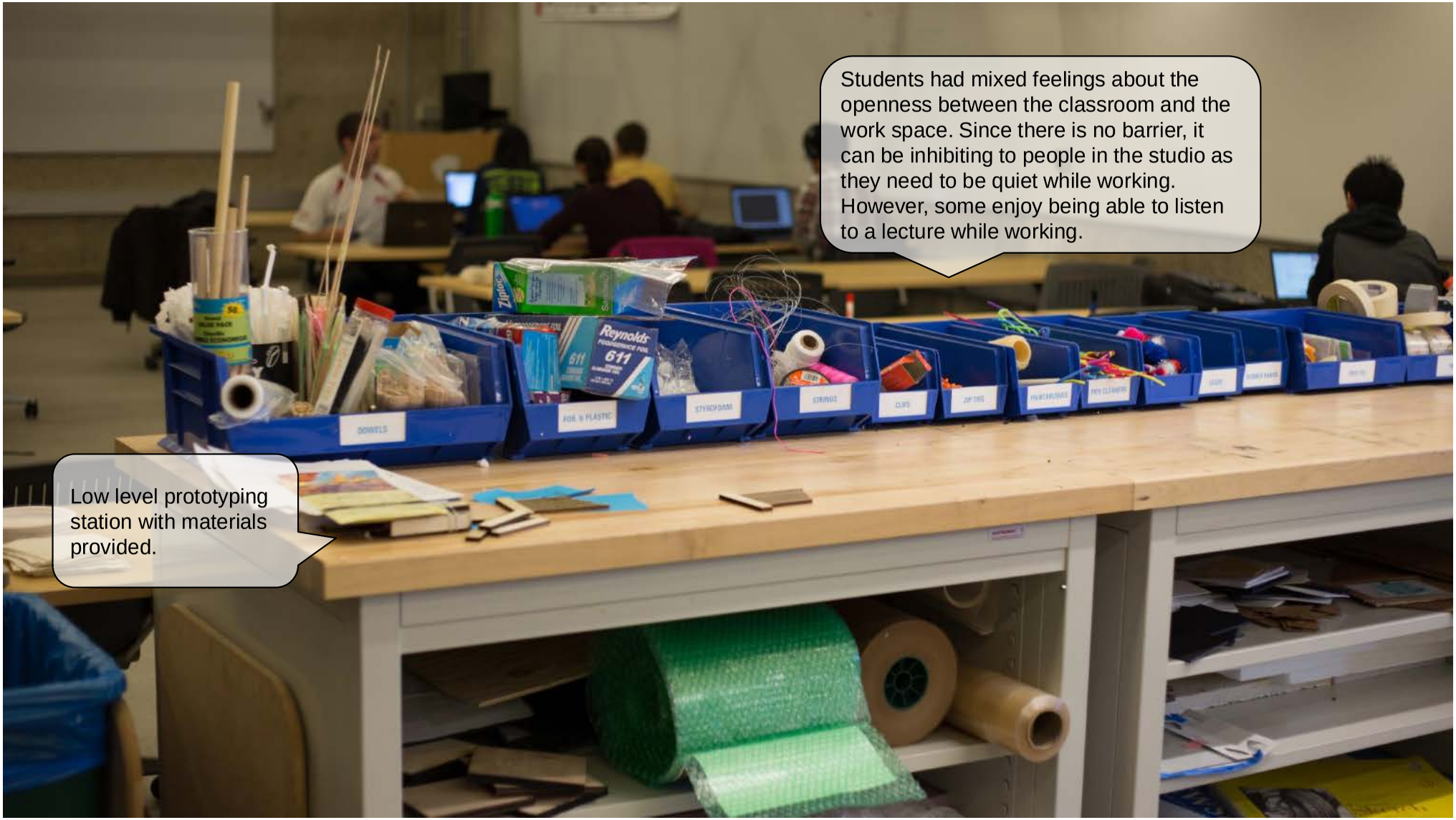
CENTER FOR ENGINEERING INNOVATION AND DESIGN

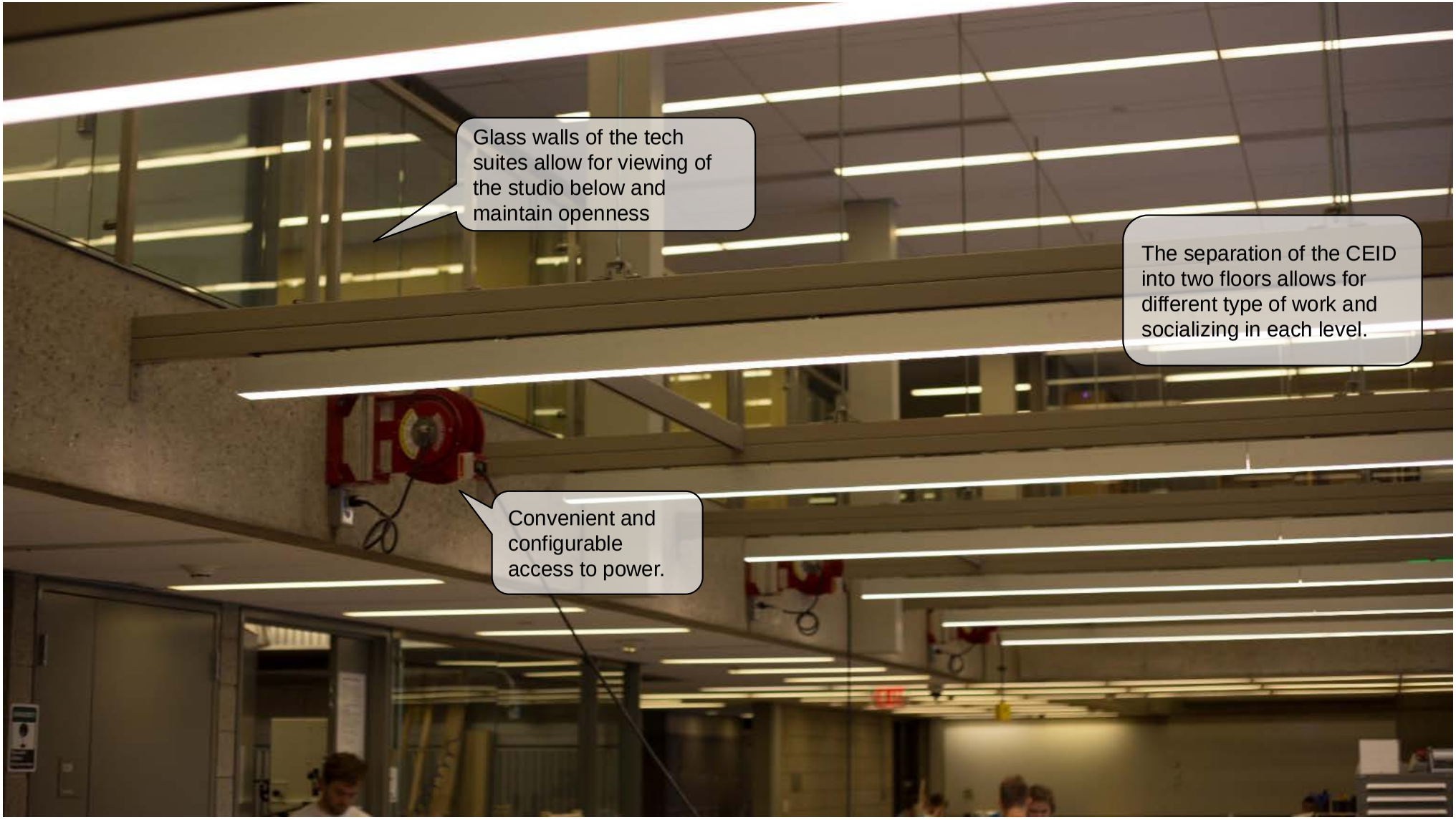
YALE UNIVERSITY

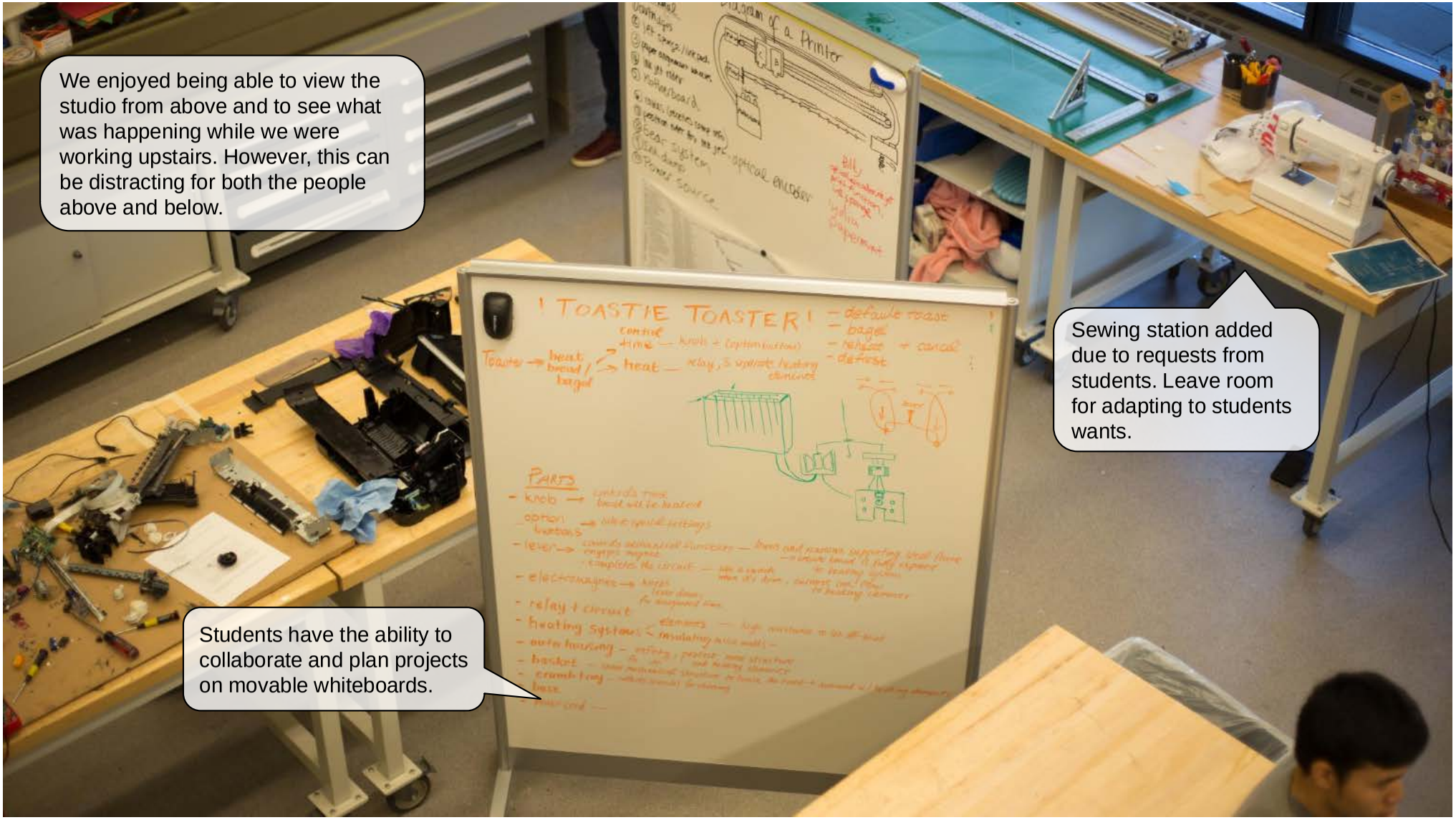
NEW HAVEN, CT


Specific work stations along the side so students have everything they need in one small space.
Light wood top tables make the room feel like a workshop, while also maintaining an inviting atmosphere.
Tables are able to move to accommodate different programs in the space.

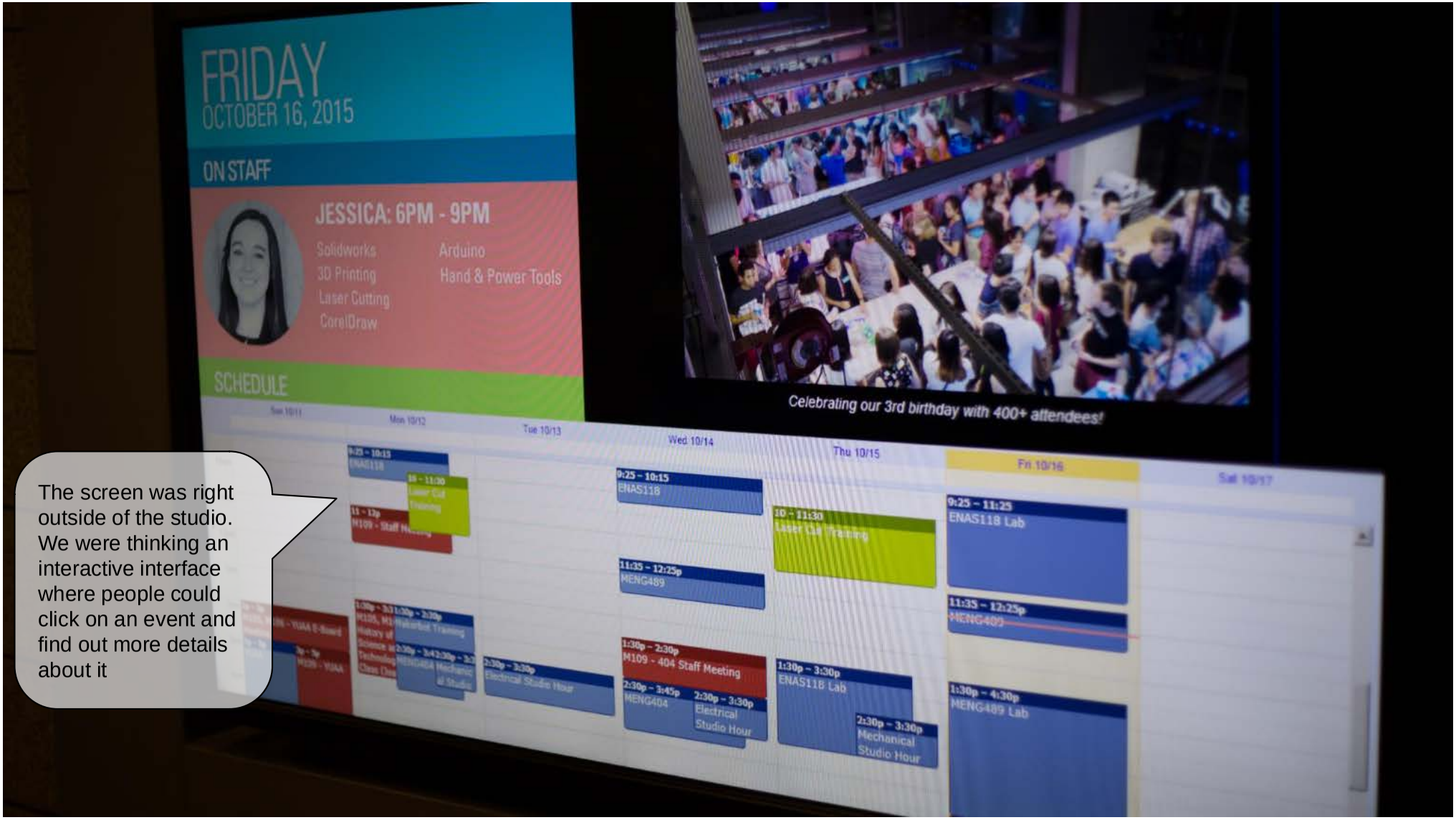

RAMS
34
00:59:01
MakerBot
MakerBot Replicator
DESKTOP 3D PRINTER
PC10
3D printing station allows the printers to be out of the way and easy to use. The printers are very close to the windows which causes them to get very hot and breakdown often


Students had mixed feelings about the openness between the classroom and the work space. Since there is no barrier, it can be inhibiting to people in the studio as they need to be quiet while working. However, some enjoy being able to listen to a lecture while working.
Low level prototyping station with materials provided.
Reynolds
611
Ziploc

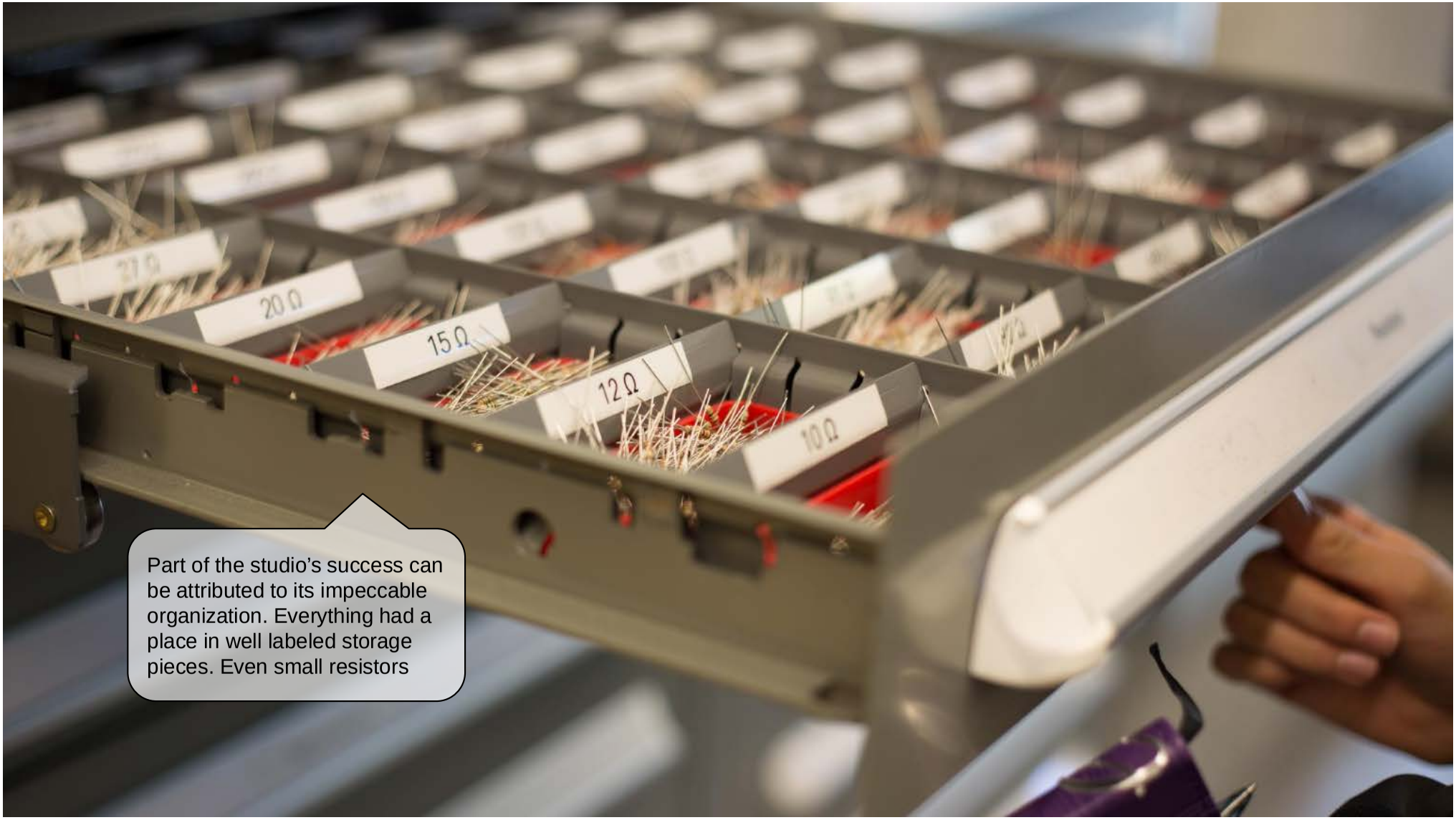

Glass walls of the tech suites allow for viewing of the studio below and maintain openness
The separation of the CEID into two floors allows for different type of work and socializing in each level.
Convenient and configurable access to power.


We enjoyed being able to view the studio from above and to see what was happening while we were working upstairs. However, this can be distracting for both the people above and below.
Sewing station added due to requests from students. Leave room for adapting to students wants.
Students have the ability to collaborate and plan projects on movable whiteboards.
! TOASTIE TOASTER !
Diagram of a Printer
PARTS

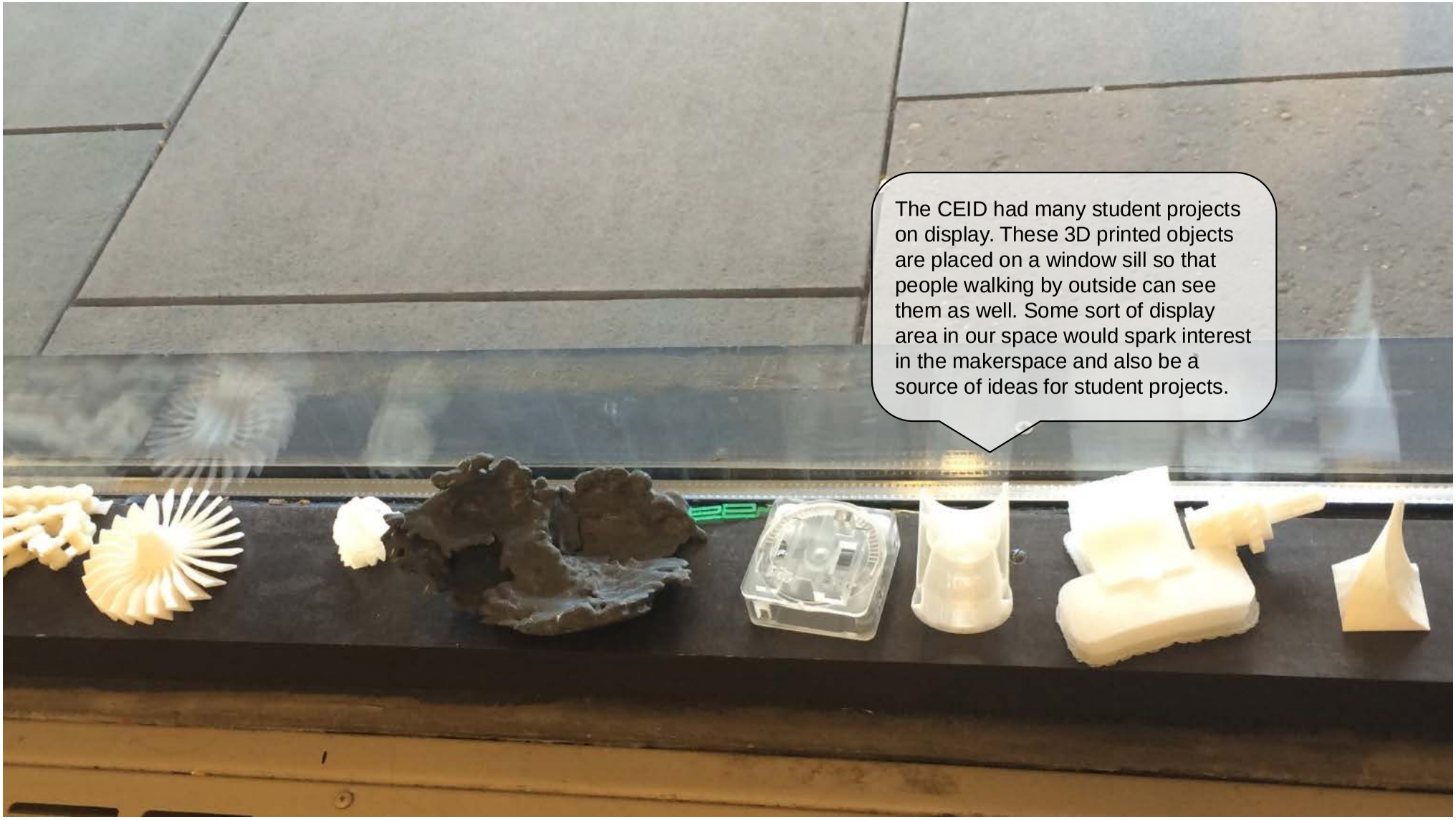

Students place images on the whiteboards to brainstorm ideas for projects. Magnetic boards would be helpful, and easier than using tape



The screen was right outside of the studio. We were thinking an interactive interface where people could click on an event and find out more details about it


20 Ω
15 Ω
12 Ω
10 Ω
Part of the studio’s success can be attributed to its impeccable organization. Everything had a place in well labeled storage pieces. Even small resistors


Lockers are available for extracurricular clubs and for students in design classes. Any leftovers can go to students doing personal projects, but it is rare to have any left over.
Connected classroom is also useful for speakers and workshops. Minimal walls maintain visibility of the classroom throughout the space.


The CEID had many student projects on display. These 3D printed objects are placed on a window sill so that people walking by outside can see them as well. Some sort of display area in our space would spark interest in the makerspace and also be a source of ideas for student projects.

A5 Index of people and places

The team would like to additionally express their gratitude and utmost respect to the following faculty members, professionals, students and organizations/places for allowing us to cite/reference them throughout the report. Their expertise in the key areas of this IQP were invaluable and are were greatly appreciated.

Places

1776: Business Incubator in Washington DC
Artisans Asylum: Community based makerspace in Somerville, Massachusetts.
Center for Engineering Innovation and Design: The hub for collaborative design and interdisciplinary activity at Yale University in New Haven, Connecticut.
Dartmouth College: Private Ivy League college in Hanover New Hampshire.
Franklin W. Olin College of Engineering: A private undergraduate engineering college in Needham, Massachusetts.
Marcus 5J (M5): The electrical and computer engineering makerspace at the University of Massachusetts Amherst.
Mechanical and Industrial Engineering Makerspace: Collaboration and 3D printing space adjacent to a machine shop at the University of Massachusetts Amherst.
Media Lab: Center for unconventional and interdisciplinary research at the Massachusetts Institute of Technology in Cambridge, Massachusetts.
Pappalardo Lab: Classroom and lab space for select courses focusing on design and fabrication at the Massachusetts Institute of Technology in Cambridge, Massachusetts.
Worcester Center for Crafts: Home to fully equipped spaces for ceramics, glass, jewelry-making, forging, bladesmithing and blacksmithing, enameling, and both digital and darkroom photography. Potential local organization to sponsor events.

Professionals

Curtis Abel: Professor of Practice in Undergraduate Studies at WPI
Torbjorn Bergstrom: Operations Manager of the Manufacturing Engineering Labs at WPI
Alfred DiMauro: Assistant Vice President for Facilities at WPI
Glenn Gaudette: Professor of Biomedical Engineering at WPI
Michael Ginzberg: Dean of the Foisie School of Business
Aaron Grossman: A member of Artisan's Asylum, leader of the mega-hexapod project Stompy, product designer by trade
Todd Keiller: Director of Intellectual Property & Innovation at WPI
Diana Lados: Associate Professor of Mechanical Engineering at WPI, Faculty representative on the Board of Trustees Facilities Committee
Laurie Leshin: 16th president of WPI and project customer
Dennis Monotone: Superintendent of Math and Science at the Bergen County

Academies in New Jersey
Jenna Noel-Grinshteyn: Coordinator of Admissions Outreach at WPI
Tom Partington: Lab Manager of the Unit Operations Lab in Goddard Hall at WPI
David Privitera: Former President of the Cambridge branch of IDEO and WPI Alum
Meagan Riley: Strategic Partnerships Manager at 1776
Jeff Solomon: Executive Vice President of Finance and Operations at WPI
Baird Soules: Senior Lecturer of Electrical Engineering and Director of Experiential Learning at Marcus 5J at the University of Massachusetts Amherst
Joseph St. Germain: Robotics Lab Manager in Atwater-Kent at WPI
Ken Stafford: Associate Professor of Robotics Engineering at WPI
Vince Wilczynski: Deputy Dean of the Yale School of Engineering and Applied Science, James S. Tyler Director of the Center for Engineering Innovation and Design at Yale University

Students

Association of Computational Machinery President: WPI Student
Biomedical Engineering Students: Two WPI sophomores that built a low-cost microscope compatible with a cell phone camera for diagnosing malaria.
Engineers Without Borders President: WPI Senior
MassChallenge Intern: A WPI sophomore that interned at MassChallenge
Robotics Club Student: A WPI sophomore involved with several personal robotics projects including an autonomous sailboat and BattleBots
Two seniors at UMASS Amherst: Two seniors that were a part of the founding of the MIE Makerspace at UMASS