Lessons from the First Early Childhood Fab Lab

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WestEd is a nonpartisan, nonprofit research, development, and service agency that works with education and other communities throughout the United States and abroad to promote excellence, achieve equity, and improve learning for children, youth, and adults. WestEd has more than a dozen offices nationwide, from Massachusetts, Vermont, and Georgia to Illinois, Arizona, and California, with headquarters in San Francisco.

Introduction

In spring 2016, the Bay Area Discovery Museum (BADM) hired WestEd to conduct an evaluation that documented the challenges, lessons, and successes associated with their development of the first early childhood Fab Lab, a makerspace focused on the use of digital fabrication tools with young children. During its first year, WestEd conducted interviews with BADM staff integral to the Fab Lab, as well as teachers who visited the Fab Lab with their students; developed surveys for parents whose children attended Fab Lab programming; and observed programming as it was implemented. This report summarizes WestEd's findings related to: the design of the Fab Lab space; staffing; programming; messaging; and parents' perceptions about what they and their children learned as a result of visiting the space. The discussion about programming primarily focuses on three of the educational programs that take place in the Fab Lab: Design Lab, Open Studios, and School Programs, which are defined below.

Design Lab: A 1-hour facilitated program with a pre-set curriculum. Up to 15 children can attend.

Open Studios: Open Fab Lab hours during which time museum visitors can drop in and work on projects in the Fab Lab for as long or as little as they like.

School Programs: Class field trips to the Fab Lab, usually for first and second graders, that are organized in advance. Each class participates in a structured, facilitated curriculum that lasts for approximately 90 minutes.

Setting up the Fab Lab Space and Tools

Although BADM staff had visited Fab Labs throughout the country and attended Fab Lab conferences to get ideas about how to set up their Fab Lab, the environment they sought to create would be the first developed for early childhood education, with children as young as three years old. They realized that what worked in Fab Labs geared toward older children and adults would not necessarily work with their young guests. Consequently, in the early stages of development, Fab Lab staff experimented "to find out what works for kids at that age range. . . to basically set the standard of what can be done and what should be done in early childhood Fab Labs."

Part of this experimentation involved creating an inviting space that allowed implementation of various kinds of programming, and also included the digital fabrication tools that are required to be part of the international Fab Lab network (e.g., a laser cutter, a 3D printer; see <http://www.fabfoundation.org> for more information). Explained one staff member:

> We did know ahead of time what tools would be used because there was a decision early on to make this space a part of the Fab Lab network. The network is over 100 Fab Labs that are international and they work together in that they

> share knowledge and learning and that model. Wanting to be part of that network was really important to [staff members] early on, and within that there are tools that every single Fab Lab has.

The process of developing the Fab Lab space involved extensive discussion and prototyping. BADM worked with TIES (the Teaching Institute for Excellence in STEM), which held a meeting in May of 2015 to outline the tenants of an early childhood Fab Lab. A staff member described:

> We started with the list from TIES, equipment and materials, and that was kind of our starting point, and we went through, as a team. . . the list and brainstormed what they recommended, then brainstormed some other things and thought, "This will work for our space and our context and our ages," and we did a lot of prototyping, too. So, we saw people and we weren't just testing things, we had people come and try things out and we made some significant changes based on those first sessions.

There were a variety of factors that influenced staff decision-making about the layout of the space, and the tools that would be used in programming. First, because BADM is housed in historical buildings, there were limitations related to changes that could be made to the Fab Lab's building infrastructure. There were also space constraints related to where the tools and equipment could be placed within the three distinct rooms that constitute the Fab Lab, since the staff wanted tools and equipment to be visible and accessible to guests. Staff also wanted to create a space that permitted collaboration between guests, and included various work stations. These factors, along with the staff's knowledge of how guests move through other parts of BADM, influenced the organization of the space. As one staff member described:

> We really wanted the equipment to be . . .really visible to kids. There are not to be any black boxes, [so] that kids could see how the equipment is working and see the computer and really get a feel for what the machine is doing and how is it doing it. . . . The other piece, we knew early on. . . the work tables and work areas are very flexible. The work table could be moved and they could kind of enable the collaborative process or they could have different stations with tables. . . . We went with this kind of hexagonal design that our exhibits team made that has really helped with making the space flexible and it affects how the children interact.

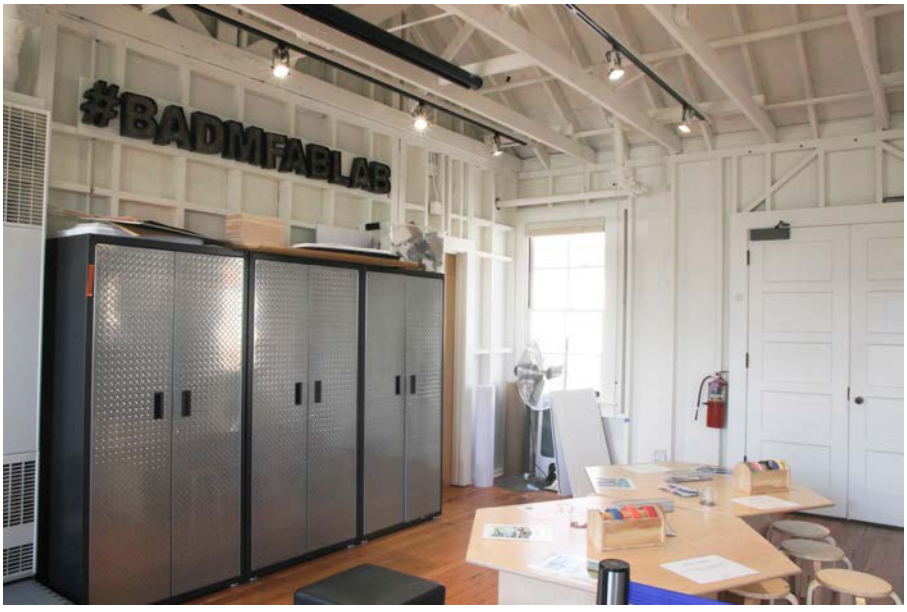
With the intention of being deliberately flexible, the Fab Lab was set up "pretty loosely," according to one staff member:

> We set [the room up] pretty loosely because in the beginning we didn't really know where things would be at permanently. I think I have seen that laser cutter moved three times. So even our cabling, we just left it hanging from the ceiling so if we have to move . . . the hard-wired computers . . . again, things aren't nailed down.

High-tech tools and work areas in Fab Lab

Over the course of its first year, Fab Lab staff continued to refine the layout of the space to best fit their programmatic and learning goals. For example, one staff member commented:

> In terms of the layout of the room itself, instead of having our circle time in the corner . . . we have our circle time in the very center of the room and we surround the room with all the different parts of the project. So, that also has seemed to create more of a "freedom" feel to it for the kids. They don't have to start in a certain spot; it is more open to them to decide the best way to go about doing a project, the best order for them to go in.



Storage space and work areas in Fab Lab

While most staff members feel that they have made progress in creating a space that meets their differing goals, there is still some disagreement about whether the space adequately works for guests who have different interests and attention spans. For example, one staff member explained that during the Design Lab program:

> It has not been a challenge at all… if you have a three-year old who is getting antsy and wants to leave, then usually kids start to filter out at the 45-minute or 55-minute mark of the class, and sometimes we have some six- to twelve-year-olds who just want to kind of hang out, so there is a very natural flow to everything. We haven't had an issue so far. By the hour mark, we have from zero to five kids left in the space and they can continue to work on things and so that hasn't been a problem at all.

In contrast, another staff member felt that the set-up of the Fab Lab needs further development:

> I think we haven't given enough thought to our overall user experience at the Fab Lab, to think of how we are structuring it and how we are using it as an exhibit space and how the layers are different levels of commitment, because there are people who want to have a Fab Lab experience but they don't want to spend an hour or they don't want to learn to use the software or whatever. And then there are others who really want more time and attention. To be able to set that up so it is clear what the different options are, just from the way the space is set up and the environment, that, I think, is something to aspire to.

Early Childhood Fab Lab Manifesto, hanging on wall

In addition to challenges associated with creating a space that met Fab Lab goals, another significant issue that was clearly associated with meeting the needs of young guests in particular related to choosing appropriate software for use in the Fab Lab. One staff member described the challenge:

> There is no [existing] software that is age-appropriate and intuitive, a balance between being constrained enough to help kids and open enough so they can actually do meaningful creation [and] for us as facilitators so we can play with it in enough ways that we can do all kinds of different programming. . . . It is frustrating because I feel like we want some company to come to us and say, "We want to do this, and you guys have a whole lot of user experience, please help us on it." It is just hard, it has been really frustrating.

Fab Lab staff experimented with a variety of software and ultimately decided to use different software for different Fab Lab programs. The staff in charge of school programs decided to go with Maker Studio, "because for them, [the fact] that it was a very scaffolded [software] was pretty appealing," according to one staff member, whereas "for the public program they wanted something more flexible and open-ended. They wound up going with Illustrator."

Staffing

The staffing structure of those who interact with BADM's Fab Lab has evolved substantially since the project first originated. Initially, there was a large focus on the physical set-up and equipment for the Fab Lab, as well as the type of curriculum that would be offered in the space. The original three staff members who spearheaded the Fab Lab planning team had expertise in areas such as early childhood education, curriculum, exhibit development, and architecture. However, they soon realized that it was highly problematic not to have someone with fabrication expertise on their team. Once they overcame the challenge of finding someone with design experience to join their staff, the planning became considerably easier. One team member described the benefit of adding this new staff person, the "Designer-in-Residence," to the team:

> [His] expertise is in the fabrication end of things and he does a lot with using the tools to bring them to a different level, showing what they can do to visitors. We didn't really have that early on; we were working more with baseline concepts…It has been very helpful to bring on [this staff member] in terms of his more technical skill set. I think that piece was missing at one point.

The team also has always included peripheral support from vital staff who interacted with the Fab Lab in a finite and specific way, to provide assistance on tasks related to communications, development, exhibits, and finance, for example. Another critical job that takes place behind the scenes is IT support, which is provided through an external consulting group for all of the exhibits and facilities at BADM.

As the Fab Lab project continued to develop, the team involved in the primary operations of the Fab Lab grew larger. The Fab Lab has now been open to the public for one year, and its core team consists of a few staff members whose primary role is to lead the daily operations in the Fab Lab, such as developing and running the Open Studios and Design Lab programming. At least one of these staff members is always present during other programming that takes place in the Fab Lab, such as school field trips, visits from the Discovery School preschool program, and summer camps.

Due to the complex web of staff members who interact with the Fab Lab, not everyone can be included in all Fab Lab meetings. There is a monthly Fab Lab meeting held for the direct Fab Lab team and supervisory staff, but it is difficult for staff to coordinate their schedules to be able to attend on a regular basis. Thus, there are also meetings held among smaller groups of staff members to discuss Fab Lab issues that fall within their purview. When the Fab Lab first started up, the team could often meet "more informally, just checking in with each other to make sure we know what is happening and who is doing it." However, as the Fab Lab staffing structure has grown in complexity, a more concerted effort to nail down the staffing organization has been made. The staff recognizes that there is now a need for "a coherent system [to be] in place to keep everybody informed about different decisions and different things happening in the Fab Lab." One staff member explained:

> We were more of a small museum and we are in the transitional state to be a medium museum, and there are just a lot of people and we are trying to think through how we can stay organized and on top of this project. This consultant would come in a few times to work with different teams really to decide what we need in terms of the immediate in terms of a project plan and then pushing out ideas, what are our goals for three and five years. The goal of using this consultant is really to put a project management tool in place which hopefully will help us stay informed about what is going on and what needs to happen next because that is the piece we are missing.

After experiencing some growing pains during the first year of Fab Lab operations in terms of its complex staffing structure, it was determined that it would work best to appoint someone to serve as the institutional owner of the Fab Lab. Ultimately, having one staff member to oversee and organize the Fab Lab operations should reduce confusion about Fab Lab programming and streamline decision-making processes. Previously, the various staff members who interacted with the Fab Lab were all part of different, parallel reporting structures within the museum, and each person had his or her own perspective on what the Fab Lab needed. Now, there will be an institutional owner of the Fab Lab, "a leader who [has] enough expertise to have a validated point of view," who can provide clear direction. The goal of this role will be to serve both as a visionary for where the Fab Lab needs to grow and develop, but also to see how the Fab Lab fits within the Bay Area Discovery Museum's larger institutional goals.

Furthermore, this provides an opportunity to increase the number of staff members who are trained on how to use the equipment in the Fab Lab. Explained one staff member, "It is time-intensive to bring staff up to speed on all of [the tools], and it is not sustainable long-term for there to be only two or three people who know how to run the programs." Therefore, this change

would assist with reducing the workload for the three core staff members who work in the Fab Lab, because at least one staff member—and sometimes more—needs to be present during any programming in the Fab Lab to ensure that everything runs smoothly. These staff members were initially also responsible for helping to develop curriculum across all the different types of programming, but that was not sustainable. Therefore, the core staff now serve in a more defined role:

> What we have done is we have set up a system where [the staff] who are embedded in the space…act as sort of advisors to other programs…One of the Fab Lab staff will stay in the space for any program as a tech, meaning they will supply any logical support that is necessary in the space. However, the program that comes into the Fab Lab, they need to bring their own facilitators or educators in the space to run their program.

However, this staffing reformation effort is still ongoing. More staff has continued to be needed in the Fab Lab than BADM originally anticipated, and the amount of time staff need to spend in the space is more intensive than was originally predicted. One staff member explained:

> Because there are only three people that actually know what is going on in the Fab Lab, the programs that get created still require a lot of lift from people in the Fab Lab, [who] pretty much have to participate in everything that is in there just to see that it runs smoothly. So it is just a real serious tax on staff.

During the process of drafting the final WestEd report, a Fab Lab staff member also commented that one major challenge has been differing staff views about whether the Fab Lab should primarily serve as an exhibit space or a programming space. Determining the role of the Fab Lab within BADM's overall mission and context continues to be an ongoing discussion among staff.

Programming

Design Lab

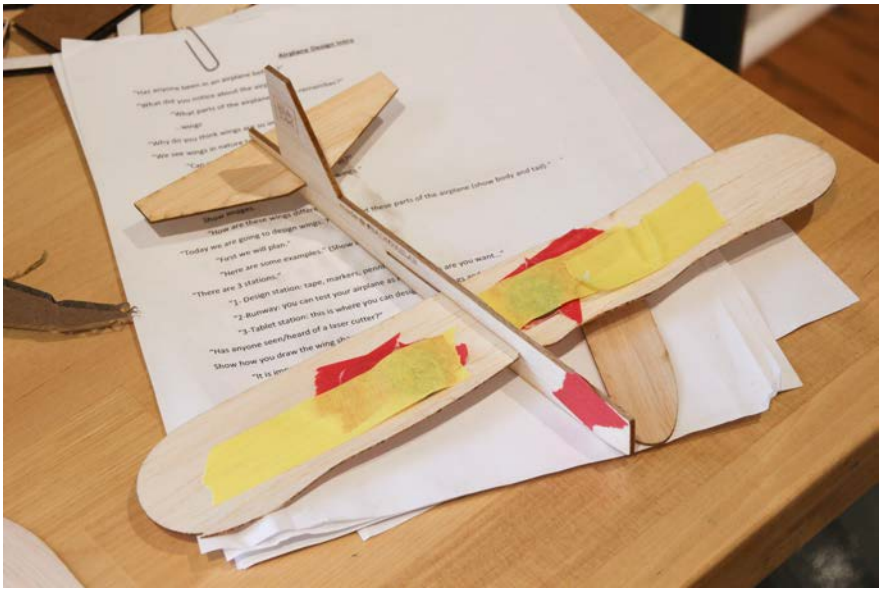
When the Bay Area Discovery Museum agreed to take on the challenge of opening a digital fabrication lab for young children, the staff initially did not know what the children would be able to do. At the beginning, as one staff member explained:

> I didn't really have an understanding of digital fabrication before we embarked on this project, so I was just getting a baseline. What is this world? What is possible? What do the machines do? And thinking about how we can possibly reconcile that and give access to little kids. . . . On the other side of that, there are a lot of low-tech makerspaces that are for little kids and are accessible, and thinking about what we might take from those spaces and add the tech element to those.

In order to provide children with the opportunity to interact with the tools while still ensuring learning, the team came up with the idea of holding a one-hour Design Lab, which would consist of a heavily facilitated program with a pre-set curriculum. Although this did allow students to

learn new STEM content, the staff ultimately concluded that the curriculum was too restrictive and that it needed more flexibility:

> The project had become a little bit too closed-ended, so it became like a craft, and here are the steps you do—you do step #1 and then you do step #2 and then step #3 and you're done. A good practice for working with young kids is kind of the opposite of that. You want to make things as open-ended as possible, where there are a lot of different angles to try and the child is directing their experience and learning. And the adult controls for a lot of things in the environment. They give careful and intentional thoughts on materials and what the different options are and what the kids can do, but the kids are actually making the choice.



Design Lab creation, airplane wings designed on tablets and cut on laser cutter

After approximately six months of running the Fab Lab, the team experienced a philosophical shift in their programming, such that there was a renewed focus on letting the kids explore and on decreasing the regimentation in the curriculum. Furthermore, some of the staff have advocated thinking of the Fab Lab as a makerspace with a range of both high-tech and low-tech tools to build student skills, rather than a makerspace with only high-tech tools. One staff member described:

> Now we have [the Design Lab program] set up in a way where there is much more of an explorative aspect to it. For our last program. . . creating your own stamps, we have the tablets out but there was also an option—we have a lot of organic material like leaves and random scraps that we laser cut that you could try to use as stamps and see how those worked. Ultimately, in the end, just about every kid ended up using the tablet but they did it on their own terms instead of us directing them to do it. The transition has been a lot smoother. It is something more familiar to them, more open to them, more available, and then from there you can move into something that is a little less familiar.

Nonetheless, there is still some division among the staff about how best to develop the Design Lab curriculum. Some feel that the program should be primarily focused on educational content and the high-tech tools in the Fab Lab. Others feel that the focus should be on allowing children to explore the tools naturally and letting the educational content develop more organically from there.

Child tests Design Lab creation in boats program

However, the Design Lab program has difficulty with decreasing regimentation while still providing students time to engage with the tools and create a unique design (e.g., designing their own airplane, designing a boat). Its more controlled structure affords children increased guidance and support, but it also limits children's flexibility in how to follow through the design process. Furthermore, opportunities to allow children to iterate upon their design must often be sacrificed due to time limitations.

School Program

The Fab Lab's School Program, in which teachers can bring their class to the Fab Lab for a design session, has a very explicit focus on aligning with the Next Generation Science Standards (NGSS) being taught in schools. One staff member explained the process for developing the Fab Lab school curriculum: "What is really important for teachers to get approved for field trips is that it is tied to the standards, so the first thing that we did is we started looking at the NGSS standards that are starting to be rolled out in California right now and that teachers have expressed a lot of concern that they need support with." In addition, staff also felt that, "Children needed to authentically be engaged with the tools," and that the curriculum should ideally include a "design thinking component."

This programming structure presents an immense challenge, because it is difficult to meet all of the museum's goals for the field trip program in such a limited time period. It was also vital for

two class groups to be able to participate in the Fab Lab program within a single day, since schools typically must to send two classes on a field trip at once to justify the cost of the school bus. Another significant challenge is finding the time to craft all of the students' designs with the high-tech tools, while still providing children with the opportunity to see those tools at work.

To meet the challenges associated with time constraints, educational goals must be clearly prioritized to ensure that both museum staff and attendees feel the programs are meeting their goals. This is true for both the school program and the Design Lab. One staff member explained, "I still think the challenge we run into is how do you make something open-ended enough that it is interesting but closed-ended enough that it is possible in a short period of time? I think we are figuring out almost like a theoretical framework about how we approach that problem."

Offering a Continuum of Experiences: Open Studios and Other Programming

One solution to the problem of time usage has been to develop different types of programming for the Fab Lab, which includes "a range of programming in terms of a very light touch to a very deep touch." On the light touch side, BADM developed Open Studios hours for the Fab Lab, in which families can drop in anytime during studio hours and stay for as long or as little as they like. During Open Studios hours, the Fab Lab essentially serves as an exhibit space instead of a programming space. Some children stay for only a few minutes, simply passing through to watch the 3D printer or the laser cutter at work, while others may work on a project of their choosing for the full 90 minutes. Deep touch programming includes summer camp programs and opportunities for The Discovery School to bring their preschool students to the Fab Lab on a routine basis, building students' design skills little by little.

Fab Lab activity set-up with tablets

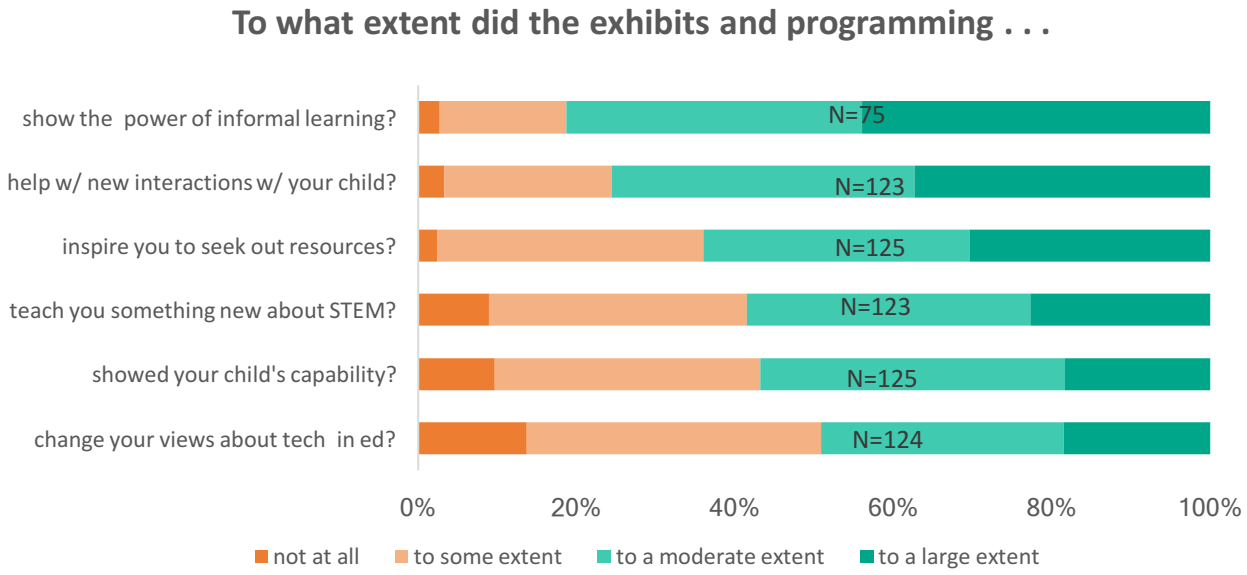
This range of programming has eased the schedule for staff somewhat, and provides new opportunities for visitors to interact with the Fab Lab. A further benefit of offering this continuum of experiences for families is that it also provides the Fab Lab staff space to develop their Design Lab curriculum and facilitation techniques. When the Fab Lab first opened, the Design Labs were held back-to-back several days per week, and the schedule was very challenging for the staff to manage. One staff member described, "We had design labs every single day and that was brutal, and then we were doing the same program every day because there was no time to think of a new program or design programs." In contrast, the Open Studios provide opportunities for the staff to learn along with the kids. A staff member explained, "Before trying to design a program, we need to see how kids interact with this technology, then we can design a program based on that…Observing tendencies of kids before kind of cramming an idea down their throats. They should be coming up with an idea and we should follow their lead."

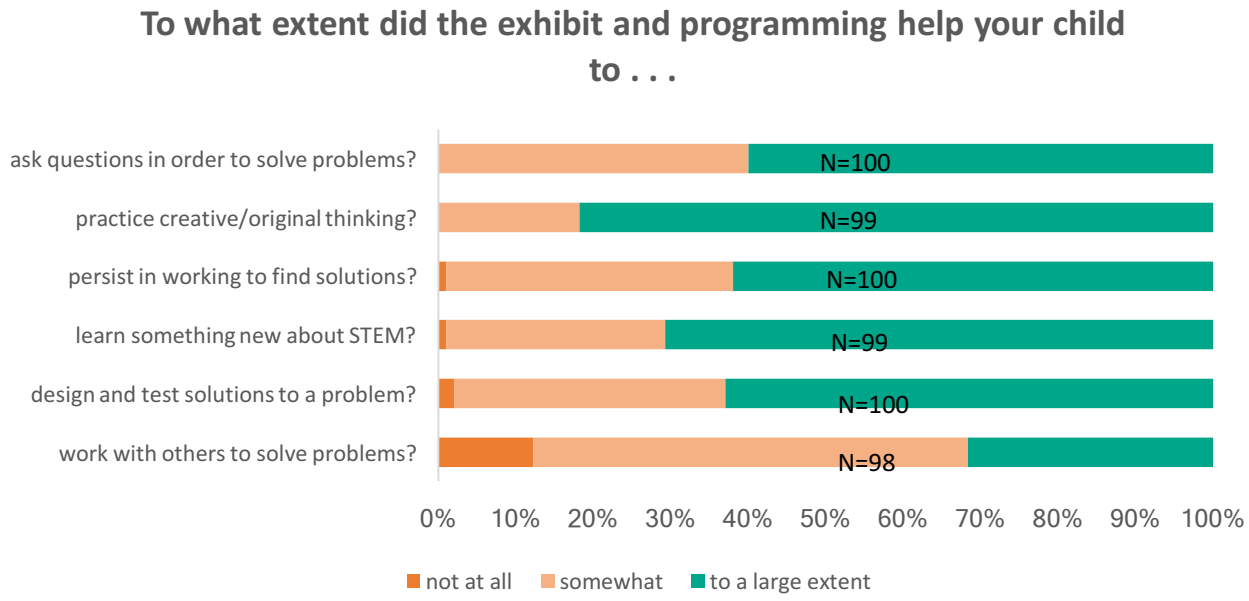
However, there are still some philosophical divisions among the staff in terms of the amount of structure and facilitation that should be embedded in the Fab Lab programming. Child visitors to the Fab Lab range from two to twelve years old, and providing these children with a high-quality experience that is not overly simplistic for an older child, nor overly complex for a younger child, is quite challenging. There has been some disagreement about the target age range for the Design Lab program, with some describing it as a program for children between five and ten years old, and others describing it as a program for children of any age. Thus, it is not surprising that there would be a range of opinions among staff on how best to accomplish that goal. Some staff members feel that the high-tech tools in the Fab Lab should be emphasized and explicitly taught as part of the design process while in the Fab Lab, whereas others feel that the high-tech tools should only be accessed when children seek them out for problem solving on their own. This latter group of staff believe that the high-tech tools should be used to *enhance* the children's learning experience rather than *drive* their learning experience in the Fab Lab.

Parent Feedback on Design Labs and Open Studios

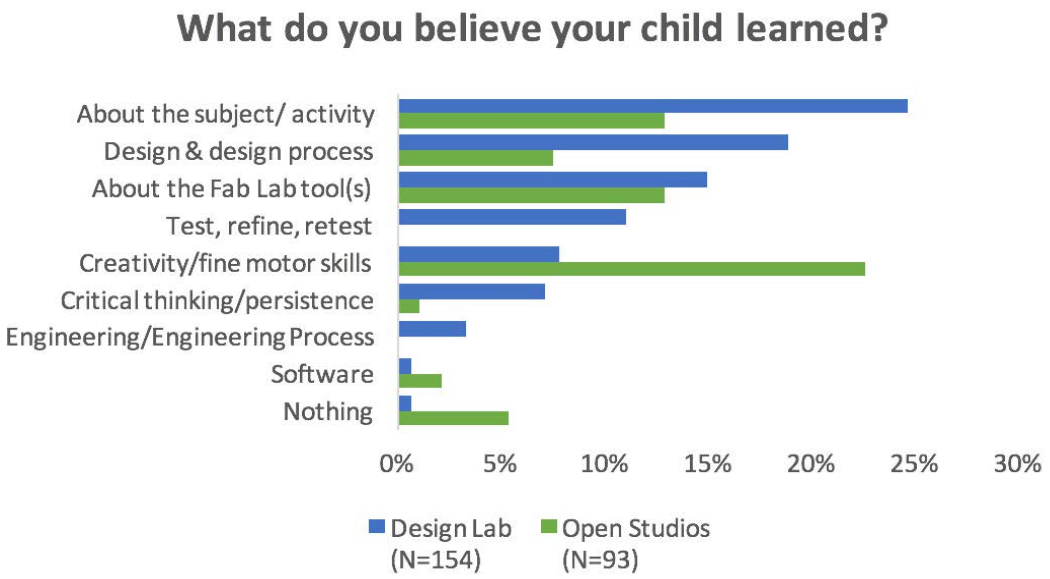
To better understand the experiences and learning outcomes of visitors to the Fab Lab, WestEd worked with BADM staff to develop five different parent surveys. BADM then collected a total of 247 surveys from parents during Design Labs and Open Studios time. Although the surveys each had a slightly different focus, all of the surveys included some demographic questions, a Likert scale section, as well as two open-ended questions on learning: 1) "What do you believe your child learned while at the Fab Lab?"; and 2) "What did you learn while at the Fab Lab?"

The Likert scale ratings that parents selected on their surveys showed that overall, they felt very positive about their children's Fab Lab experience and its impact on them. Parents largely reported that, at least to "some extent" (and often to a "large extent") during the programming, their children were practicing creative thinking, interacting with others, working to solve problems, and learning something new about STEM.

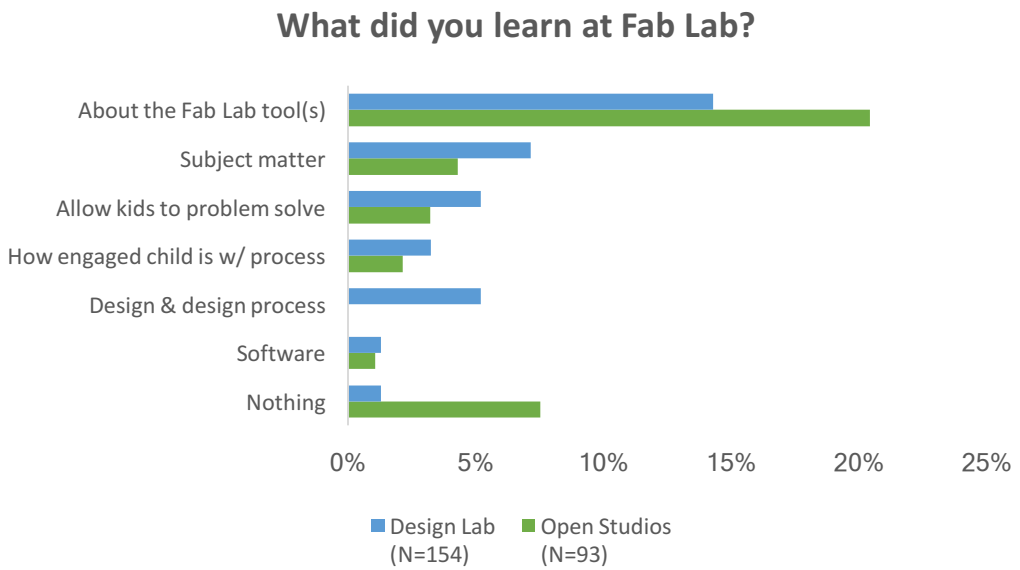




Additionally, the open-ended survey questions, which preceded the Likert scale section, provided even greater insight into parents' initial views on what they and their children were learning in the Fab Lab. The data for both of these questions, separated by Open Studios versus Design Lab attendees, can be seen in the graph below.

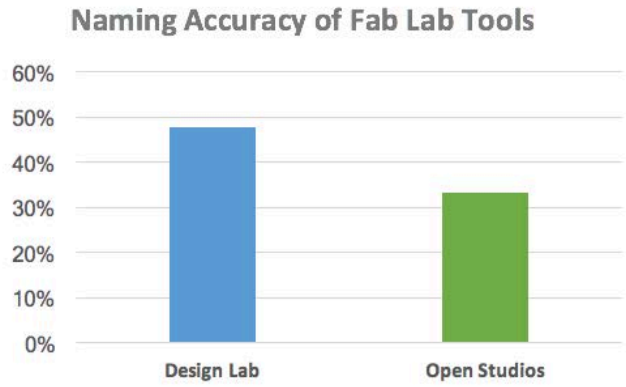


As seen above, parents who attended the Design Lab program more frequently indicated that their child learned activity content, followed by design principles, and about the Fab Lab tools. Those who attended the Open Studios program most frequently emphasized creativity and fine motor skills, followed by the activity content and Fab Lab tools.



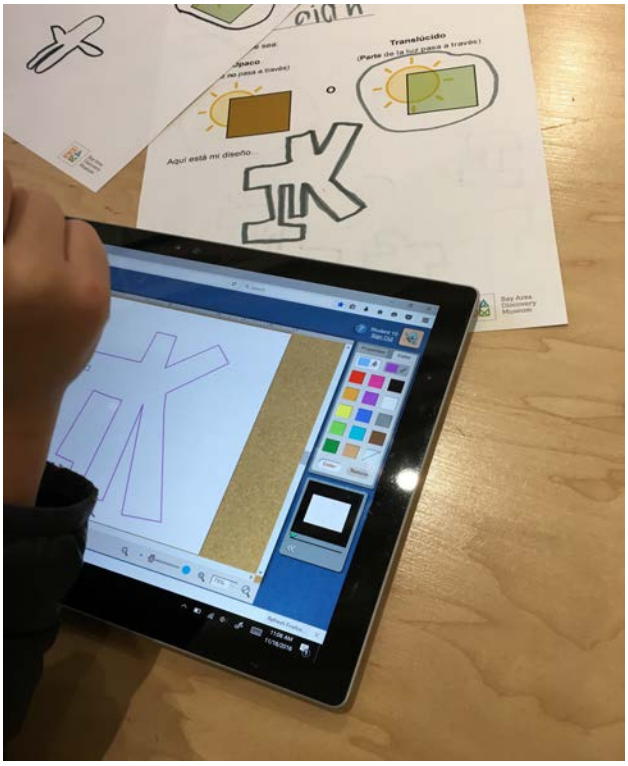
As demonstrated by the graph above, parents who attended the Open Studios program were more likely to mention having watched or learned about the Fab Lab tools than parents who attended the Design Lab program. Parents who attended the Design Lab program, were more likely to mention the activity content, design process, and problem-solving than those who attended the Open Studios. Parents who attended the Open Studios programs were also more likely to say that they learned nothing during their visit.

Although the Open Studios parent visitors were more likely to mention the Fab Lab tools than parents who attended the Design Lab program, when we examined parents' accuracy in naming the Fab Lab tools (3D printer, laser cutter, or tablet), we saw a number of frequent mistakes made by both groups of parents, with references such as the "laser printer," "the cutter," or the more ambiguous "Fab Lab tools." However, parents who attended the Design Lab program were slightly more likely to accurately and specifically reference the Fab Lab tools. For example, in the survey question that asked parents what they believed their child learned in the Fab Lab, 15% of parents in the Design Lab program and 13% of parents in the Open Studios program mentioned the Fab Lab tools. However, out of those respondents, 48% of the respondents who attended the Design Lab program accurately and specifically named at least one Fab Lab tool versus 33% of the respondents who attended the Open Studios program.



Teacher Feedback on School Programming

Interviews with teachers who had visited the Fab lab for a class field trip suggests that this confusion about technology also extended into the school program visitors. One of five teachers who was interviewed by WestEd staff exhibited confusion about the Fab Lab tools throughout the interview, repeatedly describing the activity's use of the 3D printer when in fact the activity relied exclusively on the laser cutter. The field trip curriculum consisted of an activity introducing the concept of shadow and light, with a primary focus on the words "opaque" and "translucent." The activity began with a circle time in which the concepts were introduced, and then children had the opportunity to design a shadow puppet on a tablet. Then, the first class of students would take a break for a while to allow the second class to enter the Fab Lab and do the same activity. While the first class was exploring the museum, a Fab Lab technician would laser cut all of the children's shadow puppets. Then, the first class would return to find their shadow puppet waiting for them, ready to be decorated. The students had approximately 30 minutes left to decorate their puppets with art supplies and then participate in a closing circle to discuss different types of tools.



Student recreates shadow puppet drawing using design software on tablet

The teachers all described their field trip in positive terms, with almost every teacher using the word "great" to describe their overall experience. They felt that "the environment is very nurturing and welcoming," that it was "well-organized," and that "the use of material they have for the kids to demonstrate the concepts was another plus." The teachers also felt that the opportunity was a unique one, with one teacher stating, "I was pretty excited about the fact that [the students] had access to the tablets and then the cutting tool to create the plastic shadow puppets. I felt like having first-graders have access to that type of technology to make something like that, to have that opportunity, I thought was pretty awesome."

However, a number of the teachers would have liked the opportunity to introduce the concepts of shadow and light to their students in advance, so that the Fab Lab curriculum could focus more on time to design and use the high-tech tools. One teacher explained, "If I had known [they] were going to focus on these two words, I would have drilled before we came, so we were prepared for opaque and stuff… So, if we had walked in knowing opaque and transparent backwards and forwards, we could have had twenty more minutes working on the program itself."

For the most part, the teachers did not feel that the program sufficiently met their academic needs because the lesson was so introductory. One teacher explained, "[The facilitator] didn't really give concrete NGSS information. She talked a little bit about light and shadow and kind of explained a couple of terms but not a lot, and then sent [the students] off to design their own." Nonetheless, they agreed that it increased students' interest in the topic. Described a teacher:

> This is not a middle lesson or a culminating activity, this was like an excitement, let's get them excited about it. . . . [The students] were super excited and I loved that they had the different embellishments they could add on and make [their puppets] three-dimensional . . . They took those ideas back to the classroom . . . then as soon as we got back, I pulled…the stencils out and they were able to trace around stuff and add stuff on so it was sort of…I put them in the art center with some flashlights and they were able to sort of continue on and experiment.

Student decorates shadow puppet after it has been cut out by the laser cutter

Teachers felt that the lesson was memorable for students, as evidenced by the fact that they continued to take out their shadow puppets at recess or during class lessons on shadow and light in the weeks following their visit. The teachers agreed that students retained the vocabulary words "opaque" and "translucent," and a couple of teachers said that some students mentioned the laser cutter in some capacity after their visit. However, a few of teachers felt that the laser cutter failed to make an impression on their students because, "[The students] didn't use the laser cutter. It was one of the Museum employees who did the cutting so I don't know if it had an impact on [them]. I don't know that they really thought about that when they were doing their design."

Messaging

The Fab Lab is "a space unlike any other at the Museum," according to one staff member. Given its unique nature, is not surprising that BADM staff find it challenging to describe the Fab Lab to potential guests, other staff, funders, and other stakeholders. In a recent interview, one staff member stated:

> The marketing and communications side is certainly trying to figure out how do we talk about the Fab Lab, especially as it evolves with our thinking of what is a Fab Lab, and then how do we take what we are learning and thinking and proving and measuring from a thought leadership perspective and sharing that.

Several staff members noted that it was difficult to explain to parents and teachers what students will learn until they experience it firsthand. This challenge is partly because many of the guests who visit BADM have not visited a makerspace, much less a Fab Lab. One staff member stated:

> I do think the messaging is harder for the Fab Lab. But what I think the power of the Fab Lab is that people in the moment do experience it. The Fab Lab has greater potential to push the needle in terms of what people think early childhood education is than the Art Studio . . . . They can see the complexity. [In the Art Studio] we can say, "Your child is pasting, here's all the learning that is going on." I think that is harder than, "Your child is in the Fab Lab constructing an earthquake or a skyscraper building and having it on a shaker table to see if it stands in an earthquake. They are doing engineering." . . . . It is from the get-go hard to understand, but we get so much further once someone has been in there and they are like, "Yeah, I get it, that is fun. I'm engineering."

Moreover, unlike other exhibit spaces in BADM, the Fab Lab is facilitated:

> It is not a thing the kids can just enter entirely on their own. It does require some facilitation because there is a lot of technology in the space and a lot of machines that require some adult supervision and assistance.

According to one staff member, the "messaging for . . .the general visitor audience is kind of bare-boned, just descriptive," since that particular audience may not know what a Fab Lab is, and for some, it may be the first time they are visiting BADM. Consequently, the staff member explained, "We try to be as descriptive and explicit as possible and not go into too much details as far as the program, but just explaining the intention of the space." Therefore, staff in charge of messaging sought to describe the Fab Lab in more detail and to make it enticing:

> I think we recognized that Fab Lab in and of itself doesn't mean anything to people. I think for our core audience that gets our e-mail and maybe looks at our social media and our website, I think those folks are now pretty well-versed in what we mean. But I think we need to continue to explain it to the great majority of audiences and make it fun. I think saying "digital makerspace" isn't going to sound super-fun and enticing to kids or parents or school groups, so I think putting some fun spin on it, talking about what exactly the kids will be making using the tools instead of just talking about the tools themselves.

Early Childhood Fab Lab sign, hanging on wall

In describing the messaging associated with the Fab Lab, one staff member described the effort to highlight the "intentionality" of the programming:

> We continue to talk about it as a makerspace with digital fabrication technology such as 3D printers and laser cutters, vinyl cutters, and we talk about it as being intended for early learners and that the Fab Lab is the first of its kind in the world that is aimed at early learning, so that has definitely been a consistent thread of our messaging.

Staff also commented on the need to vary messaging, depending on the audiences they are trying to reach, since these different people will have different expectations, explaining, "For the Fab Lab, [messaging] is different because what a family needs and wants and expects is really different from what a school groups needs and wants and expects and different for a camp."

In comparison, messaging for other audiences, such as parents of children enrolled in The Discovery School at BADM, is slightly more comprehensive:

> For some of our deeper-touch audience, we can go into a little more detail and those deeper-touch audiences would include our pre-school. . . . They use the

> space quite a bit and have a deeper understanding of what it means, and that parent audience, I think, has really been able to understand the value of it.

Since the Fab Lab has only been open for about a year, staff members have tried to make it clear to guests that the space is a work in progress. As one staff member described:

> I think another key factor in the way we talk about the Fab Lab is we have continued to talk about it as a space that we are prototyping. So, we officially launched it to the public last spring, spring 2015, and even since then we have continued to talk about it as a prototype and something we are continuing to evolve.

Interestingly, this message to its audience "reflects the intention of the space, because the whole point of all of this is for kids to kind of use the design thinking process of prototyping and iterating and trying things and failing and then trying again." However, the fact that the Fab Lab is going through iterations makes it even more challenging to "capture the correct message," said one staff member.

Conclusion

In BADM's efforts to build the first early childhood Fab Lab designed for children as young as three years old, BADM staff brainstormed, visited other Fab Labs, attended conferences, experimented, and conducted prototyping to learn how to build this complex, one-of-a-kind program. As this document describes, Fab Lab staff worked together to build a useable space; choose appropriate software; hire staff with the right set of skills; create curricula that appealed to different museum guests; and spread the word to different audiences about the goals of the Fab Lab. While the program continues to evolve, the lessons staff learned thus far will enable them to continue improving the Fab Lab in its second year, and will provide a rich source of information for those interested in replicating or building on their work.

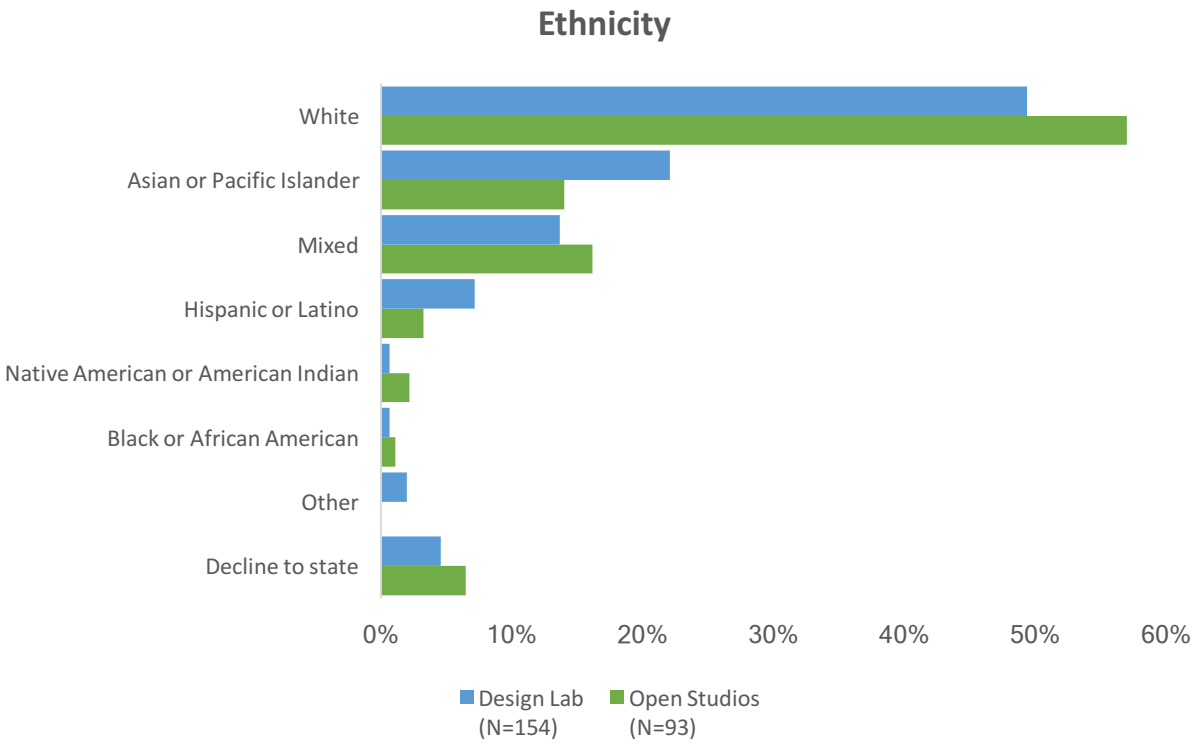
Key findings and lessons learned from this research:

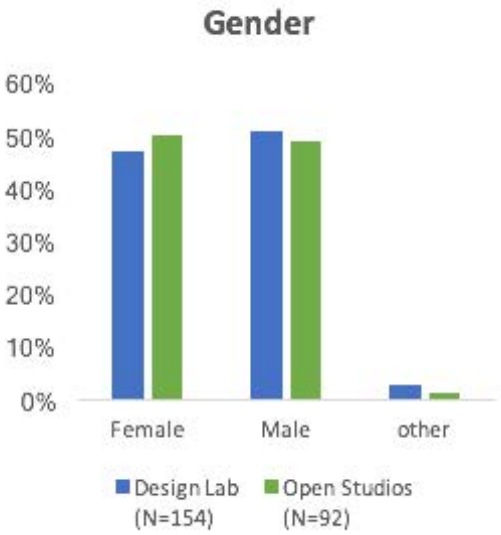
- Finding appropriate design software to use with young children presented a major challenge for the Fab Lab. Different Fab Lab programs may require different software because none of the available commercial software worked well across all Fab Lab programs. Although staff still feel that none of the available software is ideal, parents and teachers generally reported that they and their children found the software relatively easy to use (typically with some direction and assistance from Fab Lab facilitators or staff).
- Staff found that having flexibility in terms of the Fab Lab furniture and storage was important for developing the design of the Fab Lab's physical space. It was helpful in the early stages of the Fab Lab to set up the space so that furniture, equipment, and cables could be moved, rather than placed permanently. This allowed the staff to refine the layout of the space over time to best meet their programmatic and learning goals. Staff also noted the importance of including storage space.

- The amount of staff time needed for the technical team to run the Fab Lab is significant and should not be underestimated. A lead "Designer-in-Residence" should be appointed to oversee staff training and operations on the Fab Lab tools. Furthermore, it is important to appoint an institutional owner to oversee decision-making in the Fab Lab and facilitate problem-solving among staff.
- Adequately staffing people with the right backgrounds and expertise is a complex process that should be prioritized from the outset. To assemble a team with the right mix of expertise may require that people are drawn from multiple departments, which means they will only spend part of their time on the Fab Lab. Therefore, it is important to develop a protocol for meeting and communicating for all Fab Lab team members early on, so that staff can ensure that they are all working towards the same goals.
- Fab Lab programming continues to evolve based on BADM staff's goals for the space and the experience gained from running programs for a full year. Most of the Fab Lab programming is moving away from being tool focused towards a program emphasizing open-ended problem solving. In this new programming model, the high tech tools are available as an option rather than as a requirement. Staff also continue to consider how best to balance the goal of providing time for iteration with providing a more controlled structure that supports the needs of the Fab Lab audience.
- Messaging for the Fab Lab has continued to evolve over time. Staff believe that messaging about the tools themselves seems to be less effective in promoting the Fab Lab than describing how the tools will be put to use and what the children will make during their visit. Showing photographs has also been an important tool in communicating the activities in the Fab Lab.

Appendix

The following tables provide demographic information for children visiting the Fab Lab, which was compiled from the five Fab Lab parent surveys. If a parent brought more than one child, they were asked to record information for the oldest child only.

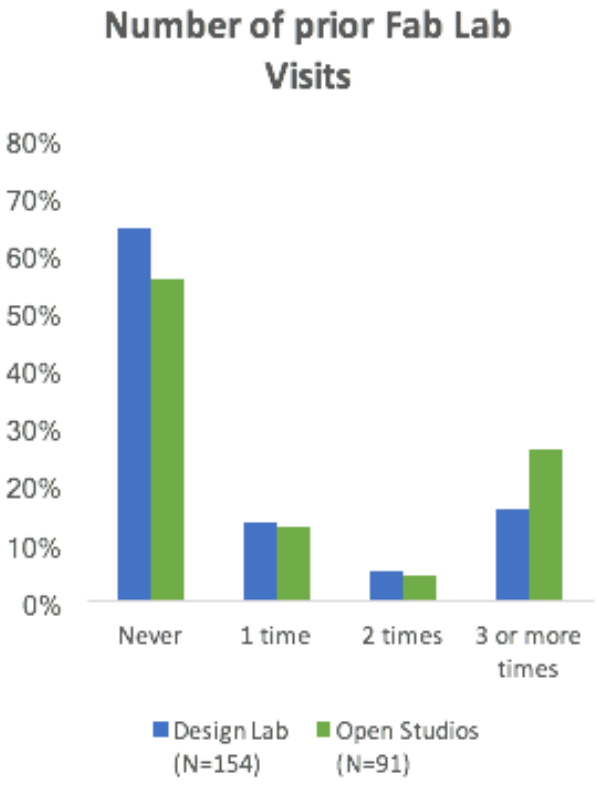




Age

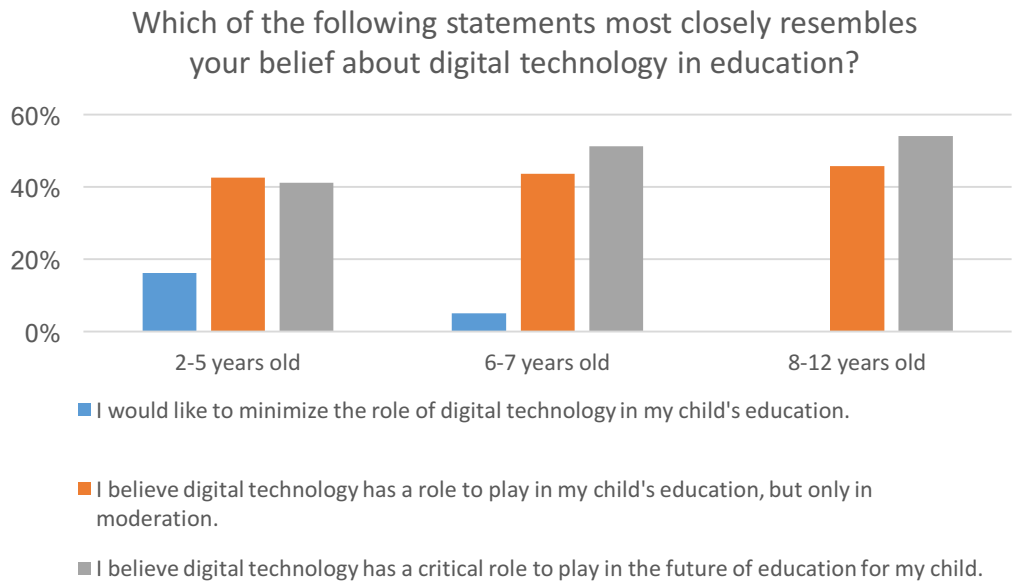
Age	Design Lab (N=154)	Open Studios (N=93)
2	0%	14%
3	2%	12%
4	3%	11%
5	29%	24% $(\bar{x})$
6	24% $(\bar{x})$	14%
7	19%	9%
8	10%	9%
9	9%	4%
10	3%	2%
11	1%	1%
12	0%	1%

Note: In the table above, $\bar{x}$ denotes the mean age for each group



Two of the Fab Lab surveys (one administered during Open Studios and one administered during Design Labs) asked parents to provide information on their views about technology use. The data is listed by age group, below:

Parents of older children are more likely to believe digital technology is important to their child's education than parents of young children.



However, most parents of children of all ages believe technology has at least some role to play in their child's education, either now or in the future.