Lowering barriers to extra-curricular use in biomakerspaces
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Introduction

With the development of enabling engineering capabilities for biology such as CRISPR-Cas [1], phage & yeast surface display [2,3], phage-assisted continuous evolution (PACE) [4], next-generation sequencing technologies [5,6], high-throughput DNA assembly [7,8,9] and resulting abilities for DNA synthesis [10], the refinement of dedicated disciplines in Biological Engineering [11] and continued multi-disciplinary interest at the interface of engineering and biology across departments, there is an increasing need for makerspaces to support the academic communities working with biology.

In the biological community, the DIY Bio movement advanced the availability of hands-on resources. Largely, these spaces have been in the community outside of the academic setting and cater to primarily an exploratory and hobbyist audience [12]. While being broadly accessible, these spaces are limited in what can be provided openly, and at little to no cost [13]. In addition to community DIY Bio spaces, commercial laboratory shared spaces, incubators, and accelerators provide space and access to equipment for serious start-up entrepreneurs [14]. Due to the costly infrastructure needed, high demand, and limited supply, access to these facilities can be difficult. Thus, neither of these types of spaces meets the needs of supporting the academic community.

Academic biological makerspaces have started to make appearances at several universities (e.g. UC Davis, Stanford, Johns Hopkins, U Penn, etc) [15,16,17]. Student groups are frequently associated with these spaces and have often been the driving force for their creation (e.g. ETH Zurich, Harvard), forging inter-institute a BioMakers Network.

Creating and sustaining biological makerspaces is a daunting challenge requiring the highest level of commitment and resourcing. All makerspaces share a series of basic requirements which include access a physical space, materials, equipment, safety programs, training, and facilities managers and supervisors [18]. However, wet laboratories and biological laboratories in particular have a unique set of challenges and logistical and safety considerations.

Due to the chemical and biological nature of projects (which vary dramatically), careful review and safety training processes are required. Spaces need to be appropriately designed and permitted for the type of work, including considerations for biological safety level (e.g. BL1 and BL2) and the type of biological samples and materials that will be used. Due to risks for cross-contamination, even projects with similar space requirements can be at conflict with each other (e.g. yeast and cell culture).

To achieve critical mass of capabilities requires a significant amount of space and equipment. Due to safety requirements, project materials cannot be taken in and out of the space regularly (as may be done in machine shops) and thus need to be stored in the laboratory across a range of temperatures. A large and diverse amount equipment needs to be accessible to maintain working temperatures, to mix and separate elements, to create safe working environments preventing exposure, measure and dispense materials, and provide support utilities. Due to the size scale and the nature of the work, analytical equipment is needed to assess the work products.

A wide range of materials, reagents, and consumable supplies are required for biological work, some of which may have restrictions in purchasing and shipping due to hazards requiring direct affiliation with a permitted facility. Many of materials and supplies are expensive, particularly enzymes, antibodies, and other biologics, and the minimum order size often exceeds the needs of a single user exacerbating the cost burden on projects.

A final major impediment is time. Biological project work requires extended duration, with schedules frequently dictated by multiple growth and incubation steps on the order of days and protocols requiring precise timing spanning hours. While all makerspace projects are likely to involve cycles of prototyping followed by testing and tinkering, these cycles are generally longer and more tedious when biology is involved. The project length and required commitment can be overwhelming to budding independent makers.

For a biological makerspace to be successful, it must address all of these challenges.

The Huang-Hobbs BioMaker Space

The Huang-Hobbs BioMaker Space is a 2,400 sq ft. facility at Massachusetts Institute of Technology (MIT) opened to the MIT community starting with Independent Activity Period (IAP) in January 2020. Thanks to the generous support of our benefactors and the vision of the founding team, the facilities of the Huang-Hobbs BioMaker Space are truly world class and can support a wide-range of top-tier independent research projects. However, we have learned that access to the facility alone is not sufficient to generate the full utilization desired. We should not live by the “if you build it, they will come” mantra; more is required for a successful Biological Makerpsace than state-of-the-art facilities.

Premise of Biomakerspace Engagement Use Cases

A. *Categories of Use*

All makerspaces support a variety of functions in the academic community. Channels for engagement can be broadly classified as courses, sponsored research, and extracurricular projects. Each category has a critical place in any academic makerspace; biological makerspaces are no exception. The balance of the uses varies depending on the sponsoring entity, the type of resources and facilities in the space, and the availability of alternative resources outside the space, and each space will find an intrinsic prioritization [19]. Generally speaking, the Huang-Hobbs BioMaker Space caters primarily to extracurricular projects, followed by courses, and sponsored research. This article focuses on extra-curricular users, however, it is important to note the importance of engagement via courses and sponsored research to fully develop the community and to expose a greater population to existence and capabilities of the biomakerspace.

B. *Extra-Curricular Projects: The BioMakers Journey*

An effective biomakerspace must be able to accommodate a wide range of interests, experience and commitment levels (Figure 1). Like all makerspaces, users come to the BioMaker Space with varying objectives and the space must be versatile enough to accommodate those objectives:

- Learn something new / see something cool (discovery)
- Learn and practice specific skill / technique (exploratory)
- Accomplish a discrete task (task / project support)
- Take on and complete a project (full project)
- Immerse in a field and community (super-user)

A "funnel" is a useful model for the number of users that fall into a given category as well as the typical progression of a single user (Figure 2). Large numbers of students enter at the discovery phase, a smaller number will progress to the exploratory phase, and an even set will pursue independent projects. The funnel should not be thought of as a stage-gate process constraining the progression of a single user or to explain the journey of every user (some individuals may jump straight to independent projects) and the goal should not be seen to progress all users through all stages of the funnel. Rather, the funnel is a typical distribution of use cases and a way to understand the average maturity and sophistication of the user base community in order to allocate resources and present opportunities and content appropriate to the population with the goal of maximizing the amount of personal growth facilitated.

While many students demonstrate interest in pursuing independent projects, the barriers to biological making can be prohibitive. Here we present the independent project user and the community advocate / super user / mentor, which are "the tail of the curve", as the ultimate best use and pinnacle of biomakerspace utilization because the facility is uniquely positioned to serve such users (hence the circumstances leading to the makerspace founding). We postulate that by aiming to maximize independent project use by cultivating a strong funnel we will build the strongest program for all users and maximize the utility and value of the makerspace.

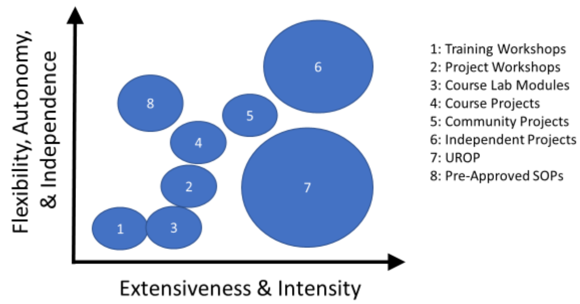

Fig.1 Uses of Makerspaces

Barriers of Biomakerspaces

Barriers for utilization of biomakerspaces fall into several main categories: resources, risks, and expertise (Figure 3). One resource barrier is access; biology dictates experiment schedules and a facility with suitable capabilities must be open at feasible times. Another resource barrier is cost; biological research materials are expensive. A final resource barrier is time; biological protocols are time consuming and must follow a prescribed schedule. Risk barriers include: safety, experimental integrity (i.e. contamination, equipment quality), and intellectual property. Expertise barriers center on experience, perceived complexity, and confidence.

Approach and Pillars for Success

Our first five years of operation illuminated three primary pillars for success in lowering the barriers in a biological makerspace to fulfills the mission and push the facility toward the maximum potential:

i) build a vibrant community by supporting student initiative,
ii) provide robust facilities to support a broad user base, and
iii) program content compelling for a wide range of interests and accessible to the full spectrum of ability and availability.

In particular, workshops serve a central role in strengthening the entire userbase, providing users with the motivation, experience, and confidence to pursue independent projects.

A. *Build Community & Cultivate Student Leadership.*

Benefits of engaging students for participation and leadership in space operation include: integration of student perspective to content and operation, peer-to-peer connection to engage the most extensive user base, growth experience for students through mentorship, and scalability of operational capabilities with minimal expense.

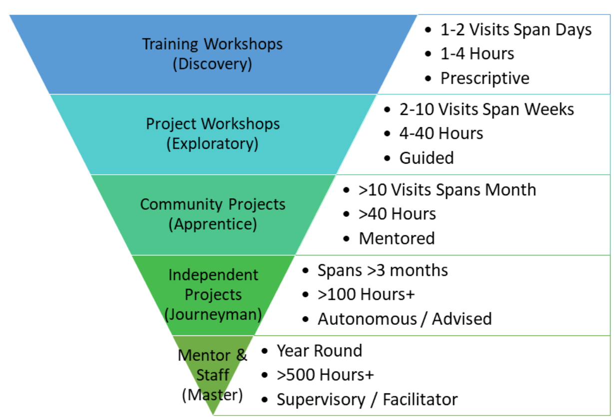

Fig.2 Funnel of Biomakerspace Users

Fig.3 Barriers to Biomakerspace Use

a. Social Programming in the Lounge Builds Community

The lounge space is instrumental in building an active community of biomakers. Furnished with ample seating and workspace, kitchenette, presentation capabilities, and creative display spaces, the lounge is used extensively for eating, planning, studying, project team meetings, seminars and lectures. Interestingly, the kitchenette has also become an important place for exploration due to the alignment between biology, chemistry, and food preparation; student projects have utilized the kitchenette for processes of making chocolate, yogurt, bread and other food items.

Coffee/tea hours and movie nights are hosted to stimulate a vibrant BioMaker community and increase awareness,. Coffee hours allowed folks to drop in and ask questions about the space and the student group in a casual setting. The movie series had biological making themes to facilitate socialization and prompt discussion about societal topics in biomaking.

b. Cultivate Student Leadership & Initiative

The formation of the Huang-Hobbs BioMaker Space was driven by several highly-motivated entrepreneurial students looking for a space to execute on independent research projects. Research faculty lab space is not a viable option for this type of student for two reasons: i) competition with sponsored research projects and the requirement for student and faculty alignment, and ii) detrimental entanglements on intellectual property (IP) hamper entrepreneurship.

Students formed the MIT BioMaker group to champion the initiative and support the needs of makers which quickly became a hub for student engagement. The student group forged relationships with other campus groups interested in biotechnology and entrepreneurship. Engagement was difficult during the remote period of the pandemic, but presentations featuring a virtual video tour were given to a variety of interested groups, and the student group maintained critical mass by holding virtual meetings and running a remote artistic project imaging household items through economical educational folding microscopes (https://foldscope.com/), demonstrating that while the physical space is important, community can exist without it.

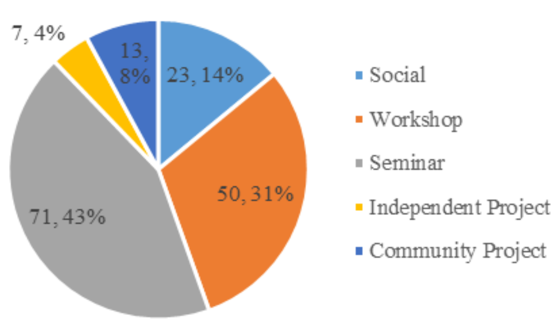

Fig.4 IAP 2020 Usage by Category

c. Seminars Provide Low Activation Energy Engagement for a Range of Interests from Education to Entrepreneurship

Seminars are an easy way to engage the spectrum on user interests. Two seminar series were offered during IAP 2020. The first focused on practical aspects of commercialization and entrepreneurship with speakers providing insights on business plans, fundraising, IP, and legal considerations of business formation. In particular, IP is a core topic, and preventing IP claims on space users is critical to removing a key risk barrier to students with commercial aspirations. The second series was about technology and ethics in which speakers discussed technologies in biomaking and facilitated discussions about applications and ethics. Both series were highly engaging, interactive discussions which worked well for the small size scale of lounge attendance (Figure 4).

To maintain community, the Huang-Hobbs BioMaker Space ran a virtual seminar series while campus access was limited. The summer 2020 seminar series centered on COVID-19: BioMaking Solutions, featuring speakers from industry and academia developing diagnostics, vaccines, and therapeutic interventions for COVID-19 (Figure 5). Well attended, the seminar series drew a different composition than the in-person and other IAP 2020 offerings. The spring 2021 seminar series, "Social Equity in BioMaking", featured topics impacting economically disadvantaged and under-represented stakeholder groups. Virtual content burnout and zoom fatigue were likely contributors to lower participation in the spring and a shift in the attendance profile more toward the composition of the student group (data not shown).

B. Optimize Breadth vs Depth of Laboratory Capabilities.

To preserve limited resources while providing a critical mass of facility infrastructure, makerspace start-up must balance long-term flexibility with short-term needs for capabilities.

a. Piloting Provides an Easy Entry Point for Biomakerspaces

The creation of a dedicated makerspace requires time and substantial resources, and a pilot period is an excellent way to assess student interests. Teaching labs offer an opportunity to leverage existing resources (outside class). The pilot period also provides opportunity to develop application, review, and training processes. After the resounding success of the MIT biomakerspace pilot period, a suitable space was identified, and funds were raised for renovation and equipping. All stakeholders were engaged in facility design led by campus facilities with external architecture and contracting firms.

b. Space Capabilities Should Encompass Community Interests

The entire Huang-Hobbs Laboratory is designated Biosafety Level 2. Separate workspaces are provided for microbiology and cell/tissue culture (TC); dedicated storage and TC Room usage protocols (e.g. cleaning, color-coded lab coats, TC-specific training, 70% ethanol wipe-in/wipe-out policy, etc.) are implemented to reduce cross-contamination. Providing strong safeguards lowers risk barriers for users concerned with the integrity of the biological work. Based on user interest, consider separate spaces for plants and fungi as well. The utility room is a critical to providing support functions to enable independent operations and includes: autoclave, ice machine, purified water system, and glassware washer.

Additional key features include: biosafety cabinets, chemical fume hoods, and instrument room with analytical equipment. Storage for common materials and projects must be available at ambient, refrigeration, freezer (-20C), and cryogenic (e.g. -80C and liquid nitrogen) temperatures.

Adjustable workbenches allow flexibility to accommodate the shifting needs of the users. The design of the mechanical, electrical, and plumbing systems may limit future flexibility, but excess capacity is costly, so advanced decisions need to be informed by equipment specifications. Using ceiling drop outlets with 120/240VAC supports future reconfiguration. Consult with professionals to ensure adherence to all relevant regulations and best practices for biological and chemical laboratory spaces including: air pressure, ventilation, climate control, electrical capacity, utility plumbing (including vacuum lines, compressed air, natural gas, and deionized water, as available), and safety equipment (e.g. safety showers, eyewash, fire extinguishers, spill kits, etc.).

c. Equipment Selection is Critical to Reduce Capability Barriers

Finding the right balance of equipment capability within space and budget limitations is a challenge. Core equipment needs to be research quality, but budget friendly, which typically means avoiding full-featured models. However, key qualities to remember when selecting equipment are: robustness, usability, ease of maintenance, and versatility.

Laboratory equipment and resources should begin with basic capabilities, with more specialized equipment focused on improving versatility and breadth of additional opportunities supported. Workbench equipment (e.g. micropipettes, etc.) need ample redundancy to support instructional workshops and large numbers of simultaneous users.

For specialized equipment, trades must be weighed between multiple equipment items for separate tasks vs. single equipment items with greater capability. Key factors weighing into that decision is the need for simultaneous use, available space, and the total financial lifecycle cost. Equipment items selected should reflect the types of projects of interest in the community. Supporting a specific type of work requires a critical mass of materials and equipment otherwise users will need to find alternative resources. In general, larger equipment should be selected which fulfills the greatest need possible. Including a limited amount of redundancy in the form of educational/hobbyist grade models can expand capacity while protecting budget.

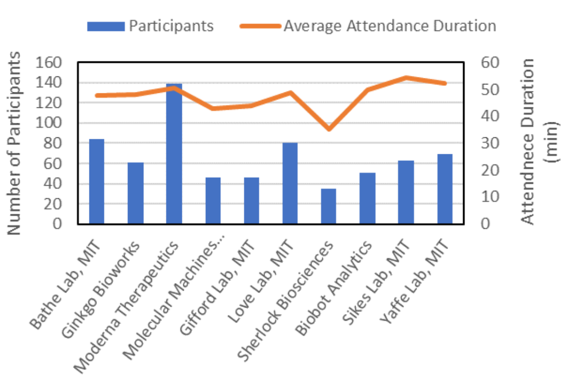

Fig.5 BioMaking Solutions Virtual Seminar Series Attendance

d. Stocking Materials Lowers Cost Barriers.

In the Huang-Hobbs BioMaker Space, stock materials, consumables, and prepared aliquots of reagents are available in common storage areas at the appropriate temperatures. The space maintains a library of common strains and genetic constructs as well as providing a limited amount of archive storage for past projects in ultra-low temperature and cryogenic storage. The availability of these materials, whether provided gratis or on cost pass-through basis, lowers cost barriers to projects, enabling less waste and more efficient use of project-specific funding.

e. Supervisor Staff & Reservation Systems Reduce Access Barriers

A strong group of supervisory staff enables greater space access. Utilizing graduate students (and a limited number of undergraduate students) and post-docs offers a budget-friendly way to enable a wider range of times than could be accommodated by faculty and staff. Supervisors should be screened for experience and demonstrated responsibility and need to be given additional training to prepare for response to issues which may arise.

Due to access restrictions during the phased reopening of campus makerspaces from the COVID-19 pandemic, a reservation system (https://clustermarket.com/) was implemented for booking workbenches to adhere to capacity limitations. While no longer needed for capacity, the reservation system aids in scheduling supervisors and ensures timely equipment access. Booking restrictions based on training status are implemented for certain equipment items.

C. Provide Programming & Support to Lower Barriers

The limitations to space utilization from experience requirements and time demands, which are inherently present in biological making are primarily met through programming and procedures to streamline access. As this type of facility is emerging, additional effort is also needed to demonstrate the opportunities available to users and the facility capabilities.

a. Introductory Training Workshops Attract Entry Users

An introductory workshop called Bacterial Photography was adapted from a synthetic biology project [20] during the pilot period. The workshop is a cornerstone of the MIT BioMaker program, training students on basic laboratory skills and introducing concepts in synthetic biology in a fun and visually engaging way. The Bacterial Photography workshop is run in a single 3-hour session and has been taken by hundreds of participants of all backgrounds and experience levels. Using this model, an introductory workshop was created and offers basics of targeted gene disruption using a CRISPR-Cas9 system with blue-white color change screening system. These experiences are the gateway of many users into the Huang-Hobbs BioMaker Space.

b. Exploratory Workshops Lower Time & Expertise Barriers

Exploratory workshops offer greater depth and experience than introductory workshops but require greater time commitment. These workshops need to be scheduled when users have suitable time available, so MIT's IAP (Figure 4) is a perfect opportunity. Analogous to equipment selection, programming should reflect the interests of the user base and align with the capabilities of the space. In addition to the variety of topics, the duration and complexity of programming should span the range of availability and experience of the user base.

An extended version of Bacterial Photography with five three-hour sessions containing additional molecular biology and cloning techniques is offered as an exploratory workshop to provide students with a greater degree of technical background and theory. In addition to Bacterial Photography, a three-week workshop called Biobots was modified from a previous course developed and offered at University of Illinois – Urbana Champagne [21], which introduces students to basic 2D and 3D TC techniques and basics of mechanical design (e.g. CAD) and fabrication (e.g. 3D printing and casting PDMS).

A recent focus has been enabling increased workshop participation (Figure 6) through the introduction of new subjects, including stomata imaging and CRIPSR. In addition, more workshops will be offered for the first time in fall 2022 under first year advising seminars.

c. Hands-On First Year Advising Seminars Leverage Workshops

Fall programming is heavy targeted at first-year students to create awareness and excitement. Introductory Bacterial Photography was offered to 50 first-year students in pre-orientation programs sponsored by Biological Engineering (BE) and Chemical Engineering (ChemE). The BioMaker student group also offered tours of the space and information sessions during orientation week.

The makerspace participates in hands-on first-year advising seminars (FAS), which allow students to explore topics of interest. The semester-long once-weekly sessions offer a special use-case for exploratory workshops. Bacterial Photography and Biobots were offered in 2019 and 2021 as projects under 6.A01 as introductions to engineering with biology. The BioMaker Space now hosts a dedicated FAS program to provide exposure to applications and techniques specific to making in ChemE (10.A01) and BE (20.A06) with an offering expanded to ten project offerings including: BioMaker TV, Bacterial Photography, Biobots, DNA Technology, Yeast Surface Display / Lateral Flow Assay, Bioreactors, Bio-electrochemical Systems, Water Reuse, Chemical Engineering at Home, and ChemE Car. In fall 2022, 100 undergraduate students participated in the seminar as participants or teaching assistants.

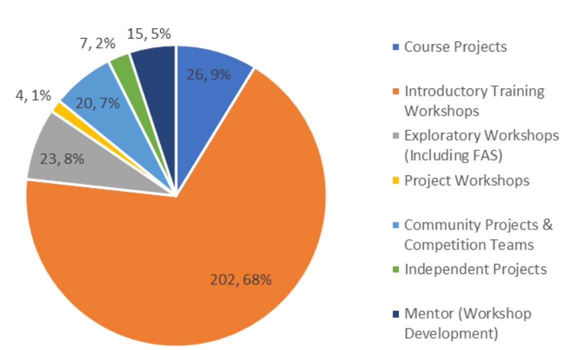

Fig.6 Huang-Hobbs BioMaker Space Participation, September 2021 – August 2022

d. Project Workshops Offer Creativity to Explore

Project workshops extend exploratory workshops by introducing an open-ended design to participants. These workshops offer greater flexibility and creativity but require additional user time and experience. Bacterial Photography has been offered as a multiple-week project workshop over IAP (Figure 6) in which students are challenged to design a system with alternative inputs and/or outputs. This project has served as an inspiration for extension projects.

e. Stream Safety Training to Lower Time Barriers for Workshops

Users should only be granted access when appropriately trained and supervised. In contrast to mechanical makerspaces, biological and chemical safety is not directly associated with equipment and can be encountered anywhere in the laboratory at any time. Thus, while equipment specific training is important in biological makerspaces, it is not sufficient for a complete safety program.

Appropriate training depends on the specific hazards of the space and considerations for the specific project. Customizing training for each user would be overly burdensome, so a general introductory lab-specific safety orientation for independent users should contain a minimum core of biological and chemical safety; project specific training items should be provided as relevant.

However, workshop users are not exposed to the full range of risks in the lab. Because workshop users work with defined materials, following prescribed protocols under constant supervision, the training materials should be limited to relevant workshop safety aspects to emphasize important content while lowering the time barrier to participation.

f. Community Projects & Competition Teams Build Independence

Community projects offer a bridge between prescriptive workshops and independent projects by providing basic training and then encouraging open-ended participation, creative contribution and exploration of project offshoots to further broader objectives. Community projects can start from independent projects or open-ended design questions in workshops, and in turn the offshoots of community projects result in new independent projects.

During the space launch, the BioMakers student group started two open community projects which engaged 13 participants (Figure 4), one on the development and testing of Manuka Honey microneedles for possible therapeutic application [22] and the other continuing the MIT '19 iGEM project engineering an immune cell storm response [23]. In 2022, a microbially induced calcium precipitation independent project turned into a community project (Figure 6).

Like community projects, competition teams offer structure, motivation, and institutional memory to catalyze participant growth. The International Genetically Engineered Machines (iGEM) competition is a fixture in the Huang-Hobbs BioMaker Space. The MIT iGEM team has worked in the space since '21 when the team project developed a probiotic therapeutic for maple syrup urine disease [24]. Despite not continuing the project, many '21 team members joined the student group and contributed to educational initiatives. The '22 team developed a therapeutic for oral mucositis.

g. Independent Projects Demonstrate the Most Barriers

During the pilot phase, 19 independent projects were proposed by 50 students over a three-year span. With dedicated space and resources, more applications were expected, but this has not immediately materialized, in part because of pandemic disruptions. We have observed poor follow-through and completion of biological registration, which we attribute mainly to barriers of time, expertise, and perceived complexity. In addition, cost barriers remain for many projects and some potential projects have been limited by suitability of space and available resources.

One student attempted to initiate an independent project during the pandemic. The first-year student proposed to extend a study of a DNA repair pathway from a high school research experience. The planning effort was highly educational but addressing the experimental design and biological safety questions was overwhelming to the student and demonstrates the challenges and pitfalls of independent projects for less experienced students. The student pivoted to developing a DNA damage quantification workshop based on established techniques [25].

An unexpected phenomenon of low project application follow-through was first observed in late spring of 2021. Many applicants did not complete a full application and/or respond to comments to finalize project registration, and as a result, summer independent projects were more limited than initially expected, raising a deeper issue.

h. Advising & Mentorship is Needed for Project Development

To facilitate the development of new project concepts, staff started offering brainstorming / planning sessions and office hours for independent projects. In IAP of 2020, seven participants which resulted in three new independent project applications. The practice has been resumed in fall of 2022. Applicants are also connected to mentors in the existing user community to help navigate the application process.

i. Two-Stage Application Process Identifies Challenges Earlier

A two-stage application process was introduced to improve follow-through and address miscommunications in the project approval process. It was hypothesized that splitting the process would lower a barrier and encourage more applications while streamlining the review process and saving review effort on unacceptable project applications. Stage 1 is a short form consisting of basic information to assess fit for the space. In 2021, Stage 1 was announced prior to the start of the fall term (8/12/2021). 15 Stage 1 applications were received for fall use. Two did not reply to request for clarification, and the other 13 were invited to complete the Stage 2 technical application to finalize safety review and biological registration. The new process appeared successful in encouraging applicants and aligning staff through the streamlined review process. However, only two applicants completed the Stage 2 application resulting in a low 15% conversion efficiency into running projects. The same trend was observed spring 2022 (data not shown).

The two-stage process has resulted in declining one project based on fit (<2%), and the low follow-though likely resulted in more dedicated users with greater level of activity.

j. Time & Complexity Barriers Remain Biggest Hurdles

We hypothesize two contributing factors to the low follow-through of the 2-Stage application. First, to accelerate information collection, the new Stage 2 format included all the questions and tables required to complete the biological registration process resulting in a more formidable and intimidating technical application. While information requirements did not change, prior applications shielded applicants from the bulk of information up front, and makerspace staff helped to manually translate information to the registration, often a rate limiting step in the registration process. Second, students returning to campus from remote learning experienced a "whiplash" effect from a higher than normal overloading which resulted in failure to follow-through on numerous endeavors. The overall conclusion was that the technical application still required too much effort and did not yet lower the application barrier.

k. Pre-Approved Materials Accelerate Entry to Space

Connections to academic courses strengthened in 2021-2022. Two senior design projects continued in the BioMaker Space via 20.381: Biological Engineering Design II. In support of curricular learning, cell culture workshops were offered through the BioMaker Space to students in the MIT NEET Living Machines program [26]. Five teams used the space to complete small projects for spring courses ranging from creation of a microbial fuel cell and a microfluidic incubator to testing of an insulating container. These teams were able to success on the space on short time-frames because of a utilization of pre-approved materials and procedures.

l. Teaching and Creating Content Promotes Mastery

The recent MIT BioMaker community centers on education, and unexpectedly the development of teaching materials has been a primary mechanism for engaging with more advanced students. During the remote period of the pandemic, students laid the groundwork for many workshops by developing background material and protocols. Through another program entitled "BioMaker TV", undergraduate students produced educational videos targeted at audiences ranging from middle school, to high school, to general public. Most videos featured animation or presentation, but one video was able to demonstrate hands-on techniques.

Conclusion & Lessons Learned

Five years of operation of the first biological makerspace at MIT demonstrated fantastic opportunities and formidable challenges. A small number of highly-motivated students were primed to take advantage of the broad capabilities in the best in class state of the art facility, but the majority of the user base was engaged through a range of programming content targeted across a wide spectrum of interests, experiences, and availabilities. Our ongoing priority is to continue increasing the accessibility of the space by lowering barriers to participation. We expect that further increasing workshop participation will increase independent project application and continued support and streamlining with improve application follow-through leading to a greater number of independent and community projects in the Huang-Hobbs BioMaker Space.

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