



Innovation 5

An Approach to Advancing Economic
Development Through Entrepreneurship,
STEM Promotion and Fostering Innovation and
Collaboration

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Impression 5 Museum

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Innovation 5:

An Approach to Advancing Economic Development
through Entrepreneurship, STEM Promotion and
Fostering Innovation and Collaboration

Michigan State University

Center for Community and Economic Development

EDA University Center for Regional Economic Innovation

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INTRODUCTION

The next generation of manufacturing

The digital revolution, which has shaped our society and economy for a generation, is entering a new era. The digital domain is moving beyond the computer screen to engage directly with the material world.



Popular Electronics Magazine,
1975

To appreciate the revolutionary impact of this development, consider an analogy from an earlier era of computation, the mainframe era, when computational resources were housed in a single autonomous structure and accessed only by highly trained engineers.

The mainframe era of computing was overwhelmed by the personal computer revolution when improved computer hardware and software gave individuals access to and control over substantial computational and communications power. The results of that revolution define our current age.

Digital controls of manufacturing equipment and processes are commonplace today (Chryssolouris et al. 2009) but, like the mainframe computer of the previous era, individuals currently can only interact with advanced manufacturing tools through highly skilled intermediaries. The equipment is costly to purchase, maintain and operate and the manufacturing facility itself is also generally inaccessible and essentially invisible to the average person.

The equivalent revolution in manufacturing is in its infancy but is anticipated to have an economic and social impact comparable to that of the personal computer revolution (Vaezi et al. 2012). This new manufacturing environment goes by many names. It is most commonly referred to by reference to one of its key technologies, additive manufacturing. Additive manufacturing can be summarized as the process of creating a physical object from a digitally encoded design through the deposition of material. We are all familiar with the ink jet printer. This technology has been adapted to deposit layer after layer of durable material with high precision that ultimately yields a 3-dimensional object (Martin, 2012). Alternative 3D printing technologies are also in development or on the market.

Rapid prototyping is another commonly used descriptive for this technology. It refers more generally to a suite of technologies including additive manufacturing that make it possible to rapidly instantiate computer designs in the physical realm. (Vaezi et al., 2012,). The Fab lab movement based at the Massachusetts Institute of Technology (<http://cba.mit.edu/>) is another feature of this landscape, and the term 'fab lab' is often used as a short generic term for this kind of facility (we often do so in this report).



Scientific American,
2012



A 50% lighter prototype jet engine part made by additive manufacturing (front)
www.ipmd.net

These technologies can produce superior products to conventional manufacturing. The ability to customize manufacturing enables a wide variety of applications in such fields as medical prosthetics. Parts can be designed and manufactured faster and stronger using less material than conventional machining.

Another key feature that distinguishes this generation of technology from prior generations of computer assisted manufacturing are relatively low capital and operating cost, accessible computer interfaces from design to manufacture and the growth of a community of users.

These technologies are being widely deployed nationally. Many colleges, universities and high schools have some rapid prototyping equipment and community resource spaces housing this technology are springing up across Michigan.

The economic impact of this new technology is expected to be profound. Giving individuals and small businesses relatively inexpensive access to highly sophisticated manufacturing processes enables innovation for new product development that was simply impossible for small firms in the past.

Tinkerers with machines that turn binary digits into physical objects are pioneering a whole new way of making things- one that could rewrite the rules of manufacturing in much the same way that the PC laid waste to traditional computing. (The Economist Dec, 2012)



A fab lab art project
<http://www.fablabinternational.org/>

community college and commercial community spaces such as Makerspaces (www.makerspace.com) and ADX in Portland, Oregon (<http://www.adxportland.com/>).

The techniques employed in these centers give the practitioners transferable skills that are now finding a place in industry, manufacturing high precision goods such as automobile components, medical prosthetics and jet engine parts

(<http://www.vizspace.com/vizspace.aspx?uid=3d732197-1476-4f95-aa71-c9832c92c372>).

This accessibility is currently being rolled out to serve everyone from adult entrepreneurs to primary school students. For example, the ‘Tinkering with Technology’ project enables primary school students to work with 3D printers (http://www.lboro.ac.uk/service/publicity/news-releases/2012/188_3D-Printing.html).

New manufacturing and STEM education



Make Magazine, 2010

One essential theme to this new technology is its democratization; enabling many people with divergent skill levels and backgrounds to participate in design and production. This technology also teaches important lessons about the practice of science; the design, test, measure, redesign cycle shares important cognitive skills with what is commonly referred to as the scientific method. The equipment and processes themselves are concrete examples of the value of STEM (Science, Technology, Engineering and Mathematics) education skills.

Many of these same themes are central to the contemporary informal science education environment. Visitors participate in hands-on activities that illustrate scientific principles and explore new technologies. It is believed (although the data supporting this idea is challenging to gather and is still the subject of research) that this exposure leads to a more positive attitude toward science and science careers and a greater interest in STEM education among visitors.



Boston Museum of Science
Design Challenges

In recent years there has been a further expansion of the informal science education environment to embrace the concept of innovation. For example, visitors to the Boston Museum of Science are now invited to try their hand at design challenges that embody the build/design/measure/redesign cycle in a structured context. The Chicago Museum of Science and Industry now has a family-focused fab lab

The concept of innovation is closely tied to entrepreneurship and economic development as well. This is exemplified by the National Science Foundation Innovation Corps (I-Corps) initiative that focuses both on fostering innovation in bringing discoveries from the lab to the marketplace and on entrepreneurship training for students (Robinson, 2012). Here, too, we see an effort to bring students into the working STEM world early in their education in hopes of fostering positive attitudes towards STEM and STEM careers.



Wanger Family Fab lab
Museum of Science and Industry
Chicago

Take home message

Understand the background of your project. If you have a new concept, become a ‘mini-expert’ in the field so you can be fairly confident that there is solid evidence that you can use to promote (and defend!) your idea.

The Innovation 5 concept

All of these threads formed the basis for the nascent Innovation 5 project. There are few places more suited to democratization of the rapid prototyping technologies than hands-on science museums, where very large numbers of people come with a predisposition to explore science and technology. There is great merit in a high school course in additive manufacturing that gives 20-30 students an in-depth exposure to the technology. However, exposing visitors to these technologies in an informal science context has the potential to greatly expand the impact of the investment in equipment and staffing. For example, the Impression 5 Science Center in Lansing, Michigan has over 100,000 visitors per year, and over 3 million visitors to date.

The demographics of hands-on science museums also argue for a facility that can appeal both to younger children and their parents who form the bulk of museum visitors, and older students and adults. Bridging the age gap between childhood and the high school/college years in STEM education in any context is viewed as an essential in fostering career interest, especially among girls and ethnic groups currently underrepresented in STEM (*Expanding Underrepresented Minority Participation* National Academy of Sciences 2011 http://www.nap.edu/openbook.php?record_id=12984&page=R1).



Lansing Community College elementary education major working with students at Impression 5 Science Center

There is clearly an opportunity for hands-on science museums to help fill this gap. A recent major study emphasizes the fact that older (16-25) students are looking for a different kind of experience in the museum environment.

There is a rapidly emerging consensus that the most successful museums of the future will be places to hang out, engage and contribute: museums that blur the boundaries between “back of the house” and the public side. They will be moderators and filters of contributed wisdom and diverse perspectives, in addition to being sources of scholarship and opinion. (Farrell and Medvedeva, 2010)

The same study emphasizes the fact that science museums are typically more successful at attracting higher-income visitors than they are at attracting families from underrepresented groups. Impression 5 Science Center is located in downtown Lansing, Michigan and so is in close proximity to the highly diverse and relatively low-income Lansing population, affording an opportunity to reach these demographic groups.

Integrating various working facilities into science museums as one way of appealing to visitors seeking a more participatory experience is an emerging area of activity. Prominent examples at leading-edge museums include the working paleontology laboratory in the Field Museum in Chicago, the Experiment Gallery at the Science Museum of Minnesota where visitors beta-test new exhibits and activities, the Tinkering Studio at the Exploratorium in San Francisco and research laboratories from Ohio State University which are integrated into the COSI hands on museum in Columbus, Ohio.

As one student put it in a focus group in the study by Farrell and Medvedeva (2010)

“I like the technological aspects of some things but definitely having the real deal is always a good thing as well.”

Based on all of these converging trends, we began to conceive of a working rapid prototyping facility that would serve the local community and would also be an integral part of the Impression 5 Science Center. To ensure that there was strong interactivity available for all age groups, we envisioned a ‘parallel play’ area adjacent to and visible from the rapid prototyping facility where children and their families could engage with hands-on activities promoting innovative thinking and we also see, learn about and possibly interact with participants in the rapid prototyping facility. Finally, we wanted to ensure that there was a mechanism to enable and encourage students in the young adult demographic (16-25) to participate in the facility.

All of these threads; new manufacturing, student interest in authentic STEM experiences, a desire to bring resources to an underserved community and the need to foster innovation and entrepreneurship to aid in the economic development of our region led us to conceive of the Innovation 5 project.

Take home message

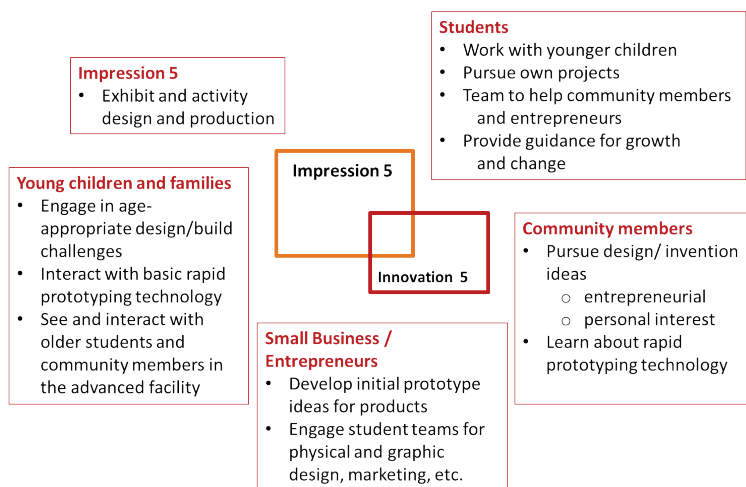
In doing your research, your concept is likely to evolve. Embrace this opportunity to think critically and creatively.

IMPLEMENTATION

First steps

Define the need

How will Innovation 5 be used?



Our original definition of need focused on the idea that community access to the tools of additive manufacturing/rapid prototyping could meet a number of needs in Lansing. The figure summarizes the outcome of our initial discussions. One interesting need that emerged that we had not initially considered was the value of such a facility to Impression 5 Science Center itself.

Hands-on science centers are, almost by definition, rapid prototyping facilities themselves. Every science center is constantly creating new

exhibits and developing new hands-on activities. Science centers have behind-the-scenes exhibit shops where this work takes place. This meant that there was a great potential for synergy between Impression 5 and Innovation 5. Impression 5 already had dedicated space and equipment for exhibit development that could to some extent be repurposed for Innovation 5. Likewise, any new capabilities that Innovation 5 made available would improve Impression 5's capabilities to quickly develop engaging exhibits and activities.

Environmental scan

It was essential at an early stage of the project to ensure that the hypothetical activities that we developed were not already being met in some way by other institutions. This can be a greater or lesser challenge, depending on the size of your community. In our case, it took several months to diligently search out any other groups that might be meeting one of more of the needs we had described. We met with people working in economic development, informal education, with inventors and with friends and neighbors, never knowing where the next lead would come from.

One lesson we learned during our search is that even in a moderately sized community such as Greater Lansing no one person had a comprehensive picture of the activities going on in this sphere. It required persistence and use of personal and professional networks to uncover as many of the related initiatives as possible. In fact, our efforts have led to the creation of a regional committee to bring together and coordinate all interested parties in the region.

Another interesting outcome of our informal discussions was the surprising number of people who, when Innovation 5 was described, responded *'Oh-that is so cool. I have an idea for that I would really like to work on!'* The respondents with ideas they were eager to work on ranged from an art gallery owner in Empire, Michigan to a surfer in Huntington Beach, California. This encouraged us that there would be a real interest in a place for non-experts to take advantage of a welcoming environment where it would be easy to begin to bring their concepts to life.

Take home message

Stretch – it can be a challenge and even uncomfortable to look hard for evidence that your idea is not needed, but you must marshal the mental discipline now. It's far worse to find this out after you have invested time and resources and the good will of you and your colleagues.

As another means to assess interest and learn about the regional situation with respect to incubators, fab labs and the like, we attended several conferences, primarily local ones that did not have high fees. One of the most productive for us was the ACE '13 - Annual Collaboration for Entrepreneurship (<http://ace-event.org/>) held in Livonia, Michigan in January 2013. We were able to talk to a wide range of entrepreneurs and entrepreneurial support groups. We also took advantage of their "Consultants Corner" which enabled us to discuss the Innovation 5 concept with experts in marketing, technology commercialization and other areas. We were heartened by the positive responses we received from attendees and experts alike.

We also decided to submit a paper for review on Innovation 5 at the ASQ Advancing the STEM Agenda Conference (<http://asq.org/conferences/stem-agenda/>) in Grand Rapids, Michigan. The paper was accepted and can be found here (<http://asq.org/conferences/stem-agenda/>) and our PowerPoint presentation from the conference can be viewed here (<http://rube.asq.org/edu/2013/06/continuous-improvement/blending-innovation-student-co-learning-entrepreneurship-and-informal-education-innovation-5.pdf>). Again, we received excellent positive feedback and made some important network connections.

The bottom line is that there was definitely a place for Innovation 5 in our region. We did learn that it was important to emphasize that Innovation 5 would serve as a resource for ‘early-stage’ community involvement in rapid prototyping. There is a significant effort to develop a considerably more substantial facility catering to experienced inventors as well as some facilities for Michigan State University students and faculty, so we decided our optimal community niche would be as the ‘on ramp to innovation.’

Another aspect of our environmental scan was to ask what examples of the type of facility we envisaged already existed elsewhere. We contacted many of the leading hands-on science centers, including the Boston Museum of Science, the Exploratorium in San Francisco, the Minnesota Science Museum, COSI in Columbus, Ohio and studied the web sites of others. We did not find any exact analogs of our concept in our search. As discussed above, the closest analogy to the Innovation 5 concept appears to be the Wanger family fab lab at the Chicago Museum of Science and Industry (<http://www.msichicago.org/whats-here/fab-lab/>). We will be traveling to Chicago shortly to meet with their staff and see what we can learn.

Take home message

What is the need? Carefully define the group you hope to serve. Be specific.

Who is solving this need? Do your best to understand everyone else who is trying to address the same need. They are not competitors, they are resources.

Who cares? Will the group you want to serve be willing to engage with you to solve the problem?

Assembling a team

Team leadership

It is a truism that every team needs a champion. This person is willing to devote significant time and energy and make a commitment to the project and keep the project moving forward. Even the most dedicated team of volunteers will falter on occasion as other commitments come to the fore. It is important to have one person who is generally acknowledged as the ‘engine’ of the initiative. Sometimes one person will take on this role by themselves, for better or worse for the project. In other cases, the team may meet, discuss and choose a leader; this can be a delicate matter as egos are involved. In any event, most project management systems consider identification of such a champion to be a key part of project success.



Nanoday 2011, Impression 5 Science Center, Lansing Michigan.
Testing 'Dr. Nano's' Nanotechnology-protected lab coat.
(Photo Credit, Robin Deits)

Perhaps most importantly in our case, we started with good working relationship with Impression 5 Science Center. Our project director had developed and obtained grant funding for NanoDay at Impression 5. NanoDay is a free-admission Saturday at Impression 5 where students from Lansing Community College and Michigan State University offer hands-on activities for Impression 5 visitors that illustrate the ideas of nanotechnology. NanoDay has become one of the most popular events at Impression 5, and the project director had obtained grant funding to support the event for 7 years. This was a great advantage in establishing credibility with Impression 5.

Take home message

It's probably possible to develop a complex idea and bring it to reality in an entirely collaborative environment, but experience says it's not likely. Someone usually needs to be the engine, either pulling from the front or pushing from behind. Embrace the engine!

Team recruitment

Our project director committed early to the concept and took the lead role from the outset. However, it is equally essential to create a motivated and effective team to move a project of this complexity forward. We were fortunate to be able to recruit and experienced educator with a strong background in classroom teaching, project development and hands-on STEM education as the second member of our team to serve as faculty facilitator.

In our discussions with Impression 5 and our newly-formed team, we realized immediately that we were making some key assumptions about the potential viability of the Innovation 5 project. That assumption was that students would be motivated to serve the key role envisaged for them in the project. At this point we had no actual evidence for this, and clearly the credibility of the project depended strongly validating this assumption.

We therefore made it a priority to seek to engage students early in the process of planning Innovation 5, both to gain their insights and to establish whether or not students would find the idea behind Innovation 5 sufficiently compelling to commit to it. The REI Co-learning project was an ideal means to obtain resources to test student interest and to engage students in a collaborative process of project planning. We were fortunate to receive funding from them which enabled us to offer internships to students for the summer of 2013.

Our initial approach to recruiting students was by means of the personal and professional networks of the project director and the faculty facilitator. We hoped to involve students from both our local community college, Lansing Community College (LCC), and Michigan State University (MSU), a major research university and ultimately to involve students from other regional educational institutions. This networking effort led to the recruitment of one excellent

candidate from LCC, but we needed more. Fortunately, LCC offered a ‘Job and Internship Fair’ in spring, 2013, ideally timed for us. We attended and were able to recruit a number of candidates. MSU offers a website for student employment called MySpartanCareer (<http://careernetwork.msu.edu/information-for-employers/postingajob>) that we were able to use to recruit additional interns.

In our case, the use of these institutional resources, in recruiting interested students, was considerably more effective than our personal networks. We had more than enough candidates and conducted interviews to narrow our choices. Ultimately, we engaged 6 students, 3 from LCC and 3 from MSU. We were excited that they were a remarkably diverse group in every way, from educational goals (ranging from elementary education to biotechnology) and skills (social media, video production, community organizing) to gender and ethnic backgrounds. Most importantly, it was clear during the recruiting process that students from both LCC and MSU found the Innovation 5 concept to be a compelling idea and one for which they saw great potential.

We constituted this group as a project planning team and set assignments for specific areas of the project; for example, we had a female engineering student from MSU with a particular interest in planning to design and equip the facility.

Much of what follows in this report is the product of the research and planning that our student team undertook. We feel that the success of this planning process is clear validation of the idea that Innovation 5 can look to the local student population as an ongoing source of skilled and motivated co-leaders of the project as it is created and beyond.

Take home message

Assemble a great team. If you can’t assemble a great team, is it really such a great idea?

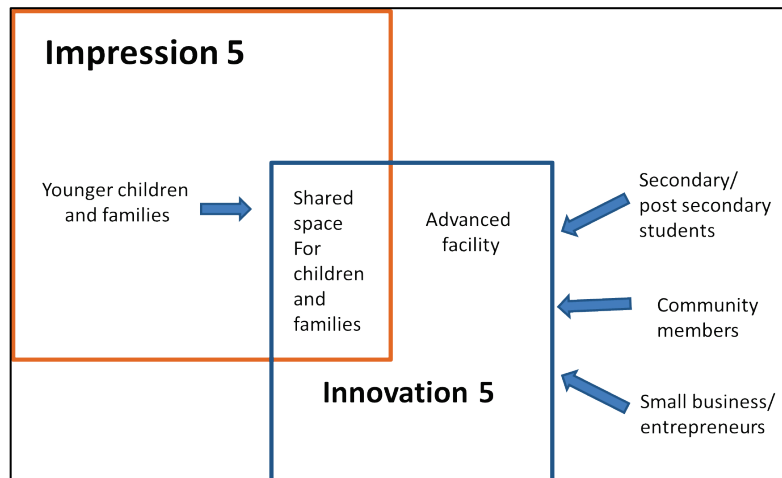
Project planning

Preliminary work to define a mission, target audience and niche within the community should precede project planning, as discussed above. Moving to the planning stage, the project planning team should consider six organizational focus areas; facility location, layout and equipment, marketing and communication, community support, educational objectives, fundraising and sustainability.

Facility location and physical layout

Team Leads: Mark Halsted and Melanie Mullett

Once we had firmed up our ideas about how Innovation 5 would relate to each of its target audiences and to Innovation 5, we created a conceptual ‘user map’ to clarify what kind of physical space would be required.



At this point we had a fair understanding of our needs and began the process of defining a physical facility layout. Our first step was to look for examples elsewhere on which we could build. One challenge was that evidently we were engaged in the first effort to integrate a community-focused fab lab within an informal science education context. Nonetheless, we were able to find a number of examples of similar facilities on which we

could base our plans.

There are a number of websites that discuss different ways of starting a fab lab or makerspace. The least expensive appears to be a ‘mini fab lab’ that started with about \$5,000 in capital and volunteer staff (<http://www.minifablab.nl/starting-a-fab-lab-is-a-matter-of-spirit/>). Lower-cost startup guides can be found here (<http://fablabatschool.org/page/how-to-get-a-fab-lab>) and here (<http://fablab.lowtech.org/w/doku.php/start>). The United States Fab Lab Network, which is primarily focused on community colleges, offers startup and operational resources (<http://usfln.org>). Finally, the MIT Fab Lab project has a very comprehensive equipment inventory – definitely a high-end place to start (<http://fab.cba.mit.edu/about/faq/>). If you want to see what can be done with virtually no resources, have a look at the Woe Lab in Togo (<http://www.siliconafrika.com/democracy-of-technology-make-everybody-equal-in-front-of-new-technologies/>)

Take home message

Others have pioneered many of the elements of creating a fab lab so learn from them. Every fab lab we have connected with has been very eager to offer help and advice. Take advantage of this early and often!

Facility location

Facilities of this type are located at community colleges, universities and at stand-alone locations. For example, Mott Community College has a fab lab (<https://www.mcc.edu/Fablab>). Massachusetts Institute of Technology (MIT) began the Fab Lab program (<http://cba.mit.edu/>). Ann Arbor Maker Works (<http://maker-works.com/wordpress/>) and Lansing Makers Network (<http://www.lansingmakersnetwork.org/>) are standalone facilities aimed at sophisticated audiences and are located in warehouse districts.

We are extremely fortunate to have the strong support of the Impression 5 Science Center for our effort. Impression 5 is an excellent venue for this facility because it provides access to 130,000 visitors per year, expertise in informal educational programming, a network of hands-on museums and space in a facility with a complimentary mission.

They are prepared to provide space within their current building envelope to house Innovation 5. Not all projects will have this good fortune, but that should not be a deterrent to working to establish such a facility elsewhere. This being said, we believe that the synergy between Innovation 5 and Impression 5 will be a real boost to both institutions. We also expect that if things work out as we hope, others will consider very seriously similar partnerships elsewhere.

Innovation 5 will combine a community-focused fab lab with informal science activities for younger children and a student organization to provide overall direction and focus. To date, we have not identified any other facilities of this type in the region or the nation. Although being affiliated with Impression 5 science museum is a great asset, there are other potential locations – libraries, community centers, stand-alone facilities – that would also be a good fit for these types of facilities. For a facility aimed toward families and children, libraries and community centers already have infrastructure for educational programming (i.e. after school programs, summer programs) and for communicating with families and community members (i.e. community education programs).

We want to make Innovation 5 as visible and accessible as possible within the Impression 5 Science Center. We are doing this by considering the best component of our layout to have in direct connection with the Impression 5 facility. The workshop space seems most appropriate to do this with because we want it to be available for family workshops. To create this visibility we are considering partial glass panel walls, displaying finished projects, and possibly a fun kid friendly exterior to the workshop with a similar look to some of the Impression 5 exhibits.

Physical layout

We believe that Innovation 5 will require two major components – meeting rooms and a workshop. Visiting local fab labs and maker spaces is the best way to visualize facility layout.

Innovation 5's layout is tightly linked to its relationship with Impression 5 and its mission of providing families, students and community members with access to state of the art personal manufacturing tools. Therefore, one of the largest considerations for our physical layout will be to provide separate and shared spaces between the two facilities.

Workshop

The main component of an innovation lab is the workshop. The equipment types and layout will largely depend on your organizational objectives.

Innovation 5 will have a “graded” workshop environment. Equipment safe for all visitors will be accessible to families and school groups. This equipment will require minimal training. Additional, advanced equipment will be available to older students and individuals that have passed mandatory training requirements.

At Innovation 5, the advanced workshops will be arranged so that they are visible to families and the general public so that they can witness the innovation process. In particular, we are eager for visitors to see people from the immediate downtown Lansing community at work, perhaps even people they know, to send the message that in time, they too, can advance in skill and become

Take home message

The physical layout of your facility should flow from the anticipated uses. Start by asking simple questions like: Will some users need a separate entrance and different operating hours than the hosting facility? How and in what way will different user groups and users interact? How can your physical layout ensure safety for all users?

innovators. We hope that this will inspire creativity, innovation and an entrepreneurial spirit among students and museum visitors.

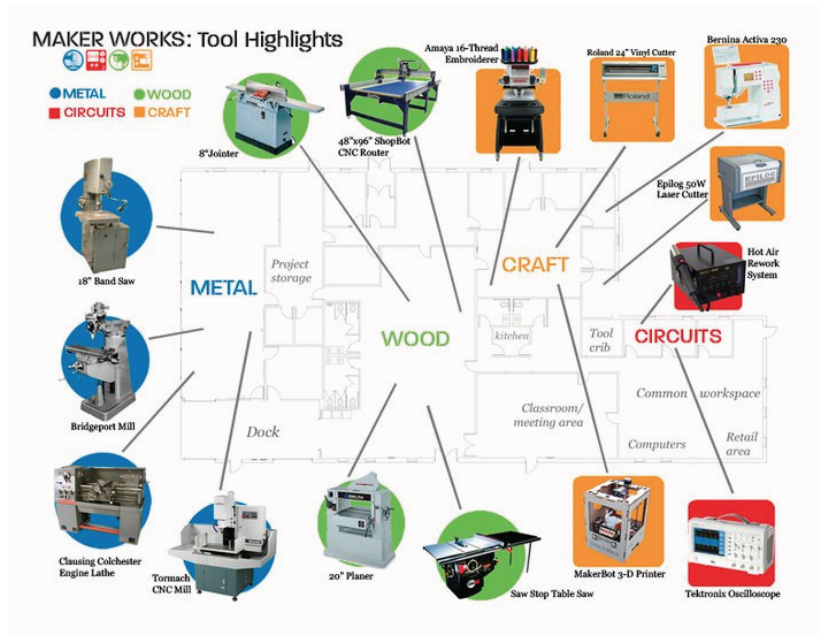
Equipment layout

Ann Arbor Maker Works provides an excellent example of equipment and workshop layout (<http://www.maker-works.com/content/floorplan>). Equipment is organized in separate rooms by category. This creates a space that has similar equipment near each other. Organizing equipment by type provides the best project flow, provides a mechanism for certification and provides proper utilities and ventilation, and addresses other safety and noise control issues. Equipment that needs class certification will be separate from the general workshop room. Noise can be managed by putting the loudest workshops away from the meeting room and using simple soundproofing.

Innovation 5 has the goal of providing individuals beginner, intermediate and advanced access to tools. Equipment must be arranged so that equipment that requires little training is partitioned from equipment that requires lots of training. But, we want to arrange the workshops so that knowledge is easily shared and interests and creativity are easily sparked. We want to enable mobility from beginner to advanced user. We anticipate that this will contribute to a large variety of people wanting to use our facility.

We anticipate that Innovation 5 will have equipment to work with wood, metal, fabric, circuits, and computer software. The starting equipment table is in Appendix One.

One way to visualize project layout and facility needs is to use free 3-D architectural software such as Sketch-up to “draw” workstations. Sketch-up (<http://www.sketchup.com/>) is an easy to



use program that allows you to organize information and can help designers determine where electrical inputs, plumbing and ventilation need to be placed. For example, see Appendix Two for an illustration of a few simple Sketch-ups for a 3D printer and scanner, laser engraver, and vinyl cutter. These Sketch-ups illustrate the dimensions of the equipment, suggested software needed and utility needs for these tools.

Safety and maintenance

Safety, usage and maintenance protocols are critical to maintaining a well-run lab. It is crucially important that Standard Operating Procedures (SOP's) are developed with the help of others and are followed to operate and maintain equipment investments and to enforce safety standards. Ann Arbor Maker Space has well developed protocols that can be used as examples. Here is a

link to a number of laboratory-focused SOP's (<http://www.gliquality.org/activity/write-sops-operating-equipment>). An SOP-based operation also teaches key workplace skills to participants, as any high technology manufacturing environment in which they may apply for work in the future will expect a good understanding of SOP's for facility safety, operation and maintenance.

Instructional classes must be required before using more advanced equipment. Each piece of equipment will have safety standards, requirements and a detailed standard operating procedure outlined in a binder. Sign-in, instructional and maintenance binders must be maintained for each piece of equipment. All necessary safety equipment – goggles, dust masks, ear plugs, work gloves – should be available at each piece of equipment for ease of access.

We will have instructional booklets and sign-in/sign-out and repair (lockout) tags next to all equipment to assist in the process even after the class. General safety equipment that will most likely be in use includes safety goggles in work areas, dust masks, ear plugs, and work gloves when necessary.

Meeting rooms

There is a need for a meeting room that could serve multiple purposes. It can be an initial idea and quiet space for people to brainstorm ideas of projects to work on. It would include a wall scale idea writing board for creative purposes. We will size the room to seat 10 comfortably. For larger meetings we can use other Impression 5 Science Center spaces on a space-available basis. The equipment in this space will include at least one computer and a projector to assist in presentations. In our discussions with other incubators, we have agreed that having some kind of inexpensive real-time visual access among facilities would be a valuable resource. We will have a link to whatever system develops in the meeting room. The MIT Fab Lab concept is based on real-time collaboration between labs ([http://wiki.fablab.is/wiki/Multipoint_Conference_Unit_\(MCU\)](http://wiki.fablab.is/wiki/Multipoint_Conference_Unit_(MCU))) to provide advice and assistance with ongoing projects, so we may tie into the Fab Lab system as well.

Take home message

Ensuring user safety, protecting against liability and training and qualifying users are challenges that have been worked out at most fab labs. At some point, though, you will probably need to review your particular situation with qualified professionals. Maybe cultivate an attorney/inventor as a volunteer?

Facility staff

Staffing is a key issue. The good news is that in discussions with staff at several facilities, there seems to be no shortage of the kind of key operations staff required. You need a person who has excellent mechanical and good people skills for training, equipment setup and maintenance. For folks with the right skill set, a job like this can be extremely attractive as it provides an outlet for their hand skills while serving a public good. The ability of your budget to support staff may

well be the limiting factor in your operation, as personnel costs typically consume about 80% the budget of a typical operation.

In addition to operational staff, there will need to be an administrative structure. A facility director (who could be the operational staff person) needs to be identified to have the final say on operations, expenditures, fundraising and other organizational issues. There will also need to be budget for someone to manage funding; this could be an outside agency, but this is expensive. If it is an individual, it is important to have financial controls in place (such as two signatures on checks, etc.) to avoid misuse. Sadly, even non-profits in Michigan have been victimized by financial staffers.

We intend to also have a steering group of primarily post-secondary students who have substantial input into the operation and growth of our facility. It may be necessary to compensate these students for their efforts, so that we can maintain a reasonable level of continuity; this is a question for the future. We very much want to engage students from both 2-year and 4-year schools. Students at community colleges are often older and have had careers. They are in school for retraining and already possess some remarkable skill sets. They are a great complement to the energy of the more typical younger undergraduate student at a 4 year university. Both groups will benefit from working together as real-world work places are diverse.

Take home message

It is possible to start a successful fab lab with entirely volunteer staff. You can grow over time, or maybe a very simple low cost operation is the best fit for your community.

Business issues

Organizational structure

The organization of your facility is likely to change over time; be prepared to adapt as you grow. For example, a committee of volunteers can probably handle a small fab lab with limited hours. A larger facility will likely need director or executive committee with overall decision-making authority as well as operational staff and a way to manage finances and communication. For most organizations, 80% of operational costs are consumed by personnel costs, so it is critical to be conservative.

If you plan to seek external funding, you will need a formal legal structure as well. The most common is the non-profit/charitable organization “501 (c)(3)” structure, defined by the Internal Revenue Service ([http://www.irs.gov/Charities-&-Non-Profits/Charitable-Organizations/Exemption-Requirements-Section-501\(c\)\(3\)-Organizations](http://www.irs.gov/Charities-&-Non-Profits/Charitable-Organizations/Exemption-Requirements-Section-501(c)(3)-Organizations)). Becoming a 501(c)(3) organization can take many months and can be costly depending on your access to legal assistance, so plan accordingly.

In Michigan and in some other states, there are a number of alternatives to 501(c)(3) non profits that you should look at. In many states, one of these options is termed a Benefit Corporation or

“B Corporation” (<http://www.bcorporation.net/>). The regulations governing B corporations are more relaxed than those for conventional corporations in recognition of the fact that their goal is a social good and that limited (if any) profits are expected. There are presently 18 states that have passed legislation enabling B corporations.

Michigan is not one of the states supporting B corporations. Instead, Michigan has adopted an alternative concept, the L3C corporation (http://www.michbar.org/business/BLJ/Summer%202009/deldin_kopietz.pdf) that has many of the characteristics of the B corporation.

More complex structures are possible, such as a 501 (c)(3) that has a subsidiary L3C for part of its operation, but skilled legal advice and a decent budget are needed to set up such arrangements.

Budget

Business plan

You can be certain that any external funding source is going to ask you to be specific about your sustainability plan and/or your business plan. You can obtain business plan assistance from a variety of sources; the Small Business Administration is the federal center for this support (www.sba.gov). In Michigan, you might consider the Small Business Technology Development Centers (www.misbtdc.org). Regional economic development organizations also often provide resources to support your business plan development.

If you are starting small, a full business plan may not be essential, though it is a good exercise to use in focusing your thinking. As you get rolling, though, keep good financial records and use them to develop a validated business plan that, over time, can help you ‘go big.’

Startup costs

Fab labs have been started for a few hundred dollars or \$100,000. So many factors come into play that it is difficult to make specific recommendations. If you start small, you probably won’t need specialized spaces with, for example, 220V utilities or high powered ventilation, but be aware that these kinds of requirements can crop up. It is a truism that renovating a space for any purpose will cost more and take more time than you think. Don’t worry about looks. Your users can create wonderful wall décor for you as they experiment.

The startup guides provided above can give you good information to use in estimating your startup costs.

Operational costs

As mentioned above, for any organization not relying entirely on volunteer labor, it is likely that around 80% of operational costs will be personnel costs. You may be able to keep that percentage lower with volunteer help, but it represents a good starting point for planning.

Other costs to consider are space (rental?) costs, utilities, materials, equipment purchases and repair; financial services (are you going to do your own books? Your own taxes?), communication costs, etc. Do not neglect to consider equipment depreciation. This is a rapidly evolving field and equipment may become outdated rapidly- who would ever expect a computer

to last 10 years? The same thing applies to 3D printers. The good news is that as equipment ages, the possible replacement equipment becomes much more capable at the same cost, or much less expensive for the same capabilities, just as seen with computers.

Revenue

In order to be sustainable, you will need to identify revenue sources that will enable you to stay open and operational. This is a key part of your plan. Some of the potential revenue sources that other fab labs employ are:

- Membership fees – individuals or small businesses can pay a daily, weekly or monthly fee to have access to the facility. These fees can be set to encourage target audiences to participate. For example, because we have a focus on the downtown Lansing community, we might offer a lower fee to city of Lansing and/or Lansing School District residents. Also, as we hope to serve as an ‘on-ramp’ to more sophisticated facilities, we may offer a relatively low daily or weekly rate. For small business customers, a more ‘market rate’ cost structure is appropriate.
- Make and take – you can provide opportunities for individuals to make a small product as an introduction to the technology or just for fun. You can make a modest charge for participation, but as a practical matter is it unlikely that you can recover the full costs (facilities, labor materials).
- Courses, workshops, etc. – In our case we see summer and weekend workshops for young people as well as professional development opportunities for teachers in our area to be good sources of potential revenue.
- Admission – For a fab lab that is part of a hands-on science museum, some visitors will come to the museum for the purpose of interacting with the fab lab facility. One option to recognize this revenue is to offer a ‘premium’ admission price that includes access to the facility. This requires careful balance between accessibility and sustainability, of course. For a smaller hands-on museum this may be too complex to implement and there may need to be a mutual agreement between the fab lab and the museum as to the balance between increased revenue resulting from the presence of the fab lab and costs associated with hosting the facility. Of course, if the fab lab is an integral part of the science museum or other institution without a specific legal structure of its own, this is not an issue.

Take home message

After extensive discussions with many facilities, there really is no one-stop startup guide or a particular process to follow. This can be frustrating or liberating – choose liberating!

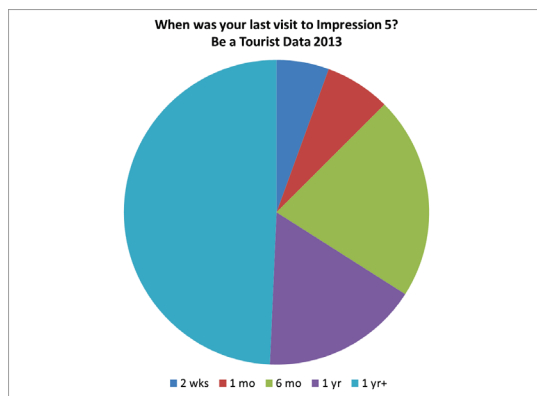
Market Analysis, Communications and Community Support

Team Leads: Megan Podschlne and Melody Teodoro

Defining the target audience

The first step is to determine the facility's target audience. This requires two steps – networking and focus groups. Through networking, you can identify your local economic development groups, find collaborators and determine “what’s missing” in your community. We spent several months meeting with as many economic development organizations, entrepreneurial groups and maker spaces (Lansing Economic Area Partnership (LEAP), Spartan Innovations, Prima Civitas, Michigan Incubators Network, Lansing Makers Network, Ann Arbor Maker’s Space, Mott Community College Fab Lab) as we could in the region. This helped us determine that there is no facility of this type either operating or planned in our region. We also learned that in our region there were several groups who were unaware of each other, despite their complementary missions. We are now working with them to coordinate resources in our area.

Students and their parents

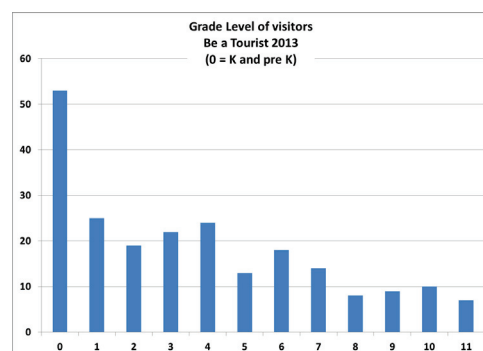


Focus groups and surveys can help evaluate interest and identify underserved groups. We conducted a survey and spoke with hundreds of children and their parents at Impression 5 during Lansing's *Be a Tourist in Your Own Town* (<http://www.lansing.org/events/batyot/>) event (See Appendix Three for survey instrument). This event is sponsored by the Greater Lansing Convention and Visitors Bureau. It allows visitors to Lansing to visit 60 area attractions, like Impression 5 Science Museum, for just a dollar. This enabled us to survey

more than 150 individuals in the Lansing region. It helped us connect to our target audience and to gather input about topics and technologies that they would find interesting.

We also treated individual families as focus groups to gather information. We connected with a large number of individuals and families that would be in experimenting with new technologies and prototyping learning activities. We recommend holding focus groups and/or surveying people as close as possible to where you hope to establish your facility. Finding community events that match your demographic is a good way to reach community members. We also recommend having some readily identifiable indication of membership – name tag, group t-shirt so that families feel comfortable when you approach them.

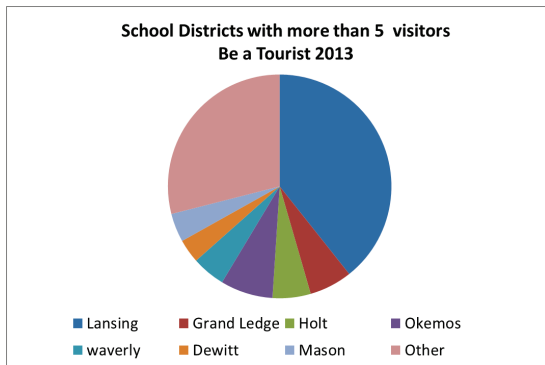
We learned valuable information from our survey:



About half of the visitors had not been to Impression 5 in over a year, if at all. The largest age group was the very young (pre K, K and 1st grade). Visitors ranged in age from younger than 1st grade to high school juniors. Consistent with what is frequently seen in a hands-on science museum, there is a falloff in participation with age. This supports our idea that there is a need to engage these older students in authentic STEM experiences and

that catching them at Impression 5 at an early age is a viable strategy.

We asked whether specific types of activities such as- robotics, circuits, flight technology and others were preferred by the children and their parents, but no strong trends emerged. Most were interested in most things that we proposed.



By far the largest percentage of visitors came from the Lansing School District. As this is our target audience for Innovation 5, this confirmed that local residents are ready and willing to come to Impression 5. We evaluated the assumption that the Lansing School District was relatively underserved by asking a question about parents' awareness of hands-on STEM-related activities in their district. Approximately 59% of the respondents attending the Lansing School District stated that their children did not have access to hands-on STEM activities, while

only 46% of respondents from all other regional school districts said the same. As our sample size is over 100, we feel that this is a significant difference.

Our survey asked if visitors would be willing to give us their email addresses to receive occasional updates on our progress. Over half of the survey respondents offered us an email address. We also asked if they would in the future be willing to come to Innovation 5 and help us with exhibit prototyping. 43% responded positively, and only 17% gave a definite 'no.' (The survey included a 'not sure' option).

The data above suggest that we will have many opportunities for exposure to Lansing School District children and community members as well as folks from surrounding communities and that a high proportion of these families will be interested in visiting and participating in Innovation 5.

Entrepreneurs and small businesses

It is widely acknowledged that small businesses employing innovative technologies are going to be a major source of job creation in years to come. Among the technology drivers for this source of economic development, the additive manufacturing/rapid prototyping technology suite is seen as having a future economic impact equivalent to that of personal computers (Vaezi et al. 2012).

Innovation 5 will serve this community as well by providing opportunities for individual entrepreneurs and inventors and small businesses to utilize these tools. However, we recognize that our primary function will be introductory. For those who are familiar with the technologies we offer or need larger scale or more sophisticated equipment to accomplish their goals, there are (or will be) other facilities in the area, as we learned in our environmental scan. We therefore plan to market ourselves as an 'on-ramp to innovation' for this group of potential clients. As our regional network of incubators and fab labs matures, we will be able to provide referrals to users to facilities that are best suited to their needs.

Estimating market size

Traffic is a key element of any marketing strategy. We feel that this is one of the most powerful incentives for siting Innovation 5 in a way that it will be accessible and inviting to Impression 5 Science Center visitors. Impression 5 has over 130,000 visitors a year, a tremendous resource from a marketing perspective. This is a remarkable number as the Greater Lansing area has a total population of approximately 450,000 as of the 2010 census.

We want to add to Impression 5's exhibits by providing opportunities to interact with innovation and rapid prototyping technology. This will, we believe, further expand their visitor base by attracting students 11 years old and older. It is part of our value proposition to Impression 5 Science Center and a key part of our goal of promoting STEM education and careers that we can attract and retain students as they grow.

We believe that our data supports the idea that we can not only find an interested audience for Innovation 5 but that the demographics of this audience match well with our goals of focusing on the Lansing community and retaining young children beyond their early years as engaged members of Innovation 5. We can also reasonably anticipate that the presence of Innovation 5 itself will increase visitor interest, numbers, and possibly geographical reach to Impression 5 Science Center, thus providing a source of indirect revenue for the project.

Take home message

Defining your target demographic for your service is an essential step in developing a strong case for your facility. It is also very important to collect convincing, preferably quantitative, data that you have access to your target audience and that they are in fact interested in what you have to offer.

Strategies for communicating with partners and stakeholders

Today's communication and media environment requires social media to disseminate and gather information. Emailing a newsletter can provide detailed updates to interested parties. Attending community events such as community meetings and other relevant scientific or technological gatherings compliments an online presence. Face to face interactions excite the community and make it seem as though they are part of the project planning team.

We are using multiple social media outlets to communicate with collaborators, partners and interested community members.

- The Innovation 5 website (www.innovation5.org) hosts a blog that discusses interesting occurrences regarding the technological world, as well as information about the I5 project and our team. We have had 258 unique visitors on our website. We are also encouraged by the fact that our site data indicates that about 20% of recipients of our email updates 'click through' to the innovation5.org website.
- We send an approximately monthly email newsletter that gives a thorough description of what our team is working on and the latest news regarding the creation of Innovation 5.

We asked for individual's email addresses at Lansing's "Be a Tourist in Your Own Town" event (<http://www.lansing.org/events/batyot/>) and received a surprisingly long list of those interested in updates. We have 130 people who have asked to be put on our email mailing list. To date, no one has asked to be removed from the list.

- Our Facebook page (Innovation 5 Lansing) shows the capabilities of technologies that could be featured at Innovation 5, as well as keeping the public updated on important information and events that our team is attending.
- Our Twitter account (@innovation_5) helps to gather interest in Innovation 5 and redirect them to our website and Facebook page for important information. This account is also used to post interesting articles related to the technologies that could be debuted at I5. We have 32 followers on Twitter.
- Our YouTube channel (<http://www.youtube.com/channel/UCUGhtUpZ3ZwJvXe2FpktXug>) shows videos put together by our team to explain the I5 project and how the community will benefit from such a facility. We have had only a few views on this quite new page; the main introductory video is also posted on our web page which may reduce the number of people clicking through to YouTube.

In the future, we may utilize television and radio to communicate events at the facility. Impression 5 Science Center has an active mass media marketing campaign in place which should be a valuable resource. Future media endeavors could also include:

- Short TV or radio commercials that will be especially helpful to show off new events and exhibits as the facility opens.
- Printed ads could also be distributed upon the opening of I5 to schools as well as nearby universities (Michigan State University and Lansing Community College) to draw in an audience.

Strategies for engaging the community:

Fostering community support and awareness is crucial for success. Cultivating community support requires identifying key groups, networking with these groups and communicating with them. We began by networking with a few groups that we knew would be critical to the development of our organization – LEAP, Spartan Innovations and Lansing Makers Network. These three groups helped us identify additional potential partners and collaborators and additional user groups. We have been engaging and communicating with these groups through face-to-face meetings, email newsletters, Facebook, and Twitter.

Take home message

Today, communication is a 'roll your own' process. This is enabling, but a challenge as well. Traditional media (TV, radio, newspapers) are all chronically under-resourced and it can be difficult to get their attention for articles, etc.

Funding and sustainability

Team Leads: Tom Deits and Katherine LaCommare

Potential funding sources for Innovation5 startup and operational costs

Federal government

The Federal government has been a significant source of funds for STEM education research and implementation of new STEM concepts and institutions. However, the entire program is in a state of considerable flux caused in part by the budget cuts necessitated by this year's sequestration and by an effort to totally reorganize funding in STEM education <http://news.sciencemag.org/scienceinsider/2013/04/a-us-makeover-for-stem-education.html?ref=hp>. As a result, there are few solicitations for funding presently active. It will be essential to keep close watch on how the funding programs evolve over the next year. You can expect some programs to pop up with relatively short times for acceptance or proposals and for new criteria to be established to assess merit. This will be one of the real challenges for all those interested in STEM education in the next two years.

State government

If you are looking to establish an incubator that will support economic development in your community, this can be an avenue to seek funding from State government agencies. States in general and Michigan in particular are focusing relatively more of the 'discretionary' spending on economic development than on enhancing education through the creation of new institutions. This will be a matter for you to consider within your particular circumstance.

Private foundations

Private foundations are a significant philanthropic force at about \$20 billion per year (although individual donations are a far larger source). There has been an increasing focus on entrepreneurship, education and STEM for workforce development among foundations in recent years, which is an encouraging sign for projects like Innovation5 that touch on all of these areas. The Impression 5 Science Center is located in downtown Lansing, Michigan, which is a diverse and underserved community both educationally and within the community, so our ability to attract a diverse audience can be another positive when approaching foundations that emphasize serving underrepresented populations.

The process of identifying and approaching foundations can be daunting. Here is an excellent introduction to the process of working with foundations that support STEM <http://www.pkal.org/documents/ObtainingPrivateSTEMSupport.cfm>. This article is focused on a college and university audience, but its overall themes are broadly relevant.

Briefly, the article subdivides the process into

1. **Preparing the case for excellence** – What is it about your idea and the people who will execute it that makes it exceptional?
2. **Preparing the case for need** – What specific need exists and how will your innovation meet this need? You need to be very clear about answering both questions.
3. **Identifying prospects** – Which foundations have mission statements, geographic focus and grants in the right size range for your project? Do you or your colleagues have personal connections with certain foundations?

4. **Cultivating foundations** – How to approach the foundation. This usually involves a preliminary letter. The authors recommend discussing your idea with foundation staff before submitting the preliminary letter.
5. **Proposal** – Developing the proposal is a lot of work and should be done in coordination with the foundation staff to help you stay focused on their mission.
6. **Office/site visits** – Some face time is a good idea; but be prepared!

Our project is, we believe, at stage 3 of the process above. Identifying appropriate foundation resources is a challenge, but critical. It is essential that you can answer the very first question any foundation will ask – ‘How does your project meet our mission statement?’ The better the match, the better your chances, so do your homework. Here is a link to one database of hundreds of foundations that have STEM education as a part of their mission <http://www.hmhco.com/educators/educational-services/grants-funding/free-grant-database>. You can search on this database, although most searches will yield hundreds of possibilities that you will need to screen.

Individual donors

This can be a challenge unless you have good knowledge of the ‘angels’ who fund philanthropic activities in your community. It may be possible to raise a small amount of funds at an early stage to enable proof of principle, but this will strongly depend on your and your colleagues’ personal and professional networks.

Social investors

There is a growing network of individuals who seek to invest in operations that may or may not have a modest return on investment over time, but that give them an opportunity to use some of their wealth to advance a social goal. Michigan is among the leaders in this relatively new field. In fact, Impression 5 just finished competing in the first Michigan Social Entrepreneurship Challenge (<http://thechallenge.michigancorps.org/>), the first event of its kind in the nation.

We did not go into this competition seeking to win (although there were some nice cash prizes) but to begin to understand the social entrepreneurship environment and to get additional feedback on our project. We did indeed achieve the latter goals, but not the first. We got excellent positive feedback from competition judges and others in attendance. We were noticed, too, as we had 4 people attending all wearing our attractive new Innovation 5 t-shirts. The marketing consultant we met with was very impressed with our promotion and branding efforts overall.

It is definitely worth keeping an eye on this trend as a possible funding source.

Crowdsourcing/Crowdfunding

The hot topic in the world of project financing is crowdsourcing or crowdfunding (both terms are in current use). At a recent national meeting of the American Association for the Advancement in Sciences, the only overflowing room was one with a seminar on crowdsourcing.

Briefly, the concept is that you make a proposal on a crowdsourcing website, offering a modest perk for a small cash investment. If enough people like your idea and/or your perk

you receive the funds; the investors get their perk but do not generally secure a share in the enterprise. Although this is best known for financing for-profit, especially tech ventures at sites such as www.kickstarter.com, there are social-goal oriented crowdsourcing sites as well. One example is <http://www.rockethub.com>, but there are others as well. Be aware, though

Take home message

Funding can be daunting. You can choose to ‘go big’ from the start by seeking a significant grant or donation, or you can start on a shoestring and grow over time - both are proven successful strategies. Be creative and be flexible.

that this is presently the Wild West of funding sources!

Educational objectives

Team Lead: Kelsey Morris

Innovation 5 was inspired by the convergence three streams in STEM education – new technology, emphasis on innovation and entrepreneurship and the necessity to inspire, engage and retain students in the STEM career pathways. Developing educational connections and programming is one of our key objectives. We would encourage any similar facility to pursue educational connections in their community. We recommend conducting surveys, interviews and focus groups with families, teachers and school administrators to determine community educational needs.

Strategies for determining STEM education needs in the community:

Our first step was to ascertain STEM educational needs and uncover any gaps in the curriculum at local public school districts, charter schools or private schools. We used a survey and teacher interviews to determine the most pressing needs within our local schools. The survey that we conducted at the “Be a Tourist Event” revealed that parents recognize the value of cutting edge STEM education, but do not feel that their students have access to these tools in their own schools.

We also interviewed teachers to determine their level of interest in a facility of this type. Interviews with teachers at several elementary schools uncovered that teachers feel that they don’t have experience with this type of equipment and that this type of curriculum is outside of their expertise. Although they could see the value in these educational opportunities, they felt like they would need training and professional development in this area to effectively include this type of curriculum in their classroom.

The survey and teacher interviews led us to determine that we should develop educational programming that aligns with local school curriculum and teacher training programs.

Student educational programming

Local or regional science museums can provide excellent models for integrating informal science educational programming with the local formal school curriculum. The Center for the Advancement of Science Education (CASE) at the Museum of Science and Industry in Chicago is an excellent model of educational programming (<http://www.msichicago.org/education/case/>).

CASE is a good model because their organizational mission is to empower teachers with informal educational programs, to excite students with hands on labs and opportunities for growth outside of the classroom, and to act as a prominent and engaging educational partner in the community.

CASE provides educational opportunities in the form of field trips, modular curriculum that can be taken to schools and in-house programming in the form of camps and afterschool programs.

CASE provides multi-level programming with each level aimed at a different set of grade levels. For instance, they have Learning Labs for elementary students, Science Minor program for middle school students and Science Achievers for upper levels students. They also have science clubs and programs for groups like Girl Scouts and Boy Scouts.

All of CASE's curriculums are aligned with local standards. We highly recommend that programming aligns with local curriculum standards so that school districts and teachers can justify utilizing resources and time to attend programs. Currently, in Michigan, all curriculums should be aligned with the Grade Level Content Expectations (GLCES).

Teacher educational programming

Providing professional development opportunities for science teachers will also be an important component of any educational programming. CASE is a good model for teacher training. They offer professional development courses, day long workshops, field trip previews and summer courses. All courses give teachers opportunities to earn continuing education credit and provide them with classroom activities that align with statewide curriculum standards.

Innovation 5 could team up with Michigan State University (MSU) and Lansing Community College (LCC) to provide credit to teachers. Similar facilities could team up with local colleges and universities.

Any training should firmly embed within its learning objectives explicit alignment with State of Michigan Grade Level Content Expectations (GLCES) (http://www.michigan.gov/documents/mde/Complete_Science_GLCE_12-12-07_218314_7.pdf). Science standards are in a state of flux nationally and it is important to watch for implementation of the Next Generation Science Standards (<http://www.nextgenscience.org/>). These standards actually align much more closely with the educational objectives of Innovation 5, as design/test cycles and real-world problem solving are emphasized in these new standards. We expect that teachers will be seeking out training and student experiences that meet these goals, and Innovation 5 can play a valuable role here.

Educational assessment:

Assessing informal education against established education objectives (i.e. GLCES) will help adjust programming, develop new programming, and acquire additional funding. Partnering with local university faculty can help ensure best assessment practices. For instance, Angela Calabrese-Barton, professor of education at Michigan State University specializes in informal educational assessment has expressed an interest in our project and we will also be meeting soon with the staff of the Michigan State University Museum

Conclusions and Recommendations

We are still early in the process of making Innovation 5 a reality. We have, we believe, learned a great deal that can benefit other groups who may not be sure how to start a project of this kind or, in fact, any project that begins at a ‘standing start’ with a good idea and a few individuals of good will.

Most importantly for our effort, we feel that we can conclude that the idea of integrating a community-focused fab lab into a small to medium-sized hands-on science museum is highly viable. We have been able to develop a strong case that

- There is a social need to engage more young people in STEM as a learning and career choice, especially those from underserved populations.
- The rapid prototyping/fab lab movement is a rapidly growing branch of STEM that has tremendous potential to inspire young people, to teach meaningful technical and interpersonal skills, and to provide an opportunity to be on the cutting edge of the next technological revolution.
- Authentic experiences that involve real projects and real engagement with others are essential for inspiring an interest in STEM or, for that matter, any other discipline.
- The economic development potential of the rapid prototyping/fab lab movement is significant and can be an additional driver for establishment of facilities of this kind.
- There are ample resources and assistance available for anyone pursuing a similar facility. However, there is no ‘cookbook’ method; you must be prepared to improvise and innovate.
- The model we have developed has real potential to be replicated at many similar institutions around the world.

We have been very fortunate in finding the support of so many people within Michigan and across the nation. We hope that others will find our experiences of value and, of course, in the spirit of the fab lab movement, we are more than happy to provide others with any assistance that we can; drop us a line at contact@innovation5.org !

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APPENDICES

APPENDIX ONE - Sample equipment inventory

Equipment List

Wood Shop

Tool	Cost	Justification	Priority
Delta Drill Press 17-959L	\$875.00	laser crosshair on the work piece	
Delta Jointer 37-365X X5 DJ20	\$2,200.00	parallelogram table adjustment system	
Delta Planer RC-51	\$2,250.00	working capacity of 20" wide x 9" thick	
Makita Compound Miter Saw LS1016L	\$575.00	the largest compound cuts in its class	
Acra Disc Sander 20-SD	\$1,800.00	the use of jigs for accurate sanding in wood	
Milwaukee's 8-1/4 in. Panel Saw 6480-20	\$1,220.00	a cutting accuracy to within +/- 1/32"	
Powermatic Band Saw PWBS-14CS	\$1,200.00	equipped with a tilting table and a rip fence	
3.0HP SawStop 10" Professional Cabinet Saw	\$2,900.00	power break on blade	
Shop Bot CNC PRS Standard with 3hp router	\$13,500.00	precise cutting, carving, drilling or machining	high
Supermax Drum Sander ShopPro 25	\$2,300.00	variable feed rate conveyer	

Metal Shop

Tool	Cost	Justification	Priority
Bridgeport Vertical Milling Maching Series I	\$4,950.00	rigid table with incredible adjustment accuracy	
Clausing Colchester Engine Lathe Series 8000	\$14,150.00	precision work in metal and plastic	
Arc Pro 4'x8' CNC Plasma table 9600	\$10,550.00	table for plasma cutter	
HypoTherm plasma cutter PowerMax 45 G4	\$2,100.00	hardness of material does not matter	high
Di-Acro Tab Notcher Model #2	\$1,550.00	an economical means for cutting notches	
Ellis Horizontal Miter Band Saw Model 1800	\$3,795.00	a built-in protractor for fast and accurate selection of angles	
Grob Vertical 18" Bandsaw 4V-18-20	\$10,500.00	USA-made	
Hardinge DV-59 Precision Second Operation Lathe	\$10,000.00	used for smaller work that can be held in collets	
Hobart Ironman MIG Welder Model 230	\$2,000.00	a wire fed continuously through a welding gun	
Miller LMSW-52T Resistance Spot Welder	\$1,540.00	a quick and efficient way to bond sheet metal together	
Miller Syncrowave 180SD TIG Welder	\$1,800.00	capable of AC and DC operation	
Pexto 37" 16 gauge Jump Shear	\$1,400.00	foot squaring shear for accurately cutting sheet metal	
Scotchman Porta-Fab 45 Ton	\$6,400.00	capable of exerting up to 45 tons of pressure on a die	
Tormach PCNC 1100 CNC Mill	\$8,480.00	capable of doing precision work in metal and plastics	

Craft Shop

Tool	Cost	Justification	Priority
Centroform EZForm LV 1827 Vacuum Former	\$1,700.00	allows forming of a variety of plastic sheet	
Quincy Lab 32" Acrylic Strip Heater 23-160	\$165.00	allow acrylic sheet to be bent	
Melco Amaya Bravo Single Head Embroidery Machine	\$8,995.00	creates colorful designs on cloth goods	
Bernina Activa 230PE Sewing Maching	\$1,350.00	powerful DC motor which penetrates layers of fabric	
Bernina Bernette 25 Sewing Maching	\$900.00	features to accomplish sewing tasks easily and confidently	
Brother Innov-is 40 Sewing Machine	\$350.00	free-motion stitching and quick-set bobbin	
EMCO Powerlab 1012 Vacuum Forming Machine	\$2,000.00	allows forming of a variety of plastic sheet	
Epilog Helix-50 Laser Engraver	\$20,113.92	capable of engraving, and marking a wide range of materials	high
HP Designjet T790 44-in ePrinter	\$4,300.00	large-format color printing	
Juki MO-655 Serger	\$580.00	differential feed and built-in rolled hemming and performs	
MakerBot Replicator 2X 3D Printer	\$2,800.00	creates objects by laying down molten plastic to build up	high
NextEngine 3D Scanner	\$3,000.00		
16 colors of ABS for MakerBot	\$800.00		
Roland GX 24 Vinyl Cutter	\$2,100.00	cutting speeds up to 20 inches per second	

Circuit Shop

Tool	Cost	Justification	Priority
Aoyue Hot Air Rework Station	\$90.00	for working with surface-mount devices	
Hakko 808 Desoldering Tool	\$179.00	a handy, portable desoldering tool w/ a built-in vacuum pump	
LPKF ProtoMat® X60 PCB engraver	\$14,500.00	drilling component holes and milling out board outlines	
MetCal MFR-1161 Soldering Station	\$525.00	excellent output power quickly heats even large components	
Saleae Logic16 Logic Analyzer	\$300.00	can save as many as 10B samples	
Tektronix Digital Oscilloscope TDS2002C	\$1,080.00	a powerful tool for visualizing electronic signals	
Tektronix PS280 Triple-Output DC Power Supply	\$725.00	provides fixed 5 V output for powering logic circuits	

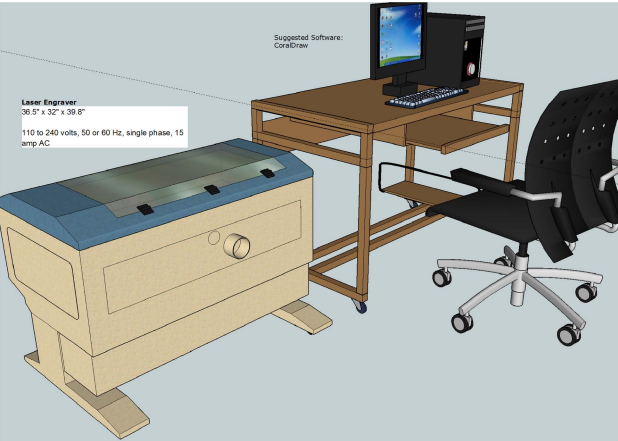
Software

Tool	Cost	Justification	Priority
Geomagic® Design Expert 3D CAD	\$1,985.00	produce G-code for a CNC machine	
CorelDRAW Graphics Suite X6	\$480.00	produce artwork for the laser and vinyl cutter	
GNU Image Manipulation Program (“GIMP”) Software	\$0.00	allows the creation and editing of bitmap graphics	high
Inkscape Vector Graphics Software	\$0.00	create graphics for the Epilog Laser and Roland Vinyl cutter	
MeshCAM Art CAM Software bundle	\$800.00	outputs G-code ready to run on a CNC machine	
VCarve Pro ShopBot Edition and PartWorks 3D	\$0.00	ShopBot-specific versions of Vectrix’s V-Carve software	
SheetCam CAM Software	\$165.00	converts 2D DXF files into the G-code	
SolidWorks 3D CAD Software	\$3,995.00	creates 3D models that are then exported as STL files	high

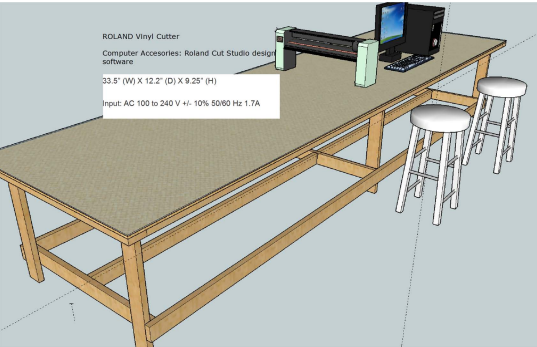
APPENDIX TWO - Instrument sketch-ups



This is an example sketch up for the 3D printer/3D scanner and software



This is an example sketch up for the Epilog Laser Engraver



This is an example sketch-up for the Vinyl Cutter

APPENDIX THREE - Survey instrument

Explain **Innovation 5**: Innovation 5 would be a new facility within Impression 5 in which families, students and community members could watch, learn about and participate in innovation (inventing and prototyping). We are gathering some information from families that use the museum to help us develop this facility.

When was your last visit to Impression 5 prior to today?

Within 2 weeks Within 1 month Within 6 months Within 1 year 1 yr or longer

What is your zip code?

What is your school district?

What grades are your children in (Circle all that apply)?

<KK 1 2 3 4 5 6 7 8 9 10 11 12

What kinds of design, build, innovation challenges does/would your child enjoy participating in?

Flight/Airplanes Construction (Bridge, buildings, materials) Floating/Boats

Robotics Circuits/Electricity Other _____

Does your child participate in these kinds of activities at school?

Yes No Not sure

Would your child be interested in participating in hands-on innovation and building projects at the science museum?

Yes No Not sure

Would you be interested in helping us prototype exhibits?

Yes No Not sure

About REI

The MSU EDA University Center for Regional Economic Innovation (REI) seeks to identify and develop new economic development tools, models, policies and practices to support innovative economic development high-growth enterprises and job creation in distressed regions across the state. REI has established a new economic development ecosystem to cope with the ever-changing global and regional dynamic. Through this ecosystem, we engage innovative and creative minds which result in new economic development practices.

The REI University Center was established in 2011 with support from the U.S. Department of Commerce, Economic Development Administration, and in collaboration with the following MSU offices:

Office of the Provost
Vice President for Research & Graduate Studies
University Outreach & Engagement
MSU Extension Office
Institution for Public Policy & Social Research
School of Planning, Design, & Construction
Department of Geography
College of Social Science

MICHIGAN STATE
UNIVERSITY

Center for Community
and Economic Development

MSU EDA University Center for Regional Economic Innovation
Center for Community & Economic Development
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The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the Economic Development Administration, U.S. Department of Commerce, or Michigan State University.