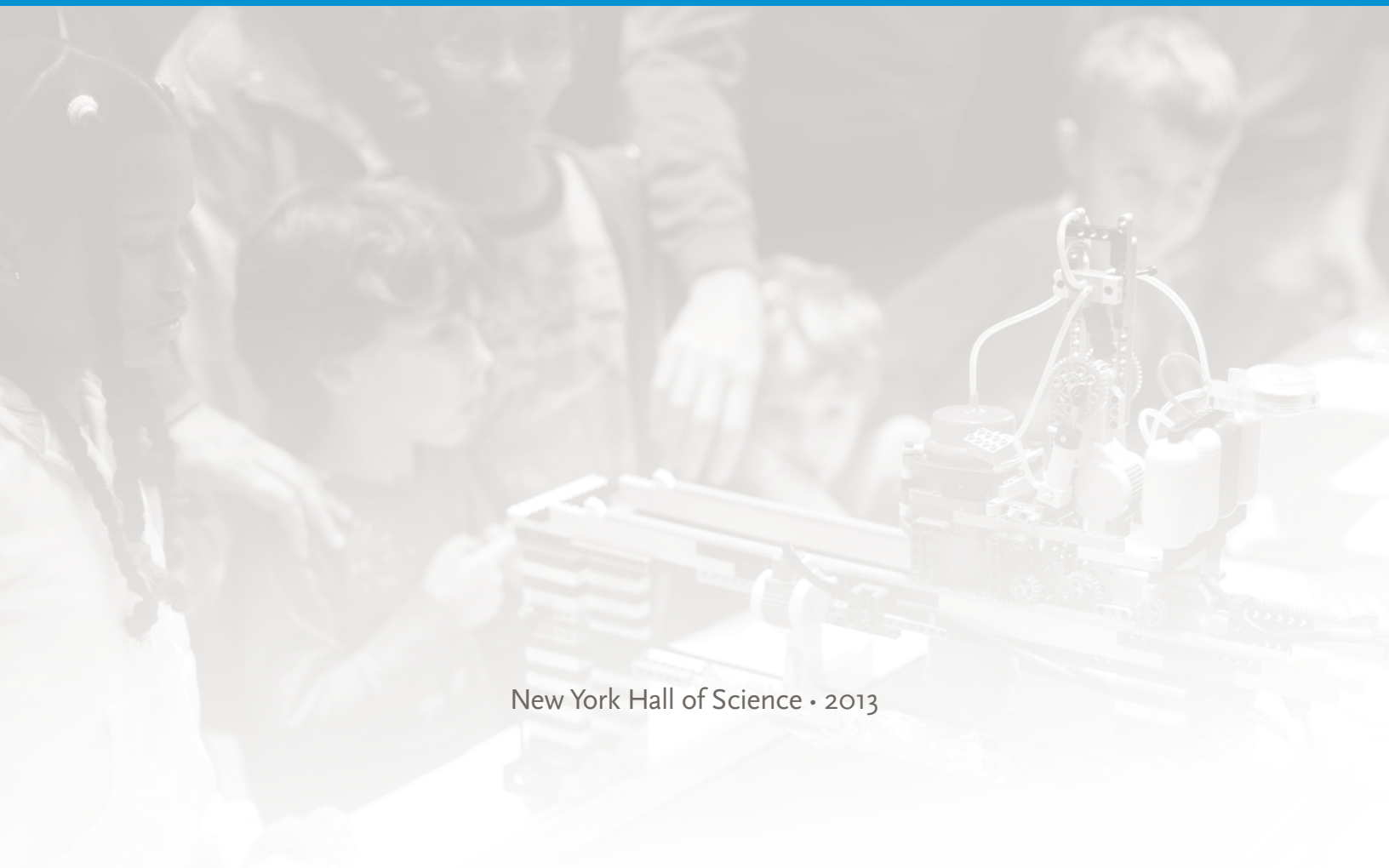
A BLUEPRINT: MAKER PROGRAMS FOR YOUTH



New York Hall of Science • 2013

CONTENTS

A Blueprint: Maker Programs for Youth 1
The Maker Movement

Designing a Program 4
Who is Your Target Audience? 5
What Kind of Space or Facility will be Needed? 6
Who will be the Maker Coach? 8
What Schedule or Format Should be Planned for Making a Program? 9
What will be the Content and/or Theme for the Program? 11
How will the Maker Program be Funded and Sustained? 13

Implementing a Program 14
Theme and Objectives
Budget
Hiring a Maker Coach 15
Secure the Location
Marketing and Recruitment
Equipment and Tools 16

Running a Program 18
Tips 20
Share Your Work 21
Programs — Assess and Adjust 23
Endings — Celebrate Student Achievement and Evaluate Success
Program Conclusion 24
Plan for the Future

Appendix
Sample Budgets I
Safety Guidelines III
Maker Coach III
Sample Projects V

A BLUEPRINT: MAKER PROGRAMS FOR YOUTH

Makers, Makerspaces, Maker programs and Maker Faires are springing up in communities large and small, young and old, public and private.

So what's all the buzz about "Making"? Making is creative, innovative, inventive, collaborative, resourceful and empowering. As the popularity of Making increases, so does the interest in introducing youth to the magic of Making. People are taking note and the benefits of Maker programs for youth are being acknowledged by community organizations, educators, parents, and most importantly, the youth who are already actively involved.

If you are interested in starting a Maker program in your community, here is a resource guide to put you on a path that can turn that idea into a reality. Let the planning process begin!

The Maker Movement

The Maker community has evolved into a growing movement of individuals who, in the words of Dale Dougherty, founder of *MAKE* magazine and creator of Maker Faire, "look at things a little differently and who just might spark the next generation of scientists, engineers and Makers." Makers play with technology to learn about it. They like to figure out how things are made, how to fix them, or how to use them in a whole new way. They are non-linear thinkers, curious inventors and problem-solvers. According to Thomas Kalil, deputy director of the White House's Office of Science and Technology Policy, the Maker movement really "begins with the Makers themselves — who find making, tinkering, inventing, problem solving, discovering and sharing intrinsically rewarding."

The Maker movement embodies science, technology, engineering and mathematics (STEM). Equally important is the role that arts and crafts play in the Making process. Making encourages a deep engagement with content, critical thinking, problem solving and collaboration while sparking curiosity. The 2010 President's Council of Advisors on Science and Technology Report states that "the problem is not just a lack of proficiency among American students; there is also a lack of interest in STEM fields among many students. Future economic development and job creation is dependent on our ability to innovate and the Maker movement exemplifies the kind of passion and personal motivation that inspires innovation."

Maker programs are believed to stimulate an interest in STEM. Early interest, not proficiency, has been identified as a predictor in determining whether a student chooses to pursue a STEM career. A 2006 study by Paul Baskin included surveys that indicated:

- 8th grade students who expressed interest in science but who had average math scores had a 34 percent chance of graduating from college with a science or engineering degree.
- Students with above-average math scores and no preference for science had only a 19 percent chance of earning such degrees. [1]

Making fosters lifelong learning by encouraging learning by doing. A Maker program provides a flexible environment where differentiated learning engages young people in STEM learning. This type of environment is inviting for students who have found school unsatisfying, tedious and boring. This setting helps students identify and follow their interests and provides an opportunity to develop their own ability to do things. The interdisciplinary nature of Making and the blending of low-tech and high-tech strategies lends itself well to both boys and girls across a broad range of socio-economic backgrounds. A Maker program provides an opportunity for anyone to be a Maker, not just crafty kids or ones that like to build or do science projects. This noncompetitive environment allows students to do something because it is fun, which is more likely to be meaningful than if done for credit, a reward or to learn a concept.

> *"Thinkering — engaging the hands and the mind."*
> — Elliot Washor of Big Picture Learning

A Maker program strikes a balance between focused activities and free play. It is not a traditional school or a classroom, so the activities, rather than the curriculum, drive the program. The students move through hands-on, design-based activities at their own pace, and develop their own solutions to challenges. The learning follows, or simply put, is the result of the activities.

> *"Ready Fire Aim, not Ready Aim Fire."* — Jon Santiago of HTink

Although there are no set or prescribed models for Maker programs, there are certain core ideas that remain the same. As you begin to shape your Maker program keep these guiding principles in mind:

- Hands-On is key. Offer children the opportunity to build, make and create.
- Children make something (design process) versus doing experiments (scientific process).
- Programs can follow a set of planned activities, but should encourage trial and error and allow for individual creativity and experimentation.
- Children own their creations. When a project is completed, kids should be able to take their project home.
- Programs should be long enough in duration that children can immerse themselves and result in a meaningful experience.
- Make sharing of ideas, projects, skills and knowledge an integral part of the program.

A Parent's Insight: Idea to Reality

Meg Kaufer, who started a grassroots program in her basement called Larchmont Young Makers, is a parent who saw a need to find a way to nurture her son's limitless curiosity about things.

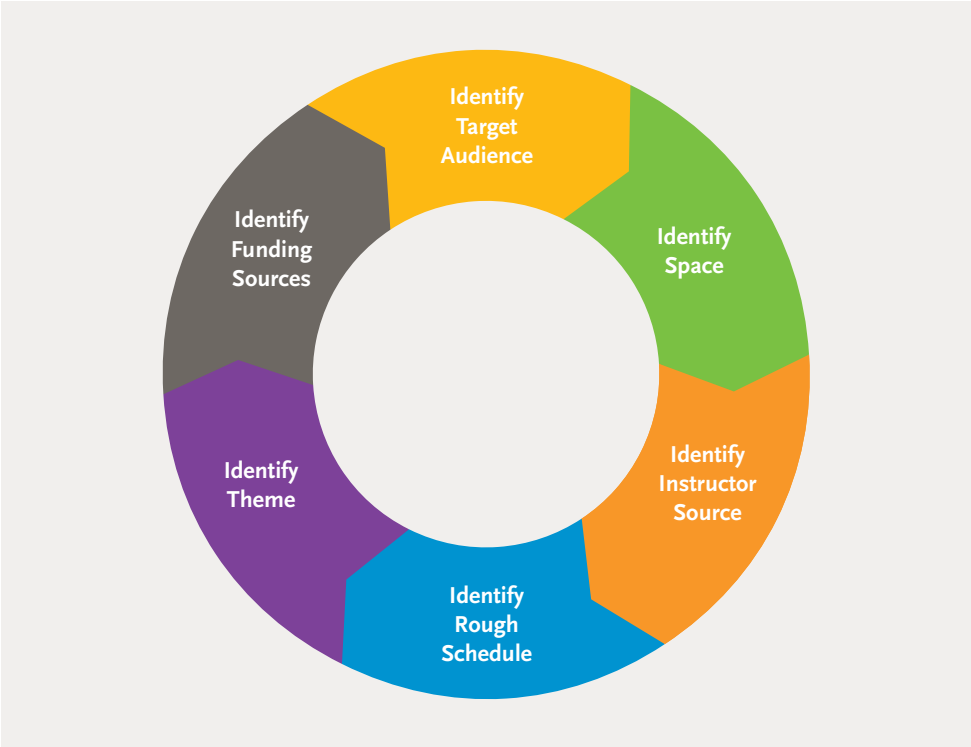
Meg offers five points on how to get a program started:

1. Be a relentless advocate and spokesperson.
2. Find out what is out there; leave no stone unturned.
3. Start a database of like-minded people.
4. Be an audience at any level. Be a presenter at any level.
5. Do-It-Yourself does not mean Do-It-Alone.

DESIGNING A PROGRAM

As you begin to design your Maker program, you'll find that many aspects of the program are interdependent. The age of your target audience and the expertise of the Maker coach will determine the kinds of projects you offer and the space you will need. The projects in turn will determine the tools, materials and facility specifications for your program. A wide range of projects can include anything from electronic gadgets, robots and software programs to crafts, music or technology-enhanced clothing. The hosting organization or group may have constraints on the scheduling, size of the space, or the audience served, which in turn dictates the size and age of the group and the type of projects they plan.

There are multiple entry points from which you can begin to plan a program. This may seem a bit daunting so begin with what you know or have access to. Just get started and keep in mind that a program like this will require a funding source. The graphic below illustrates an iterative planning process in which each major aspect of the program depends on the others.



Who is Your Target Audience?

Since you are already interested in providing a Maker program, chances are that you have a particular audience in mind. If you are an established organization your mission statement may identify your target audience. For example, the mission of Girlstart in Austin, Texas is "to increase girls' interest and engagement in STEM through innovative informal education programs." If you are a public school, students are organized in grades K–12, indicative of age and a measured skill and content level. Community organizations focus on distinct populations demographically, geographically and culturally. Mt. Elliot Makerspace serves a southeast Detroit neighborhood from the basement of the Church of the Messiah and concentrates on learning experiences and entrepreneurial opportunities like the flagship "Earn-a-Bike" program. In terms of program size, a general rule of thumb is to limit the enrollment to 12–15 participants per session.

Identifying Your Audience

A target audience can be found within an existing community — a neighborhood, organization, school or club — or you can solicit like-minded individuals who are interested in Making. Here are some examples of existing Maker programs and their targeted audiences:

The Children's Aid Society helps children in poverty to succeed and thrive by providing comprehensive supports to children and their families in targeted New York neighborhoods. A summer program was hosted in the Intel Computer Clubhouse at the Frederick Douglass Center in Harlem. Ages ranged between 12 to 14 for boys and girls.

DreamYard is the largest arts education provider in the Bronx serving K – 12 students in both in-school and out-of-school hours. By tapping into students previously enrolled in DreamYard programs and marketing to in-school participants, a group of 12 teens enrolled in a Maker program that incorporated both the arts and design process.

Big Picture Learning is an alternative high school whose philosophy is to find a way to keep students engaged in school by allowing them to follow and develop their interests. Structured as an internship, high school freshmen met at the Newark Museum where art and science exhibits were incorporated in the program framework.

Take into consideration the following:

- What ages will the program target? How will you group the ages?
- Who is in your community? Is your community a neighborhood, organization or public school? What are the needs of your community and how does that dictate who your audience is?
- Will there be only boys or girls or a mixed group?
- Will there be targeted levels such as beginner, intermediate and advanced?
- Will your program be in a rural or urban setting?
- Making is popular with young and old alike. Would you like to make this a family program with participation open to parents who might like to join in the fun?
- Can you access an existing audience by offering a Making program as a supplement to an established after-school or summer program looking to expand activities?

What Kind of Space or Facility will be Needed?

Making can happen anywhere — on a kitchen table or laboratory work-counter, in a home or public building, in a space donated or leased, designated or communal, temporary or permanent. You will need ample space to accommodate the activities, students and facilitators. Past programs have found that a minimum of 300 – 500 square feet is required to accommodate 12 to 15 students. Some programs use a mobile model, where they bring all tools and equipment to the space each week. In some cases the program moves between various locations.

Identify buildings in close proximity to your target audience or within reasonable distance if dependent on public transportation. Be sure that the building can accommodate the additional flow of traffic during specified program hours. A good place to start is by visiting the public spaces in your community such as libraries, museums, schools and neighborhood centers. One of the considerations during planning is to identify a partner organization that is interested in starting a Maker program that has a readily available space and capacity to house the program. Safety and security are top priorities for both the participants and the capital investment of tools and equipment. Operational necessities such as lighting, electricity, internet access, ventilation, storage and flooring that is easily

maintained should also be on your checklist. You may also consider starting off in a temporary location before moving to a more permanent space.

Detroit	Mt. Elliot Makerspace	church basement	several rooms repurposed for different Maker programs
Newark	Newark Makerspace	museum	two rooms, 12 feet by 21 feet
Harlem	Frederick Douglass Center	community center	Intel Computer Clubhouse room, 20 by 20 feet
Detroit	H.Y.P.E. Teen Center	public library	one room, 12 feet by 12 feet, with additional open space within library
Queens	New York Hall of Science Maker Space	museum	1200 foot space
Larchmont	Larchmont Young Makers Program	Basement of parents' home, restaurant	varied widely

Who will be the Maker Coach?

A critical element to the program is having one or more Maker coaches. A Maker coach is the person who will lead the sessions, and could also be called a teacher, instructor or facilitator. See Appendix lV for a Maker coach role description. Begin to identify potential Maker coaches early on. The availability and background of the Maker coaches may influence the type of activities that are offered and budget requirements.

Possible Maker coaches might include: engineers or science, technology or shop teachers from local schools, Maker Corp[2] members, museum staff, graduate students, new media specialists or artists. In the recent Maker Market Study, Makers most often describe themselves first as hobbyists and tinkerers, followed by engineers and builders, so it is

important to look outside of the professional ranks. What is important is to find someone who is passionate about tinkering and understands the concept of "learning by doing". Each brings a different quality to your Making program. This is a good time to begin thinking about ways to utilize volunteers in your program and to build a database of knowledgeable Making talent in the community.

The number of Maker coaches needed depends on the size of the group. One lead Maker coach with an assistant-in-training is the recommendation for a group of 12 – 15 students. This allows each child to get the attention and guidance they need. If enrollment exceeds 15, you should consider splitting into two sections that meet at different times. This will also allow you to divide the content to accommodate different interests and levels of competency. First and foremost keep safety as a priority, providing ample supervision and monitoring during the introduction of new tools, such as soldering irons and power drills.

Maker Coaches Among Us

Pulling human resources from community networks helped shape the vision of the Creation Station in Middletown R.I. A team of Maker coaches included a parent who was a Maker, two educators from local middle schools (public and parochial), a professor from Salve Regina University, a local hydroponics businessperson, and a semi-retired community organizer.

What Schedule or Format Should be Planned for a Making Program?

It is important to note the similarities and differences in a Makerspace and Maker program. A traditional Makerspace is a location where Makers convene to work on Maker projects. It can be similar to a club, with little structured activity that offers drop-in or ad hoc Making. It is conceivable that a Maker program could be hosted at a Makerspace, however, a space that is temporarily provisioned or has the capacity to be mobile is more likely. In addition, a Maker program is designed as an after-school, in-school or summer session that meets over a predetermined duration of time.

The suggested duration of the program should be at least 20 to 40 hours to give students the opportunity to overcome initial reservations about Making and increase the chances of sparking the Making passion. Regardless of how many hours a day or how many weeks, a minimum of 20 hours is necessary to become fully immersed in a project and to have a lasting and meaningful experience. Although 20 hours is recommended as the minimum, there are programs that are much shorter. A day or weekend workshop provides an introduction to Making, however the completion of a project within a condensed timeframe limits the type of project.

Making in Public Schools

The Maker movement is now garnering the attention of educators as an innovative approach to address shortfalls in science and math. Public schools are viable settings for Maker programs, as exemplified by P.S. 107 in the Bronx. P.S. 107 concentrated their efforts on fourth graders in anticipation of upcoming assessments. By securing a grant from Cognizant's Making the Future education initiative, the school was able to hire a special instructor with Making experience. Every Monday, for 10–12 weeks, classes with approximately 20–25 students visited the Making room, a traditional science classroom equipped with worktables and ample storage space for projects. During the 40-minute allotted science period, students worked on simple kits, circuits, hydroponics and other hands-on projects.

A variety of delivery schedules are possible, depending on the needs of the sponsoring organization and the children they serve. Here are a few formats that have worked successfully for Maker programs:

- After-school, meeting once a week for two hours for 14 weeks.
- Week-long winter school vacation week camp, meeting four hours per day.
- Two-hour program embedded in an eight-week summer day camp.
- A summer-long series of workshops.
- A two-hour program meeting each Saturday from October through May.
- An in-school program, offered in 40-minute blocks once a week.
- A school-day internship model, meeting five hours twice a week, for 14 weeks.

Another widely used model is a workshop that introduces a particular aspect of Making, facilitated by expert Makers who share their area of expertise. Workshops may be for one-day or a weekend and participants can choose from a variety of offerings such as electronics, computer-aided manufacturing, glassworking or metalworking.

What will be the Content and/or Theme for the Program?

There are different ways to organize and shape the content of your Maker program that will guide the learning process. Use overarching themes, content and challenges that connect the different activities and encourage creativity. An example of an overarching theme could be time travel or superheroes. Or you may focus on one or more content areas such as electronics, and then add physical computing as used in e-textiles. Kids enjoy finding solutions to challenges. At a 4-H program in Utah, kids were challenged to create a pumpkin launcher to be used at the upcoming community Pumpkin Launch Holiday Celebration. The seasonal theme coupled with a challenge guided the Making and encouraged creativity, while meeting the criteria of being hands-on and relevant.

The types of activities and the skills that are introduced are wide-ranging. Here is a starter list of ideas as you begin to plan a program:

- Electronics.
- Robotics.
- Mechanics (such as bicycle repair, equipment repair).
- Digital fabrication 3-D and 2-D.
- Hydroponics.
- Physical computing.
- Musical instruments (mechanical and digital).
- Craft mediums such as wood, metal and plastics.
- Textiles, wearables and e-textiles.
- Software development/web-based programming.

Leonardo's Basement

Leonardo's Basement (leonardosbasement.org) is located in Minneapolis, Minn. Leonardo's Basement provides innovative learning environments for children aged 6–16 and their families to design and build creative projects. Some of their program options include a Saturday Open Shop and Creative Convention hosted on school release days.

Workshop Weekend

Workshop Weekend (workshopweekend.net) is a community-based two-day event in Oakland, Calif. that offers dozens of short, hands-on workshops taught by local, passionate instructors with years of experience in their craft.

A Maker likes to Make things. This isn't anything new. In the past people made and fixed things all the time. It feels good to figure out how something works and how you can make it; it's empowering. It doesn't matter what you Make, it matters that you Make.
— David Wells, New York Hall of Science

How will the Maker Program be Funded and Sustained?

You will need resources to implement a program whether donated, in-kind, human or financial.

Grants may be available from foundations, government agencies, community organizations and corporations. Collaborate with existing non-profits or education programs to leverage resources. Funding will be necessary either to get a program up and running or to supplement existing donations, volunteer manpower or rent-free space. A fee-based program is a viable option to offset some or all program costs.

Thinking long-term about how to sustain a program will help guide your initial business plan. Identify sources for materials: recycled, discounted and donated. Visit local public facilities such as libraries, museums, civic centers and recreation centers along with nonprofit agencies like the Boys and Girls Club, Girl Scouts, Boy Scouts, churches and United Way to identify available space. Negotiate a lease that fits within your budget utilizing cost-saving measures such as sub-leasing, shared space, first and last month free, long-term occupancy (only if a long-term program plan is in place) or exchange of services in lieu of rent. Build a database of experienced Makers who may provide a volunteer pool that will be invaluable in developing a strong and diversified program. Take advantage of open-source materials.

Equipment can be one of the largest expenditures so keep your eyes open for organizations that upgrade then donate computers. Pawn shops, resale stores, garage sales and craigslist are great places to find used hand tools, computers, printers and sewing machines. Post a notice of the items you want at a local coffee shop or library.

Be prepared for the arduous task of fund-raising. Find creative ways to fund your program. Invite local businesses to sponsor a Maker program from year to year, much like a Little League team. Ask advice from development professionals at local nonprofits who can explain the process and make introductions. Partner with a high profile organization that has

It's Not Just About Technology

Kids Making It (KMI) in Wilmington, N.C. is a long-term program that teaches woodworking to students from elementary to high school. Students develop skills such as using hand tools to build go-carts in elementary school, to using power tools in their teen years. By high school students are using woodworking equipment that interfaces with computer technology. Students sell their creations in the KMI retail store.

strong support from the philanthropic community. Become a spokesperson to spread the word and make new connections. Start early and be persistent. To raise start-up funds or money for equipment, online 'crowdfunding' tools like Kickstarter.com and Indiegogo.com can be helpful. If a fee-based program is your only option, think about ways to provide scholarships for students who otherwise would not be able to attend. Do your homework by defining your mission, audience and needs before presenting to potential funders.

IMPLEMENTING A PROGRAM

In order to implement your program you will need to fine-tune each component of your Maker program model. This section will provide more detailed guidelines to get started.

Theme and Objectives

To move forward, a decision will need to be made as to the content of the program. The theme and objectives need to be established in order to finalize the accompanying components of the program.

Budget

The budget will be determined by size, activities, duration and location. Although the amounts may differ, the budget categories will stay the same. Be aware that it is easy to overlook minimal costs but they do add up. Below are basic budget categories.

Direct Costs	Indirect Costs	Capital Expenditures
Labor	Rent	Equipment (examples)
Coaches	Utilities	*3-D printer*
Administrative	Insurance	*Vinyl cutter*
Project kits	Permits	*Computers*
Project consummables	Repair and maintenance	*Sewing machine*
Operational supplies		Hand tools (examples)
Storage bins		*Power drill*
Marketing outreach		*Soldering iorns*
		Drill press
		Software

Refer to the Appendix for sample budgets from Making the Future programs run during 2012. It is important to note that there are many details to coordinate and finalize. You will need to allow ample time to receive all program materials and equipment. The procurement of materials and equipment will dictate when you can actually start the program. Planning for a summer program at the beginning of the summer does not allow for delays unless you have contingency plans in place. As you begin to order materials you may face shortages or back order issues. The old adage of "proper planning prevents poor performance" applies here.

Hiring a Maker Coach

The selection of a Maker coach is a key element in providing a quality Maker program. As lead facilitator and lead motivator, he/she will guide the process and outcomes. It is important to find an individual who can support the activities and has experience working with youth in a learning environment.

Verify their availability for the hours and duration specific to your program and negotiate the fees or stipends accordingly. Complete a background check on all facilitators, ensuring that safety remains a top priority.

Secure the Location

Whether a facility is provided by a partner organization or you are leasing a space, confirm the location before the start of the program, preferably at least one month in advance. Negotiate the lease, if necessary, and begin to prepare and outfit your space. Take a walking inventory tour to identify placement of workstations, equipment, Internet access, electrical outlets, storage, security and lighting. Check on facilities such as restrooms for boys and girls and additional sinks as needed for washing and cleaning art projects. Schedule necessary inspections for permits and obtain insurance, if necessary. Determine availability and options for Internet access. Set up the entire space prior to the first session.

Marketing and Recruitment

To publicize your program, you will need to prepare marketing collateral. Start by creating or finding a logo or illustration that depicts the theme of your Maker program. Provide all specifications for your program

Meet Maker Coach Jon Santiago

Jon Santiago works with schools, cultural institutions and community-based organizations to create after-school programs. As co-founder of the HTINK educational cooperative, Jon has helped start Young Maker programs throughout the New York tri-state area that get middle school and high school students interested in electronics, computer programming, design and the use of traditional hand tools. He has also worked with MakerBot Industries to develop 3-D printing curriculum and professional development workshops for teachers, and has served as adjunct faculty at the Polytechnic Institute of NYU. Jon graduated from the Massachusetts Institute of Technology (MIT) where he worked with the FabLab program, a global initiative to bring digital fabrication laboratories to communities around the world.

along with contact information. Utilize all distribution channels available including Facebook and other social media outlets, presentations and local publications.

You will need to get the word out in a timely manner and have an enrollment process in place even if you are partnering with an existing organization with a built-in audience. As this is not a drop-in program, you will need to collect information along with parental permission for participation. Include liability waivers for potentially dangerous equipment and tools, and photo release forms. When advertising to larger audiences, concentrate your efforts in locations where parents and children congregate such as schools, libraries, museums, youth organizations and churches. Teachers are your best promoters so be sure to share program information with them so they can pass it along to their students.

Equipment and Tools

One of the largest investments you will need to make is for equipment and tools. It is not necessary to buy everything new or to buy everything at once.

- **Beg and borrow.** Hold a tool drive in your community. Garages are full of tools, many of which are sitting idle. Check to see if your community has a "tool library", where you can check out tools the way you can check out books from a library.
- **Buy used.** Many tools, especially power tools, include lifetime warranties. By buying used equipment, you can save 50 percent or more with no loss of functionality or quality. Keep your eyes open on sites like craigslist for liquidations, garage sales and moving sales.
- **Invest in one piece of great equipment.** A 3-D printer such as a MakerBot can bring excitement to a learning environment. The on-the-spot creation of a tangible product can transform thinking and increase interest in STEM disciplines.
- **Just-in-time purchasing.** You don't have to have a fully equipped shop to get started. Seek alternative approaches by outsourcing to shops and services. The cost may be more reasonable than the initial outlay for the

Have a PLAN B

Sometimes you need to be flexible and have a backup plan. When Jon Santiago was running the program at the Newark Big Picture Learning, the MakerBot (3-D printer) didn't arrive in time for the session on 3-D, but Jon still wanted to move forward. After the kids created their 3-D designs in SketchUp, they exported their designs as a polyhedral (a 2-D design that can be folded into a 3-D object). They printed the 2-D layout on cardstock using a vinyl cutter and then folded the cutout into a 3-D object. When the MakerBot arrived, the students were able to create their 3-D model in plastic with a much deeper understanding of designing in 3-D.

equipment, especially as you try to stretch the dollars in your budget.

- **Wait for critical mass and for prices to come down.** There's nothing lonelier than a $3,000 machine collecting dust, while its more powerful, smaller, cheaper cousins roll off the manufacturing floors. If a project needs to use a particular tool, you might find that it's more economical to rent one or use a service that can create the part for you. Once there's momentum and you see that your members really can't create their projects without that tool or machine, you can fund-raise to buy one. Luckily, you will already have some great anecdotes and visuals to support your claim that it's necessary for your program.
- **Not all technology costs money.** Use open source platforms, freeware and file sharing programs available on the Internet that will allow kids to access programs at home to keep working, exploring, playing and innovating.
- **Buy in bulk.** Materials will be needed to create projects for everything except software-based projects. These may include electronic components, Arduino boards, gears, wheels, fabric, wood, PVC, glue, batteries, LEDs and recycled materials. Buy in bulk where you can; a gallon of glue can be divided into individual containers and batteries can be purchased in giant packs.

RUNNING A PROGRAM

Ready, set and GO! You are now ready to begin Making.

Remember this is fun. Setting the tone of the program starts at the beginning. The introduction by the Maker coach should highlight Making experience, reasons for involvement, and at least one relevant fact that connects with the students. The next item on the agenda is to review safety procedures, guidelines and expectations. Follow up next with a tour of the space including a demonstration of equipment while familiarizing the students with proper placement of tools and materials. Introduce the theme of the program and preview the scope and sequence of activities over the program duration.

It is important to note how choice and freedom fit into a Maker program. Mitchel Resnick who heads up the Lifelong Kindergarten Group at the MIT Media Lab duly notes that "freedom is not the absence of structure but rather a different structure for learning." The emphasis is on collaboration, multi-disciplinary learning, creating things and student empowerment, encouraging risk-taking and trial and error, and intrinsic motivation.[3]

In the introduction of Tina Seelig's book *Ingenius* she shares her view of an "innovation engine" that shapes creativity first from the inside with knowledge, imagination and attitude along with the outside with resources, habitats and culture. A coach is charged with the task of shaping the inside of the "innovation engine". Coaches will need to prepare both a progressive and comprehensive outline that culminates with an end project, as well as the individual sessions that introduce and incorporate the knowledge and skills necessary at each step along the way.

Time management will be critical for each session to set the stage, identify the goals, prioritize hands-on engagement, clean up the area and reflect on the process. Be sure to walk through the session outline, practice a mock demo and check to see that all tools, equipment and Internet are functioning. Early on, it is important to establish mechanisms for sharing space, equipment and materials, as well as identifying a location to store computer files.

To start, you will need to assess the needs of the group. A recap of the previous session, an overview or a demonstration can get things started. Regardless, provide enough information to prompt the activity along with any quick reminders on safety protocols. Making is both an individual and collaborative experience. If some kids move quickly through projects,

encourage them to help others who are going at a more measured pace. This encourages a community of collaboration and sharing which is fundamental in a Maker program. This serves as a teaching mechanism that guides and reinforces the learning curve.

Tips

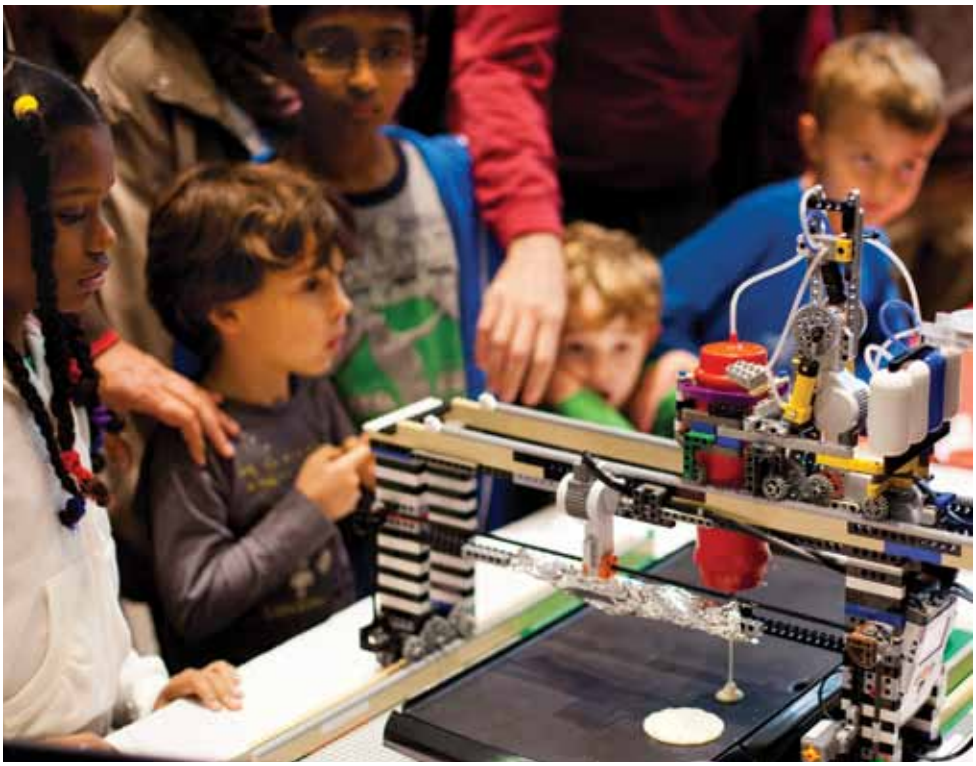
- Establish guidelines for the group: how to manage file sharing, materials and equipment and showing respect for others and their creations.
- Create a structure to channel the energy children have into Making. A beginning, middle and end to each session adds a bit of ritual to the experience and helps with keeping kids focused.
- Ignite interest. Some kids will need ideas and a push and others will run with an idea on their own, so you need to be sensitive to individual participant's needs.
- If the program can accommodate it, invite parents to be involved.
- Enter at a place your group is familiar with and build on that. A good place to begin is with 2-D design drawing.
- Supervise but don't control the experience; let kids find their own way into the project.
- Don't discourage or encourage group projects. It's best to start with independent projects so participants can make something themselves. Later, once the kids have gained some competency and skills, they can evolve into groups. Let the group activity emerge naturally.
- It's best to use open source software so that kids can continue working at home without any financial investment on their part. If all the software has to be licensed, it may be a deterrent.
- Give any young Maker working on a project feedback in a positive, creative and dynamic spirit.
- Capitalize on "teachable moments" when they occur; expose the underlying math, science and engineering concepts in an inspiring and engaging manner.
- Let kids fail; this is an important part of the learning process. Help them figure out why their project failed and discover alternative approaches.
- Set aside a time for reflection at the beginning and end of each session.

At the beginning of the session, the kids can discuss what they did during the previous session, including challenges they faced and goals they set. At the end of a session, they can review the day's work and set goals for the next session.

- Connect your young Makers to the larger Maker movement through local Maker Faires, visits to community Makerspaces, videos on Making, and special guests who are Makers. Showcase the students' projects in a celebratory setting with family and friends.

Share Your Work

Sharing the work of your group has several benefits: it gives them a chance to reflect on their own progress, it is a way to brag about them, and it promotes your program to a larger audience. Students can share their work through various social media sites, but be mindful of the rules governing child protection and privacy. Obtain the necessary written parental approvals for Internet access, Internet postings (mandatory for children under 13 years old), photos and video. Invite local officials, business owners and community newspapers to sit in on a session. The publicity may help you obtain funding for your program.



Programs — Assess and Adjust

You can't anticipate how each group of kids will respond to a set of activities. Look for key indicators of engagement and observe how the kids are behaving: Are they bored? Engaged? Skipping out? Watching the clock or overwhelmed? It may be necessary to change what you've planned and adapt to the level and interests of each specific group. Behavioral issues may be related to the space or length of the program. Evaluate the activity and determine if there is enough space for the planned activities and enough equipment and materials to go around. Consider providing snacks if the kids' energy lags or they get cranky. In general, watch the dynamics in a group and adjust as necessary.

Endings — Celebrate Student Achievement and Evaluate Success

The Maker program is about creating something, not about competition. It's important to celebrate and share every participant's accomplishments. That being said, Makers are driven by the challenge of the projects they tackle. Here are some ways to acknowledge the children and their work:

- **Recognition** — Give each participant a certificate of achievement at the end of the program.
- **Reflection** — Integrate a time for reflection into the program, where kids can talk about their work and their own progress.
- **Showcase/Exhibit** — At the end of the program, organize an open house for the community where kids can exhibit their work.
- **Teach-backs** — During the program, children teach-back what they have learned. This is a great way for them to practice oral communication skills
- **Portfolios** — Have each participant keep an online portfolio or blog during the program. Portfolios are becoming part of the criteria and certification necessary for acceptance to high school and college programs and job internships. It can include text entries, photos and videos that describe the Making process. It can be a platform for young Makers in your program to share and exchange ideas with their peers. An online presence will give as many children as possible the opportunity to have their work viewed, appreciated and recognized. In addition, kids will develop skills in communication, presentation and web-based media.

Share with a Tumblr blog

Create a blog about your Making journey, complete with pictures and commentary. Tumblr is a feature rich and free blog-hosting platform that offers professional and fully customizable templates, bookmarklets, photos, mobile apps and social networking. Tumblr lets you effortlessly share anything. Check out DreamYard's documentation of their Making experience at: Dreamityourself.tumblr.com

Notes:

1. Basken, Paul. 2006. "Early Education Key to Scientific Career Choices." *The Boston Globe* at www.boston.com/news/education/k_12/articles/2006/05/29/early_education_key_to_scientific_career_choice

2. http://makered.org/makercorps/

3. Wagner, Tony. 2012. *Creating Innovators.*

Program Conclusion

As the program comes to a close there will be important steps to complete for evaluation, assessment, funder reports or as part of the planning process for the next session. Review your program objectives and identify ways to measure the success and shortfalls of those objectives.

Exit surveys are a great way to gather the opinion of the participants in regards to interest, personal satisfaction and knowledge gained. Both quantitative (ratings) and qualitative (short answer) format can provide an assessment of the program. Anecdotal comments are useful not just in reporting to funders but more importantly in publicizing the program. Personal messages serve as powerful insights that in turn generate support and interest in the program.

It is important to analyze the projected budget versus actual costs. Regardless of whether it is a funder requirement, this information will be useful in planning future programs and estimating the scope of future funding requests. Identify waste, unnecessary spending, areas that exceeded anticipated costs, and areas where money can be saved.

Solicit feedback from stakeholders on what did and did not work with the program. Identify specific challenges such as lack of instruction, materials, equipment usage and student motivation. Be prepared to make adjustments to provide a quality experience and program.

Plan for the Future

How do you build on an initial program or the momentum that has been gained? Be a good steward of individuals, organizations, parents, students, funders, public officials and the media. They will become your best advocates and future voices that guarantee both sustainability and expansion. Nurture your advocates and be a good steward of relationships that can assist you in moving forward. You never know when you have ignited an entrepreneurial spirit that becomes an ongoing source that can maintain a program. Get started today and bring a Maker program to your community.

APPENDIX

Thinkerlinkers
Thinkerlinkers
30

SAMPLE BUDGETS

Budgets will vary greatly depending on the type of program you offer. As projects get more complex, they tend to become more expensive to build. For budget considerations two sample budgets are provided below. A comprehensive list of tools and materials is also provided by MAKE at: http://makerspace.com/wp-content/uploads/2012/04/hsmakerspacetoolsmaterials-201204.pdf

Sample Budget 1:

Equipment/Tools	Quantity	Unit Cost	Cost
Laptops	5	$500.00	$2,500.00
Roland Vinyl Cutter	1	$595.00	$595.00
Materials	1	$50.00	$50.00
MakerBot Replicator	1	$1,749.00	$1,749.00
Plastic	1	$60.00	$60.00
Conductive Dough	3	$50.00	$150.00
LEDs	36	.50	$18.00
DC Motors	18	$1.79	$32.22
9v Batteries	32	$4.95	$158.40
Mini Plastic Gearmotor	18	$4.95	$89.10
Cardboard Sheets x5	2	$6.89	$13.78
Wheel Pair	18	$7.16	$128.88
Thermistor	18	$1.08	$19.44
Arduino Uno	18	$30.00	$540.00
Sewing Machines	5	$150.00	$750.00
Modkit Micro Software	18	$35.00	$630.00
H-Bridge Shields	18	$15.00	$270.00
Soldering Irons	5	$42.74	$213.70
Flush Cutters	5	$7.76	$38.80
Wire Strippers	5	$14.41	$72.05
Digital Calipers	5	$11.99	$59.95
Instructors			
Primary Instructor	1	$25 an hour; 3 hours per week for 20 weeks	$1,500.00
Co-Instructor	1	$20 an hour; 3 hours per week for 20 weeks	$1,200.00
Training for Instructors	6 hours	6 x 25; 6 x 20	$270.00
Other Expenses			
Food	25 students for 20 weeks	$2 per student	$1,000.00
Transportation	$150 per week	20 weeks	$3,000.00
Miscellaneous			$1,800.00
Total			**$16,908.32**

Sample Budget 2:

Equipment/Tools	Quantity	Unit Cost	Cost
Soldering Irons	12	$55.00	$660.00
Assembled MakerBots	2	$2,100.00	$4,200.00
Roland Vinyl Cutter	1	$1,900.00	$1,900.00
Desktop Mini Band Saw	1	$150.00	$150.00
Scroll Saw	1	$150.00	$150.00
Desktop Drill Press	1	$80.00	$80.00
Dremel	2	$75.00	$150.00
Combination Sander	1	$80.00	$80.00
Sewing Machine	1	$170.00	$170.00
Misc. Handtools	1	$400.00	$400.00
Storage Units, Bins, etc.	1	$200.00	$200.00
Netbook or Laptop Computers	12	$300.00	$3,600.00
Projector	1	$450.00	$450.00
Subtotal:			**$12,190.00**
Program Costs (14 weeks)			**Cost**
Instruction, 14 sessions			$4,200.00
Management/Coordination			$800.00
Components, Kits, Misc. Consumables			$2,250.00
Facility/ Institutional Overhead			$3,200.00
Misc Expenses, i.e. Snacks, Transportation, Etc.			$1,200.00
Subtotal:			**$11,650.00**
Grand Total:			**$23,840.00**

Safety Guidelines

Your workshop should be a welcoming and friendly place. The key lies in creating a safe and secure environment. Before embarking on a new project, it is a good idea to take a close look at the working conditions in your space. Inspect, review and evaluate your space and make whatever changes seem necessary to make your location safe.

Here are some general safety tips from the members of MAKE's Technical Advisory Board.

- Obtain a pair of polycarb goggles, leather work gloves and a protective lab coat or apron. Make them attractive and stylish so that wearing safety equipment is fun.
- Tie back long hair.
- Secure your work when using hand or power tools. Always use clamps, not your hands, to hold a work piece on a drill press table. If the tool binds, the work will spin dangerously.
- Aim away from yourself. When cutting with a utility knife, position yourself so that when you slip, the blade does not cause injury. Use hand tools carefully, keeping both hands behind the cutting edge.
- Keep hands away from moving/rotating machinery.
- Do not touch a bare wire, or cut any wire, until you are sure where the other end goes. When in doubt, measure the potential. This will save you from a possible electrical shock.
- Always keep a first aid kit in your workshop, and always know where it is. First aid kits can be purchased ready-made or you can put one together yourself. Essential items include bandages, pads, gauze, scissors, tweezers and tape.
- Wear closed-toe shoes if you work with heavy things such as timbers or angle irons, or if you are prone to dropping tools.
- Install a smoke detector in your shop and place a fire extinguisher in an easy-to-reach spot. Make sure the extinguisher is rated for all types of fires.
- Wear a particle mask when appropriate to avoid breathing dust and other particulate pollutants common in workshops. Sawdust from treated wood and some plastics have known health risks.
- Protect your ears by using full-sized, earmuff-style protectors. The high-decibel noise generated by power tools such as table saws and circular saws can damage your hearing.
- Slow down and work deliberately. Wait 12 hours between sketching the plans and starting the construction process. People tend to get hurt when they are in a hurry. Always be patient; never rush in the workshop.
- Always listen carefully to the teacher and follow instructions. Ask questions if you do not understand. Do not use a machine if you have not been shown how to operate it safely by the teacher.
- Do not run in the workshop. You could bump into another student and cause an accident.
- Report any damage to machines or equipment, as this could cause an accident.

Maker Coach

A critical element to a Maker program is having experienced Maker coaches to facilitate the program. Look for individuals who are part artist, part instructor, part collaborator and who are passionate about tinkering.

Essential Duties and Responsibilities

- Provide design process-based instruction for craft, technical or building projects.
- Create an environment for learners to arrive at their own conclusions.
- Model, scaffold and coach hands-on projects.
- Manage facilities to ensure a safe and healthy learning environment.
- Secure and maintain tools and equipment.
- Incorporate problem solving, collaboration and teamwork to encourage innovation and creativity.

- Design, develop or refine project plans for the appropriate grade level class including learner-centered activities, resources, materials and opportunities for reflection.
- Support students in documenting projects on a web-based digital platform.
- Supervise and manage staff and train future instructors.
- Evaluate and assess program quality and prepare final reports.
- Monitor the overall program to ensure success.

Qualifications, Knowledge and Skills

- Demonstrated experience with technical, craft and/or building projects.
- Basic knowledge of engineering/ design process.
- Experience working with youth in an instructional setting such as a classroom, club or camp.
- Experience with facilitating a learning environment for minimum group of 10 students.
- Working knowledge of a variety of Making platforms such as electronics, robotics, 3-D printing, sewing, physical computing and craft mediums such as wood, metal and textiles OR curiosity and commitment to developing such skills.
- Working knowledge of tools and equipment specific to program projects.
- Well-developed oral and written communication skills.
- Strong planning, project and time management skills to effectively run program and oversee hands-on student projects.
- Well-developed interpersonal skills to work effectively with diverse student, staff and volunteer participants.

Candidate Profile

A Maker coach is part of a creative class of individuals that may be found within the professional ranks of engineers, designers, scientists, educators, artists, craftsmen or mechanics. A Maker coach may be a Making enthusiast, student, inventor, volunteer or hobbyist who is a creative, innovative and curious tinkerer. Common among all Maker coaches is the desire to encourage young people to create, build and invent.

Additional Considerations

- Any combination of experience, education and skills should be considered.
- Work hours and calendar dates will be determined by each program and location.
- Background checks should be performed on all instructors.
- Instructor fees or stipends can be negotiated with the partnering organization.

Sample Projects

A core principle is that there is no set curriculum but instruction is tailored for the age and demographics of the participants. A Maker coach will guide the project selection from his or her own Making experience that will most engage the children. This sample catalog will provide the project, the target age level, tools required, materials required, and skills and competencies developed in making the project.

Instructional websites may change or be discontinued. Additional instructions can be found on alternative Maker sites by searching via the project name.

Project Name	Target Grade	Description	Skills	Links
Squishy Circuits	K – 5	Light LEDs with "squishy" circuits	Basic Electronics Circuits	http://courseweb.stthomas.edu/apthomas/SquishyCircuits/howTo.htm
BrushBots	K – 5	Turn a toothbrush into a robot	Basic Electronics	http://blog.makezine.com/projects/building-brushbot-kits/
LED Art Kit	K – 5	LED-lighted art frame	Basic Electronics	http://www.makershed.com/product_p/mkkm2.htm
Papertronics	K – 5	Toys with paper electronic circuits	Basic electronics	http://beyondbitsandatomsblog.stanford.edu/spring2012/final-projects/papertronics-2/
Homopolar Motors	K – 5	Motor from battery, magnet and wire	Basic electronics	http://www.arvindguptatoys.com/toys/homopolarmotor.html
Rubber Band Cars	K – 5	Cardboard cars with rubber band motors.	Basic electronics	http://www.hometrainingtools.com/physics-rubberband-car-projects/a/1780/
Origami Flying Disk	K – 5	Paper flying disk (Bernoulli's principle)	Basic science	http://blog.makezine.com/projects/origami-flying-disk/
Origami Spinner	K – 5	Spinner made with paper	Basic science	http://blog.makezine.com/projects/origami-spinner/
Rodent Powered Nightlight	K – 8	Light generated by a hamster wheel	Basic electronics	http://blog.makezine.com/archive/2006/07/make-podcast-weekend-proj-1.html
Soda Bottle Hydroponics	K – 6	Hydroponic systems, rafts and windowsill gardens	Measuring, predicting and inferring Plant growth and reproduction	http://www.kidsgardening.org/exploring-classroom-hydroponics
Soda Bottle Sub	K – 5	Underwater submarine	Basic engineering	http://www.howtoons.com/?page_id=48

Project Name	Target Grade	Description	Skills	Links
Scratch Programming Projects	K – 8	Underwater submarine	Basic engineering	http://blog.makezine.com/2008/02/21/diy-underwater-rov/
Soda Bottle Rocket	3 – 7	Make a rocket from a plastic bottle	Basic science Propulsion Aeronautics Fabrication	http://blog.makezine.com/projects/make-05/soda-bottle-rocket/
Compressed Air Rockets	3 – 7	Make compressed air rockets	Basic science Propulsion Aeronautics Fabrication	http://blog.makezine.com/2008/12/13/compressed-air-rocket/
Supercap Racers	4 – 7	Racer with a super-capacitor power source	Basic electronics Soldering Wire Cutting	http://www.makershed.com/Supercap_Racer_Kit_p/mstin4.htm
Vinyl Cutter / Inkscape Projects	4 – 12	Design and print vinyl cut-outs	Computer modeling Fabrication	http://www.expressionsvinyl.com/pages/project-ideas.html
3x3x3 LED Arduino Cube	5 – 9	Solder and animate original constructions	Basic electronics Soldering Programming	http://www.makershed.com/3x3x3_LED_Cube_Arduino_Shield_p/mkjh1.htm
Zoetrope using Recycled Parts	5 – 9	Zoetrope from recycled electronic components	Electronics Soldering	http://blog.makezine.com/archive/2008/08/build-an-electrified-zoet.html
Solar Cars	5 - 10	Make solar cars	Basic science Electronics solar concepts	http://www.sunwindsolar.com/a_scripts/n_educational_kits.php
Robotics	5 - 12	Various robotics projects	Electronics Sensors Programming Robotics	http://www.makershed.com/Make_Robot_Bundle_p/mksb005.htm http://www.parallax.com/go/boebot http://www.legoeducation.us/eng/product/lego_mindstorms_education_nxt_base_set/2095
Arduino Light-up Banner or Hat	6 – 12	Decorate items with programmed LEDs	Electronics E-textiles Sewing Programming	http://blog.makezine.com/projects/arduino-blinking-bike-patch/
Mobile Phone App Programming	6 – 12	Create mobile apps	Programming	http://appinventor.mit.edu/explore/

Project Name	Target Grade	Description	Skills	Links
Make a Diddley Bow	6 – 12	Make an elemental slide guitar	Measuring Cutting Basic fabrication	http://blog.makezine.com/projects/make-22/the-diddley-bow/
Build a Drum Bot	6 – 12	Build a drum-bot that plays real drums	Mechanical design Electronics	http://blog.makezine.com/projects/drumbots/
Simple Electric Generator	6 – 12	Make a generator and light a bulb	Electronics Renewable energy	http://amasci.com/amateur/coilgen.html
Make a Solar Charger	6 – 12	Charge AA batteries using sunlight	Electronics Renewable energy]	http://www.solorb.com/elect/solarcirc/aacharge/index.html
Windowfarms	7 – 12	Build a hydroponic window garden	Simple electronics Fabrication	http://www.windowfarms.org/buildyourown
Green Machines: Build a Wind Turbine	8 – 12	Design a wind turbine	Basic electronics Electromagnetic induction Alternative energy Digital drawing	http://store.kidwind.org/wind-energy-kits/complete-kits/science-fair-wind-project
Cigar Box Guitar	8 – 12	Make a three-string guitar	Measuring Sketching Fabrication Wood working	http://blog.makezine.com/projects/cigar-box-guitar/
Paperduino	8 – 12	Paper version of the Arduino board	Electronics Soldering	http://lab.guilhermemartins.net/2009/05/06/paperduino-prints/
Make a Video Game	8 – 12	Make your own video games and controllers	Electronics Programming Game Design	http://scratch.mit.edu/
Make a Freeduino	8 – 12	Assemble an Arduino board	Basic electronics Soldering	http://www.freeduino.org/freeduino_open_designs.html
El Wire Tron Bag, (and related El Wire projects)	8 – 12	Use El Wire to adorn bags or clothing	Electronics	http://learn.adafruit.com/tron-bag
Garduino	8 – 12	Manage a garden using robotics	Electronics Programming Sensors Soldering Simple fabrication Permaculture	http://www.instructables.com/id/Garduino-Gardening-Arduino/

Project Name	Target Grade	Description	Skills	Links
BeatBearing Tangible Rhythm Sequencer	9 – 12	Build a unique musical instrument	Fabrication Electronics Physical computing Programming	http://blog.makezine.com/projects/make-17/the-beatbearing-tangible-rhythm-sequencer/
Sketch-up Projects	8 – 12	Build with a 3D modeling tool	3D Modeling Computer Aided Design	http://blog.makezine.com/projects/sketchup-101/
3D Printing Projects	K – 12	Design and print 3D objects	Computer Aided Design 3D Printing	http://thecreatorsproject.com/de/blog/turning-childrens-drawings-into-3d-printed-figurines
Video and Audio Editing and Producing	All	Document projects	Communication Video editing	http://blog.makezine.com/2010/03/12/diy-movie-making-article-roundup/

nysci New York Hall of Science
Cognizant Cognizant Technology Solutions

New York Hall of Science • 47-01 111th Street • Queens, NY 11368 • 718-699-0005 • www.nysci.org