Build a Successful Fab Lab in 5 Easy Steps

Create a fun space for your students to gain real-world, hands-on engineering design and manufacturing skills

Consider how you'll power all your machines. Think about where the compressed air will go, filtration needs, and storage equipment.

Think about any noise concerns from the machines in your Fab Lab. Do you need to implement a removable wall to muffle the sound from your laser cutters so they don't distract the people at work stations?

Consult other departments that might have similar lab set-ups. This could include your IT department, nursing, manufacturing, and construction. See what has worked, what hasn't, how they got funding, and what they might do differently. It could save you a lot of time in the long run!

Meet with the maintenance staff to figure out how the room will be serviced and maintained and how that might impact the building of the space.

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Even though this looks like a straightforward process, it can take a lot of time! Make sure you build that into your Fab Lab schedule. For reference, it took Roth and Hamilton about three years to get from ideation to having a fully functioning Fab Lab.
The Fab Lab: Home to Innovators and Makers

The world is full of “Makers,” those curious people who’d rather create something than buy it

Imagine a space where students, faculty, and industry experts can come together to experiment, test, iterate, and repeat. Imagine a place where students get hands-on experience with real machinery used in industry today.

This is a Fab Lab!

Fabrication Laboratories (Fab Labs) are designed to be collaborative, innovative spaces where Makers can roll up their sleeves and, you guessed it, start making things! Typically, Fab Labs are full of 3D printers, computers equipped with CAD software, laser cutters, and additional tools for digital fabrication.

If you’re interested in building a Fab Lab of your own — or you’re just curious how it works — we’ve created this guide for you. Here, we’ll explain each of the 5 steps in detail:

1. Set your Fab Lab goals
2. Create a blueprint of the space
3. Get buy-in from key stakeholders
4. Choose the right tools
5. Embed your Fab Lab into your curriculum
6. Tips, tricks, and advice

We’d also like to give a shout out to our experts for sharing their experience creating a Fab Lab at Ivy Tech Community College in Indiana:

- **Jason Roth**, Assistant Dean for the School of Advanced Manufacturing, Engineering, and Applied Science and Program Chair for Design Technology
- **Jamie Hamilton**, Associate Professor for Design Technology and Mechanical Engineering Technology
- **Lauren Watkins**, Product Marketing & Education at Formlabs
Step 1: Set Your Fab Lab Goals

Why do you want to create a Fab Lab?

There aren’t many rules surrounding Fab Labs — there’s no perfect number of machines you have to include or a specific number of square feet (there is a list of critical machinery, but we’ll get into that in Step 2). According to the Fab Lab Foundation, there’s really only one major stricture around Fab Labs:

“The idea is that all labs can share knowledge, designs, and collaborate across international borders… If I walk into a Fab Lab in Russia, I should be able to do the same things that I can do in Nairobi, Cape Town, Delhi, Amsterdam or Boston Fab Labs.” – Fab Lab Foundation

The flexibility of Fabs Labs is part of their charm but it can also mean that you can dive into the process of building one without any direction. So, consider what you’d like your students, faculty, and others to get out of the lab and how that will inform its creation. Don’t forget to think over whether or not you’d like the larger community to have access to your Fab Lab, too!

Not sure what goals to set for your Fab Lab? Check out the goals Jason Roth and Jamie Hamilton had for their new Ivy Tech Fab Lab:

• **Facilitate collaboration between students**: Roth and Hamilton recognized the huge need for engineering and STEM students to have soft skills like communication, teamwork, collaboration, and more, and designed their lab to foster the development of those skills.

• **Invest in tools that enhance curriculum and provide real-world skills**: As the U.S. demand for qualified engineers and manufacturers increases, Roth and Hamilton wanted to ensure their students have the real-world design, prototyping, and manufacturing processes skills to quickly gain career success after college.

• **Create a space that faculty and students want to spend time in**: This is both a practical and idealistic goal. On the pragmatic side, if you want individuals to spend a lot of time in your space, you need to provide restrooms, comfortable seating, and quality tools. On the intellectual side, the more a student and faculty member wants to be part of this space, the more creating and learning they’ll do there.

• **Be a Fab Lab leader and differentiate their school**: Fab Labs are incredibly powerful marketing tools. If an engineering student is on the fence about joining your school, take them into your fancy Fab Lab and show them all the industry tools they’ll have (supervised) access to. Greatness inspires greatness!
Step 2: Create a Blueprint of the Space

Get started by finding the right space

Ideally, you want your Fab Lab to be a spacious, open room that can fit larger machines as well as work stations for students. Many Fab Labs are actually renovated computer labs while others are former library rooms, large classrooms, and more.

The Fab Lab Foundation recommends providing enough space for about 20-30 users at a time and then double that to accommodate the necessary machinery. For reference, the Chicago Fab Lab at the Museum of Science and Industry is about 177 square meters. The Foundation explains that the “ideal” Fab Lab space is about 18 meters x 20 meters. You don’t need to comply to these measurements, but they can give you a general idea of how much space you’ll need.

Grab your graph paper and pencil and start sketching

Once you’ve identified the space you’re planning on using, it’s time to start mapping it all out. For Roth and Hamilton, that meant creating a 2D blueprint that showed exactly where everything would go. Here’s an easy process to follow when organizing your space:

1. **Measure all the physical space in your room.** When you’re doing that, consider how much room should be devoted to printers, scanners, laser cutters, computer stations, work stations, and storage.

2. **Consider how you’ll power all your machines.** Think about where the compressed air will go, filtration needs, and storage equipment.

3. **Think about any noise concerns from the machines in your Fab Lab.** Do you need to implement a removable wall to muffle the sound from your laser cutters so they don’t distract the people at work stations?

4. **Consult other departments that might have similar lab set-ups.** This could include your IT department, nursing, manufacturing, and construction. See what has worked, what hasn’t, how they got funding, and what they might do differently. It could save you a lot of time in the long run!

5. **Meet with the maintenance staff** to figure out how the room will be serviced and maintained and how that might impact the building of the space.

6. **Consult your stakeholders to ensure you include any of their requirements.** Stakeholders might have different needs from the Fab Lab than you, so consult with them when you’re sketching out the space. It can save you time in Step 3! And don’t forget about your students. You want to make sure you’re creating a space that they’ll enjoy being in.

Even though this looks like a straightforward process, it can take a lot of time! Make sure you build that into your Fab Lab schedule. **For reference, it took Roth and Hamilton about three years to get from ideation to having a fully functioning Fab Lab.**
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Additional resources to help you plan your space

- The Fab Lab Foundation offers a few different floor plans and schematics to help you plan out your space. However, if you're working with a smaller space or a more limited budget, these plans might be a little robust.

- The Rocky Mountain College of Art – Design explains what went into the creation of their Fab Lab. And it does look pretty fab!

- The U.S. Department of Education also has some great resources for teachers looking to undertake the “CTE Makeover Challenge.” Whether you're investing in a full-blown Fab Lab or looking to start a smaller Makerspace, they can help you out.

- Or use the Fab Lab Locator to find different Fab Labs and see which ones you want to model your lab after!

Make It Mobile
Roth and Hamilton wanted to create a space that could — literally — move and grow with the needs of the school. Here's how they did it:

- Machines and equipment that require dedicated power lines, compressed air, etc. are on the outside of the room.
- All the items in the central area of the room are on caster wheels so they can be moved around.
- Hamilton and Roth built a raised floor above the original concrete slab so they can run cords and outlets underneath to help with overall flexibility.

Talk to Industry Experts
Talk to local industries to see what skills they need incoming employees to have. Then, consider how you can build your Fab Lab in a way to foster those skills in your students. Consider asking them:

- What CAD, CAM, or BIM software they use
- What 3D printing techniques they require
- What CNC or shop experience they need
- What soft skills they look for
Step 3: Get Buy-in from Key Stakeholders and Secure Funding

Make sure you have detailed blueprints for the space

You have this incredible idea to build a Fab Lab and you're ready to shout it from the mountaintops. Hold up a second. Make your life easier and go back to Step 2: Create a Blueprint for Your Space. Roth and Hamilton explain that the key to getting stakeholder buy-in is being able to present firm plans that the stakeholders can comment on and critique.

If you don't have those blueprints ready to go, the stakeholders won't have a great concept of what you're trying to build, how you're going to do it, and what kind of work it will take. With that much uncertainty, it's difficult to sign off on a large project. It helps to know facts like:

- What you can do internally to supply power and water
- What do you need to outsource and who might it be outsourced to

It's also helpful to have an idea for how you're planning on funding the space, whether it will come out of your department's budget, it will come through grants or donors, or a combination of different funding sources. (See our chart for ideas!)

Connect with all stakeholders, not just the obvious ones

When you think of key stakeholders, the first people who come to mind are probably your chancellor, vice chancellor, dean, your department chairs, and any senior faculty in your department. And, of course, you need to meet with these individuals about your ideas. Explain your reasons for wanting to build a Fab Lab, present the detailed plans, and ask for feedback.

Roth and Hamilton also point out that it helped them to talk to other areas of the school. The art and design department, the architecture department, nursing, IT, and more will likely be very interested in your Fab Lab. Make sure you also get buy-in from the maintenance team and ensure your plans are feasible from their perspective.
Ways to Fund Your Fab Lab

With all the machines, software licenses, training programs, and materials required for a Fab Lab, expenses add up quickly. If you need extra funding resources, this table can help.

<table>
<thead>
<tr>
<th>Type of funding</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public grant money</td>
<td>● In most cases, this is “free money” that doesn’t have to be repaid</td>
<td>● Many grants are only available on a short-term basis, so you’ll need to recoup that funding elsewhere when it runs out</td>
</tr>
<tr>
<td></td>
<td>● Long-term grants can help increase the overall viability of your Fab Lab</td>
<td>● It can be time consuming to apply for different grants</td>
</tr>
<tr>
<td></td>
<td>● You can choose specific projects or materials to fund via grants</td>
<td>● You’re dependent on the grants you can find</td>
</tr>
<tr>
<td></td>
<td>● We have a list of grants to get you started</td>
<td></td>
</tr>
<tr>
<td>Membership fees</td>
<td>● Your Fab Lab will generate a reliable income source</td>
<td>● Lower income students and those with tight budgets might not be able to pay the fees</td>
</tr>
<tr>
<td></td>
<td>● Incentivizes members to come to the Fab Lab, as they’re paying to have access</td>
<td>● Your Fab Lab will need to devote resources to gaining new members</td>
</tr>
<tr>
<td>Private funding and corporate partnerships</td>
<td>● You’ll be working closely with an industry contact, which can open up doors with other industry contacts and provide important connections for students</td>
<td>● With a corporate sponsor, you might give up some autonomy, for example, choosing the brand of machinery you want or determining who else you might partner with</td>
</tr>
<tr>
<td></td>
<td>● You can get great publicity from taking on a corporate sponsor</td>
<td>● There might be loans you have to pay back or revenue goals you have to hit</td>
</tr>
<tr>
<td>Fees for providing services</td>
<td>● If you start to charge for producing small items, you increase engagement with the local community</td>
<td>● This will require a large time investment on behalf of staff, as they will need to monitor the projects closely to ensure they’re industry-ready</td>
</tr>
<tr>
<td></td>
<td>● You can also use this as an opportunity to enhance your students’ portfolios, as they’ll have experience creating usable products</td>
<td>● Clients might want you to create products that are complicated or beyond the means of your students</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● You’ll need to consider any legal protections required</td>
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**Getting Buy-in: Why Are Fab Labs so Fab?**

When you’re explaining the need for a Fab Lab at your school, here are some great reasons that will help you convince stakeholders to make the investment:

- Fab Labs appeal to all different types of learners, creating a more robust learning experience for all students.
- Students get hands-on experience with the tools and machines used in industry today, better preparing them for the workforce.
- Fab Labs capture students’ attention better than the average lecture or reading assignment.
- Students can design, build, test, and iterate on real projects to enhance their portfolio.
- Students have the opportunity to work with industry experts and meet local leaders who could help connect them with jobs or internships.
- Fab Labs provide a safe space for students to try new things and fail, so they won't make those mistakes on the job.
- Fab Labs mimic actual work environments much more than classroom lectures and reading.

- During their time in the Fab Lab, students gain the soft skills employers require: communication, collaboration, motivation, interdisciplinary teamwork, and more.
- Students get experience teaching others how to use the software and machinery, increasing their knowledge and confidence while enhancing important soft skills.
Step 4: Choose the Right Tools for Your Lab

Sort out your software and technology needs

Let’s start with the easier stuff: computers, technology, and software! Here are some important considerations to make when picking out the computers for your lab:

- Do they provide the ability to upgrade RAM and video cards?
- Do you need dual monitors so that students can view SolidProfessor tutorials and software simultaneously?
- Who will be managing technology requests: you or your IT department? What system will you use to submit technology work requests?

Next up, let’s investigate your software needs. You’ll need some kind of CAD software (common CAD software include SOLIDWORKS, AutoCAD, Inventor, Fusion 360, and more). For reference, Roth and Hamilton chose Fusion 360 and Inventor. You also need to purchase the proprietary software for your 3D printers. Roth and Hamilton elected for Formlabs, Stratasys, and 3D Systems (3DS).

Remember: Once you purchase the software, you need to install it on all the computers. This might be an IT task, so make sure you explicitly list out who’s responsible for that process. This also includes any training software or tutorials that you need to install (like SolidProfessor). Did you know that SolidProfessor offers a Task Pane Add-In feature, so you can view our interface directly within SOLIDWORKS? If you have any questions about this feature, please reach out at info@solidprofessor.com!

Harness the power of hardware

Let’s find some CNC machinery! While there are hundreds — if not thousands — of CNC machines to choose from, Making Society encourages Fab Lab creators to focus on these five categories.

- **A laser cutter**: These are among the most straight-forward machines in a Fab Lab. Students can laser cut engravings or a piece of wood into any number of shapes. This high-precision machine does require a good ventilation system. Roth and Hamilton purchased the Universal VLS 6.60 Laser Cutter.

- **A CNC router**: This fun machine is used for cutting various hard materials like wood, composites, aluminium, steel, plastics, glass, and foams. CNC routers usually produce high-quality work and improve overall factory productivity. Automation and precision are the name of the game!

- **A 3D printer**: Fun, useful, and very popular, 3D printers are a staple in any Fab Lab. There are tons of options, such as home printers like Makerbots and Ultimakers. Or, you can invest in industrial 3D printers manufactured by 3D Systems, Stratasys-Objet, or EnvisionTEC. Roth and Hamilton chose: six Formlabs printers, 3DS 660 Projet, Stratasys 30Prime Objet, Markforged Mark 2, Axiom Airwolf, Monoprice III, and an FDM Homemade Printer.

- **A milling machine**: While a 3D printer adds material, milling machines subtract it. They’re typically used for making all kinds of prototypes and products from jewelry to molds.

- **A vinyl cutter**: You can use your vinyl cutter to make signs stickers, apparel decoration, or large graphics. This is a great machine, especially if your school has a Formula SAE (FSAE) team and they want to create custom vehicle decorations.
Aside from the machinery, there are some other supplies that you'll need to purchase for your Fab Lab:

- **Safety and personal protective equipment (PPE):** Make sure you have all the essentials and then some. Roth and Hamilton purchased face shields, safety glasses, gloves, face masks, fire extinguishers, SDS books, and a fire cabinet, among others. [MIT](https://www.mit.edu) offers general safety protocol as well as a list PPE.

- **Furniture:** If you want students and faculty to spend a lot of time in your Fab Lab, the furniture needs to meet their needs. Roth and Hamilton purchased quite a few work benches, chairs, stools, portable whiteboards, tool cabinets and other tool storage, and portable wire racks. Make sure you have plenty of options for storage and seating!

- **Power tools and hand tools:** [The Fat Cat Fab Lab](https://www.fatcatfablab.com) lists out important tools you might want to consider for your Fab Lab. The list includes a table top drill press, cordless drill, chop saw, jig saw, screw drivers, wrenches, ratchets, Alan key sets, scissors and razors, glass cutters, and chisels.

**Insider tip:** This is a great time to check in with local industries to see which CAD software and 3D printing skills they look for. Make sure your students have the ability to learn that software in your Fab Lab if possible!

**Additional resources to help you choose your tools**

[The Fab Lab Foundation has a list of materials](https://www.fabfoundation.org/materials), including hardware, software, technology, and consumables, that all Fab Labs should contain. This is a robust list of tools and machinery, and it might not be realistic for your lab right away. Use it as a reference list and/or a wishlist. Additionally, you can see a [list of materials](https://www.fatcatfablab.com/materials) broken up by topic area on the MIT website and the [Fat Cat Fab Lab website](https://www.fatcatfablab.com).

Many existing Fab Labs display their materials lists, so if the examples above aren't working for you, check out Fab Labs that are similar to the vision for your Fab Lab. You can use the handy [Fab Lab Locator](https://www.fabfoundation.org) to get started!
Picking the Perfect 3D Printer

With all the different kinds of 3D printers on the market, it’s tough to know which ones are right for your lab. Lauren Watkins from Formlabs breaks down the benefits and requirements of each type.

<table>
<thead>
<tr>
<th></th>
<th>FDM</th>
<th>SLA</th>
<th>SLS</th>
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<tbody>
<tr>
<td>Applications</td>
<td>Low-cost prototyping; proof of concept models</td>
<td>Functional prototyping, high-resolution models</td>
<td>Short-run production, custom manufacturing</td>
</tr>
<tr>
<td>Benefits</td>
<td>Low-cost consumer machines and materials</td>
<td>High accuracy, great value, smooth surface finish, range of functional applications</td>
<td>Strong functional parts, design freedom, no supports necessary</td>
</tr>
<tr>
<td>Ancillary Equipment</td>
<td>Support removal system, finishing tools (sandpaper, epoxy)</td>
<td>Washing station (IPA), post-curing station (optional), finishing tools</td>
<td>Post-processing station for part cleaning and material recovery</td>
</tr>
<tr>
<td>Facility Requirements</td>
<td>Air conditioned environment or preferably custom ventilation</td>
<td>Desktop machines suitable for the lab environment</td>
<td>Workshop environment with moderate space requirements for benchtop systems</td>
</tr>
</tbody>
</table>

**Fused Deposition Modeling (FDM):** This plastic-based 3D printer uses classic filament and an extruder to create the object layer by layer. It operates on the X, Y, and Z axes, and the most commonly used material is ABS and PLA plastic. This printer is typically used by hobbyists and the results are low fidelity.

**Stereolithography (SLA):** This resin-based 3D printer uses UV lasers guided by mirrors to selectively cure liquid resin, turning it solid layer by layer to create the object, which makes it a more precise process. The result is a high-resolution, very accurate print that’s best for high-fidelity prototyping to validate form and fit. The material is liquid photosensitive resin that simulates plastic.

**Selective laser sintering (SLS):** This 3D printer uses a laser to center plastic-based powder material into a solid structure. The powder is dispersed in a thin layer on the platform and the laser scans a cross-section of the 3D model, heating up the powder to a melting point to fuse those molecules together. The result is a very strong object that’s great for testing functionality or even for creating end-use parts.
To make these ideas work, Roth and Hamilton leverage a flipped/blended classroom, where students watch SolidProfessor tutorial videos and complete online reading in their own time. Then, they come to class with their questions. Roth and Hamilton point out that the goal is to make sure their students spend as much time as possible in the CAD software, designing cool objects and honing their techniques. They explain that the ability to assign SolidProfessor videos really opened up class time for their students to dive into the software, while Roth and Hamilton help them address any problems or questions.

Before changing to the flipped/blended classroom with SolidProfessor, Roth and Hamilton spent their time giving step-by-step instructions during class. This ate up a ton of time, didn’t help students really dig into the material, and they had to stop the entire class whenever someone had a question. Under the new model, they get more done and students have more hands-on experience with the software.

Don’t Forget: Soft Skills Matter!
One of the biggest benefits of Fab Labs is that they help students build soft skills as well as technical skills. The Workplace Learning Report surveyed thousands of experts to determine the most important soft skills for engineering students:

1. Communication
2. Creativity
3. Adaptability
4. Collaboration
5. Leadership

Curriculum application: CAD + 3D printing = career readiness

There are thousands — if not tens of thousands — of ways to leverage your Fab Lab in your curriculum, and we’re by no means going to discuss all of them. However, we’ll go through some easy ways to get your students involved, whether they’re CAD neophytes or connoisseurs. These ideas and examples are based largely on Ivy Tech and how they’ve built a truly exemplary curriculum in conjunction with their Fab Lab.
Here are some ways to get your students hooked on CAD and 3D printing while imparting important knowledge in the process:

- Start by having students create simple objects and 3D print them. This is a great way to help students visualize how to go from 2D projects to 3D projects. Not sure how that 3D shape on your computer will look in real life? Let’s 3D print it to find out! This gives students valuable design knowledge that they might not otherwise be able to visualize.

- Require students to build objects and models that are functional. In the real world, everything we design must be functional, so why not in the classroom?

- Challenge your class to design models that not only function correctly, but look very different from anything else on the market. For example, have them create something that functions like a brick but looks completely different than the general brick design.

- Allow students to create, test, and repeat. Let them fail! Roth and Hamilton explain that a key function of their Fab Lab is to give students a space to fail safely. This emboldens them to try new things and methodologies and see what happens. Not only do they learn valuable lessons along the way, but they also understand how to accept failure without freaking out. It’s better to fail in a Fab Lab than at a large scale when they get to the industry.

- Encourage advanced students to be volunteers or mentors in the Fab Lab to help beginners learn the ropes. There are so many opportunities for the student to become the teacher, which not only boosts students’ knowledge of design and additive manufacturing, but also enhances important soft skills like leadership, communication, collaboration, and more.

- Challenge your students to get industry certifications, like their Certified SOLIDWORKS Associate (CSWA). Roth and Hamilton say that their goal for students is about more than just getting a degree — it’s about giving them the technical skills, credentials, and certificates to differentiate them in the hiring process.

- Reach out to local businesses and industries and see if they have projects your students can tackle. Roth and Hamilton say that companies in their area sometimes even send engineers to their Fab Lab to help students create products and parts for them. This is an incredible way to give students hands-on, real-world experience while learning from industry experts.

As we mentioned earlier, there are so many ways to leverage your Fab Lab in your curriculum that we couldn't possibly list them all here. If you'd like to learn about more ways to utilize a Fab Lab at your school, give us a call at (619) 269-8684 or email us at info@solidprofessor.com. We love talking about all things engineering and manufacturing!
maybe it means down the road, or perhaps it means that you need to do it differently. Be prepared and nimble when those curveballs are thrown your way.

- **Understand the limitations of your space.** With a Fab Lab, you’ll need power, water, air filtration, flooring finishes, painting, lighting, HVAC, sound control, workbenches, computer desks, and so much more. Have an incredibly detailed understanding of how all of those factors and more will be accounted for in your space.

- **Include plenty of storage.** Roth and Hamilton explain that their room is already shrinking as they acquire more materials and supplies. Prepare for that inevitability upfront by investing in smart shelving, cabinets, and other storage options.

What do Ivy Tech students think of their fancy new Fab Lab?

Roth and Hamilton report that the impact of the Fab Lab on their students and faculty has been huge! Students say that they can actually talk to each other and get their questions answered quickly and easily. They have their own space to work at, rather than being confined to a desk.

And, most importantly, when class is over, students want to hang out in the Fab Lab, creating new things, experimenting, and being part of the bustling atmosphere. Roth and Hamilton explain that this is a huge culture shift, and it’s incredibly exciting to see students want to come in to the Fab Lab and work.

So, what are you waiting for? Get on the path to Fab Lab greatness!

General Tips, Tricks, and Advice about Building a Fab Lab

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**Have Questions? Ask Us!**

SolidProfessor is here to help you with all your Fab Lab needs:

- Looking for training to help students better understand their CAD, CAM, and BIM software? We have courses for that!
- Need to boost your students’ knowledge of engineering methodologies? Check out our online videos on GD&T, Design for Manufacturing, and Engineering Graphics and Spatial Visualization.
- If you’d like to talk to an academic specialist, give us a call at (619) 269-8684 or email edu-sales@solidprofessor.com.

**Some parting advice for building the most fabulous laboratory**

As Roth and Hamilton launched into building their Fab Lab, they hit some roadblocks and detours along the way. They’ve offered some advice to help you better navigate those roads when you look to create your own Fabrication Lab:

- **Be ready to adjust!** Have contingency plans for everything and always prepare for a “no.” Sometimes that “no” means never,