Session III

Research, Laboratories, and New Initiatives

The Rhode Island Mobile Maker Lab:
A Collaboration to Bring Design, Technology, and Manufacturing Practices to Rhode Island's Students, Businesses, and its People.

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Introduction:
A unique partnership was created in fall 2015 among several public and private entities in Rhode Island. The IYRS School of Technology and Trades, Rhode Island College, Polaris Manufacturing Extension Program, and the Rhode Island Commerce Corporation collaborated to create a 28' mobile maker lab that delivers programs to public and charter schools, after school programs, state sponsored career events, and public gatherings in Rhode Island. The goals of this effort were to create experiences for students, who may not ordinarily have access to advanced manufacturing equipment; to assist in the exploration of trade careers, design processes, engineering occupations, and other significant technical fields; and to build awareness of new manufacturing careers in Rhode Island. The Rhode Island Mobile Maker Lab, designed and built as a modular system, is equipped with laptop computers, CNC routers, laser cutters, digital embroidery machines, vinyl cutters, 3D printers, programmable robots, littleBits electronics kits, and appropriate hand tools. However, central to the mission of the Mobile Maker Lab is that the learning process would take precedence over the equipment housed on the Mobile Maker Lab.

With the support of two Industry Cluster Innovation Grants from the Rhode Island Commerce Corporation the Rhode Island Mobile Maker Lab became a reality in 2017. From August through December, 2017, all aspects of the Mobile Maker Lab were field tested to insure that students and other visitors received the maximum benefit from their visit to the lab. In October of 2017 a ribbon cutting event, featuring Governor Gina Raimondo, Secretary of Commerce, Stephan Pryor, and other local and state dignitaries, took place at the Blackstone Academy Charter School in Pawtucket, RI. At the close of the reporting period, October 2018 the MML has visited over 25 schools and participated in 30 public events engaging with 4,600 participants of various ages. As part of the Mobile Maker Lab's outreach and improvement of our branding the lab visited several local ocean beaches during the height of the summer, where it attracted a wider audience. The RI Mobile Maker Lab just completed its first year of delivering high quality technology and manufacturing learning experiences to students and the public.

MML Milestones:
Recognizing the need for improving Rhode Islander's opinion of manufacturing and to stimulate high school students and underserved populations in Rhode Island to consider entering the technical workforce, Terry Nathan, newly retired President of IYRS, met with different organizations in the fall of 2015 to determine if there was interest in collaborating on a project to create a novel teaching and learning space: a mobile maker lab. Rhode Island College (RIC) was invited by President Nathan to participate because we shared much of the same technical education emphasis in our courses, had expertise in technical training, and could easily develop curriculum. It was also helpful that RIC has the sole Technology Education program in Rhode Island which provided an already in-place network of technical educators that would be recruited for participation in this project.

In the following months the group of interested entities coalesced into a collaborative team that shared a common vision for the Rhode Island Mobile Maker Lab (MML). Each member of the team brought a unique set of resources and abilities that guided the plan to create a mobile making lab. Meetings were held monthly in order to refine the details of the project, identify strategic practices to gain support, and ascertain the needs of our student base to align the purpose of the MML for delivery of best teaching and learning practices. In early winter the team began to explore the possibility of grant support to take the lessons we learned in the first three months and turn them into a viable plan for development of the MML. As it turned out, the State of Rhode Island was beginning a program for funding innovative practices that would support workforce development and showcase manufacturing occupations that were available in Rhode Island. Members of the MML team went to work developing a grant proposal for the Industry Cluster Grants Program: Technical Assistance Planning Grant. Our

efforts were rewarded in the early spring 2016; the project was awarded $75,290 by the Rhode Island Commerce Corporation to begin our proof of concept phase. Stefan Pryor, Rhode Island Secretary of Commerce stated, “We’re glad that, supported by this grant, more young people will have the opportunity to engage with advanced manufacturing and design in their classrooms. We are pleased to support such industry clusters as they collaborate to make their business ecosystem stronger.” (IYRS, 2016)

The planning grant provided us with the resources to plan project goals, plan for implementation, investigate the feasibility of the project, develop a comprehensive survey for teachers and manufacturers, visit other maker labs, identify other sources of revenue, review equipment needs, plan for sustainability, develop a cadre of partners, and support charrettes. Over the ensuing months work began in earnest to develop potential activities and a curriculum for the different grade levels of students who would take advantage of visits from the MML. The MML team sought out the opinions and expertise of teachers from around Rhode Island, who would help us focus on the educational needs that could be satisfied from engagement with the MML. The Rhode Island Department of Education also helped to identify schools with technical programs, after school programs, and community based programs that might benefit from working with the MML. Ongoing was the development of content outlines that would also help with identifying the technology that might be installed on the MML; not every idea was feasible due to the nature of the equipment. Any technology, machine or material that was placed on the MML had one critical criteria to meet – it had to travel well!

When we had formed consensus among the team members, teachers, the Rhode Island Commerce Corporation, designers, and manufacturers, we began to look at equipment that could be used on the MML. During the late spring and summer the team met with vendors who demonstrated their equipment and provided us with very helpful information. We developed a catalog of equipment and vendors during this time in the likelihood that we would be funded to build and equip the MML during the following year. One of the more exciting events was the research and development for the specifications of the trailer that would contain the mobile lab. It was easy to see that when we had reached this stage that there was a great possibility that our goal would be realized.

Monthly reports were filed with the Rhode Island Commerce Corporation. And, their responses to our efforts were generally favorable for continuation of the project. The MML team continued outreach to different education and industry groups in order to confirm that the MML would be useful in the many iterations that had been suggested.

The months of December 2016 and January 2017 were very busy as the MML prepared another grant proposal through the Rhode Island Commerce Corporation’s Industry Cluster Grants Program: Technical Implementation Grant. Armed with the information gleaned over the last year, and with a design proposal and drawings, and the support of educators, designers, and manufacturers, the grant proposal was submitted to build the Rhode Island Mobile Maker Lab. The MML team continued their work while the proposal was in review. This process spurred us to look for other sources of funding to sustain the MML, too. In February 2017, IYRS and its collaborators were informed by the Rhode Island Commerce Corporation’s Industry Cluster Grants Committee that the project, Rhode Island Mobile Maker Lab would receive $279,000 to fund the development of the MLL and its associated activities.

***Defining the Mission of the MML**:*
As the Maker Movement began to expand, Reich (2014) chided starry–eyed participants with the following admonition:

> *In an educational context, we might say that whatever makers hope will happen by buying 3-D printers, Arduinos, and Makey-Makeys will not happen just from buying these things. Whatever outcomes we hope for in our students--creativity, innovation, ownership of learning, design thinking, tinkering, the freedom to explore--will not happen because we bought these things. Technology isn't magic; teachers are magic. Buying new technology is easy. Creating the cultural, policy and political contexts where innovative teaching can thrive is really hard.*

This statement resonates even today. The MML's primary focus is not on the technology, but on expanding student and citizen awareness of Making, technology and 21st Century manufacturing.

The Charrettes
Once funding was acquired, it became necessary to finalize the design for the trailer and to make decisions about the equipment that would be onboard. In order to accomplish this, the new MML manager, Mr. Seth Wiseman and his colleague, Mr. Walter Zesk, both of Conform Lab, offered to facilitate charrettes based on what had been learned during the previous year.

In a fortuitous coincidence, the Rhode Island Commerce Corporation reached out to the MML team to see if we would be willing to produce an advanced manufacturing pop-up at a site that will become part of Rhode Island's advanced manufacturing and information hub; 1 Ship Street. We agreed! The 3 day event, M+M Symposium, would bring together Makers, manufacturers, designers, and the community at large to explore making and advanced manufacturing.

During the 3 day event, three charrettes were offered in the afternoon to all participants and visitors. We also took the opportunity to communicate directly with people who had offered their advice in the early stages of the project.

What we learned from these first charrettes was enlightening.

Charrette 1 (Ship St.)

- The experiences discussed in the charrettes however were not primarily focused on demonstrating new technology. Perhaps surprisingly, the technology tended to be supporting rather than center stage and, in most cases, needed first and foremost to be robust, transparent and flexible rather than cutting edge.
- In the charrette discussions, there was a continuous movement away from specific experiences or resources towards Core Principles. This suggested that there are indeed

core principles underlying the set of experiences the MML should support and creates an opportunity to craft an identity for the MML that is linked to those experiences.
- That link and distillation of the MML experiences to a core set of principles adds value by improving the coherency and consistency of the MML branding, messaging and curriculum.
- The movement towards principles and commonalities throughout the experiences discussed in the charrette suggested that there was an opportunity to develop a modular curriculum where resources are grouped together in modules corresponding to specific outcomes and curricula linked those modules together into sets of experiences that matched the learners and the logistics of a particular educational partner.

During brainstorming activities with each group the conversations transitioned to outcomes and transformation paths, and other ways to differentiate learner starting points emerged that pertained to process and mental posture. The outcomes, new knowledge and skills learners take away from experiences on the MML could be used as learner starting points. They were defined as follows:

1. *Spatial Awareness*: The degree to which a learner can translate between 2d and 3d objects, envision 2d and 3d relationships and communicate 2d and 3d concepts with collaborators.
2. *Technical Awareness*: The degree to which a learner knows of or has facility with tools and technologies required for manufacturing
3. *Creative Mindset*: In the charrette, this emerged in different ways --- willingness to make a mess, ability to find inspiration, tolerance of risk.
4. *Design Process*: The degree to which a learner can employ design strategies, such as iteration, rapid prototyping, purposeful making, concurrent collaborative design and ideation.

Participants suggested that based on the above principles that MML programming, "may be an opportunity to develop a modular curriculum where resources are grouped together in modules corresponding to specific outcomes and curricula links those modules together into sets of experiences that match the learners and the logistics of a particular educational partner" (Wiseman, 2017).

Charrette 2

The discussion focused on the organizational goals, physical attributes, and opportunities for network development & roll-out for the Mobile Maker Lab.

- The Industry Cluster Implementation Grant required that high school aged learners are the initial target audience for MML, though all DC.2 attendees acknowledged the potential to expand into other age groups in the future..
- There emerged a desire to encourage learners to test boundaries, build awareness & take risks that might lead to failure.
- The group acknowledged the potential for a wide variety of programming paths including linear, concurrent and loosely structured.
- The ideal trailer occupant load was determined to be at 5-10 learners with one instructor & one support person, though this was later constrained to 6-8 learners. Modules were defined as project-based lessons administered over the course of four cycles with a goal of developing longer term, recurring relationships with schools and various organizations.

Charrette 3

The focus of this charrette was to begin to develop program strategies and concepts for the first phase of the MML roll out. Additionally, the criteria for the finished trailer was discussed.

- The finish system, both interior & exterior, is intended to displace the premonition that manufacturing settings are dark, dirty spaces.
- The system is designed to cultivate a clean, creative environment where ideas are literally written on the wall & opportunity is at the student's fingertips, whether design thinking, advanced technology or innovative materials.
- A review of trailer manufacturers and trailer features was conducted.
- The equipment list was reviewed and linked to potential curriculum.
- The consultants proposed the use of a MML Programming matrix.
- Scheduling of the MML must fit with the existing school schedule.
- Start and finish of the MML experiences must be standardized.

Programming

One of the performance goals the MML achieved during the testing period between August and December of 2017 was to provide programming for eight schools and eight public events. During that period activities were designed to be Introductory, Intermediate, and Advanced. In most cases, the MML brought the activities to the school. In other cases, teacher leaders identified activities that they wanted to use to explore manufacturing with their students. In these situations the teacher would inform the MML instructor of their students' level of expertise. Activities were developed on a spectrum of 1 – 3; one was having little experience, two was some experience, and three was having greater experience.

An organizational strategy that seemed successful was the use of the round robin. Once the MML was in place at a school, the classroom teacher and the MML instructor would provide introductions and instruction for lab activities. A large cohort of students would be broken down into manageable groups to insure that everyone was accommodated on the MML. Students in this scenario would rotate through design and prototyping activities in the class, then move onto the MML. Generally, 6-8 students could work comfortably in the MML, though the facility was tested when student participation exceeded expectations. Program duration lasted as long as two hours or as little as 30 minutes, depending on the bell schedule and the desired results expected to be achieved.

Programming often began before the MML arrived at a school. An early discovery was that too much time was being spent dealing with computer software on the MML to deliver instruction and design products; so much time, in fact, that projects could not get started or had to be completed off site. While facility has a limited inventory of laptops on board, there are not enough to equip a full classroom. So, instruction often begins after a walk-through visit or introductory presentation that prepares students for the MML's return at a later date. Working closely with teachers, the MML staff also adapts to the needs of teachers that have students who are proficient in their design work. The lab is brought to these schools to support the teacher's efforts to teach about advanced manufacturing. Students complete their pre-designed projects on the MML during these visits.

Walk-through visits are used at the schools and when the MML provides programming to public events. During public event programming participants are introduced to the MML concept, programming, and equipment. The on-board presentation is lite programming featuring a variety of work stations with different technologies processing various projects. There are opportunities for

simple equipment demonstrations, as well as opportunities for participants to customize project samples that are prepared and saved on each machine.

Benefits of Engaging with the MML

There are clear benefits from participating in the MML experience for our students, educators, and manufacturers. Making is an instinctual teaching and learning process. It provides a way for students to engage in thoughtful design and hands-on experiences that might otherwise be underdeveloped or go unrecognized. Making can be a powerful educational tool that fosters collaborative problem solving, creativity, sharing, exploration, and support for human agency. Students learn by doing, including by experimentation, building, and working in collaboration with others. The MML provides an environment for making mistakes with no risk, and celebrating success for solving problems that students may have never encountered before.

Hira and Hynes (2018, p. 2) observed:

> Having a space to be able to Make what is personally meaningful to an individual is often the biggest selling point of newly constructed commercial Makerspaces [*referencing* Rendina, D. (2017)]which has translated into the promise of educational activities that connect to students' interests and passions. This promise of Makerspaces can roughly translate to the idea that a learner who is choosing what they want to make is bound to be more interested in seeking out the knowledge, skills, and abilities to make their dreams a reality (Hira and Hynes, 2018, p. 2).

It is our hope that participants gain significant insights leading them to understanding that maker and manufacturing careers like an engineer, designer, and technician are realistic options and obtainable with directed effort. The MML creates capacity and a 21st century maker workforce, the groundwork for progress. Jepson (2017) reminds us, "Our modern manufacturing future isn't a revival of factories or assembly lines. It's a smart, tactical embrace of advanced manufacturing, from subtractive to additive. It's about finding the sweet spot of speed and efficiency in the path from design to manufacture."

Summer Workshop for Teachers

We created and delivered one–day summer workshops for teachers who would be familiarized with the MML's equipment (CNC routing, Laser cutting, 3D printing; CNC embroidery) and then trained them to deliver lessons of their own creation related to the manufacturing processes that are available on the MML. We believe that teachers who participate can significantly impact student learning by challenging them to use and synthesize STEM skills to solve technological problems.

After the workshops, teachers return to their schools to work on design problems that could be solved using advanced manufacturing techniques. Once the students had designed an appropriate solution at their school, they test and build their designs using the equipment available on the MML. In one instance, the entire high school freshman class of approximately 200 students cycled through the facility at 75 minute intervals, an engagement only achievable with preparation and assistance provided by trained teachers.

As we move into our second cycle, we are targeting engagement with our industry partners in the development of programming, as they know the skills and process knowledge that students need to become successful in manufacturing enterprises.

Challenges:

As the MML moves into its second year of programming, it is faced with a number of challenges that will determine its sustainability. Eventually, state funding for the project will run its course. While we

remain solvent at this time, team members have resolved to seek out patrons who can support this project. Making connections with appropriate industries has been challenging, and those relationships must be more fully developed. We have often thought about charging a fee for services rendered to schools or creating a subscription service that would guarantee a defined number of visits to a school system. However, many of the school systems, especially those in the urban hub, may not have the additional resources to fund such a proposal.

Making a case for support will require more than anecdotal evidence. The MML offers a unique opportunity to research the value of making by students. This type of research would allow for the design and implementation of maker based curriculum integrated with STEAM based learning outcomes. In that vein, developing appropriate metrics that demonstrate positive change in students achievement and dispositions toward manufacturing and other technical occupations, would go a long way to support our cause.

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