2021 MAKERSPACE
IMPACT REPORT

UNIVERSITY OF MARYLAND
18 56

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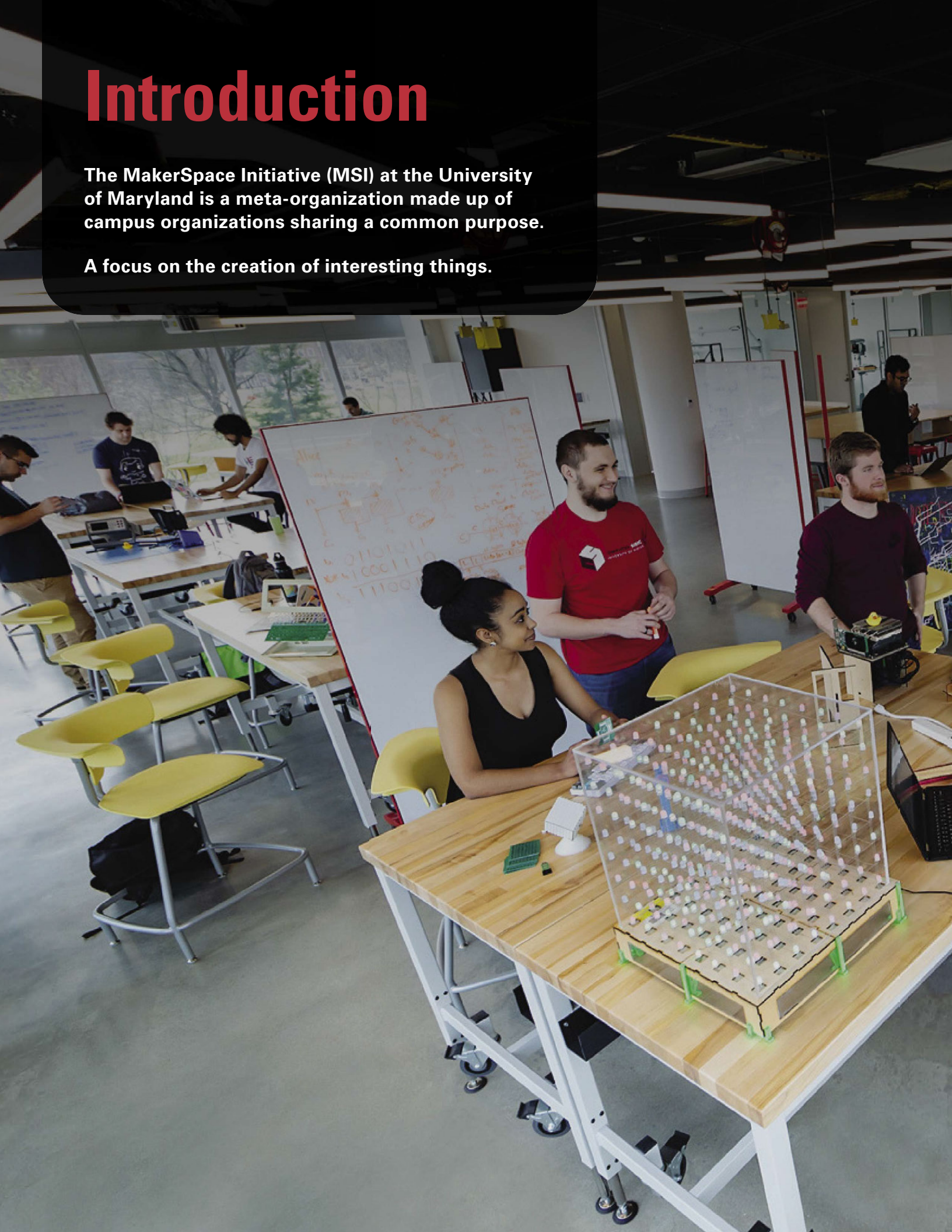
Introduction

The MakerSpace Initiative (MSI) at the University of Maryland is a meta-organization made up of campus organizations sharing a common purpose.

A focus on the creation of interesting things.



A FOCUS *on the* **creation** *of* **interesting things**

MSI member organizations have physical locations where their maker-members gather to create the interesting things they are passionate about. Each of our locations is different; many are chock full of technological gizmos such as 3D printers and laser cutters, while others focus more on high-touch offerings such as letterpress printing and woodworking.

As a meta-organization, the MSI was formed to better share our resources and to collectively improve access and safety in lab spaces used by the campus community.

To help the reader better understand our work, this document provides an overview and history of makerspaces in general and a brief history of makerspaces on the College Park campus. The creation of the Makerspace Initiative, its founding principles, first year goals, and challenges are discussed. Since many readers will care most about the impact MSI has had on the UMD community, we've included a section that provides examples of projects created at MSI makerspaces and joint initiatives undertaken by MSI members.

Having established the historical narrative, future iterations of the annual report will focus on the previous year's accomplishments. This report covers the time from the start of the initiative until June 2020.

Background & History of
Makerspaces

Interest in Makerspaces has accelerated over the past decade or more. The increasing power and decreasing cost of computer technology led to its use by hobbyists to automate traditional machine tools through conversion to Computer Numeric Control (CNC) operation.

This led to consumer versions of tools such as 3D printers and laser cutters.

While these tools were becoming cheaper, for some the cost was still beyond what they could justify for hobby use. In the late 1990s and early 2000s, groups of hobbyists began forming shared workshops and equipped these with this new technology. Initially these were called **Hackerspaces**, since many of the early members were also computer hobbyists and self-identified as **Hackers** who solved problems and built new things by hacking their way to a solution.

Later, after the launch of *Make Magazine,* the terms Makerspace, Maker, and Making became more commonly used to describe the same ideas. All of this happened at a time when many were rekindling their interest in do it yourself (DIY) projects, feeling nostalgia for long-shuttered school woodshop programs, and missing the satisfaction experienced through the creative process. These individuals were drawn to Makerspaces to learn new skills and foster their creativity.

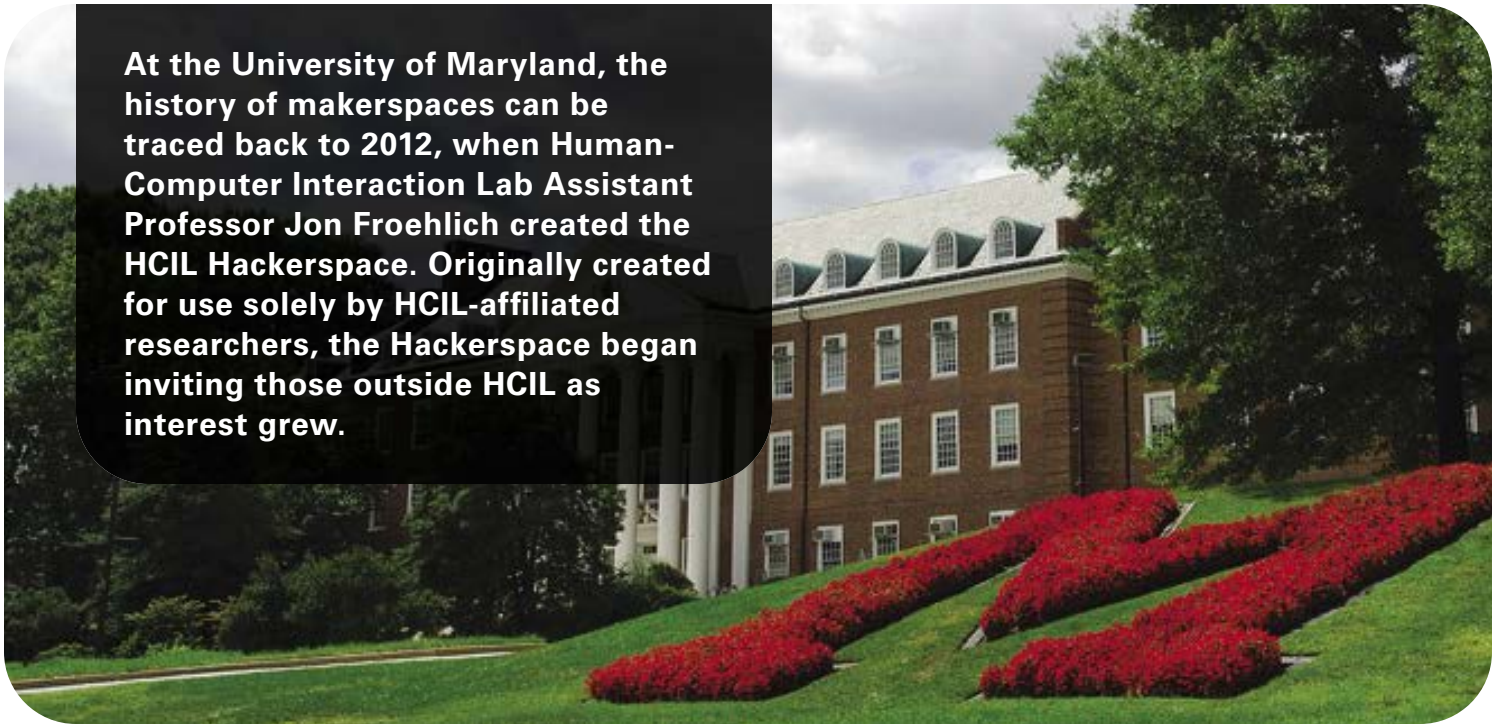
Finally, the past 10-20 years have seen the creation of entirely new forms of media, which empower individuals to become content creators and even media celebrities in their chosen niche. Makers began sharing their projects and knowledge on social media channels such as YouTube and Instagram as well as on special interest forums (such as Hackaday.com, ElectronicsHub.com, and CNCzone.com). Interest in making has spread so quickly that traditional broadcast media is only recently catching up, with TV shows such as NBC's *Making It.*

University Makerspaces evolved over this same period of time but had a more deeply-rooted history to draw on.

Many academic institutions have long operated machine shops, architectural model shops, art studios, scenery shops, and other spaces for creation of physical artifacts related to particular programs or courses. In 1938, students at MIT, working with the Institute's Vice President at the time, Vannevar Bush, created the Hobby Shop as a general-interest workshop open to all students. Several other institutions created similar student spaces and these have evolved from machine shops and woodworking shops to more modern makerspaces. A unique type of compact academic makerspace, FabLab, began in 2001 as an NSF-backed research project and has grown to more than 1750 locations worldwide.

History of Makerspaces at the

University of Maryland



At the University of Maryland, the history of makerspaces can be traced back to 2012, when Human-Computer Interaction Lab Assistant Professor Jon Froehlich created the HCIL Hackerspace. Originally created for use solely by HCIL-affiliated researchers, the Hackerspace began inviting those outside HCIL as interest grew.

The first publicly-accessible makerspace on the UMD campus opened in 2014 when student organization Terrapin Hackers opened Collider Makerspace in the basement of the Chemistry building. Because it was student-run, it had irregular operating hours and lacked well-defined procedures for training and enforcing safety rules. Around this same time, Preston Tobery's initial offering of 3D printers in McKeldin Library became the John and Stella Graves Makerspace. Terrapin Works was founded at the Clark School of Engineering to provide access to advanced additive manufacturing tools to the Engineering community. It was quickly adopted by the freshman engineering course ENES 100: *Introduction to Engineering* and the Clark School Keystone Program. From there, it expanded to provide a mix of hands-off production services and hands-on experiences with a wide range of fabrication technologies throughout the Engineering curriculum.

In 2015 Professor Bill Pugh opened the first Sandbox Makerspace in the Computer Science Instructional Center.

Makerspaces quickly became a greater part of campus life. A 2016 article on Medium.com listed four makerspaces among seven of UMD's Spaces for Creative Thinkers.

The author, Amritha Jayanti, tells readers of her surprise that *"attending [one] event would change the rest of my college experience."*

New makerspaces continued to open on campus while others closed. The STEM Library began offering 3D printers for patron use in 2015, which led to the opening of a formal makerspace in 2017. Vortex opened in the former Physics Welding Shop in early 2018 and BookLab opened its space in Tawes Hall in September 2018. Sandbox moved to a larger space in the newly-built Iribe Center when that building opened in April 2019. Collider shut down when student leaders of Terrapin Hackers moved on. The HCIL Hackerspace went dormant subsequent to the founder's move to another institution.

Individual makerspaces were developing their own informal knowledge and support networks within the University but no formal organizational structure existed. Each of these openings represents a duplication of effort as new leaders struggle to navigate the startup process, implement policies and procedures to ensure compliance with regulations, create training materials, and promote their new spaces across campus. The closing of any makerspace also results in the loss of organizational knowledge.

Creation of the

Makerspace Initiative

In early 2018, Emeritus Professor Bill Pugh proposed making a donation to support the future of makerspaces on campus.

Dr. Pugh began negotiations with the Department of Computer Science and the Clark School of Engineering to plan a sizable donation he intended to make in support of makerspaces. Most of his donation would be given to the Department of Computer Science to cover initial operating expenses for Sandbox (the Jagdeep Singh Family Makerspace) in the Brendan Iribe Center. One third of Pugh's donation would be directed to Terrapin Works in the Clark School to support the creation of a campus-wide organization supporting makerspaces.

Dr. Pugh understood that this effort would be an exercise in building a coalition of the willing makerspaces on campus, and as such, there were no obligations for any makerspace to join the newly-created Makerspace Initiative (MSI).

Founding Members

The newly-formed MSI reached out to all workshops, machine shops, labs, and makerspaces on campus and invited each to a series of monthly meetings with tours of each other's spaces. These meetings helped interested parties understand the goals of the MSI and determine if they wanted to take part in the initiative. MSI was able to recruit all existing makerspaces and several other workshops — such as the Scene Shop at The Clarice Performing Arts Center — that don't necessarily fit the traditional definition of a makerspace but will contribute a great deal of expertise in important areas. The founding MSI maker spaces are profiled in this section.

BookLab

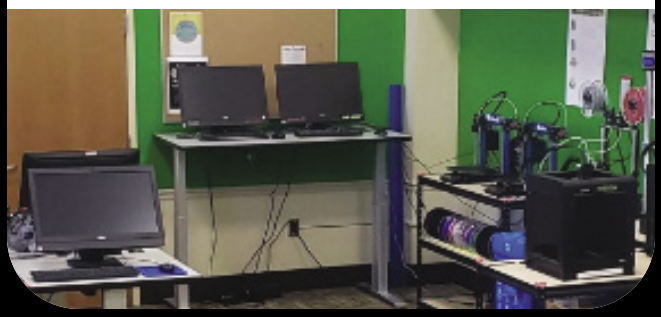
BookLab in the Department of English offers a space combining elements of the traditional book arts with new platforms for digital expression. Far from believing that books are "dead," BookLab aims to have students and others explore this moment of media transition in creative and active ways—from movable type letterpress to 3-D printing, from page to screen and everything that happens in between. To that end, BookLab maintains a printing studio with traditional presses and hand-set type. It also offers materials for bookmaking and bookbinding, a library of rare and unusual books, 3D printing, wearable and embeddable sensors, and more. BookLab supports classes throughout English, ARHU, and elsewhere on campus.

Sandbox: The Jagdeep Singh Family Makerspace

The Jagdeep Singh Family Makerspace is a 5,400 square foot makerspace in Iribe Center which provides a welcoming and inviting setting to master a wide range of maker technologies. The space, informally known as The Singh Sandbox, has individual studios for electronics, crafting & sewing, digital media creation, woodworking, CNC machining, and rapid prototyping using 3D printing and laser cutting. Access to Sandbox is free to anyone with a UMD ID. It uses the ELMS/Canvas Learning Management system to host basic training modules so makers can begin their maker learning journey before stepping into the makerspace. The volunteer staff of roughly 25 students serve as mentors to makers learning to use new tools and technologies.

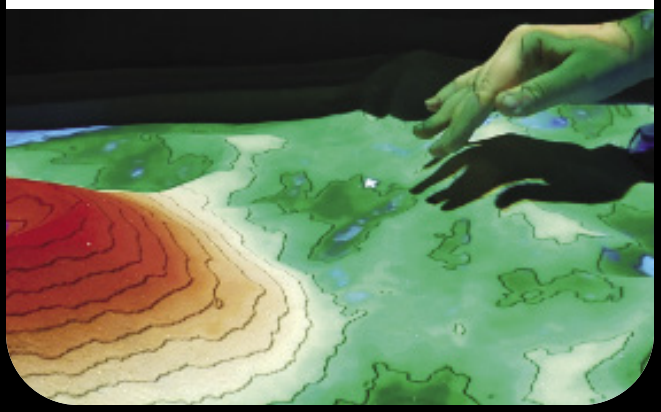
The John & Stella Graves Makerspace

The John and Stella Graves Makerspace is located in the Terrapin Learning Commons on the second floor of McKeldin Library. Open to the entire campus community, the makerspace allows users to experiment with emerging technologies, create 3D models and 3D printed prototypes, digitize legacy media, and create podcasts.



STEM Library Makerspace

STEM Library Makerspace aims to provide university students, faculty and staff with hands-on experience and access to emerging technologies. It currently teaches and trains on 3D printing, laser cutting, and augmented reality through the use of its AR Sandbox. The hope is to empower the UMD community to create, innovate, problem solve, and learn through activities in a multitude of disciplines.

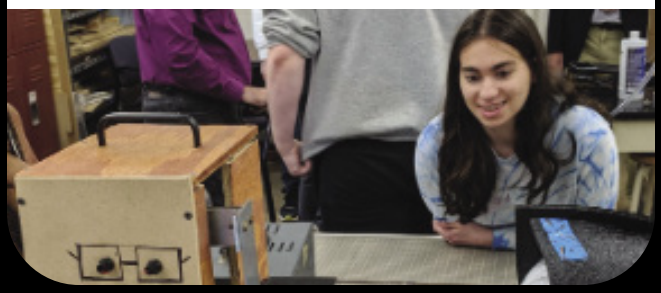


Terrapin Works

Terrapin Works is a collection of rapid prototyping, advanced manufacturing, and digital design resources provided as a service to the campus and surrounding community. These resources range from 100+ consumer, research and industrial grade 3D printers, to high-end subtractive production systems capable of creating complex parts in a variety of materials. Terrapin Works offers production and design services as well as access to equipment in our 17 locations and 28,000 square feet of lab space across campus.

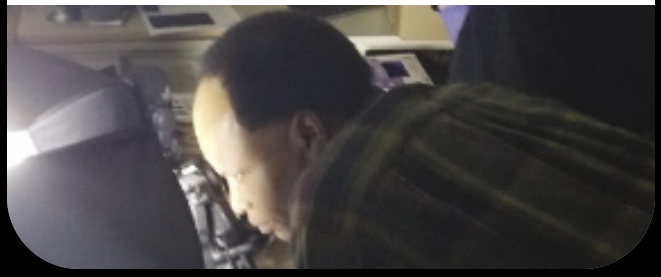
Vortex

Vortex encourages learning, investigation, and collaboration through practical projects in electronics, fabrication, coding, and more. The focus is on skills that are useful to a physics major in their career, but are not taught in any courses at UMD. While built around UMD physics, the same skills are useful in a range of fields so all are welcome. Vortex is located in the former Physics Welding Shop (Building 111), tucked away in the courtyard between the physics and chemistry buildings.



Architecture, Planning & Preservation FabLab

The Fabrication Lab (FabLab) enables students and faculty members to construct digital and physical 3D scale models of urban sites, landscapes, buildings, and building components. The FabLab consists of two shop spaces: one space is principally devoted to fabrication of architectural model components in a range of materials using both traditionally analog and digital CNC shop equipment; the second space utilizes rapid prototyping equipment including 3D printers and laser cutters to complement the full scope of industry standard fabrication capabilities.



The Clarice Scene Shop

The Clarice Smith Performing Arts Center (The Clarice) is equipped with a series of workspace responsible for creating costumes, scenery, props, and lighting for the Department of Theater, Dance and Performance Studies (TDPS), School of Music (SOM), and supports performers from the Artists Partnership Program (APP), as well as other programs that come into any of The Clarice venues. The Scene Shop shares spaces, materials and equipment with the Prop Shop and Paint Shop and works in conjunction with them as well as with the Costume Shop and Technology Shop (which provides lighting, video/projections, and audio production). All told, The Clarice production shop spaces support or employ several hundred students, faculty, and staff during an academic year. Since the shop's primary responsibility is supporting productions and training Clarice students, it does not offer a community workshop space but does frequently contribute expertise and equipment to MSI projects.

Creation of the Makerspace Initiative

Architecture, Planning & Preservation FabLab
School of Architecture Planning & Preservation
Architecture
ARC 0110

BookLab
College of Arts & Humanities
English
Tawes 3248

Singh Sandbox
College of Computer Mathematical & Natural Sciences
Computer Science
Iribe 1231

STEM Library Makerspace
University of Maryland
Libraries
STEM Library

The Clarice Scene Shop
College of Arts & Humanities
The Clarice Smith Performing Arts Center
PAC 1702

Terrapin Works
A. James Clark School of Engineering
Engineering
Many Locations

The John and Stella Graves Makerspace
University of Maryland
Libraries
McKeldin Library

Vortex
College of Computer Mathematical & Natural Sciences
Physics
Physics Welding Shop (Building 111)

MSI

Guiding Principles

Much of MSI's first year was dedicated to making connections between the spaces on campus and better understanding the challenges we face. Initial goals and initiatives were established and work began on these while the process of formalizing MSI's mission statement continues.

As an initial framework for building out our formal mission statement, MSI established our Guiding Principles, which echo the University's top-level mission statement. **MSI strives to assist our members by supporting excellent teaching, research, and service to all MSI member makerspaces.**

Teaching

- Provide high-quality, standardized training beyond the basic use of common tools.
- Provide office hours for learners to hone their skills with expert guidance.
- Support students moving between makerspaces by allowing training portability.
- Support campus teaching programs that would benefit from makerspace access.
- Supplement theoretical classroom learning with hands-on experiences completing real world projects that combine the elements of STEAM.

Research

- Support new and ongoing research projects, assist researchers by providing tools and services, and help them to find solutions to obstacles in their work.
- Support collaboration across Schools and Colleges, departments, and campus units.
- Promote visibility of makerspace efforts to researchers across campus.
- Serve as a resource for researchers interested in working on topics related to maker education, digital fabrication, and other areas related to the maker movement.
- Offer solutions to other colleges and universities and to non-profit community makerspaces.

Service

- Provide venues and resources for hack-a-thons and other maker-related events.
- Provide venues and support for campus departments and student organizations.
- Serve as a resource to the various makerspaces on campus and advise campus leadership on makerspace activities and policies.
- Provide/share functionality that will support makerspaces across campus.
- Solicit additional support for the campus-wide maker community.
- Share lessons learned with others in the maker community.
- Serve others in the region, solving problems appropriate to our technologies.

MSI

Startup Goals

Focusing on Initial Priorities

During our first year as a group, MSI established a set of startup goals based on our founding principles and discussions among members. Most of these discussions revolved around common themes such as improving visibility, efficiency, and safety.

An early indicator of the need for an organization such as the MSI was the general confusion and lack of knowledge about existing makerspaces on campus. The situation was explained in more detail on page 16 and was perhaps best described by a *Diamondback* columnist:

> **The University of Maryland has a variety of designated makerspaces scattered across the campus. These spaces have materials available for student use, but they aren't always marketed broadly. They're a bounty for any student at this university, and they can be used to support powerful student initiatives. Activists should seek to utilize this university's bevy of makerspaces to galvanize their movements, and the university should likewise work to advertise their makerspaces more widely.**
>
> > Student activists should use Makerspaces. UMD should make them more visible.
>
> *Lexie Werner*
> *Diamondback, 2/20/20*

MSI identified the most important areas of focus and set their initial goals.

ALIGNING
MSI Makerspace Goals with Department and College Strategic Plans

INCREASING
Campus Awareness of MSI Makerspaces

IMPROVING & STANDARDIZING
Makerspace Training Materials

DEFINING
Key Metrics, Create and Deploy Surveys and Systems to Track these Metrics

STANDARDIZING & IMPROVING
Makerspace Safety Policies and Practices

IDENTIFYING & PURSUING
Other Cooperative Efforts

ALIGNING
MSI Makerspace Goals with Department and College Strategic Plans

MSI believes that member makerspaces should align their individual operations and goals with the larger goals of their departments, schools, colleges, and the University.

Alignment with these higher-level goals helps makerspaces to be more relevant to the University and to contribute more directly to its successes. **A couple of examples are:**

The Office of Sustainability's GreenOffice program. Several MSI members are working to achieve targeted levels in this program by applying GreenOffice principles to their makerspace operations. The Clarice Scene Shop has worked diligently to have their lab spaces follow better environmental awareness practices and has attained a GreenOffice "Silver" status. This endeavor extends beyond Clarice students and staff and includes working with vendors and campus Waste Management to come up with creative ways to be a more green space.

Aligning makerspace operations to higher-level goals often requires planning ahead and recasting these goals to better apply to the specifics of makerspace operations. An example of this is Terrapin Works creatively reworking of GreenOffice principles into their GreenMakerspace initiative. Rather than throw away failed 3D prints, Terrapin Works has been sorting these by material and color, storing the waste material in the most reusable form possible while continuing to search for a practical and cost-effective recycling solution.

Using some of this stored waste material, Terrapin Works tested several commercially available recycling options as they became available. After evaluating promising technologies, they developed a plan to invest in an injection molding machine capable of producing new objects from the formerly unusable waste. Assuming this proposed solution receives funding, multiple benefits will be achieved. Not only will several hundred pounds per year be removed from the University's waste stream, students will gain access to a new manufacturing capability, learning to use the most ubiquitous manufacturing methodology at reduced cost by re-purposing the waste stream from Terrapin Works 3D printing operations.

Once this process is implemented, other makerspaces could have their waste material recycled, potentially removing a thousand pounds or more of plastic from our waste stream. To accelerate this process, Terrapin Works has begun applying for university grants provided through the office of sustainability and facilities to help subsidize the cost of acquiring this specialized equipment.

While the pandemic shut down forced us to shift priorities and slowed progress on our alignment goal, it presented a new opportunity to better align makerspace operations with the pandemic-imposed university goal of supporting remote learning:

The Clarice Technology Shop is working in conjunction with the Michelle Smith Performing Arts Library and the Division of Information Technology to stream performances over the Internet. They are making use of new technologies and streaming software. While coordinating with venues and departments, the Technology Shop is working with libraries to evaluate the potential of archiving performances and navigating issues pertaining to broadcast rights. This project included streaming She Kills Monsters, the TDPS production at the end of the Spring 2020 semester, which garnered international acclaim for innovative use of technology to stream the show with cooperation from the playwright.

The STEM Library is planning an online training module that allows a student working remotely to learn most of what they will need to know before using their Glowforge laser cutter. This training will remain useful even after students return to campus, providing an additional learning path to help them master the finicky aspects of marking up a design created in Adobe Illustrator to properly instruct the laser how to cut, score, or engrave a particular part of the design. This course will allow the student to more completely understand and make use of the Adobe Illustrator software package included in the UMD student software library. By helping students gain skills so they move more directly from an idea to a laser-cut project, this training module will continue to benefit MSI by reducing some of the waste produced by trial-and-error learning efforts.

Leveraging our efforts to provide tool training using the ELMS / Canvas LMS, MSI made plans to create additional makerspace training modules that could be completed remotely. While it's obviously not possible to learn how to safely use a dangerous tool such as a table saw or milling machine via remote learning alone, there are other makerspace skills that can be completely or partially learned this way. Sandbox created a proof of concept training module on the basics of soldering that made use of short video clips to replace some of the visual learning opportunities lost by not being on campus. This pilot was followed up with additional modules on using a popular computer aided drawing (CAD) program and a planned module on the Raspberry Pi single board computer.

INCREASING
Campus Awareness of MSI Makerspaces

Helping students better understand the availability of campus makerspaces was clearly a need.

Increasing our participation in the Student Organizations Resource Center (SORC) database and events. By cooperating as a group, we were able to increase our visibility to students. MSI was active participants in many events such as, First Look Fair and Maryland Day.

MSI created a new website that lists campus makerspaces and provides information about each space. Before the creation of this website only incomplete makerspace information was available which was not being regularly updated. Information on makerspaces was spread across many different websites. The new page is already generating traffic, having been mentioned on Reddit and other sites.

MSI Website and Locator Map

makerspaces.umd.edu

The MSI website includes an interactive map showing each campus makerspace's location. Each location's pin provides information about the type of makerspace, website, and a point of contact. MSI worked with the campus GIS and Facilities Management on developing and incorporating this data into the official UMD map maps.umd.edu as a campus service.

Future enhancements to the MSI website will include:

- **A searchable database of tools** available at each makerspace so makers can determine the best space(s) for a particular project.
- **A shared calendar of makerspace events.** This would widen the audience for any event by any MSI makerspace.

IMPROVING & STANDARDIZING
Makerspace Training Materials

One the most resource-consuming activities for a makerspace is the creation of training materials, policies, and standard operating procedures.

As drafting many of these materials requires a high level of knowledge and experience, the task can represent a significant investment for a makerspace trying to establish itself.
MSI sought to address this concern in several ways:

Create Shared Repository for MSI Members
As the MSI is composed of both established makerspaces and startups, one of the first actions for the organization was to create a shared location for MSI members to build a repository of training materials and policy documentation.

Test Self-Directed Training Using ELMS/Canvas LMS
One early initiative tested by the Singh Sandbox was to create self-directed training modules for makerspace tools. The use of self-directed training was important for the success of their model which used a volunteer staff. Less expertise would be required from them if they were not responsible for ensuring all students received uniform tool training. By allowing students to complete much of their training independently using UMD's ELMS/Canvas Learning Management System (LMS), simple tools, such as a battery powered hand tools, can be used immediately after completing the training and passing a quiz. More complex tools, such as laser cutters, require the student to demonstrate proficiency by completing an assigned project designed to simplify evaluation of student success. The success of these efforts led to wider use of ELMS training mentioned elsewhere in this section.

Implement System for Maintaining Internal Procedures
Realizing the need for well-organized internal procedure documentation, Terrapin Works researched available systems to support this need and negotiated a contract with provider Dozuki that allowed use by all MSI members.

Create Working Group to Standardize Training Materials.
The initial ELMS/Canvas efforts mentioned above prompted the creation of the SOP/Training working group in June 2020. This group took advantage of the pandemic shutdown to begin work on a series of more generic training materials that could be used by any MSI makerspace.

DEFINING
Key Metrics, Create and Deploy Surveys and Systems to Track these Metrics

MSI is working to understand the metrics that matter most to campus stakeholders inside and outside of our organization.

We need to better understand these stakeholders to be able to best characterize and collect relevant data. As part of this process, MSI created a Metrics Working Group to look at what's been done in this area and plan for future enhancements. **A few examples of our efforts in this area:**

The STEM Library Makerspace keeps metrics on things like filament usage, hours printed, number of training sessions completed and parts requested through their "print a part" form. These metrics are important for day-by-day management purposes as they tell a lot about what's happened, but they do little to explain why it's happened. For example, did the space receive an increase in interest one month because a promotional event was successful? Or was this increase because another lab went down on campus? Being a part of MSI, and having better communication with the rest of campus should help us face these types of challenges.

Install System to Automate Collection of Makerspace Usage Data
Several MSI makerspaces began collecting data about visitors using their spaces by repurposing a software tool called LabSwipe which was written and maintained by students in 2017 for Terrapin Works and modified for broader use in early 2019. This system was originally designed to collect usage data by requiring visitors to swipe their university ID card when entering the space.

A substantial upgrade by Terrapin Works is planned for release and LabSwipe will be renamed Makerspace Manager (MSM) in 2021. Most of the changes are to improve stability and make future improvements easier to implement. Feature additions were discussed as well, such as allowing users to find tools at other makerspaces across campus.

Based on experience using LabSwipe, several desired enhancements were added to the development list for future upgrades. The most significant of these was expanding the system to provide a lock out of individual tools based on the card holder's training accomplishments. This would require a separate card swipe to occur each time a potentially dangerous tool was used. While the primary motivation for this change was to help enforce safety rules, this new capability would also improve tracking of tool usage and could help us know more about the length of visits and visitor engagement. Related to this enhancement was another that would provide an integration between MSM and the ELMS/Canvas LMS to ensure that training accomplishments were automatically updated from Canvas to MSM.

Sandbox created a survey in Fall of 2019 to gather information about users of the space, their needs and preferences, and suggestions for improvements. The results of this survey helped guide the creation of training materials and setting open hours. STEM Library surveyed Makerspace users in 2018, completing interviews with users and professors about what equipment/services they felt were missing on campus. These initial surveys demonstrated their value and prompted the planning of a follow-up survey in 2020 that would be coordinated by MSI. Unfortunately, this follow-up was postponed because of Covid-19 closures.

In December 2019, Sandbox collected information from the LabSwipe access system they started using that September. LabSwipe is a computer system used to track users of a lab space. Even this limited dataset was useful for showing busy times of day, frequency of visits, and popular versus unpopular equipment. This analysis also demonstrated some limitations of the data collection methods and suggested improvements we should make to the LabSwipe system to address these. As an example, a recommendation was made that data collection would be greatly improved by modifying the system to have card swipes done closer to each tool being used rather than at the entry door. This would have the add-on effect of improving the measurement of length of visit.

Create Ongoing Surveys

Based on initial analysis of the results from Sandbox's Fall 2019 survey, it was decided to move forward with an expanded annual survey of makerspace users. Planned for the fall of 2020, this annual survey was postponed because of the pandemic shutdown. While future surveys will continue to collect information about current use of makerspaces, we also plan to ask questions intended to reveal more about respondents' perceived barriers to their use of makerspaces.

STANDARDIZING & IMPROVING
Makerspace Safety Policies and Practices

Starting and running a campus makerspace is a challenging endeavor.

With many tasks competing for the manager's attention, it's easy to lose focus on the need to create safety policies and procedures, especially if the manager is unclear on what is necessary. **MSI sought to address this concern in several ways:**

Assist New Makerspaces with Establishing Safety Policies. MSI makerspaces — such as Terrapin Works and the Clarice Scene Shop — that are familiar with campus safety practices have worked to help guide the establishment of policies for other makerspaces on campus that are just starting up or are encountering new issues. Working together, we help with matters such as specifying what PPE is required, establishing basic shop tool use protocols, and the handling of injuries and required forms for them. Most importantly, new spaces are walked through the process of establishing a relationship with the UMD Department of Environmental Safety, Sustainability & Risk (ESSR) to ensure these spaces become part of the ESSR monitoring system.

Develop Standardized Training in ELMS/Canvas. The Training / SOP group developed a series of standardized training modules for commonly used tools such as a battery-powered drill. As the COVID lockdown continued, additional training modules were created for skills such as soldering and learning to use the Arduino microcontroller using the electronic circuit simulator at TinkerCAD.com. These training modules provide a useful way for students not on campus to continue improving their maker skills and remain engaged with their on-campus makerspace.

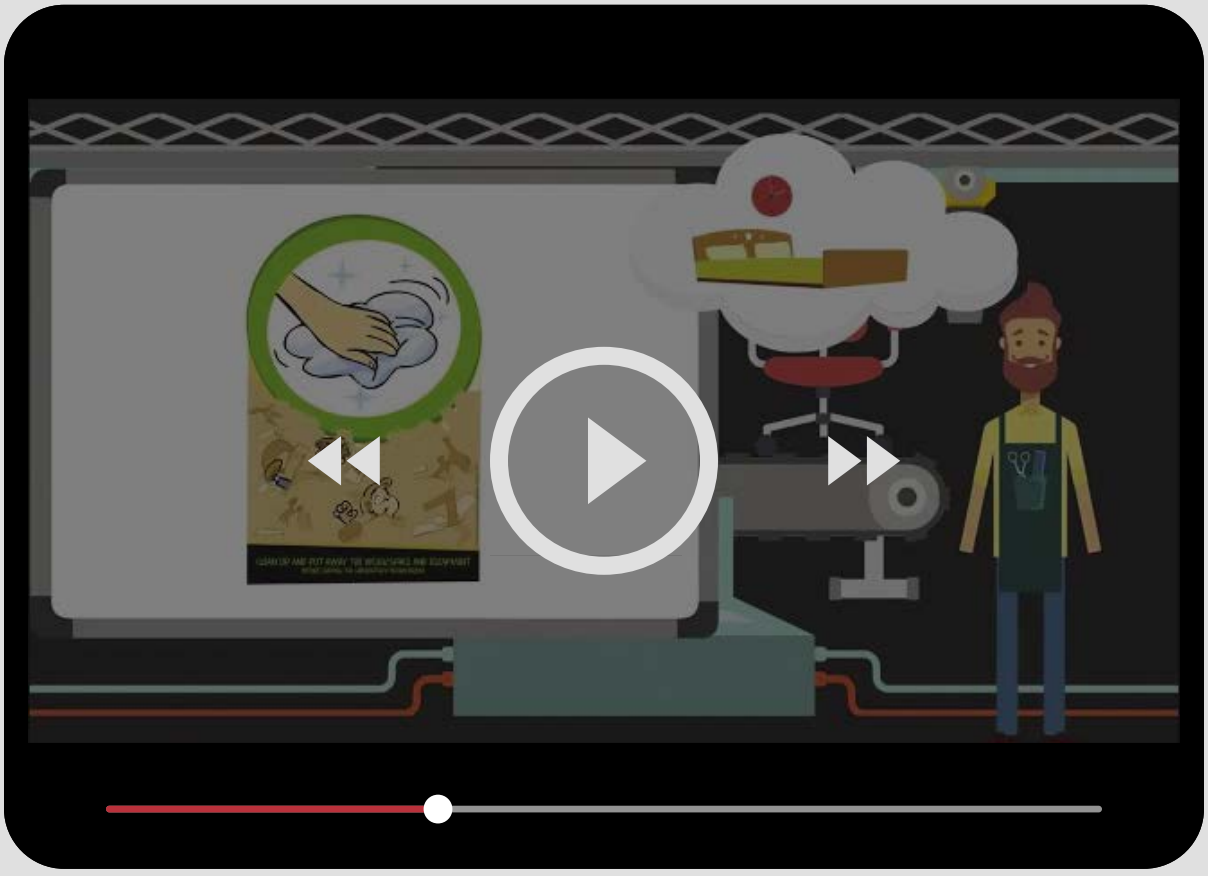
Standardized Training Modules
For off-campus students to continue improving their maker skills

Work with ESSR to Refine Campus Safety Rules for Machine Shops and Makerspaces.
MSI members are working with ESSR to review and revise their Machine Shop Safety Program document, with the goal of expanding the university-wide program to include campus makerspaces. Tool safety is an important issue but is not adequately addressed by the existing Machine Shop Safety Program. Initial meetings were very productive, but unfortunately this committee had to defer meetings while COVID-19 remains a priority.

Create a Safety Training Video.
The Training / SOP group scripted a single safety video to be used by all MSI makerspaces. Since this work was initiated at the beginning of the lockdown the lack of available students on campus to work as actors pushed us to create the initial version using an animated cartoon style. The completed safety video is available for use by all MSI makerspaces, we hope to receive their feedback for the next version once they are fully reopened.

Animated Safety Video

First step by MSI to standardize training materials



IDENTIFYING & PURSUING
Other Cooperative Efforts

Individual MSI members frequently have specialized knowledge and skills that other members lack.

By working together on projects, MSI members can bring these new skills to a broader audience. One example of this is the operation of a sewing machine, a skill well understood by The Clarice Costume Shop but perhaps unfamiliar to an engineer attempting to create a wearable electronic device. **MSI members are identifying these opportunities and planning cross training events.**

The STEM Library Makerspace worked with the Clark School of Engineering to create four different portable toolkits in May of 2019. These kits are intended for students to check out. Each of the four kits have a different focus: electronics, woodworking, fastening, and general engineering. The STEM Library was able to combine their curation and circulation management expertise with Terrapin Works' knowledge of tools to create a unique and valuable offering to students. These kits benefit other MSI makerspaces as well: when a student asks about borrowing tools from any makerspace, we can promote the availability of these loaner tool kits from the STEM Library.

The Clarice Scene Shop is facilitating a project where Theater, Dance, and Performance Studies (TDPS) graduate students work with The Clarice Technology Shop and Terrapin Works to produce custom gobos to be used in front of theatrical lights to project a shape for lighting designs. This allows for much more creative design concepts at a greatly reduced cost.

BookLab began a series of experiments with Sandbox to use a laser cutter to produce wood type and ornaments for BookLab printing presses. Applying a 21st century fabrication technology to make materials for an antique printing press is an exciting pathway for collaboration, offering both creative and practical dividends.

The Clarice Prop Shop was working with Terrapin Works engineers to design a "magical" sword for *She Kills Monsters* before the pandemic shutdown. By learning how to fabricate the sword to be controlled remotely, the Prop Shop is gaining knowledge for their future projects and Terrapin Works engineers gain experience working on a project outside their usual experience.

First Look Fair kicks off each fall semester with a vivid demonstration of the wide variety of campus organizations vying for students' attention. In past years campus makerspaces were not always represented at this event (or the similar Second Look Fair held each February) because of the time commitment required to staff a table for a total of 8 to 10 hours over two days. One of the first MSI group objectives was sharing this effort. A group of MSI member volunteers signed up to work shifts at a shared MSI table at the First Look Fair in September 2019. This reduced the time commitment for any single makerspace and ensured students would learn about all makerspaces on campus. All who participated agreed it was a worthwhile effort, and we plan to continue our participation in future First Look and Second Look Fairs. In addition, we're happy to be part of the upgraded Student Organizations online database, TerpLink.umd.edu and have added listings for MSI makerspaces.

After several successful joint projects, MSI members are learning new ways to communicate ideas and more efficient systems to speed fabrication projects. Such collaborations work to foster inter-departmental cooperation and problem-solving, and help break up some of the isolation bubbles of campus departments. These projects have also helped create innovative solutions, which often lead to a better outcome, reduced costs, and faster delivery. There is an added benefit of exposure to new ideas and new ways of thinking, and an appreciation of what others on campus can do, which leads to new partnerships, friendships and camaraderie.

MSI Startup

Challenges

During our first year in operation MSI identified several key challenges and set out to address these in our startup goals.

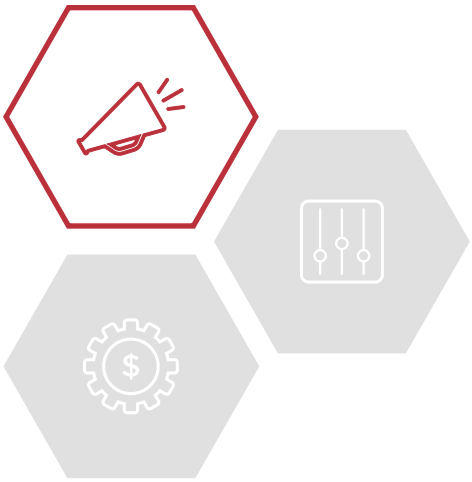
We made substantial progress on these challenges, but more remains to be done. When asked about the key challenges each MSI makerspace faces, several common threads were identified.

BUILDING
Visibility and Outreach

NAVIGATING
Campus, State, and Federal Regulations

MAINTAINING
Sustainability and Funding

BUILDING
Visibility and Outreach



Each makerspace wants to be more successful, to do more and to be more visible on campus.

The most universal challenge relates to visibility and outreach. MSI members continue to share their experiences in this area and are working more closely to copy what works, while cooperating to create fixes to problems.

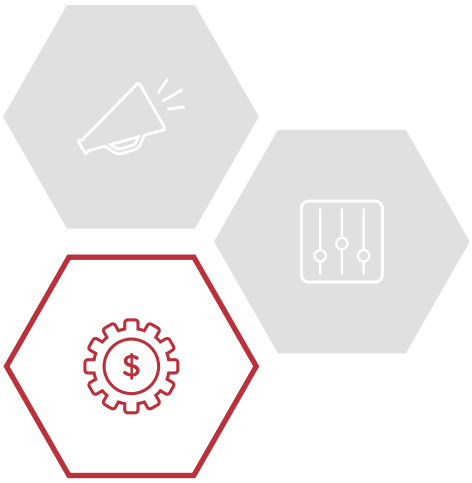
For example, BookLab has been successful with a forward social media strategy using Instagram and Twitter to build visibility and recognition on campus and beyond. They identified as problematic the lack of scaffolding for comprehensive campus-wide communications about programming and events. This inhibits their ability to reach constituencies beyond their college.

STEM Library and Sandbox makerspaces identified similar issues which led to MSI prioritizing the addition of the interactive map feature as well as a calendar and events feature to the makerspaces.umd.edu website in 2021. Additionally, several MSI members are looking forward to making use of the new TerpLink Student Organizations site and will share their findings with other MSI makerspaces.

A key navigational concern in this area is clearly identifying which new opportunities and initiatives we should pursue to maximize outreach while remaining focused on our individual goals and remaining relevant to our core audiences.

> **The problem we have is an issue of accessibility. Our obligations are to the performing arts departments, their classes and productions, and performances within The Clarice, such as the Artists Partnership Program. That makes our availability to the student body as a whole very limiting in terms of what we can do. We do not have the space or abilities to have open shops or lab space for student projects, while still meeting these obligations. Therefore there is not a lot of outreach beyond academic students and student employees, because we would have to turn students away regularly. And yet we still strive to expand beyond our building to bring art into the campus and College Park community as a whole, and to work collaboratively with other makerspaces on campus, both to help them and so they can help us.**
>
> ***Reuven Goren***
> *The Clarice Scene Shop,*
> *Scene Shop Coordinator*

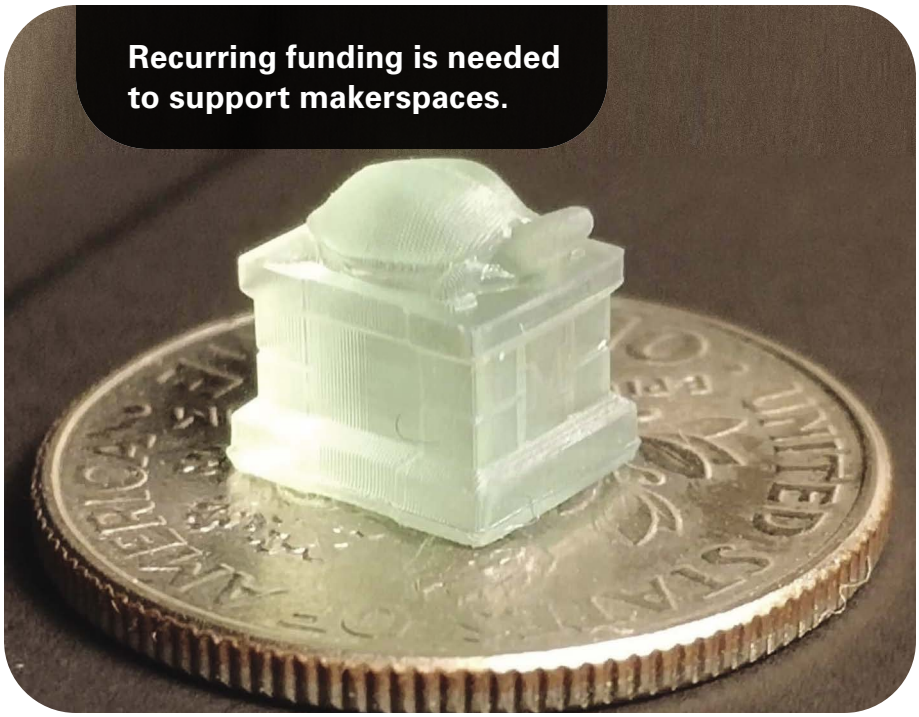
MAINTAINING
Sustainability and Funding



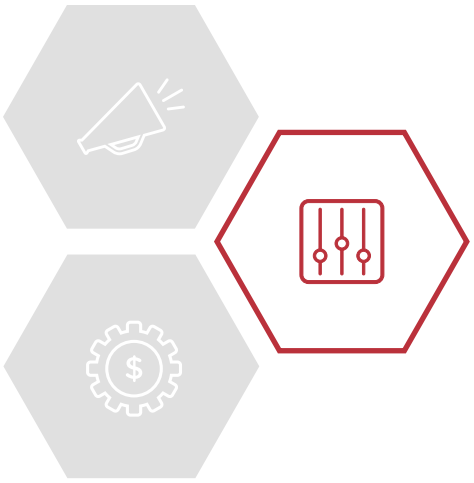
Closely related to the issue of visibility and outreach is the problem of maintaining a sustainable operational model that ensures makerspaces have adequate funding to remain open.

Some MSI members such as the STEM Library Makerspace are able to accomplish their current goals with the annual operating budget provided by their department, but envision being able to accomplish more with additional funding. BookLab identified funding as a concern, to the extent that it prevents growth beyond their current capacity. Thus, BookLab is evaluating long-term funding strategies and opportunities. The Singh Sandbox is in startup mode thanks to generous grants from faculty and alumni supporters, but it must also develop a long-term funding strategy to ensure sustainability and account for any future expansion of offerings. Terrapin Works charges for many services as a means for long term sustainability but these rates are subsidized for internal users.

Recurring funding is needed for new equipment, consumables, and staffing. Raising the campus awareness of maker activities and increasing their impact should assist in increased funding opportunities for all our member spaces. These funding opportunities could be from external donations and sources or lobbying for additional internal resources. In its current form, the MSI is able to share the experiences from each makerspace with each other on what they have learned about long-term funding strategies.



NAVIGATING
Campus, State, and Federal Regulations



Safety is a fundamental challenge.

No matter how well MSI does at increasing visibility for our makerspaces and how effective we are at developing sustainable operating models for each to follow, if we fail to maintain a safe environment for students and others using our makerspaces, then these successes and all of our positive impact on the university will be less apparent as they will be viewed through the shadow of this failure.

Safely operating a makerspace and ensuring that operations stay in compliance with campus, state, and federal regulations is an intimidating challenge, and helping in this area was identified as a startup goal for MSI. An individual makerspace may not be able to locate and hire staff members who are fluent both in fabrication technologies and safety regulations and practices, especially when these can include Campus, State, and Federal Regulations. Working as a group, MSI can reduce the burden by sharing specialized safety knowledge among members and providing guidance for each makerspace to follow to ensure their operations remain in compliance with all applicable safety regulations.

An even more long-lasting benefit of this cooperation would be the added oversight that would result from MSI managing makerspace safety rules in tight collaboration with representatives from ESSR and the Fire Marshall. Acting individually, a makerspace could grow lax in their adherence to safety regulations or be slow in responding to a changing safety environment -- delaying implementing changes to respond to new safety challenges. In a worst-case scenario this could result in an accident occurring before the issue was even identified by ESSR. As a group, MSI could implement a review process where individual makerspaces are visited by the MSI safety team to observe and identify safety issues on a more frequent basis than ESSR or the Fire Marshall. This form of oversight would be less intimidating than an official safety audit, could be done more frequently, and would come with the expectation that MSI members would assist the makerspace in implementing any needed changes.

By having the most experienced MSI members lead our efforts to increase safety we not only allow our other members to save time and money implementing a safety program, but we also demonstrate to ESSR and the Fire Marshall that MSI members view a commitment to safety as paramount.

Impact of MSI

Makerspaces

IMPACT
On Students

IMPACT
On Research

IMPACT
On Academic Programs

IMPACT
On Campus Infrastructure and Services

IMPACT
On Campus COVID-19 Response

IMPACT
On College Park Community and Beyond

IMPACT
On Students

MSI makerspaces make a positive impact on the University of Maryland.

Positive impact can take many forms: improving student life, incrementally adding value to our academic programs, providing alternative approaches to campus infrastructure improvements, facilitating the needs of researchers, and many others. The impact varies from day to day and from makerspace to makerspace, but the sum of these become significant week by week and month by month. This section describes selected projects and activities undertaken by MSI makerspaces.

Student employees giving demos and answering questions, at the Annual Engineering Picnic.

Student Projects

The broadest impact from MSI makerspaces results from student projects. By providing tools and a shared workspace for students to exercise their creativity (or just to repair something that is broken), makerspaces improve campus life. Each student project represents only a small impact but there are many every day.

Engagement Ring

Lost wax casting from a 3D print

David Kriesberg, Terrapin Works

Catan Game Pieces

Laser-cut

Matt Marks, Sandbox

Shelf

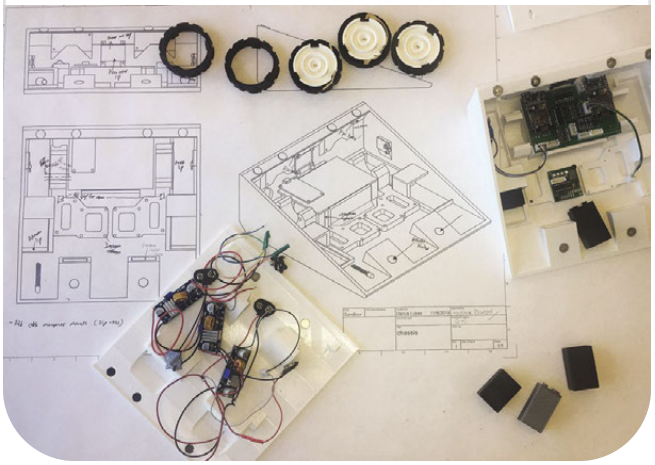
Aluminum and oak with hidden fasteners

Matt Marks, Sandbox

Robot Controller Case

3D modeled and printed

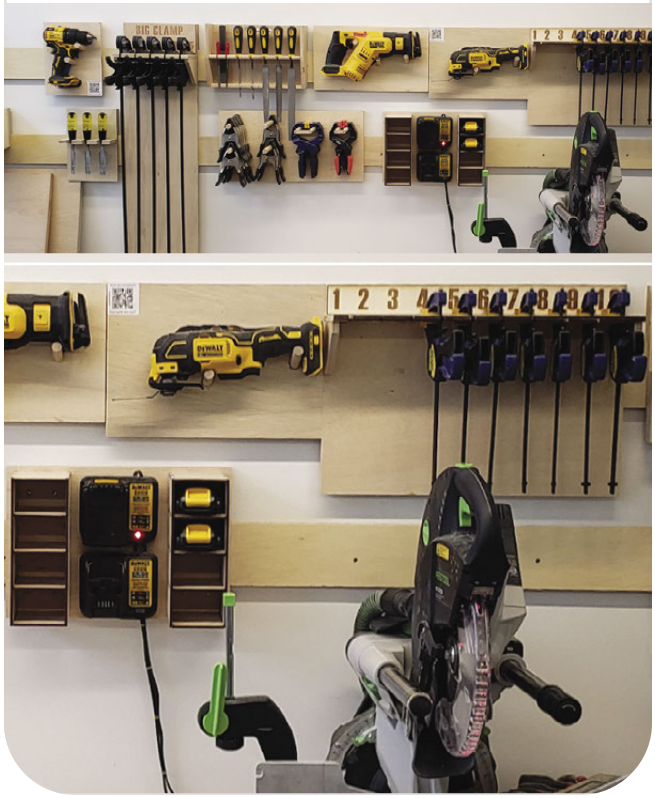
Darius Lukas, Sandbox



Tool Wall

Flexible storage wall for hand & power tools

Hrithik Bansal, Sandbox



Puzzle

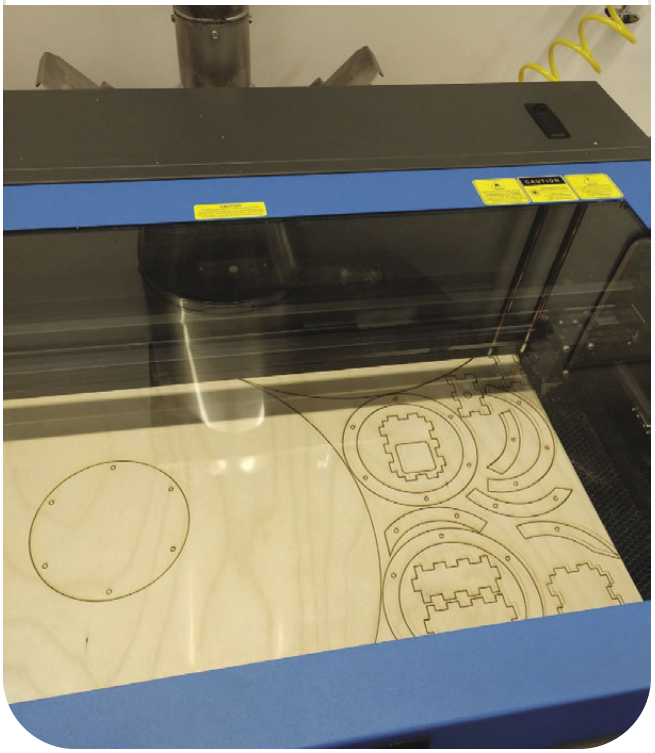
Laser-cut in maple and walnut

Matt Marks, Sandbox

Electronic Drums

Converted from thrift shop drum set

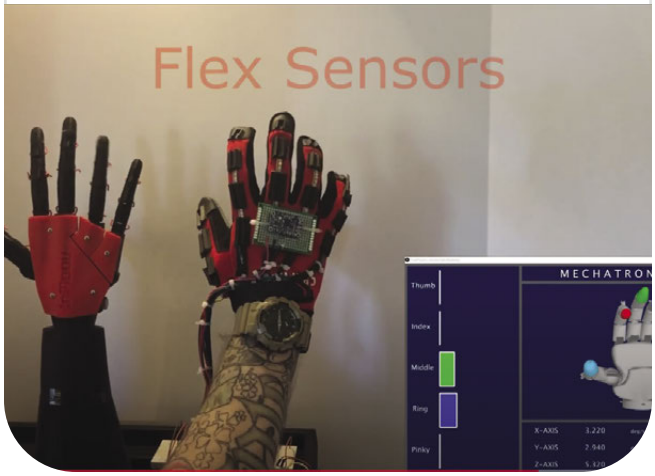
Jeremy Booth, Sandbox



Robotic Arm

Project for ENME 351

Chad Tibbs, STEM Makerspace



Student Competitions and Organizations Support

Student Organizations and Competitions contribute enormously to the texture of university life.

Some student organizations provide a much-needed opportunity to blow off steam while others provide students with real-world experience in journalism, engineering, software development, business management, and many other important skills. Support could mean providing a meeting space, while for other groups, having access to additional resources makes a huge difference in their organization's ability to facilitate the members interests and curiosity.

Student competitions give students a chance to practice and hone their newly gained knowledge by way of practical demonstrations in a competition setting. The competitive setting encourages students to strive for a deeper understanding of their curriculum such that they are able to exploit that knowledge for a competitive edge for their team and gain recognition for the university on a national level. The following testimonial from the Leatherbacks Combat Robotics Club highlights the importance of the services provided by makerspaces on campus.

Our most successful robots have utilized a variety of processes, from 3 different lab spaces and over 7 different machines operated by Terrapin Works. These robots have gone to inter-state events and helped Leatherbacks become noticed due to the quality of parts made with Terrapin Works resources...

...Terrapin Works has supported Leatherbacks since our founding in 2018, and without this support our team would never have had the resources to build a successful or sustainable combat robotics team at the University of Maryland. Since that time, their support through services, sponsored materials, access to resources and invaluable knowledge has been a fundamental part of our organization.

Chinmay Sevak
Co-founder Leatherback Combat Robotics Club

MSI members have the knowledge and experience to help student organizations learn new skills which enables those teams to push their designs to the next level. As highlighted by the Leatherbacks, access to MSI equipment acts as a force multiplier, pushing those team's capabilities even further without having to purchase that expensive equipment on their own.

- **Terps Racing Internal Combustion Engine teams** participate in SAE International (previously known as the Society of Automotive Engineers) competitions. While Terps Racing has an impressive shop with a full complement of tools, they are still assisted by MSI makerspaces. The Clarice Scene Shop assists in creating forms for molds designed by Terps Racing. These are created on a large-format CNC Router in The Clarice and are used by Terps Racing to create body parts and aerodynamic components such as spoilers for their competition vehicles. Additionally Terrapin Works oversees the training and maintenance of the CNC Mill and CNC Lathe inside Terps Racing's garage. Furthermore Terps Racing has used several pieces of specialized equipment in the Terrapin Works labs to fabricate custom parts such as molds for carbon fiber exhaust manifolds and custom steering wheels.
- **Terps Racing Electric Vehicle** is supported by the Singh Sandbox who assists with the manufacture of Delrin® and Lexan® components on their CNC router and 3D printers. These components are used to make several battery modules for their competition vehicle.
- **The Augmented Reality Sandbox Competition** run by the STEM Library encourages students to learn about augmented reality by creating topographic maps of various real world locations in a sandbox. The inaugural winner Michael Dawson won with his recreation of Harper's Ferry.

The Cypress Building, located just off campus on Baltimore Avenue, is home to several student competition teams that use this 8,000 square foot former auto dealership and garage to push the limits of manufacturing and engineering. Working with faculty advisors, teams operate independently under the supervision of Terrapin Works to excel in their respective events with Terrapin Works managing the space, providing training on the shared tools, and helping to ensure the teams work in a safe and cooperative manner. The following are examples from the multiple teams and organizations supported at Cypress.

- **Gamera** currently holds the world record for human powered helicopter flight and is currently redesigning to achieve solar powered helicopter flight.
- **Concrete Canoe** competes in a long-standing racing competition. Teams create a lightweight canoe from concrete and compete in timed races. The competition pushes students to find the limits of what can be achieved with the concrete medium in terms of its strength to weight ratio.
- **Hyper Loop** competed in the SpaceX Challenge which had a goal to innovate on the drive train for a prospective new form of high speed transportation. After winning awards for design and performance, the team has moved on to the "Not-a-Boring Competition" hosted by the Boring Company.

Another avenue of support for MSI members is via Hack-a-thons and startup incubators. Hack-a-thons and start-ups require remarkably similar support in the form of design consultation, code debugging, CAD troubleshooting, fabrication services, and access to more powerful computers and software. The primary difference between the activities is their time scale; hack-a-thons usually only last a weekend whereas start-ups can need support for years on end. The following are some of the **largest hack-a-thons and startup incubators supported by MSI members.**

- **Bitcamp** is the University of Maryland's premiere student-run hack-a-thon that occurs every year in April. Thousands of students come from across the country to participate in Bitcamp. Bitcamp places an emphasis on participant experience and mentorship instead of competitiveness and points.
- **Technica** is the world's largest all-women & non-binary hack-a-thon. Over 1000 high school, undergraduate, and graduate students come to participate in a hack-a-thon that is the hallmark of diversity, inclusion, and empowerment in STEM.
- **Startup Shell** is the University of Maryland's student-run startup incubator. Startup Shell has incubated over 150 successful startups valued at over $60M. "The Shell" places a strong focus on entrepreneurship through collaboration and fosters a tight-knit community that strives to mentor the next generation and solve the world's most challenging problems.

Forms for Composite Parts

Terps Racing

The Clarice Scene Shop/Terrapin Works

Terps Racing 2020 EV Battery

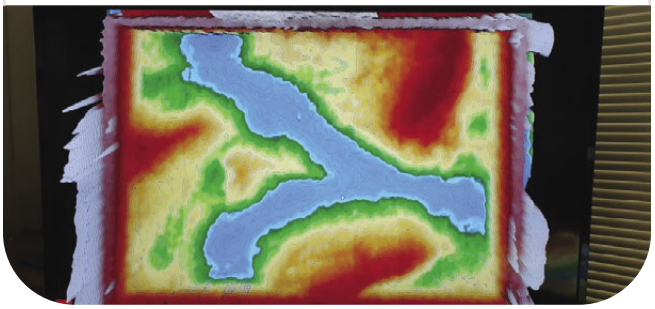
Terps Racing

Sandbox

AR Sandbox Competition

Michael Dawson

STEM Library



Student Experiential Learning Opportunities

Makerspaces provide environments that allow and enable students to learn by doing, both inside and outside the curriculum.

These environments provide opportunities for students to examine a problem from a variety of perspectives and reinforce the interdisciplinary aspect of most projects.

In some makerspaces, the focus may be narrowed to spotlight a particular set of learning objectives tied to a course or department discipline. In other makerspaces, focus is left to the student, perhaps somewhat influenced by the resources and tools available in that space or by the knowledge and interests of the individuals taking on that project.

Experiential learning opportunities closely tied to curriculum are the foundation of spaces such as Clark's Keystone Labs. Other spaces — such as BookLab, the ARCH FabLab or The Clarice Scene Shop and Technology Shops — are indirectly connected to curriculum, providing space to exercise directed creativity while focusing on gaining hands-on familiarity with tools of the trade such as stage lighting and scenery, bookmaking materials, or architectural design models. These makerspaces give opportunities for practical demonstrations and applications of first principles that are critical to making the connection between theory learned in class and practice in the field. They set students on a path to be more engaged, effective, and innovative problem-solvers in their chosen careers.

Makerspaces such as BookLab in ARHU, Sandbox in CMNS, and The John and Stella Graves and STEM Library Makerspaces support learning, inquiry, and action by providing structured and unstructured opportunities for problem solving, group projects, and learning.

These workspaces empower technically-minded students to play creatively and provide a loose framework for creative students to master engineering-oriented projects in robotics, electronics, and other disciplines. Maker technologies facilitate collaboration among people with different backgrounds. Students with knowledge of a subject informally teach those with a curiosity to learn more, sharing their skills and creating a unique experiential learning model where student and teacher roles shift dynamically depending on the task at hand.

Terrapin Works end of the semester wrap-up

One such example is the partnership between the Clark School Keystone Program, Women in Engineering (WIE), and Terrapin Works. In late 2019 WIE noticed that a unacceptably large number of their students were having a consistent issue in certain topics while enrolled in ENES 100 classes. They reached out to Terrapin Works and the Keystone Program administrators to brainstorm ways to help these students. Terrapin Works staff designed a series of workshops that addressed the deficiencies in 3 key areas: computer aided design, basic electronics, and digital fabrication. While still a new program, during the 2020 Fall Semester 30+ students regularly attended the virtual workshops.

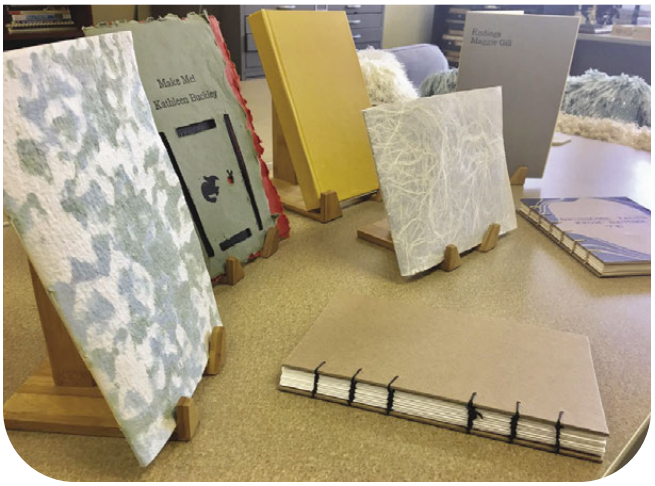
MSI's goal for this program is to produce a series of workshops for both virtual and in-person environments creating a catalog of projects for students of all skill levels. Fully implemented, the workshops would change from a rigid model where everyone works on the same steps at the same time, to a more flexible and inclusive model allowing students to select their projects from the catalog. Experienced student/staff will provide mentoring to aid students with their self-directed learning. Once developed, these training modules would be available for use at other MSI makerspaces.

The NextNOWFest!

A student creativity and experiential event held at The Clarice, The NextNOWFest! is also a cooperative endeavor partnering the Division of Student Affairs, academic departments, and organizations across campus and throughout the College Park community.

BookLab

Visitors can walk through the door empty-handed and use a kit of provided materials to make their own paper from scrap, print on that paper with traditional hand-set movable type, and then bind the sheets together to create a book. More experienced visitors can chart their own path in the space; for example, by creating a traditionally printed book using type or a printing plate created using digital fabrication techniques on a 3D printer or laser cutter. Experiences with more direction are provided through classes taught in the space by the English Department. In lieu of the traditional term paper, students are asked to imagine, design, and make a complete book (broadly defined) of their own. The results range from writer's chapbooks to zines, and from unique books to ones that are reproduced as multiples.



IMPACT
On Research

Campus makerspaces provide support to a variety of research projects across campus, serving as a valuable resource for researchers.

Singh Sandbox Makerspace:

- **The Sandbox makerspace** has provided support to several researchers on projects that were perhaps too small to be outsourced but also beyond the fabrication capabilities of the lab requesting assistance. One example of this cooperation was the production of several small components for an unmanned aircraft system (UAS) being designed by researchers in the Department of Aerospace Engineering.

UMD X-Lab used rapid prototyping capabilities for aircraft construction within a project which is part of a collaboration with industry. The research involved design and manufacturing of sensor casings, pitot tube mounts for UAS, servo motor covers, among other aircraft components. Working with Sandbox was delightful, we were able to advance our research and flight testing due to the timely response and collaboration. [Their] advice on materials for our project was also instrumental, as we needed a strong yet light material for our application. We had plenty of options and were able to explore different solutions. Working with Sandbox over the summer helped us advance the goals of our UAS project.

Lina Castano
Researcher

- **Assistant Professor Huaishu Peng** has a well-equipped research lab with a full complement of digital fabrication equipment that gives his team broad capabilities to fabricate components needed to support their research goals. On several occasions when Peng's lab lacked equipment or tooling needed to fabricate more specialized components, he was able to make use of the capabilities at Sandbox. This eliminated the need to have this work outsourced to a contract machine shop and provided a faster turn-around time.

The Sandbox makerspace has assisted several on-going research projects for my lab. They not only helped us with high-quality and custom fabricated artifacts but also provided fast turn-around time. As one example, we are working on a research project that can offer VR haptics feedback in real-time using mobile robots. The robots that we designed need to carry a heavy load, thus require strong cases with custom aluminum panels. Sandbox was able to fabricate the robot housing for us using the CNC machine. They also helped us to build the supporting structure with custom aluminum extrusions. In another example, we needed to customize a 3D printer building plate with an extended aluminum rod. We were working towards a research deadline, so time was limited. The sandbox was able to build the extension for us within half an hour with their in-house equipment. In sum, the sandbox makerspace has been very supportive for our research, and I'm grateful that we are located close to each other.

Huaishu Peng
Assistant Professor, Computer Science

STEM Library Makerspace:

- **Ohad Paris and Beatriz Shobe,** at the University of Maryland Baltimore College, used the Glowforge laser cutter to create over 40 acrylic birdhouses for use in their experiments. Both are involved with avian conservation and research, pursuits that are time sensitive and require "practical and long lasting solutions." The houses were rigged to open and close at certain intervals, thereby allowing or denying access to food in various areas. He hoped to study how this affected their migration and mating patterns.

The Clarice Scene Shop:

- **UMD Fire Protection Engineering** enlisted The Clarice Scene Shop's production capabilities to fabricate components to help with their fire whirl research, relating to oil-spill clean-up.
- **Mechanical Engineering students** taking a course in Product Engineering and Design modified DeWalt DCF-815 impact drivers in an effort to increase the performance of the internal cooling fan, with an emphasis on improving heat removal while minimizing additional vibration and noise. As part of their testing experiments, they asked The Clarice Scene Shop to use the modified tools and provide feedback on the changes. The group was able to use that feedback to present their designs and analysis to a panel of graders that included a DeWalt Design Engineer.
- **Innovation Partnerships (Kim Engineering Bldg) in partnership with Homeland Security Advanced Research Projects Agency (Science and Technology Directorate)** worked with The Clarice Scene Shop to provide a safe environment to run tests of anti-drone technology. The Scene Shop created a testing space in a performance venue to conform to needs for testing drone-mounted methods of tracking and disabling "enemy" drones, which included backdrops to create fields for the tracking cameras, and material for keeping drones that were "shot down" from crashing into the floor.
- **Electronic Theater Controls Inc. (ETC)** uses The Clarice Technology Shop for small group early Beta-testing before the products are released to public Beta-testing. Testing includes prototype lighting fixtures and lightboards, and operational software for them.

UMD Fire Protection Engineering

Fire Whirl Research

The Clarice Scene Shop

Terrapin Works

Supporting research is one of the core functions of Terrapin Works. Whether by teaching grad students how to fabricate their projects or acting as a service bureau with research equipment to enable individual research groups to focus on research instead of machine acquisition and maintenance, Terrapin Works endeavors to democratize advanced manufacturing by lowering the barriers of entry to any technology in their ecosystem for the School of Engineering and the campus as a whole.

- **Students from the School of Journalism, with guidance from Terrapin Works**, built 80 sensors to monitor extreme summer heat and humidity in Baltimore homes. The concept was modeled after the Harlem Heat Project, a 2016 investigation by WNYC and AdaptNY which found indoor spaces remained intolerably warm throughout the day in the Manhattan neighborhood as temperatures rose and fell outside.
- **Researchers in The Clark School's Advanced Heat Exchangers and Process Intensification (AHX-PI) Laboratory** led by mechanical engineering Professor Michael Ohadi took part in a design competition created by the American Society of Mechanical Engineers and General Electric. The competition allowed research groups from across the country to present unique heat sink designs that leveraged GE's new metal additive manufacturing system. The UMD team, supported by Terrapin Works, was able to present as one of five finalists in the competition along with Arizona State University (ASU), Perdue University, Pennsylvania State University, and Trinity College Dublin.

Building Sensors to Help Baltimore

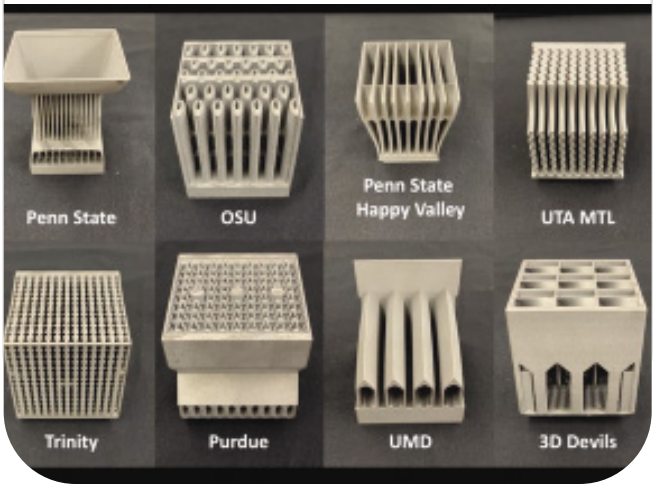
Terrapin Works

Justin Marine and Makayla Jefferson of Wide Angle Youth Media complete heat sensors.

Innovative Heat Sinks

Terrapin Works

Terrapin Works helped UMD researchers become a finalist in a GE-sponsored competition to design 3D-printed metal heat sinks to effectively cool down electronics.



IMPACT
On Academic Programs

Some MSI makerspaces are tightly integrated with academic programs of a particular department or course, while others operate mostly independent of any academic program.

There is overlap between these roles with independent makerspaces sometimes supporting an academic program and academic spaces sometimes offering community access.

Terrapin Works

Terrapin Works views supporting academic activities as one of its core functions and has a track record of effectively supporting the strategically important Keystone Program and the course ENES 100: *Introduction to Engineering.*

Keystone [was designed to] help improve student retention and graduation rates by ensuring students the best possible learning experience in the early, formative stages. In the long term, Keystone will help to attract more students to the Clark School, further enhance the school's already strong academic reputation and produce alumni who have an even deeper connection to the school because of the great teachers they found here.

Nariman Farvardin,
Professor and former Dean,
A. James Clark School of Engineering

Terrapin Works has been a wonderful and trusted partner to the Keystone Program and has enhanced our program in numerous ways over the last 5+ years! Their efforts impact thousands of first and second-year students each year in positive ways…

In addition, members from the Terrapin Works team have contributed significantly to the creation of instructional content within this course and others. For example, they have created training videos and other instructional resources for additive manufacturing (3D printing), solid modeling (CAD), and laser cutting…. Most notably, they support the technical operations of the wood shop which allows hundreds of students each year to have experience cutting, constructing, and testing wooden structures. For many students this is their very first experience working with woodworking tools. Without Terrapin Works the hands-on learning experiences available would not be nearly as meaningful to our students.

Kevin Calabro,
Director Keystone Program and Keystone Instructor

Terrapin Works also supports academic programs outside of Engineering. Dr. Daniel P. Lathrop, Professor of Physics and Professor of Geology, made use of their facilities for a course.

Terrapin Works supported my PHYS 499X class in the Spring of 2019 and 2020 in very important ways. They made available the woodshop for class sessions that focused on safety and the woodworking tools. Terrapin Works staff led the safety training and then were on hand as the students completed a course assignment to make two wood parts. Each student made a wooden dice (cube) as well as a more complicated part based on a dimensioned drawing. The TW team was great and the students had an excellent hands-on experience.

Dr. Daniel P. Lathrop
Professor of Physics and Professor of Geology

BookLab

BookLab regularly supports instruction in the Department of English, as well as in Studio Arts, the Design, Cultures and Creativity Program, Honors Humanities, and the Jiminez-Porter Writers' House, among others. We host visiting classes, arrange instruction and activities, and organize workshops with visiting printers and scholars. We are regular participants in Maryland Day. To offer just one student comment as representative of many:

I loved that we went to the book lab to experience what it was like to publish books in that era. I feel it left me with a greater... respect for writing in the 18th century as a whole.

Anonymous

The Clarice Production Shops

The Clarice Production Shops primarily support academic programs by creating a safe environment for students to learn how to use tools while working on the fabrication of department-supported student productions. The designs for these productions, envisioned by graduate students in the TDPS design program, with performances by student performers, may present challenges converting vision into reality. The Clarice shops provide an opportunity for students to create and learn how to communicate their ideas and information so that the shops can fabricate their designs.

As an example, one challenge was to build an 8' tall replica of the Renaissance statue Apollo and Daphne by Bernini. The sculpture had to be created on a tight deadline and fit into the budgetary constraints of a theater production. Plus, there were additional requirements that the statue be accessorized with a string of lights and a fog machine, and be easily moved by performers between scenes. This project required the efforts of four different production shops (Scene, Props, Paints, and Technology), with many hours of work done by staff and students.

The Clarice shops also have a history of working on projects across a wide range of university departments. One notable example is the design and prototyping of new furnishings for the Applause Cafe. The furniture was installed in 2019, but work on the project began in 2016 as a collaboration between The Clarice shops, Dining Services, Facilities Management and ARCH 406, Professor of Architecture Madlen Simon's graduate-level design studio. The project provided a unique opportunity for ten ARCH 406 students to practice the real-world skills of an architect, such as managing client relations, working with construction project managers, and dealing with multiple overlapping code requirements. Each student proposed their personal design solutions and from those proposals all ten students collaborated to produce the final prototype. Multiple versions of small-scale models were built by the students. They worked with The Clarice shops to gather feedback on the designs, then got tool-use training, guidance, and assistance in the fabrication and testing of prototypes, which were then set in the actual Applause Cafe location to get feedback from eventual users of the space. The final design was then professionally fabricated, and is currently in use at Applause Cafe. While architecture students have countless opportunities to propose design solutions during their study, it is rare for them to see these designs proceed beyond the model stage. Simon's students reported being incredibly engaged in the project and were enthusiastic about being part of an educational experience with a uniquely tangible result.

Replica of Apollo and Daphne
The Clarice Scene Shop

Applause Cafe Furnishings
The Clarice Scene Shop

The Singh Sandbox

The Singh Sandbox Makerspace was chartered specifically to be independent of any particular department or class, but has provided academic support for faculty and students by providing maker resources and equipment used in several classes:

- Students from Department of Art Assistant Professor Cy Keener's digital sculpture class are given students extended access to the laser cutters and one-on-one support for their projects. The presence of art students in Iribe Center provides opportunities for student managers to see the facilities being used to create many unique and creative projects.
- When the College of Information Studies (iSchool) wished to teach an inaugural graduate seminar on makerspaces, Sandbox was able to provide a lab space for these graduate students.

> **Sandbox was a key differentiator in the success of our makerspaces class in the iSchool. Access to a variety of fabrication tools, and the general get-it-done atmosphere of the space, really brought focus to my student's mindsets. They were unable to concentrate to the same degree, and I did not see a variety of committed work from them once we no longer had access to the space. We also now know that as the College of Information Studies moves forward, we will need to budget cash and space for laser cutters and hand tools. The difference in student outcomes is quite persuasive: they really loved having the course in person, and though my readings improved, the things made did not seem at all so engaging once we were no longer in a supportive, fabrication-oriented environment.**
>
> ***Alex Leitch***
> *Lecturer, College of Information Studies*

IMPACT
Campus Infrastructure and Services

One of the largest financial impacts makerspaces have had on campus is the ability to extend the lifetime of obsolete equipment or create custom solutions to unique problems.

Terrapin Works helped the Research Greenhouse avoid replacing 30 electronics controls cabinets. Chris Behnke was kind enough to provide the following testimonial.

At one of our UTCC meetings the subject of engineering having a center of 3D printers was presented to us. At the time I thought that was nice but I will never need it. At the research greenhouse we have 30 cabinets 6 foot by 6 foot that house electronics to control windows, water, fans, grow lights etc... The clips that keeps the cabinets closed were breaking (last count 32 clips). The cabinet doors must be kept closed tight due to water moisture. (Remember this is a greenhouse) Our vendor no longer has replacement clips and the fix from the vendor now was to replace all the cabinets with new ones and move all the electronics. Cost about $3,000 per cabinet x 30 then the cost of reinstalling the electronics. (FYI it cost us around $4,000 to fly the vendors tech in for a day and a half. That was just for the cost of the tech, no parts) Thanks to the UTCC meeting, I went to 3D makerbot lab. They took the old clip, created new and improved ones at a cost of under 5 dollars per clip.

Chris Behnke
Department of Plant Science and Landscape Architecture

Wireless Covers

3D printed covers for installation of WiFi access points in residence halls

Terrapin Works has worked with the Division of IT (DIT) on creating 150 custom covers for WiFi access points that have been installed in residence halls. The covers provide an attractive, easy to install solution for an access point refresh program. These covers prevented the additional cost of drywall work in 150 locations and enables DIT to complete the installation project in one visit.

Gift to University Foundation Donor Mr. Mark Butler

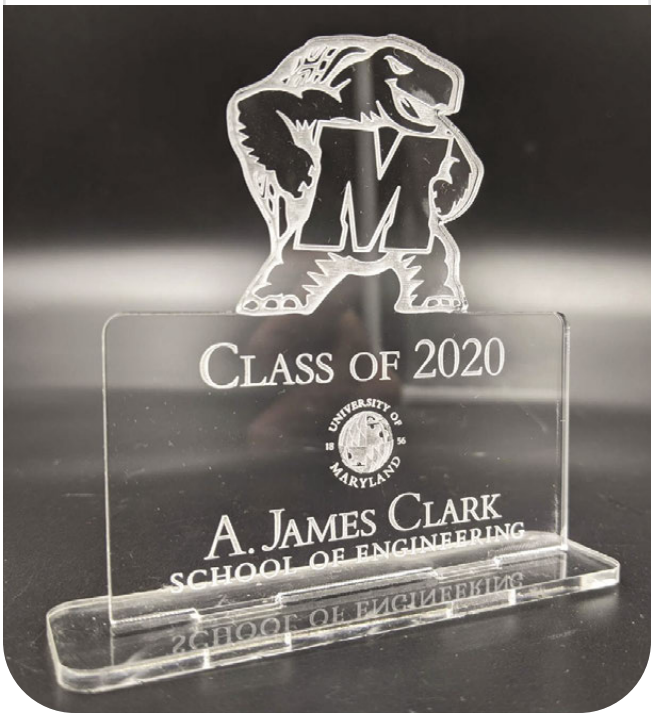
Designed and fabricated gift for donor

Terrapin Works partnered with University Relations to create a one of a kind gift that was presented to Mr. Butler, who's donation funded the creation of a tunnel bearing his name to the football field. This gift combined a piece of Cole Field House's floor with a 3D printed representation of the tunnel that connects Cole Field House with the stadium.

Gifts for Graduating Engineer

Designed and fabricated custom present for all Engineering graduates

The last several School of Engineering graduations have featured a gift for all of their students of an acrylic stand-up featuring Testudo and their graduating class. These gifts were made by Terrapin Works.



IMPACT
Campus COVID-19 Response

In response to COVID-19 critical work was completed under the most difficult of circumstances.

In March of 2020, as the pandemic rapidly spread, most campus makerspaces closed as part of their departmental lock-down plan. A few were able to obtain permission to stay open with limited staff and refocused their efforts on creating PPE and other COVID-related projects. Ad-hoc partnerships formed between the few MSI makerspaces still open and healthcare institutions and first responders. These efforts demonstrated the benefit of makerspaces to our University and community. Looking back, this was an excellent learning opportunity and chance for the University to directly help our local communities which underscores the need for MSI and Campus/Department Administration to have a plan for how we will respond to future emergencies. We should work as a group to plan our path, perhaps by establishing an emergency response team tasked with coordinating efforts with explicit support from campus administration during future emergencies. Additionally, we need to communicate the work we accomplished to ensure the administration and the larger community is aware of our potential value and will view MSI makerspaces as assets available to assist with future emergencies.

Terrapin Works

During the early stages of the campus response to COVID-19, a partnership formed between Terrapin Works and the Architecture FabLab to produce face shields for those who needed them: primarily hospitals, first responders, nursing homes, and food distribution centers. Additionally, other labs' efforts, such as the creation and distribution of Terpsanitizer, were coordinated. In recognition of those efforts, several news outlets and publications wrote stories.

> **Early on in the pandemic we faced many challenges, but two of those challenges were that we needed to distribute food to those in need safely and we couldn't find hand sanitizer or face shields to purchase anywhere. We heard the A. James Clark School of Engineering was producing hand sanitizer and immediately reached out. We found a willing and eager partner at UMD and were able to procure bottles of hand sanitizer and 3D printed face shields. This PPE equipment, along with face masks we were able to source somewhere else, helped provide peace of mind for our volunteers to safely distribute food to residents who were in truly desperate need in the greater Riverdale area.**
>
> ***Dannielle Glaros***
> *Prince George's County Council Member*

Custom Scanned Face Masks

Scanned clients and fabricated a reusable custom face mask with disposable filters

Terrapin Works worked with Fischell Biomedical Device Institute on a project to 3D scan healthcare professionals and provide them with custom masks that would interface with Commercially available filters.

Protective Shields

Custom designed and installed protective shields to protect frontline workers

Terrapin Works created custom solutions to assist in safely reopening. These solutions included desk shields that protected people who needed to continue to interact with the public.

Intubation Box

Custom designed and fabricated protective box for intubating patients

Terrapin Works worked with the University of Maryland Baltimore Medical School on creating an intubation box that would minimize healthcare workers exposure during an intubation. The box prevented exposing the entire room to airborne particles during this procedure.

Bus Hand Sanitizer Holder

Custom designed hand sanitizer holders printed for all the buses

Terrapin Works worked with the Department of Transportation Services to create custom holders for hand sanitizer that have been installed on all the buses. These were originally designed for the buses but have also been installed on many parking pay stations.

Sandbox

Sandbox ceased regular operations in March 2020, with one employee remaining on campus and focused on creating PPE for first responders. Sandbox worked with local makerspaces as well as with national groups, such as MdMakersUnite.org, GetUsPPE.org, NationOfMakers.org, and OpenSourceMedicalSupplies.org, to distribute the PPE they manufactured.

These combined efforts:

- Assisted a local maker with a 3D printed "mask shield" intended to prolong the life of N95 masks, refining the design into one that could be laser cut from plastic film, slashing manufacturing time and material costs. The team manufactured and delivered these mask shields as well as laser cut face shields based on a design from Georgia Tech.
- Worked with DC Fire & EMS and Nova Labs Makerspace in Virginia to make several small batches of parts that first responders were unable to obtain from the manufacturers. These included CPAP adapters and spacers for Metered Dose Inhalers (MDI spacers) to assist breathing of patients being transported by ambulance.
- Joined forces with Nation of Makers in May 2020 to obtain a donation of PET plastic sheet material from a soft drink bottling company. A truckload of material was shipped to five makerspaces in the southeast, each receiving several hundred pounds of raw material useful for making face shields and other PPE.

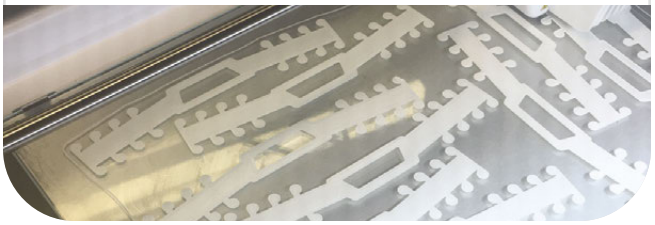
The Clarice Costume Shop

The Clarice Costume Shop coordinated with several local professional and university shops to produce cloth masks for INOVA Fairfax Hospital, who approved the mask style and composition. After producing several hundred masks for that project, they turned their collective efforts to production for Route 1 Mask Match, and have donated more than 1,500 to date. The Costume Shop is also coordinating and making masks for the College of Arts and Humanities as part of the college's "back-up" strategy.

Ear Savers

Fabricated for first responders

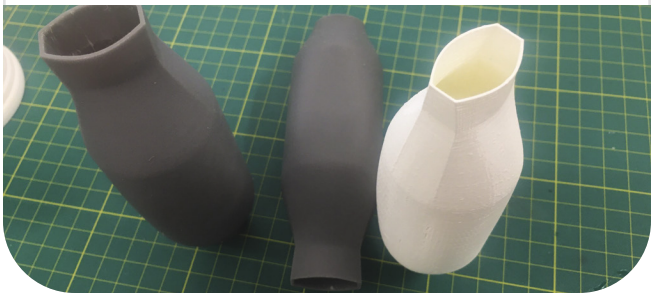
3D printed "Ear Savers" allow the straps from disposable masks to rest on the necks of first responders while keeping the masks in place.



Inhaler Spacer

Requested by DC Fire & EMS

Sandbox created inhaler spacers which allow a more effective dosage to be obtained in patients with reduced lung effectiveness.



Cloth Face Masks

Designed for INOVA Fairfax Hospital

After producing several hundred masks, for the hospital, The Clarice Costume Shop turned their collective efforts to production for Route 1 Mask Match, and have donated more than 1,500 to date.

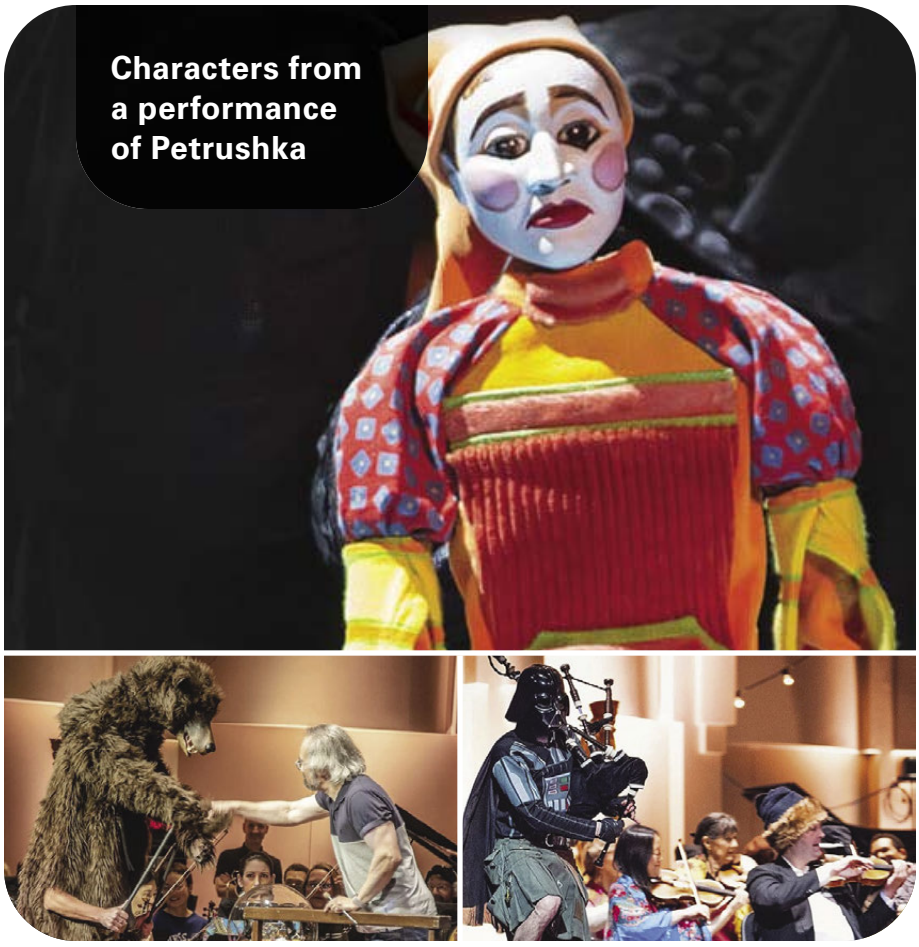
IMPACT
College Park
Community and Beyond

The makerspaces are involved throughout the College Park community and the state of Maryland.

Arts Organizations

The Clarice Scene Shop and Prop Shop: Working with National Orchestral Institute + Festival and the New York Philharmonic, The Clarice Shops have been an integral part of helping to create a touring production, Petrushka, which has involved innovative use of video and projection technology interacting with musicians and puppeteers.

BookLab actively seeks community partnerships. Most notable to date has been an ongoing and mutually supportive relationship with Pyramid Atlantic Arts Center in Hyattsville. They have exchanged students and visiting artists, collaborated on events, and brought students to Pyramid's facilities for instruction. BookLab has also become something of a national model, as evidenced by regular requests from faculty and staff seeking to establish similar concepts elsewhere. Just prior to the Covid-19 shutdown, BookLab had hosted visitors from Rutgers (both Newark and Camden), Northeastern, and Auburn Universities, all seeking to observe our operations.



Characters from a performance of Petrushka

Prince Georges County Schools

The Clarice Production Shops and Production Management also had a collective outreach to help Hyattsville Middle School. Working with Ms. Precious Carter, their Performing Arts Coordinator, and a couple members of their staff, expertise and resources were used to make repairs and modifications to their underfunded and outdated performance space. By doing so, they were able to make a safe and functioning place for the students to do their performances, plays and dances, as well as provide a venue for school functions like graduation and spelling bees . They repaired overhead rigging to comply with safety standards, the theatrical lighting system to operating and controllable, and the audio system, eliminating the loud hum and feedback that had crept into the system . This type of endeavor fosters a positive relationship between The Clarice (and the university overall) with the neighboring community, and helps provide for a more positive educational environment .

Custom Lighting scene

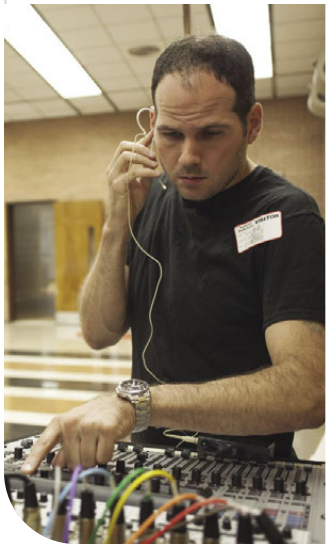
National Fallen Firefighters Memorial Weekend

The Clarice Technology Shops worked with Terrapin Station - College Park Volunteer Fire Department #12. Using equipment and expertise in a collaborative effort, the firehouse was illuminated for *Light the Night for Fallen Firefighters,* in conjunction with the National Fallen Firefighters Foundation and National Fallen Firefighters Memorial Weekend.

Theater Equipment

Upgrade Hyattsville Middle School Theater Equipment

The Clarice Production Shops and Production Management worked with Ms. Precious Carter, their Performing Arts Coordinator, and a couple members of their staff to make repairs and modifications to their underfunded and outdated performance space.



Unity Mural

Honoring Lieutenant Richard Collins, Killed on Campus in 2017

The Clarice Paint Shop worked in conjunction with art teachers from the University of Maryland and Bowie State University to create the Unity Mural to honor Lieutenant Richard Collins, who was killed on campus in 2017. The Paint Shop ordered supplies and provided space, technical expertise, and methods of UV protection to allow for longevity.

Conclusion

The Makerspace Initiative as a collective group is able to amplify the impact of work done individually by our members.

We work cooperatively with our member organizations to maximize the result of our efforts, providing standardized training materials, recommending best practices for operations, and assisting members tailoring the offerings of makerspaces to provide the best possible experience to our students, faculty, and staff patrons. By serving as a repository of shared knowledge we can reduce duplication of effort required to respond to technology changes, new regulations, and other external pressures and events.

While the day-to-day activities at any given makerspace may vary widely, by supporting these diverse needs the MSI is creating a positive impact on the student experience, expanding faculty academic capabilities, providing ad-hoc support for a wide range of research activities, and positively impacting the local and regional communities around us.

The founding members of the MSI have gained enough traction and accomplished preliminary goals demonstrating the value of the initiative that we feel the MSI is not a temporary endeavor. Our plan for the next year is to build on these successes and continue to increase the impact of making and makerspaces at the University of Maryland.

On behalf of the MSI, we'd like to thank all of the supporters of our work, our colleagues, and our supervisors. Your continued support enables us to fulfill all of the weird and crazy ideas that we come up with in the hopes of being able to make the world a slightly better place.

We'd like to thank all of the MSI members who contributed to this report. While it was truly a collaborative effort, we would like to especially recognize the contributions of Rick Blanton, Reuven Goren, and Gordon Crago who worked tirelessly organizing collaborative contributions into a cohesive whole.

Finally we'd like to thank Anastasia Vullis for her creative skills and artistic eye which elevated our committee creation into something closer to a work of art than we could have ever imagined when we began this project.