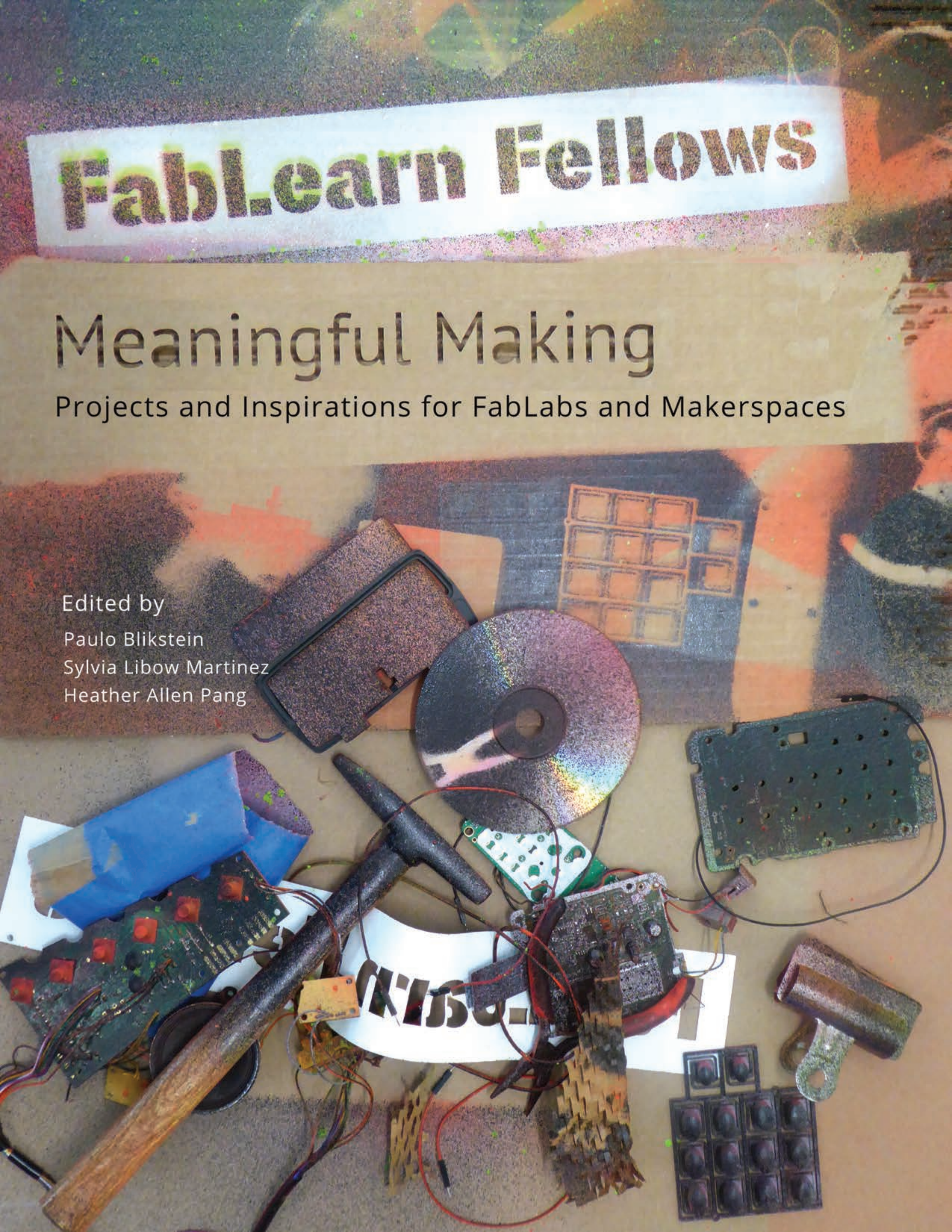
FabLearn Fellows

Meaningful Making

Projects and Inspirations for FabLabs and Makerspaces

Edited by
Paulo Blikstein
Sylvia Libow Martinez
Heather Allen Pang



Meaningful Making:

Projects and Inspirations for FabLabs and Makerspaces

Edited by Paulo Blikstein, Sylvia Libow Martinez, and Heather Allen Pang

Constructing Modern Knowledge Press
Torrance, CA USA
cmkpress.com

ISBN: 978-0-9891511-2-2

Version 1 compiled and released online November 20, 2015

Table of Contents

Constructionism in Action

How Do We Know? Assessment and Documentation

Making It Happen: Society & Inclusion

Projects to Explore In Depth

Project Snapshots

About the FabLearn Fellows Initiative

The FabLearn Fellows are part of a larger project sponsored by the National Science Foundation entitled "Infusing Learning Sciences Research into Digital Fabrication in Education and the Makers' Movement".[1] The FabLearn Fellows initiative brings together experienced educators from all over the world to create an open-source library of curriculum and contribute to research about the "makers" culture and digital fabrication in education.

FabLearn Fellow Goals

Despite the recent popularity of the maker movement and fabrication labs (FabLabs) in education, most teachers work in isolation, cut off from other practitioners doing similar projects, as well as learning sciences researchers. One of the main objectives of the fellows program is to bring researchers and practitioners together to help bridge these gaps, learn from each others' experiences, share these lessons with their local community, and together, create educational materials for the rest of the teaching community.

Through this project, we hope to answer three major questions:

- How can we generate an open-source set of constructionist curricular materials well-adapted for makerspaces and FabLabs in educational settings?
- How are teachers adapting their own curriculum in face of these new "making" technologies, and how can they be better supported? What challenges do teachers face when trying to adopt project-based, constructionist, digital fabrication activities in their classrooms and after-school programs?
- How are schools approaching teacher development, parental/community involvement, and issues around traditional assessment?

The 2014/2015 FabLearn Fellows cohort is a diverse group of 18 educators and makers. They represent eight states in the U.S. and five countries, and work with a wide range of ages at schools, museums, universities and non-profits.

About this e-book

This e-book is a compilation of some of the work of the 2014/2015 cohort of FabLearn Fellows. Included are long-form articles about making and fabrication in many different learning spaces, ideas for projects, reflections, assessment strategies, and much more.

NOTE: Some of these projects call for tools and materials that can be dangerous if used improperly. Always follow manufacturer's guidelines, safety rules, and use common sense.

[1] NSF Award #1349163, Division of Information & Intelligent Systems, Program Managers: Janet Kolodner and Christopher Hoadley

Many of the included articles and projects have links to read more, and every FabLearn Fellow has a page on the FabLearn site where they can be contacted.

Acknowledgements

Contributing FabLearn Fellow Authors: Aaron Vanderwerff, David Malpica, Erin Riley, Gilson Domingues, Heather Allen Pang, Jaymes Dec, Juliet Wanyiri, Christa Flores, Keith Ostfeld, Roy Ombatti, Mario Parade, Mark Schreiber, Nalin Tutiyaphuengprasert, Susan Klimczak, Susanna Tesconi, and Tracy Rudzitis.

Editors: Paulo Blikstein, Sylvia Libow Martinez, and Heather Allen Pang

Editorial guidance and section introductions: Sylvia Libow Martinez

Cover and section heading art: Erin Riley

FabLearn Project Principal Investigator: Dr. Paulo Blikstein, assistant professor at the Stanford Graduate School of Education and (by courtesy) the Computer Science Department, and Director of the Transformative Learning Technologies Lab.

FabLearn Fellows Program Mentor: Sylvia Libow Martinez, co-author of *Invent To Learn: Making, Tinkering, and Engineering in the Classroom* and president, Constructing Modern Knowledge.

Thanks to Claire Rosenbaum (FabLearn Program Director), Brogan Miller, Janet Kolodner and Christopher Hoadley (NSF Program Managers), Alicja Żenczykowska, students and postdocs at the TLT Lab.

The Transformative Learning Technologies Lab

The Transformative Learning Technologies Laboratory (TLTL) is a multi-disciplinary group designing and researching new technologies for education. We understand new technologies not only as a way to optimize the existing educational system, but as a transformative force that can generate radically new ways of knowing and learning.

Constructing Modern Knowledge Press

Constructing Modern Knowledge (CMK) Press is a publishing company dedicated to producing books supporting modern learner-centered approaches to education.

Meet the FabLearn Fellows

Jaymes Dec

New York City, United States

Jaymes Dec is a middle school technology teacher at The Marymount School of New York, an all-girls independent school. He was the Program Manager at GreenFab, a National Science Foundation program for students from the South Bronx that taught STEM skills through classes on sustainable design and green technologies. Jaymes co-founded the NYC Makery, a public makerspace for children and communities in New York City and he is on the Board of Directors for the Nerdy Derby, an educational nonprofit that organizes creative design challenges for children. A graduate of the Interactive Telecommunications Program at NYU, Jaymes has taught makers of all grade levels between kindergarten and graduate school.

Links

- Jaymes' FabLearn blog posts

Gilson Domingues

São Paulo, Brazil

Anhembi Morumbi University - Design and architecture school

Designer. Middle School, High School and College / University Teacher. Lives in São Paulo, Brazil. Arts degree with interactive mechatronics systems masters research. As a designer develops physical and digital products and interactive systems for interactive games. As a teacher works with prototyping teaching subjects related to rapid prototyping and design methodology. Researcher in rapid prototyping methods of mechanics, structures and electronics.

Links

- Gilson's FabLearn blog posts
- Luthieria de Robôs
- Inventania Blog
- Gilson's Channel

Christa Flores

Hillbrook School
United States

Christa Flores is the coordinator of the iLab for Making, a classroom designed for analog and digital making, at the Hillbrook School in Los Gatos, California. She teaches 5th graders Problem based Science in the iLab with an emphasis on material science, design thinking, working in collaborative teams and sharing work. Before joining the Maker Movement in Education, she taught lab-based science for 10 years in New York City. Christa graduated from the University of California San Diego with a degree in Biological Anthropology, has done graduate level work in primatology research through the New York Consortium of Evolutionary Primatology and obtained a masters in Secondary Science Education from Teachers College, Columbia University. Christa has blogged and written articles about her experiences in the iLab and has presented her questions and observations about the link between progressive education and the Maker Movement at conferences. She is passionate about making, research and design in PreK-8 learning environments.

Links

- Learn more about the work students are doing at Hillbrook from her blog.
- @sciteach212
- @P_b_Sci
- www.problembasedscience.com

Susan Klimczak

Boston, United States

I am the education organizer of Boston's Learn 2 Teach, Teach 2 Learn program at South End Technology Center @ Tent City, passionate about engaging our youth.

Links

- Susan's FabLearn blog posts
- L2TT2L Slide Presentation
- Introduction to South End Technology Center @ Tent City
- L2TT2L Project Expo Program

David Malpica

Los Altos, United States

David is the Director of FabLab@BCS, a FabLab@School embedded at Bullis Charter School in Los Altos, CA. FabLab@BCS started serving students in August of 2013.

Links

- David's FabLearn blog posts
- FabLab@BCS Website
- LinkedIn
- 2D and 3D art portfolio

Roy Ombatti

Narobi, Kenya

Roy has a background in Mechanical Engineering from the University of Nairobi. During his time as a student at the university, he worked on various projects at the Nairobi Fablab further fostering his passion for making and learning. He co-founded the Fablab Robotics Outreach Program that aimed at teaching constructionism and making to children, primarily those from low-income households. Currently, Roy is the founder and CEO of a local hardware start-up company in Nairobi called AB3D (African Born 3D Printing). AB3D is a social enterprise that deals in the local production of affordable 3D printers and 3D printing filament all from waste materials. Through partnerships with other local institutions, Roy is setting up his 3D printers in schools and trying to set up lean makerspaces around these.

Links

- Roy's FabLearn blog posts

Keith Ostfeld

United States

Keith Ostfeld is the Director of Educational Technology and Exhibit Development for the Children's Museum of Houston (CMH). Keith has led the development of many of CMH's exhibits and related programming. For the past three years, in his alter-ego "Mr. O," he has produced over 100 "O Wow Moment" STEM-related videos available through the CMH blog (www.cmhouston.org/videos). Most recently, his interest has been in the blending of multimedia and mobile technology with hands-on exhibit experiences to provide deeper and more customizable experiences for CMH visitors. The Instructables: Made In Your Mind exhibit created multimedia touchscreen interfaces for children to use as they developed their Maker skills while creating different projects, many of which are being placed onto the Instructables website (http://www.instructables.com/member/Childrens+Museum+of+Houston/).

Links

- Keith's FabLearn blog posts
- Children's Museum Blog

Heather Allen Pang

United States

Heather Allen Pang teaches United States History to the 8th grade at Castilleja school in Palo Alto, CA. She herself is a graduate of the all-girls school (class of 1984) and also serves as the school archivist. She integrates making into history and also teachers middle school making electives. Before returning to Castilleja to teach, she taught at UC Davis, Santa Rosa Junior College, and American River College. In addition to her teaching duties, she is co-author of *Castilleja: Celebrating a Century*.

Links

- Heather's FabLearn blog posts
- Teaching Portfolio

Mario Parade

FabLab Potsdam / Science Shop Potsdam

Germany

Founder of FabLab Potsdam and Science Shop Potsdam - FabLab Manager since 2012 - Working Subjects : Citizen Science, Repair Cafes, FabLab and School workshops with Kids and Students

Links

- Fablab potsdam
- Science shop potsdam

Erin Riley

Greenwich, United States

Erin Riley is a visual artist , educator and curriculum developer. Since 2003, she has been teaching at Greenwich Academy, a K12 all-girls school, in Greenwich CT where she is currently Visual Arts Department Chair and Director of the Engineering and Design Lab.

Prior to this, Erin was a teaching artist with Studio in a School in Brooklyn, NY, where she focused her teaching practice around material-based exploration and student choice.

At the E+D Lab, Erin teaches digital fabrication and the engineering design process where students merge art, design and STEM through the making of functional and artistic objects. Erin also serves as a faculty partner supporting teachers in the development of cross-disciplinary integrated projects incorporating woodworking, 2D and 3D design and fabrication, electronics, and programming.

Links

- Erin's FabLearn blog posts
- Portfolio

Tracy Rudzitis

New York City, United States

Tracy has taught middle school in the NYC public school system for 14 years with a focus on digital media, computer programming and robotics. In the fall of 2012 Tracy established a drop in MakerSpace for her students during their lunch hour. The success and interest of the space inspired her to revamp her curriculum to include hands-on, materials based learning activities during the school day. The STEAM Lab was inspired by Tracy's belief that making should be something that is made available to all students within the context of the school day.

Links

- FabLearn blog posts
- What You Teach
- Digital Media Class Blog
- STEAM@CS

Mark Schreiber

Tokyo, Japan

Mark is the Director of Innovation and Design at the American School in Japan, an Educator of Design & Engineering, and a happy father of 3 beautiful girls (that love to create all sorts of fun stuff).

Prior to his international move, Mark was the Director of Technology & Home School Enrichment at Frontier Academy Schools in Greeley, Colorado. For the past 15 years Mark has also taught Design and Engineering students how to turn their ideas into new physical objects. With a BA degree in Technology Education and Industrial Technology and a Masters in Construction, Technology, and Engineering ED from Colorado State University, Mark is already an active member of the "maker generation." He is the owner and creative of the "Design Case Curriculum": and a member of MIT'S international FABlab network.

Links

- FabLearn blog posts
- www.DesignCaseCurriculum.com

Susanna Tesconi

Barcelona, Spain

Susanna Tesconi is an educational designer and researcher at Laboral Centro de Arte y Creación Industrial. She creates learning environments that use design and digital fabrication in order to promote a methodological change in public school teachers.

Since 2012 she collaborates with LABoral, Gijón, Spain, an art centre that operates as an open lab for technological, social and cultural exchange, allowing the interaction between creators, educators, school and university.

She's also a PHD student at UAB, Autonomous University of Barcelona, Spain, researching about making and prototyping as pedagogical tools for teacher education.

Links

- FabLearn blog posts
- Website
- LABoral Art Centre

Nalin Tutiyaphuengprasert

Bangkok, Thailand

My background is in filmmaking. I became a teacher at a small pilot project based learning school in Bangkok since 2001. I am interested to work with children and the media that help children learn better in school. I have been involved with using logo and robotics to help students develop their learning skills in project based classrooms. I had introduced Gogo board in high schools and elementary schools in Thailand since 2010.

I helped established Fab Lab in K-12 school in Thailand in 2013 at Darunsikkhalai School for Innovative Learning, a small pilot project Constructionist school in Bangkok. Recently, I am interested in developing agency in children from making both in arts and sciences. I have a Master's degree in Learning, Design and Technology in 2015 from Stanford Graduate School of Education. Currently, I am starting a research and training center of Constructionist teaching and learning in Bangkok, Thailand.

Links

- Nalin's FabLearn blog posts
- DSIL Bangkok Thailand

Aaron Vanderwerff

Oakland, United States

Aaron Vanderwerff is the Creativity Lab & Science Director at Lighthouse Community Charter School, a K–12 public charter school in Oakland, California. He is passionate about making and inquiry, and believes that learner-centered, hands-on education can revolutionize our educational system. In his current role, he collaborates with teachers to integrate making into Lighthouse's core instructional program, electives, and after school program. For the past five years, Vanderwerff has taken students to display their work at the Maker Faire. He has taught high school science in the Bay Area for ten years, and taught math in Burkina Faso through the Peace Corps prior to that. Vanderwerff received his BS in Electrical Engineering from the University of Illinois and a MA in Education from Mills College. He lives in Oakland with his wife and six-year-old daughter, who loves to make things.

Links

- Aaron's FabLearn blog posts
- Lighthouse Creativity Lab
- Lighthouse Community Charter School

Juliet Wanyiri

Nairobi, Kenya

Juliet Wanyiri is the co-founder of Foondi Workshops in Nairobi, Kenya which runs collaborative design workshops with the aim of capacity building.

Juliet is an electrical engineer and is also both an organiser and alumni of the International Development Design Summit (IDDS) - an annual design and innovation summit organised by the Massachusetts Institute of Technology (MIT) D-Lab. Juliet joins this year's inaugural IDIN Workshop Fellowship program.

Prior to this, Juliet was the lead instigator of Gearbox makerspace. She was also part of the engineering team behind BRCK.

Foreword
by Paulo Blikstein

You cannot think about thinking without thinking about what Seymour Papert would think

There is a paradox in education: the closer the world comes to realizing Seymour Papert's vision, the less is his work remembered. In a sense, this is perhaps the best outcome possible for a visionary -- when what used to be radical becomes a mainstream idea. Papert and his collaborators dreamed up a world where all children would be able to program and make—except that they did it in 1968.

If a historian were to draw a line connecting Piaget's work on developmental psychology to today's trends in educational technology, the line would simply be labeled "Papert." Seymour Papert has been at the center of three seismic events in research: child development, artificial intelligence, and technologies for education. He was born on February 29, 1928 in Pretoria, South Africa. He was a philosophy student at South Africa's University of Witwatersrand, where he received a PhD in mathematics in 1952. He proceeded to St. John's College at Cambridge, where he earned a second PhD in 1958. As part of his doctoral work, he had spent time at the Henri Poincaré Institute in Paris, where he would meet Jean Piaget. He would spend four years working under Piaget at the University of Geneva, and was profoundly influenced by Piaget's work on how children make sense of the world – not as "miniature adults" but as active theory builders. Papert wrote in 1991 a wonderful definition of what the "maker movement" would reinvent in the 2000s:

> *"Constructionism shares constructivism's connotation of learning as 'building knowledge structures' [...]. It then adds the idea that this happens especially felicitously in a context where the learner is engaged in constructing a public entity."*

During his time in Geneva, Papert had made another serendipitous connection: In 1960 he met Marvin Minsky. Later with Minsky, Papert became co-founder of MIT's Artificial Intelligence Lab, and the MIT Media Lab.

If one were to, a bit unfairly, measure Papert's career by the sheer number of people a project touched, Logo would eclipse all other achievements. In 1968, Papert, Cynthia Solomon, Daniel Bobrow, and Wally Feurzeig crafted Logo, a revolutionary programming language, the first designed for children. His vision, almost 50 years ago, was that children should be programming the computer rather than being programmed by it. Papert's work entered mainstream consciousness in 1980, with the publication of the seminal book, *Mindstorms: Children, Computers and Powerful Ideas*. His Epistemology and Learning Group at MIT attracted a legion of bright students and researchers who over the next decades, would bring to millions of children computer programming (Scratch), robotics (LEGO, Cricket, Pico Cricket, Makey Makey), multi-agent modeling (NetLogo), cybernetics, system dynamics, and digital fabrication. Because of Papert's book, of course, the LEGO company named its robotics kit "Mindstorms."

His awareness that children's cognitive evolution requires designing rich toolkits and environments rather than force-feeding knowledge has set the tone for decades of research. The combination of developmental psychology, AI, and technology proved to be extremely powerful—through a fortuitous historical accident, a disciple of Piaget bumped into Marvin Minsky, ended up at MIT, and gave us Logo and Mindstorms.

If you want to do work on computational literacy, programming for children, or the maker movement, there is no way to ignore Papert. His extended team laid out the theoretical and technological foundations for the popularity of these ideas today. Instead of allowing this story to be forgotten, we should instead establish a culture in which we don't reinvent the wheel every ten years, but stand on the shoulders of our giant Logo turtles.

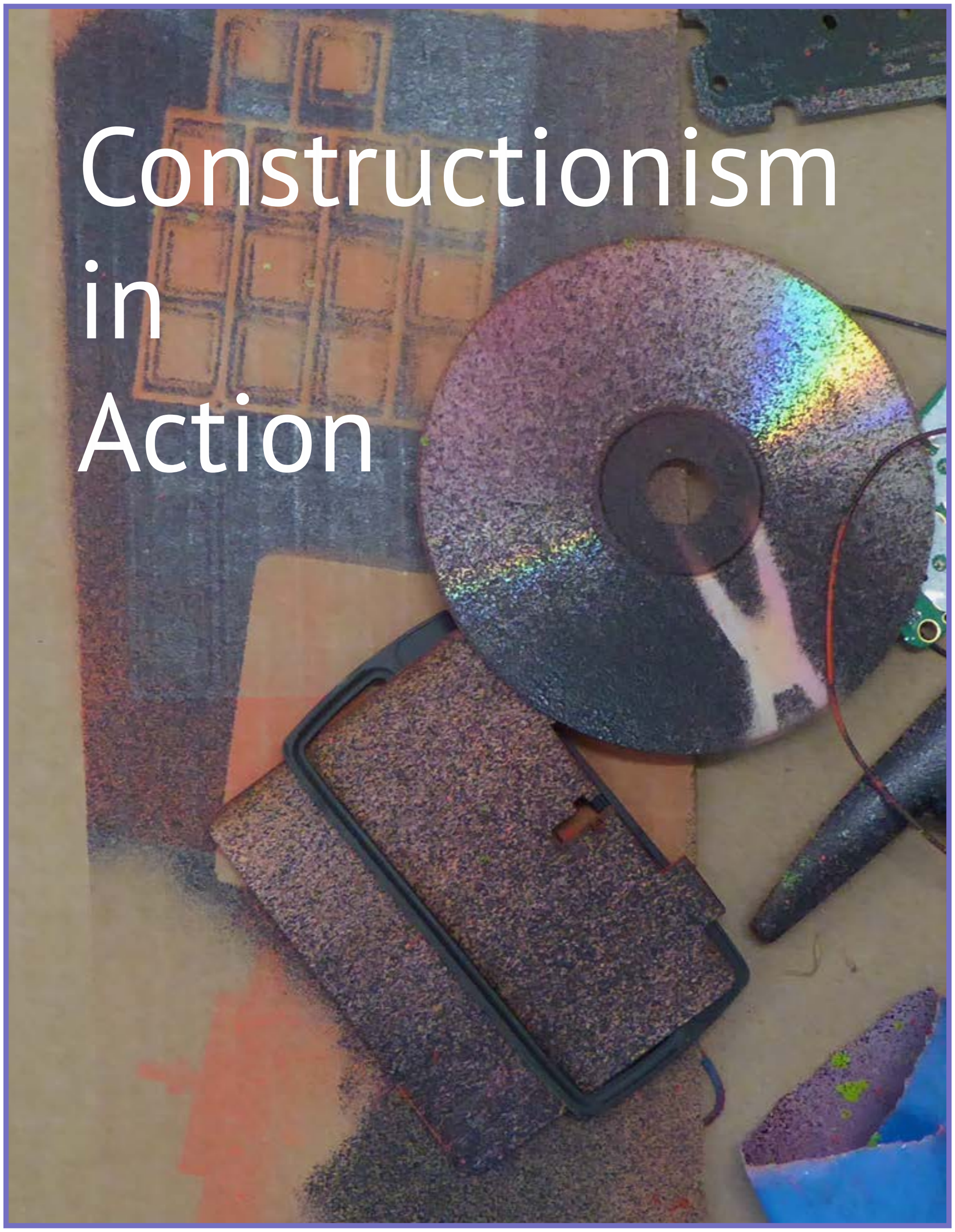
Constructionism has, at its heart, a desire not to revise, but to invert the world of curriculum-driven instruction. One of the main lessons is that there can't be making without sense-making. But although this might sound radical, the first step is to acknowledge that constructionism has won the battle for the minds. Everyday we see people, children, and parents getting excited about the things they can see, program, make, and do together. The Maker Faire is a worldwide exhibition of constructionism. There are literally hundreds of school starting FabLabs and makerspaces. Scratch and NetLogo are used by millions of children and adults, in 50 languages. Thousands of schools have robotics programs. Papert won. But now we have to claim his victory, and tell the world, for academic and historic justice, that many of these ideas were first thought out by him. But we also have to announce what's next, and our new visions. And what is next? We should not take Papert's ideas as a finished and unquestionable canon, but as the start of a much larger project.

In the famous "Gears of My Childhood" preface to *Mindstorms*, Papert states what he has always considered "the fundamental fact about learning: anything is easy if you can assimilate it to your collection of models. If you can't, anything can be painfully difficult." Education needs a collection of models demonstrating the impact of implementing Papert's ideas in school. Maybe then they will not anymore be painfully hard to implement, but a lot easier. This book is a collection of such models, written by visionary educators that took on the job of bringing Constructionism to their schools, building labs, creating activities, toolkits, and curricula. They understand that we are at a crossroads, where yet again two different philosophies of education battle: on one hand, the proponents of mass-produced instructionism, now powered by internet video, and on the other, the advocates of the highly personal forms of learning that come from making, building, and creating your own theories. At first sight, it seems like a lost fight between a few innovative teachers against multinational publishing companies and over-hyped entrepreneurs. But this time, I believe that there is a way to win. We might have to put aside our own idealized views of how things work, and understand that overnight changes in education are hard – and that even Papert was a bit too optimistic about it. A more productive path might be, indeed, to create multiple models of implementation, assessment, and curriculum construction, document inspiring narratives of success or failure, and do rigorous research on the learning that happens. With enough of those models and proofs of existence, it will be increasingly less threatening for new teachers to join, new districts to embrace the ideas, and ultimately whole school systems to try to incorporate making and constructionism into their curriculum.

Maybe, after all, the revolution will not happen overnight, but one school at a time. But until then, it is our job to build those models, tell these stories, do the research, document the work, and tell the world about the incredible things students can do when they are empowered to build, think, and create.

Let's make Seymour Papert proud.

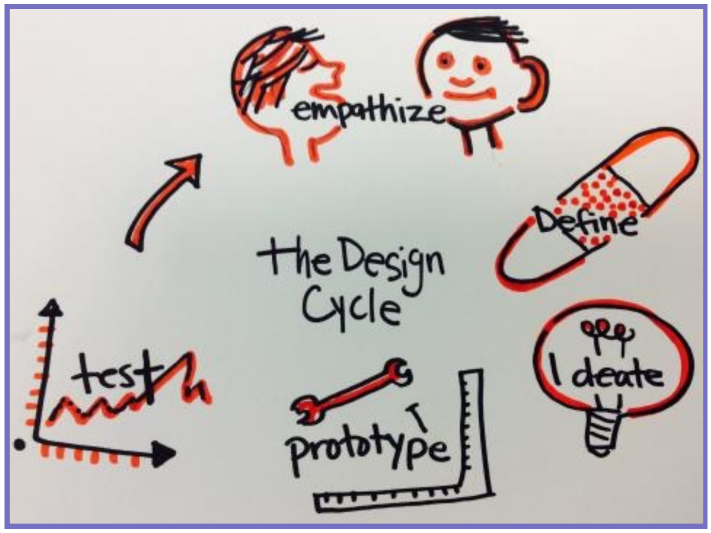
Constructionism in Action



The first section of this book is a collection of articles about how Seymour Papert's theory of learning, Constructionism, combines with the modern tools and technologies of the Maker movement to create new opportunities for learning. The FabLearn Fellows offer their views on various topics from the nature of learning to creating environments for children that foster deeper understandings and connections with powerful ideas.

By placing these big ideas in real contexts of classrooms and other learning spaces, theory comes alive and vision becomes action.

From Name Tags to Lasting Artifacts: Fostering a Culture of Deep Projects
by Christa Flores



Introduction

Much hype has been made about incorporating Design or Design Thinking into education, but what is design and why is it "suddenly" a valued 21st century concept in education? Anyone who has taken a Design Thinking workshop knows that little is gained from a one hour design cycle, especially those based on product development that may or may not be a sustainable use of resources. On the other hand, understanding the actual process of design through first hand practice requires time, a lot of time. Years in some cases. That being the case, are schools that are pushing design into their programs allowing students to know more than the terms of design (brainstorm, iterate and empathy) or are they truly teaching the value, and intricacy of the design process? Inspired by Paulo Blikstein's contribution to Agency by Design's Makeology book (in press), I am writing this blog on the importance of "fostering a culture of deep projects" as it relates to the work that I do in science with my 5th graders.

The Design Process, Design Thinking or Design Science

Anyone can search wikipedia for "Design Thinking" to discover the term is rooted in the product design industry which grew out of Stanford's d.school. David Kelly, one of Design Thinking's co-fathers is a revolutionary thinker; his "human-centered" approach to design is more than colorful post-it notes and white board doodles. Design Thinking is based on an older idea referred to as Design Science or The Sciences of The Artificial.

"The central task of a natural science," according to Simon Herbert author of the book The Sciences of the Artificial (1969), *"is to make the world commonplace, to show that complexity, correctly viewed, is only a mask for simplicity; to find pattern hidden in chaos."* The sciences of the natural sought to make the wonderful "not incomprehensible," argues Herbert who then describes the "artificial," as any artifact created by man. Design thinking evolved from a perspective that the act of design is the use of thinking routines applied to the natural sciences, to inform how to construct artificial means for

humans to interface with the world. With the addition of the concept of empathy, deep listening or storytelling, design thinking can and should be more than a mindless march to mass produce.

In a book entitled *How Designers Think: The Design Process Demystified*, architect and design researcher Bryan Lawson argues that applying the design process is a skill of the mind, akin to riding a bike, or playing an instrument. His research suggests that thinking like a designer can compliment thinking like a scientist, when it comes to problem solving with constraints.

For Kenya Hara, author of *Designing Design,* “There are an unlimited number of ways of thinking and perceiving. In my understanding, to design is to intentionally apply to ordinary objects, phenomena and communication the essence of these innumerable ways of thinking and perceiving.” Design in this sense is a mindset, a lens through which you can see the infinite layers of detail in the world.

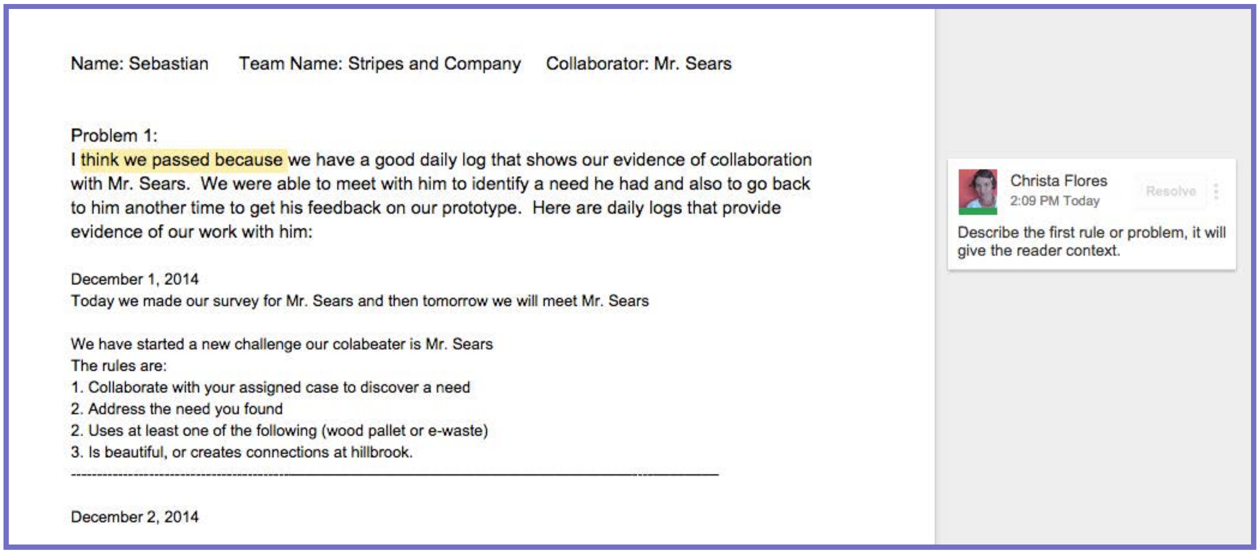
The Design Process allows the designer to apply the knowledge from the natural sciences to a creative science. The creation of the artificial, whether it be room temperature, a modernist chair or a school system, is solution finding, armed with scientific knowledge; with or without a strong focus on the user. Placing the user at the center of why we make things brings to the engineering process a story. Stories create connections and allow students to empathize; and in turn gain diverse perspectives of the world they live in.

Making for Change; the Value of Design in School

Kyle explains their blacksmithing curriculum and how it has informed their students in areas ranging from conscientious consumption, molecular structure to ancient cultures.

I recently visited the East Bay School for Boys and got a huge crush on their metal arts program. At this five year young, agile, middle school serving under 100 students, I saw projects that allow boys to identify with their culture and their emotional and physical selves (they have capoeira class, beekeeping, they made a half-pipe skate ramp and make their own steel knives). I also saw projects that get boys to work with local homeless residents and projects where boys gain empowerment through capstones based on a super hero theme for social justice. Kyle Metzner and David Clifford are the creative minds behind the EBSB design thinking program. Kyle comes from a professional background in design and fabrication and David has a fellowship at the Stanford d.school where he is part of a cohort of individuals *"working in a variety of ways to invent, disrupt and innovate in and around complex social systems."* The value of teaching the design process, claims Metzner is that *"you can not hand hold a student through the design process."* Design is the ultimate test of creativity and willingness to iterate, he explains.

In problem based science level 5 at Hillbrook, we are in the midst of a six month long design project that we affectionately refer to as the “spring hard problem.” For this year’s challenge my 10 and 11 year old students have to follow four simple rules or prompts. In May, they will grade themselves on the design and engineering process by arguing for a pass or fail grade. This construction of an argument, as well as a detailed log of skills and topics employed to solve problems, is another avenue for practicing the design process.


Name: Sebastian   Team Name: Stripes and Company   Collaborator: Mr. Sears

Problem 1:
I think we passed because we have a good daily log that shows our evidence of collaboration with Mr. Sears. We were able to meet with him to identify a need he had and also to go back to him another time to get his feedback on our prototype. Here are daily logs that provide evidence of our work with him:

December 1, 2014
Today we made our survey for Mr. Sears and then tomorrow we will meet Mr. Sears

We have started a new challenge our colabeater is Mr. Sears
The rules are:
1. Collaborate with your assigned case to discover a need
2. Address the need you found
2. Uses at least one of the following (wood pallet or e-waste)
3. Is beautiful, or creates connections at hillbrook.

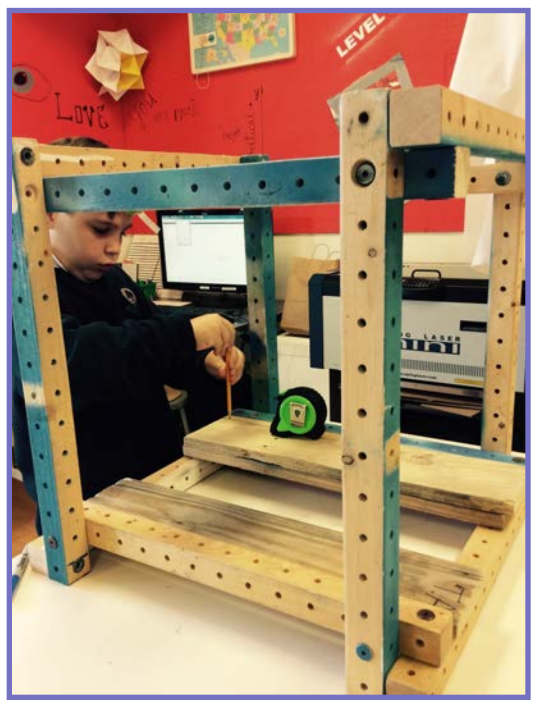
December 2, 2014

Christa Flores
2:09 PM Today
Resolve
Describe the first rule or problem, it will give the reader context.

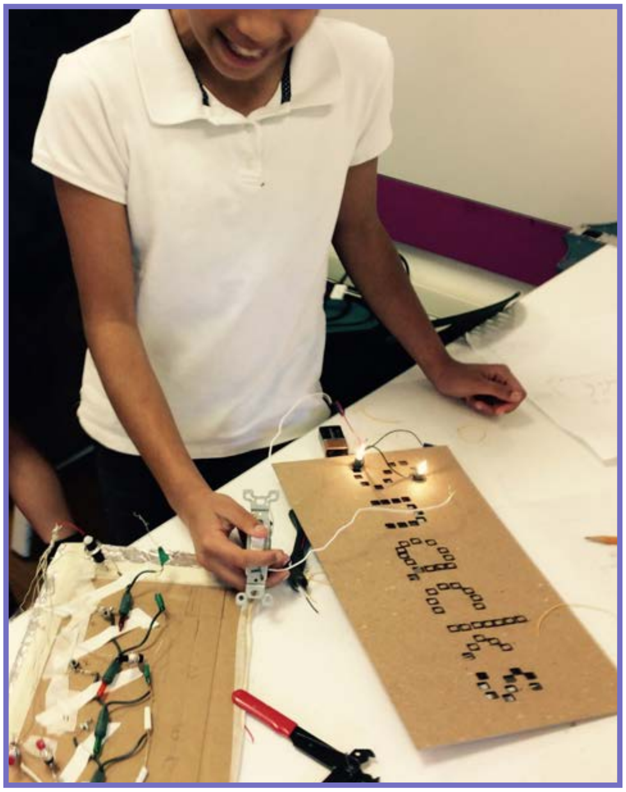
We use Google Docs when working on process, as they offer students easily accessible tools for self-publishing, as well as a quick and permanent means for me to give students feedback. We use terms such as craftsmanship when working with words or wood.

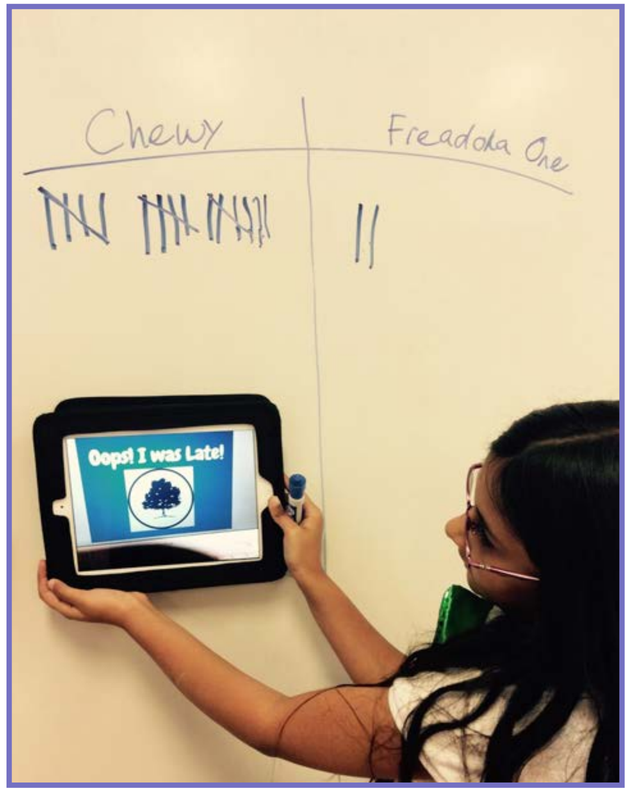
When my students invent, they take ownership over an idea, then face real world problems on their route to making their idea come to life.

At the middle school level the design process is a creative exploration of hard, yet fun, problems (rigor + risk + reward), positive identity formation (I am creative, I am a scientist, I can solve problems) and collaborative learning that questions the status quo. Add responsible resource management and exposure to social justice issues, and design becomes a thinking tool for empowerment and stewardship. These are a few reasons why we incorporate the design process into the sciences at Hillbrook. What do you see your students gaining from the design process at your schools?



Measure twice, cut...well it depends. The iterative process almost never follows a straight line.





Small successes, for big solutions. This young lady is endeavoring to build a 60+ light display using a single wall outlet plug with a 12 volt output from our e-waste pile.

Science through survey for peer feedback. This was the winning font for the re-design of the Hillbrook Late Pass. We decide as a community what quality and beauty are.

WORKS CITED

Blikstein, P. & Worsley, M. (in press). *Children are not Hackers: Building a Culture of Powerful Ideas, Deep Learning, and Equity in the Maker Movement In Halverson*, E., Peppler, K., and Kafai, Y. (Eds.). Makeology. Routledge.

Hara Kenya. (2011). *Designing Design*. Lars Muller Publishers.

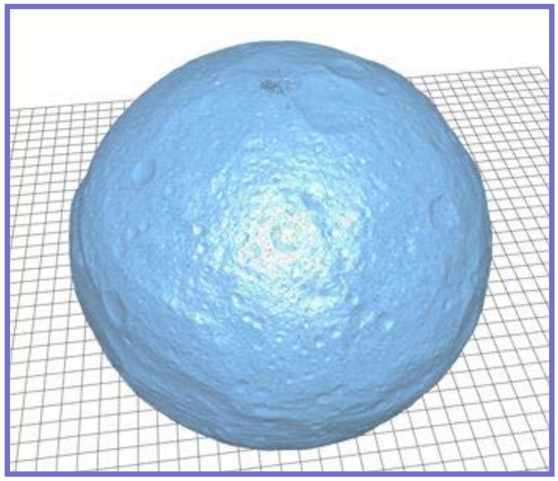
Simon, Herbert (1969). *The Sciences of the Artificial*. The MIT Press.

Lawson, Bryan (1997). *How Designers Think: The Design Process Demystified*. Oxford: Architectural.

Martinez, Sylvia Libow., and Gary Stager (2013). *Invent to Learn: Making, Tinkering, and Engineering in the Classroom.* Torrance, CA: Constructing Modern Knowledge, 2013.

Thoughts On Learning and Engagement and the Pluto New Horizons Mission

by Tracy Rudzitis



I am sitting next to one of my 6th graders, J., as he flips though one of his favorite books. This book accompanies him to MakerSpace every day and if he is in the lab after school he typically has the book so he can refer to it. The book is a large picture book of the planets and their moons. He is showing me some of his favorite parts, and reading passages to me. As he is doing this, he is holding a model of one of the moons described in the book.

J. designed this moon in Tinkercad and has printed it out using the 3D printer in the lab. It is just one of a half dozen moons or planets that the has designed then printed. Ranging in size from a ping pong ball to a tennis ball, they don't really look like much, but when you hear J. describe the features and the characteristics of the moon and how he was able to translate that into his own design and then print it and hold it, the shape takes on incredible meaning.

Watching J. and listening to him read about some of his favorite moons, I witness an intensity for learning and a motivation for uncovering more information and exploring creative ways to further be engaged. I see him grasping a physical object, of his own creation, even if it is not something he is actively referring to as he is reading.

NASA provides some incredible 3D resources for those interested in space and space exploration at nasa3d.arc.nasa.gov. The recent Pluto fly-by, "New Horizons" gives us all an opportunity to rekindle the fascination with outer space.

Student's can explore their interests in 3 dimensions, and students like J. can imagine these far away worlds in a more personalized and immediate way through designing their own 3D models based on their own imaginations, research, and picture books. I am fortunate that my students interests in space led them to these NASA resources. Teachers can also explore and share with their students the many readings about how 3D printing technology and materials are used in the space program.

LINKS

- A collection of 3D models, textures, and images from NASA. All free to download and use. http://nasa3d.arc.nasa.gov
- http://www.nasa.gov/topics/technology/manufacturing-materials-3d/index.html

What Do People Learn From Using Digital Fabrication Tools?

by Erin Riley

In response to the question of what one actually learns from 3D printing, I thought more deeply about the work we do in our school. While I know conceiving an idea and shepherding it into a tangible form is significant, it is important to be able to articulate its value within an educational setting. It's also important to reveal the many stages in digital fabrication, especially illuminating the often hidden design process where much of the learning takes place.

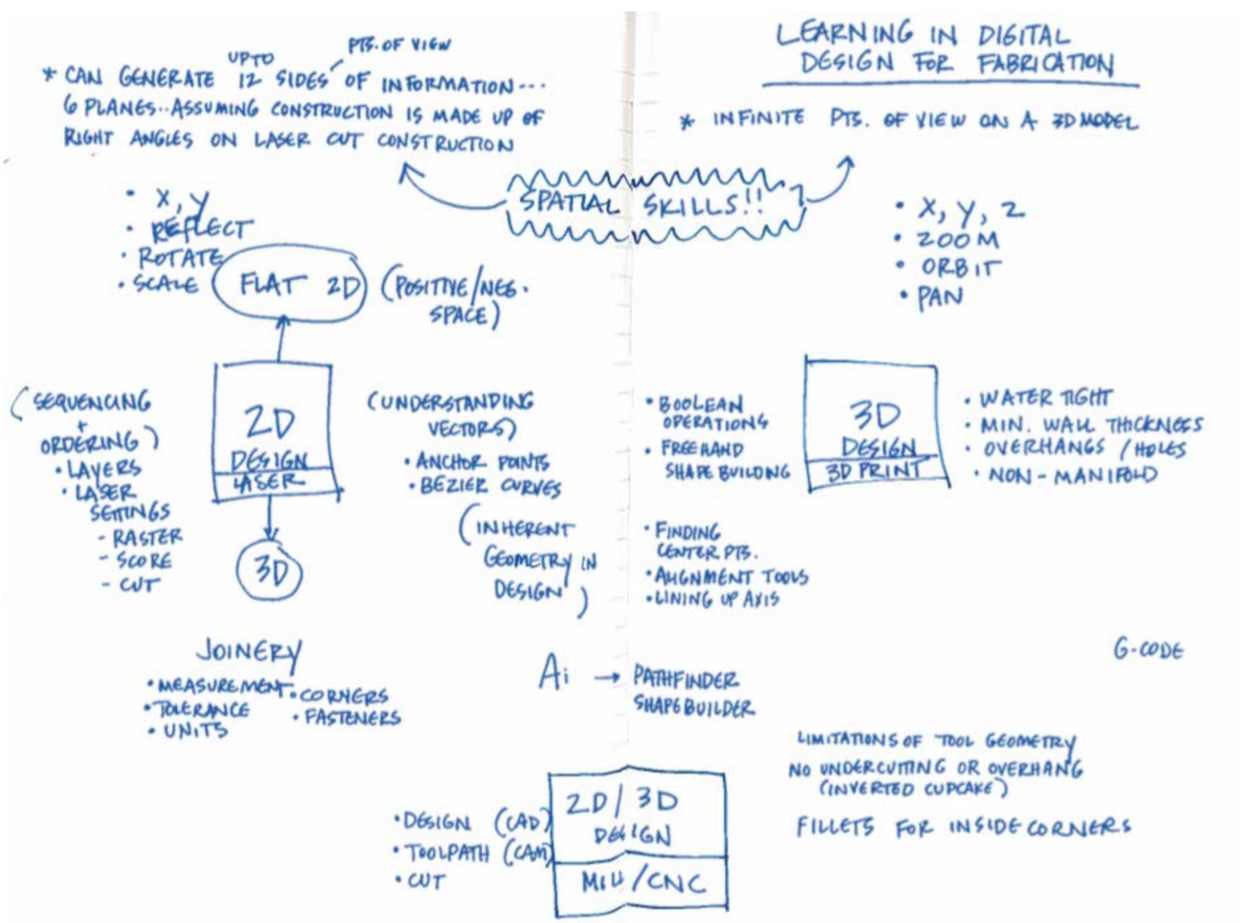
Digital fabrication, which begins with digital design and ends with output from a fabrication machine, parallels pre-digital processes for making things. A laser cutter and CNC router cut designs in a manner similar to a scroll saw. A sculptor can build up clay in an additive approach, just as a 3D

printer lays down lines of plastic, or chisel marble with a subtractive approach, as the CNC milling machine would carve wax. Digital design adds precision, scaling, cross-machine capabilities, and reproducibility to the mix.

Those of us working with students using these tools know that digital fabrication is the merging of the human with the technical. The result is a creative product formed from their ideas and executed through a series of complex design decisions. I often observe that through 2D and 3D design and making, students develop multiple skills, not only in growing proficiency with 2D and 3D design, but also in spatial development and a variety of mathematical concepts.

It is also worth noting students' learning goes beyond acquiring skills and includes strengthening critical thinking as an outgrowth of working through design and fabrication problems. Gaining facility, and refining their ability to be mindful, active learners isn't limited to digital fabrication; making in general promotes curiosity-driven, self-directed, creative learning.

Using the lens of my own experience helps me address the challenge of articulating what 2D and 3D fabrication projects teach students. New to digital fabrication myself, I started designing and making objects on these machines less than three years ago when our first 3D printers arrived on campus.



Skills-based learning: 2D and 3D design and spatial development

Returning to the original question: What does one actually learn from digital fabrication? What is the breakdown of skills acquired through the process of digital design and production, including controlling the machine to make that product? An online forum for teachers using digital fabrication tools recently addressed a similar topic. (The K12 makerspace Google group). Themes that emerged from the conversation included the development of spatial reasoning, math concepts, and 2D/3D design. The posts revealed that many of these teachers see many layers of learning embedded in the design-to-making process.

A simple way of looking at the skills-based learning that occurs in digital fabrication might be by looking at each machine and design approach used.

3D Printer

Learning from the design process:

- Math and Spatial Reasoning: Navigating the 3D design environment, Designing on all sides-X, Y, Z, Alignment tools, Geometric shape building, Dividing and combining, Measurement tools, Units, Scale, Ratio, Rotating, Mirroring, Boolean operations, and Precision.

Learning from the fabrication process:

- Machine operation: Machine settings-raft, supports, infill
- Designing for the machine including its limitations: slicing a model into smaller parts that later get attached, designing supports like cones that can be cut off later, re-orienting the model for better support.
- Science behind the process: The technology of additive processes, slicing, G-code.

Beginners can jump right into 3D printing with the help of user-friendly software like Tinkercad. The solid geometric forms students build with are watertight which can alleviate certain printing problems and prevent frustrations later on. Complex forms are built up through manipulating positive and negative space and grouping. The learning curve for machine operation is low and students can get involved in the entire design through fabrication process easily. Once students are comfortable navigating the 3D design space, they can translate their ideas into the 3D world. After a successful introduction to 3D printing, students are excited to attempt more complex projects.

Laser Cutter

Learning from the design process:

2D

- Math and Spatial Reasoning: Navigating 2D design environment, X,Y , Geometric shape building, Dividing and combining, Measurement tools, Units, Scale, Ratio, Rotating, Mirroring, Positive and negative space, and Precision.
- Graphics: Vector design, Alignment tools
- Ordering, sequencing and visualizing: Layering for the sequence of etching and cutting.

2D-3D

- Math and Spatial Reasoning: Joinery, Visualizing the translation of 2D to 3D (from shape to form).

Learning from the machine cutting process:

- Machine operation: Machine settings- stroke, fill, hairline, RGB black.
- Science behind the process: Laser technology.

The laser cutter makes 2D and 3D objects. A laser cutter cuts (or etches) material in two dimensions, and flat objects can be made three-dimensional by joining the pieces after they are cut. Designing for the laser cutter involves planning and generating these multiple pieces.

Students quickly begin 2D design by converting hand drawn designs into vectors and outputting them to the laser. The next step is to learn to draw with basic 2D design programs tools such as the shape drawing tools, the pen tool, and shape builder tool in Adobe Illustrator.

When moving from 2D to 3D on the laser cutter, joinery comes into play. Here students refer to a timeless pre-digital skill that requires them to consider width of material; visualizing how flat pieces unfold and potentially fit together engages spatial skills.

CNC/Milling

Learning from the design process:

2D

- Math and Spatial Reasoning: Navigating 2D design environment, X,Y, Alignment tools, Geometric shape building, Dividing and combining, Measurement tools, Units, Scale, Ratio, Rotating, Mirroring, Positive and negative space, and Precision.
- Graphics: Vector design
- Ordering, sequencing and visualizing: Layering for sequence of drilling, milling and cutting.

2D-3D

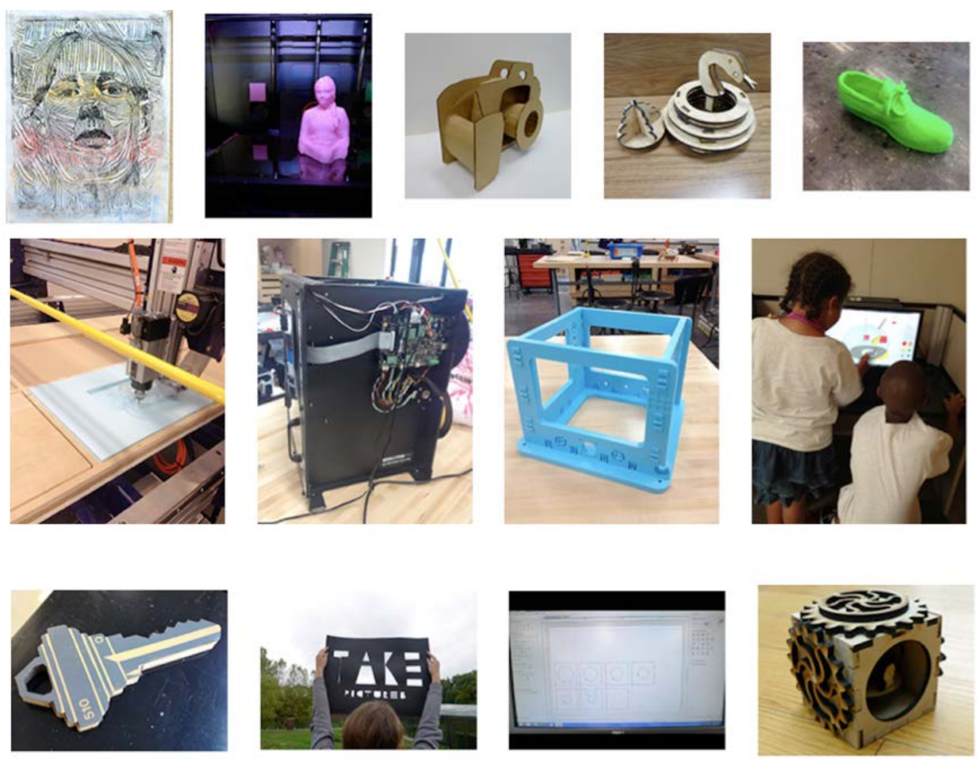
- Math and Spatial Reasoning: Joinery, Visualizing the translation of 2D to 3D (from shape to form).

3D

- Math and Spatial Reasoning: Navigating 3D design environment, Designing on all sides-X,Y,Z, Alignment tools, Geometric shape building, Dividing and combining, Measurement tools, Units, Scale, Ratio, Rotating, Mirroring, Boolean operations.

Learning from the fabrication machine process:

- CNC Routing and Engraving software software: Tool paths: drill, profile, pocket, V-Carve, 3D modeling, slicing, tool geometry, feeds and speeds, G-Code, measuring.
- Machine operation: loading stock, zeroing X,Y,Z, switching tools
- Science behind the process: CNC and milling technology.



A Computer Numerical Control (CNC) machine cuts materials by moving a rotary cutter to remove material and create an object. The laser cutter and the CNC share many of the same design considerations; both require use of layers and sequencing when planning cuts, carving, drilling and milling. There are limitations inherent in the geometry of the cutting tool that does not account for undercuts and corners. It is also more complex on the machine side with the additional step of selecting appropriate cutting tools and using separate software to generate tool paths.

An added level of learning for the CNC machine is the finish work involved with a woodworking project. Parts are tabbed into the material and require removal and filing. Some projects generate parts that later need connecting, clamping, filing, and sanding.

The skills acquired from design and fabrication have real world applications in engineering, art, design, science, computer science and math. In addition to these important skills, the culture of a makerspace itself can help students become independent learners driven by curiosity and intrinsic motivation. I experienced this as part of an early user team involved with Greenwich Academy's establishment of a lab. Mastery of each machine and the unique design considerations required to output to them was new to me. This is what I learned:

I can teach myself to do this.

- I can learn how to design in 2D and 3D and use a machine to make that object by seeking out resources to help.
- Like with so many new and emerging technologies, there are many resources available. Books, websites, how-to's, video tutorials are readily available for self-learning.
- Why this is important for students: Self-directed learning is a practice that will serve students in all areas of their learning.

I can seek help to troubleshoot problems.

- If I can't find an answer to my question with the resources I have available, to can reach out to others.
- When you are really stuck you can call someone, consult an online community, or bug your friends at the local makerspace.
- Why this is important for students: There is no shame in asking for help.

I can teach others to do this.

- Even if I'm not an expert, the knowledge I have can help others.
- When we opened our digital fabrication lab we were all newbies in using the technology. Each one of us learned as we went along, and had something to share with the group.
- Why this is important for students: Students contribute to the collective knowledge base.

I can solve new problems.

- I can merge ideas, extrapolate, and find connections when I do not have a solution to my specific problem.
- Learning comes with all sorts of challenges. Maybe the software isn't compatible; maybe you have a Mac but they have a PC; perhaps what you are trying to do doesn't quite match up with the resources you have at hand. We have all experienced a situation when we cannot neatly follow a step-by-step recipe to arrive at a solution. It forces us to dig a little deeper, perhaps learn something different but related, and by doing so, make the connection.

- Why this is important for students: It encourages flexible, creative thinking. It provides opportunities for learning to be applied to a situation in a new or indirect way.

Learning is not a one-time thing.

- I can tackle increasingly complex problems
- The iterative nature of these kinds of projects, plus the unlimited versatility of these tools creates a positive reinforcement cycle. Even when tools are difficult to use, or don't work as expected, students learn to adjust and accommodate their designs to these constraints. As they use the tools more, they increase their competency and therefore can tackle more complex designs.

It's okay to go on a tangent with your learning.

- I find more opportunities to learn when teaching myself.
- The journey of self-learning opens the door to new ideas. Stumbling upon projects, processes and new tools are the raw materials for idea generation. If I don't know exactly how to get to my goal, there is room to move off course.
- Why this is important for students: Students follow their interests in the process of learning. Students learn there is more than "one right answer."

Grades four and eleven working together on digital fabrication problems

In the quest to answer a question, I find myself with more questions.

- The more I learn, the more questions I have.
- I think it must have something to do with wanting to find connections between ideas, but I find as I seek answers to questions, more emerge.

- Why this is important for students: Learning fuels curiosity.

I can learn my way.

- There are different ways to achieve the same goal.
- Learning is personal when you can craft your own strategies for solving a problem. They may not always the most efficient, but they are yours, and become part of your larger body of knowledge. As new ways of doing something are adopted, an old strategy can be applied or modified to future situations and becomes part of a creative problem solving vocabulary.
- Why this is important for students: Creative, personally meaningful solutions are prized.

I end with this: making, digital fabrication in schools, is a creative process. Students learn all sorts of skills and ways of thinking that help them become better learners. Whether it is Boolean operations or how to research problems, the main thing they learn, is how to navigate the process of going from idea stage to final object.

WORKS CITED

Blikstein, P. & Worsley, M. (2015). *Children are not Hackers: Building a Culture of Powerful Ideas, Deep Learning, and Equity in the Maker Movement In Halverson*, E., Peppler, K., and Kafai, Y. (Eds.). Makeology. Routledge.

Hara Kenya. (2011). *Designing Design*. Lars Muller Publishers

Simon, Herbert (1969). *The Sciences of the Artificial*. The MIT Press

Lawson, Bryan (1997). *How Designers Think: The Design Process Demystified.* Oxford: Architectural

Martinez, Sylvia Libow., and Gary Stager (2013). I*nvent to Learn: Making, Tinkering, and Engineering in the Classroom*. Torrance, CA: Constructing Modern Knowledge

Launching Boats
by Erin Riley

I once heard teaching compared to the act of launching boats. I love the visual evoked by that metaphor. Could we think of the work we do in our makerspaces a similar process to preparing for, and ultimately taking off on a self-guided journey? Students captain the ship and teachers watch from the shore.

Learning through Play

Children learn through play and exploration. From floating sticks downstream to ducks in the tub, early lessons in how the world works come from play. Could this be the first step in the progression towards mastery? In other articles, I have written about sequencing activities to support discovery. By building upon play, a mode of learning that is rooted in curiosity and joy, we can engage our students in a truly authentic way. For instance, a project involving electronics can be launched with a session with circuit boards, or wood working with a one-block challenge. Both of these activities originate from two of my favorite resources for exploration-based maker activities: the Tinkering Studio at the Exploratorium, and the Makerspace at the New York Hall of Science.

Mastery: Learning the Ropes

Play sparks interest. Interest drives the desire for mastery. Practicing and gaining mastery build confidence. The teacher strives to find the balance between guidance and autonomy. Excitement over making connections, getting better at making things, completing projects, and overcoming obstacles is the process that builds confidence as students move towards full independence.

At Greenwich Academy, one student documented in her maker portfolio, her process for building a paper circuit project including challenges and breakthroughs along the way. She wrote:

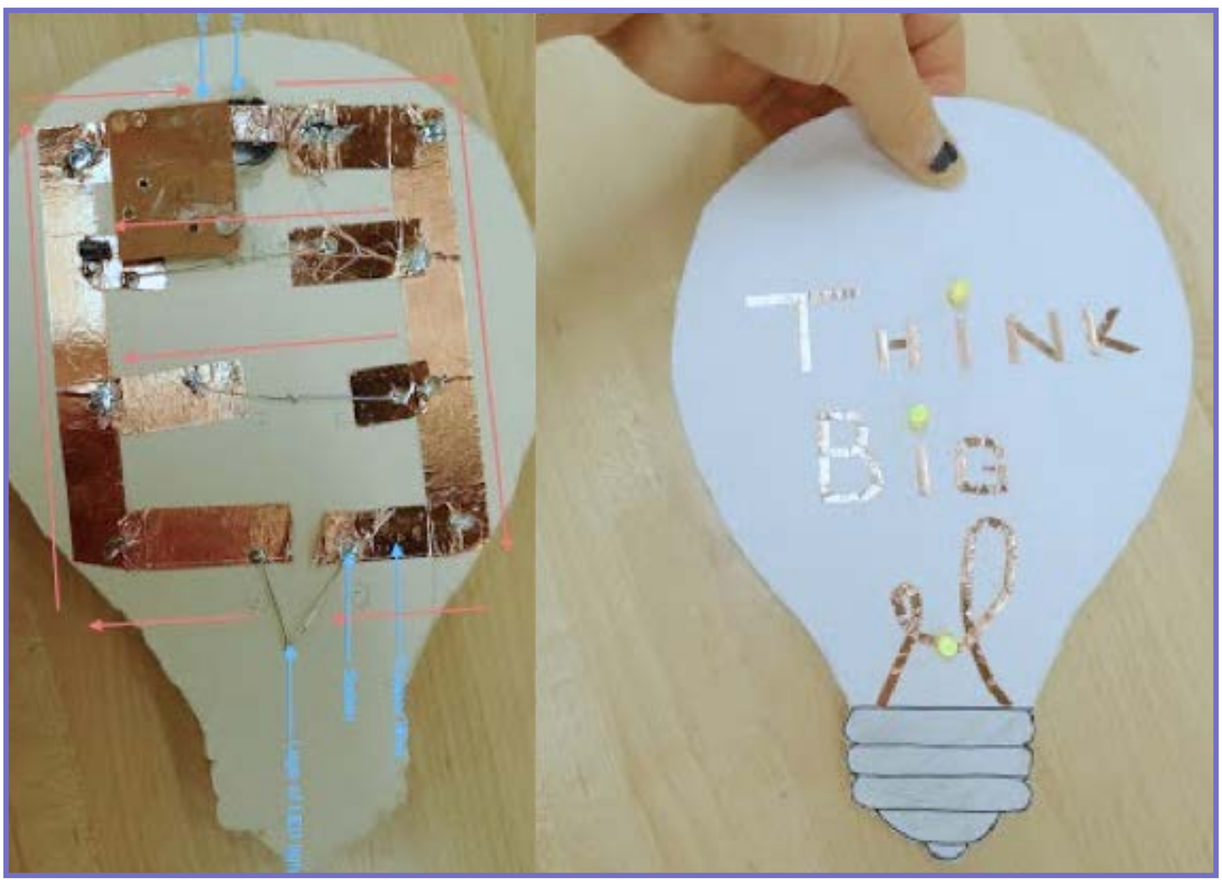
"A great maker is not only one who is willing to make mistakes but one who is willing to still think big in spite of the threat of mistakes. In keeping with that theme I decided to create an Easy Button...

...I even left a little room for myself to think big during the project. While pasting copper wires down I realized I was missing an essential element to my Think Big Button, a noise component. I remember my favorite part of the Staples Easy button was the little phrase it spit out each time you pressed it...

...So I went to CVS, bought a singing card and removed the sound circuit. The circuit contained a circuit board with and an attached speaker. Probably the hardest part of the whole project was trying to figure out how to get the sound to go off...

...After much trial and error, I found the happy medium that required me to extend the length of the copper switch so it nestled in the center of the battery and placed the clip for the sound right next to the copper...

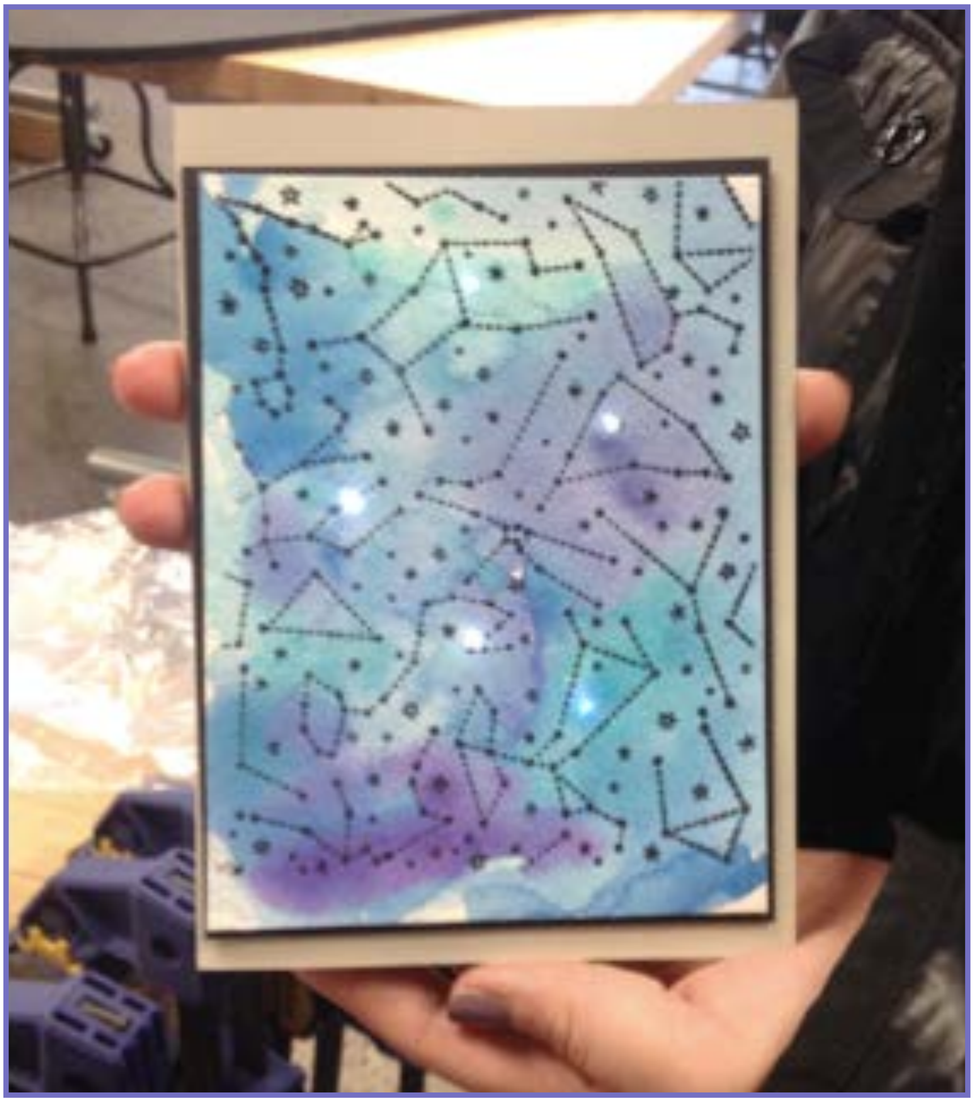
...This process has not only yielded a successful project but a successful [me]. It shows that I am one step closer to achieving my goal as a confident maker. "



"Think Big" Button design

The launch and the teacher at the shore

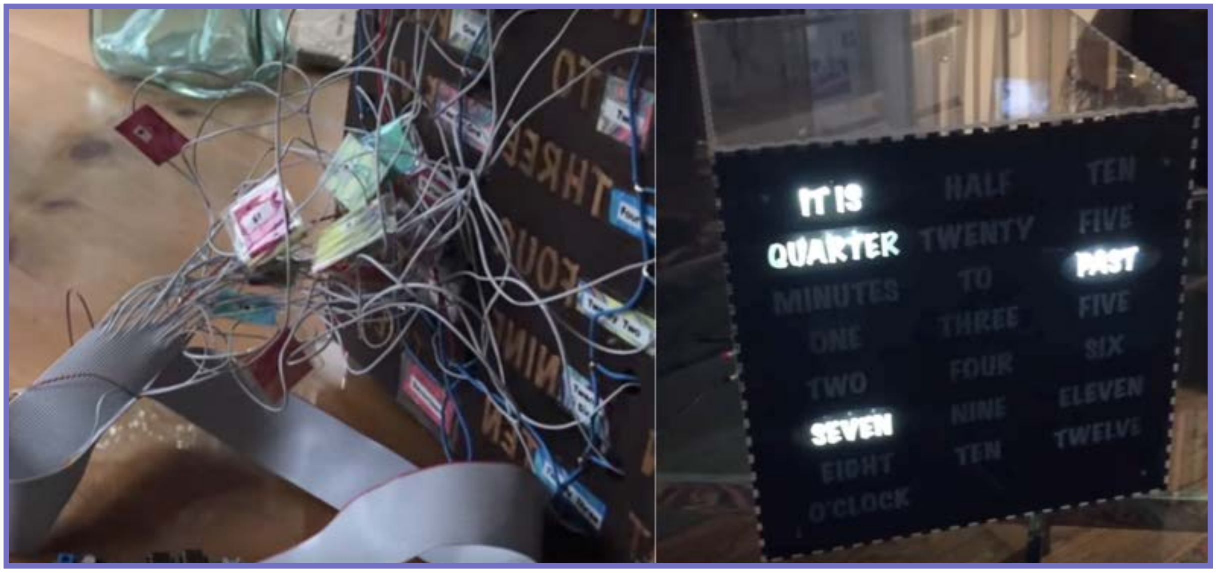
On her journey towards understanding her circuit, this student recognized an increase in her confidence. She was well on her way towards steering the ship. The teacher steps back and the student takes the lead.



Hand embossed card with an LED circuit

Another student's paper circuit project evolved into artistic handmade paper circuit cards. Accomplished in the art studio, she found her voice through the fusion of media to express her ideas. In this case, this student built upon a strong knowledge of art and craft process, and incorporated an emerging skill base in electronics.

The next object she made, a word clock, built around [Doug's Word Clock board](), included handmade marbled paper in the enclosure and her documentation revealed the carefully considered aesthetic and design decisions she made, while demonstrating confidence and independence with electronics.



Transparent word clock enclosure design with marbled paper

Her reflection about learning in the lab, underscored the importance of building skills on her way to becoming an independent maker. She wrote:

> *"By the end of this course, I would like to be a maker that thinks beyond 'outside of the box.' To me this means, challenging the norms, breaking patterns, and figuring out new ways. The maker I want to be is one that never stops thinking. Even outside of the lab, I want to be thinking about how to take my projects one step further than my mental capacity. Furthermore, I also believe it is important to first build a strong platform on which to build from. I also think it is important to keep an open mind as anything is truly possible. Inside the lab with limitless resources, I believe with enough drive, passion, and learning I will become just that."*

Fostering a Constructionist Learning Environment: The Qualities of a Maker-Educator
by Christa Flores

> *"Constructionism is not interested in pitting serious against playful, but instead finds ways to live at the intersection of the two" - Paulo Blikstein (2015)*

In other articles I have addressed the role of co-teaching in a maker classroom, as well as the intersection of Reggio Emilia practice and working in a makerspace in hopes of redefining the role of teacher in a Constructivist learning environment. Lately, the FabLearn cohort has also been discussing the essay written by Paulo Blikstein and Marcelo Worsley, soon to be published in *Makeology*. In this chapter of the book, the power of the culture of making is said to be highly dependent on the pedagogical style and attitude of the teacher. Fostering a constructionist learning environment is no small charge, as it turns out. Once established, however, this environment offers a world of learning experiences that are pitted to challenge the status quo teaching and learning we see in most schools today.

So what qualities would a teacher possess in a constructionist environment and how would these superheroes behave? Thank you to FabLearn Fellows Mark Schreiber and Erin Riley for their feedback for this post. They are quoted below from our small group meeting on April 7th. Here is a list of top five qualities and behaviors to keep in your tool kit for fostering a constructionist learning environment.

Keep it Brief, Relevant and Open! Gary Stager and Sylvia Martinez have a great approach to lesson planning for Maker education — use prompts instead of teacher led and cookie cutter curriculums for best results in constructionism. Good prompts are simple enough for kids to understand, vague enough to allow a diverse and open array of solutions, and immune to standardized testing. Prompts mirror the effect of using essential questions to deepen engagement, understanding and love of learning. Like essential questions, prompts also allow for the natural integration of math, science, technology, the fine and performing arts, social studies and language arts. In other words, relevant and real problems look like real life.

Model the Maker Mindset! Be willing to co-learn, see the use of technology as an opportunity rather than an insurmountable challenge. Gary Stager is famous for saying, "*You can't teach 21st century* *learners if you haven't learned this century."* Erin Riley notes that maker spaces are not your everyday classroom environment. *"The Maker Space attracts 'those kinds of teachers' willing to take a risk in teaching old content in a new way,"* says Erin. Teachers have to be ready to throw out what simply looks like "good teaching" for more effective teaching, which will look different in different settings. It might look like a play, a concert, a cave mapping robot, a scratch video game, or…the list is endless.

Act like a Scientist! You are exploring new territory as a maker educator. Record using images, self-reflections, portfolios and any tool at your disposal to reveal how and what your students are learning. Mark Schreiber reminds us that one of our roles is, *"to assess how this work is better or complementary to the current practices of our peers in their classrooms."* Do not get intimidated by testing something that has never been done. A scientist will revel in the unknown. Constructionism and making may offer a better vision of school and learning, let's prove it together by showing and sharing work.

Reward Curiosity and Passion with Rigor! Fredrick Douglas is famed for stating *"Without struggle there is no Progress."* Take out progress and insert learning, and you have a recipe for what constructionism feels like. Never tell a student their ideas are too hard or above grade level. Let them discover their own natural boundaries and when they get stuck, brainstorm possible solutions with them or in a team. This concept of allowing the learner to step beyond themselves is explained in Vygotsky's concept of Zone of Proximal Development as an essential element of learning.

Keep it Safe! Social emotional learning is a large part of what we do as educators. Fostering a safe space that values; new ideas, nontraditional uses for tools and materials, as well as taking risks to solve hard problems, is working against the inevitable consequences of more traditional systems of teaching and learning. What does keeping it safe look like in real terms? According to *Constructionism: Tools to Build (and Think) With*, *"Creating a safe space for students to learn includes a welcoming, friendly, space that is as free as possible from the pressures of time."* Time to be creative is what kids need; show your value for this skill by devoting time to foster it. Lastly, a safe environment is one in which students participate in their own assessment, allowing them to see its value and to gain literacy and autonomy through it. Judgment slips away in the face of critical feedback allowing the sharing of ideas to be a rewarding part of their learning journey.

Have fun practicing the above and share your thoughts on what you would add to the list!

RESOURCES TO LEARN MORE

Situating Constructionism by Seymour Papert and Idit Harel.

The Nature of Constructionist Learning, a special topics course outline with various reading resources.

Invent to Learn Chapter Two: Learning by Gary Stager and Sylvia Martinez, and its Resources. http://inventtolearn.com

Falbel, A. (1993). *Constructionism: Tools to build (and think) with*. Toronto: LEGO DACTA.

Learning by Making: An Introduction to Constructionism https://www.youtube.com/watch?v=DCSMvGB-sVA

STEAM, STEM, and Making
by Tracy Rudzitis

What do these words mean? How are they interpreted by teachers, by administrators, by students, by politicians?

In the past few months I have been a part of a number of discussions surrounding this question. The conversations are genuine and in most cases have the best interests of students and learning in mind. There is one thing that I have noticed, there can be a wide range of perspectives and responses to these questions.

A question I was asked recently comes to mind, "How can we create a STEAM curriculum that will prepare students for the AP Physics exam?”

Perhaps it is time to break away from the idea that studying for and passing the AP Physics exam is what defines a rich and engaging inquiry based experience. Instead of asking, will a STEAM or Maker program allow my students to score well on an exam, we should be asking, how will the STEAM or Maker program foster a genuine love for investigation, for asking questions, for curiosity and engagement about the world we live in. How can infusing a hands on and open ended experience allow students to discover and attempt to manipulate their world, while learning and experiencing the over arching concepts that make up a science (or math etc.) curriculum?

We have the momentum now to alter the way that learning can take place in schools. So many are jumping on the Maker/maker bandwagon and the STEM/STEAM/STREAM acronyms are everywhere in the news. These new opportunities and ways to experience learning should remain true to the spirit in which they exist and not be diluted or changed because existing curriculum and pedagogy are being imposed upon them. It is important to have resources at hand for those interested in understanding more about the maker movement and how it is situated in pedagogy and learning theories.

Hands-on and inquiry based exploration is nothing new to education, but one could get the impression that it is a brand new idea in this data-driven, test-prep environment that most schools are deeply entrenched in. In the book "Invent to Learn Making, Tinkering, and Engineering in the Classroom" (2013) the first chapter is dedicated to the history of making. It illustrates how making meaning through the exploration of materials is not a new concept but one with a rich and varied past. It is important that as educators we are aware of this history and it should inform our approaches to teaching and making in our classrooms and be a part of this current dialogue on making.

One hundred years ago John Dewey wrote of the importance of creating meaningful experiences for students from which knowledge emerges. Democracy and Education (1916), Experience and Education (1938). His idea that learning is social and the classroom should be a social environment where ideas and knowledge is constructed and shared as a community could be the mantra of any modern day makerspace and for any age group.

Seymour Papert's constructionism is also rooted in the social experience. *"Important concepts are consciously engaged and public entity. Constructionism is not just learning-by-doing, but engaging reflexively and socially in the task. Both the creation process and the produced artifacts ought to be socially shared."* A Journey into Constructivism Dougiamas, M. (1998).

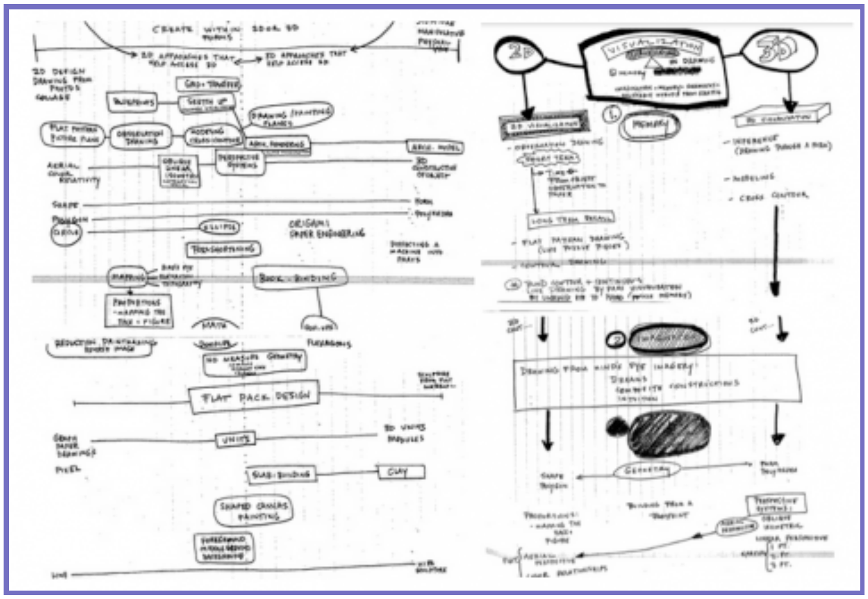
But even with such a rich history of maker pedagogy, there are still so many educators who are unaware or who don't trust the methodology or the process where children can learn without being directly and explicitly told what it is they are supposed to be learning. An excellent essay on Constructivism/Constructionism is "Situating Constructionism" Seymour Papert and Idit Harel (1991). This paper goes into great detail about the nature of knowledge vs the nature of knowing. I recommend this reading as just one of many possible starting points for these discussions on STEM, STEAM, and making that are happening in so many schools and districts right now.

How can we bring to the forefront the educators who do have successful programs where students are actively engaged in this way of learning? Whose students are immersed in authentic and genuine projects that are meaningful to them? I challenge all educators who believe in the power of the maker movement to bring change to the dominant pedagogical practice of teacher disseminated knowledge and data-driven standards and testing that is so prevalent in this country right now, to create spaces for this important dialogue.

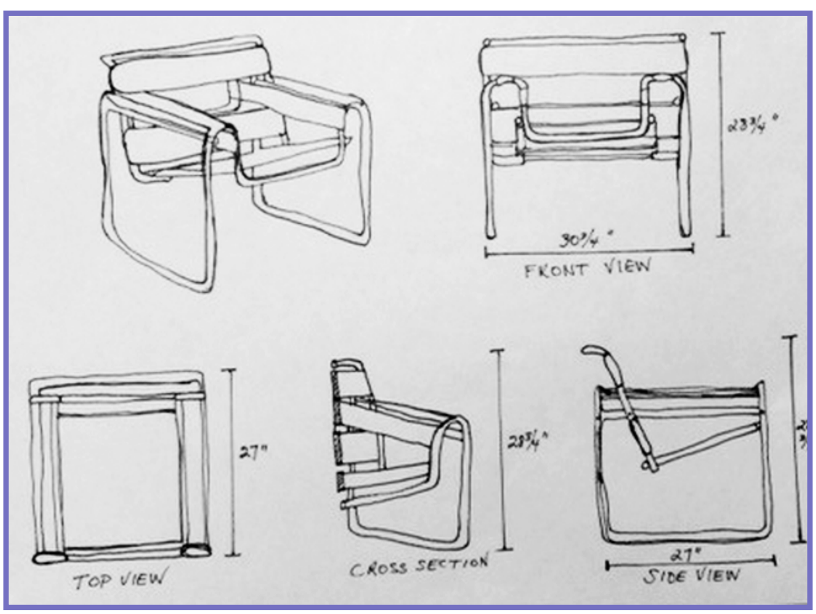
Instead of situating STEAM and making into a traditional pedagogical framework of teaching and assessment, it must remain true to the spirit of making. Within the educational environment it is important that hands-on inquiry and discovery learning reference the work and research of constructivists and constructionists that have gone before.

The Power of Making What You Can Imagine

by Erin Riley



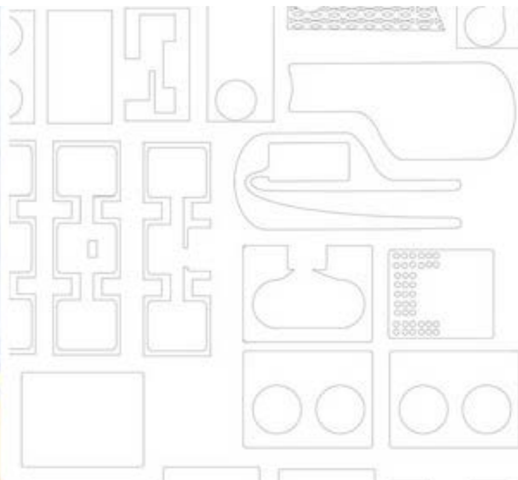
Several years ago while while teaching an upper level drawing class I noticed that some of my students were struggling to understand 3D space on the 2D drawing plane. In an effort to help these and future students, I reimagined a way of keeping track of studio projects based on where they might be organized by their 2D-3D "ness" on a spectrum, and identifying the sorts of visualization that would be involved as they cross into other spatial forms. My notes, part curriculum development, part brainstorm, part webbing structure, took the form of mind maps and at the time helped to organize my ideas. This set into place a way of thinking about art, design and making activities that I use in the Engineering and Design Lab and art studio today.

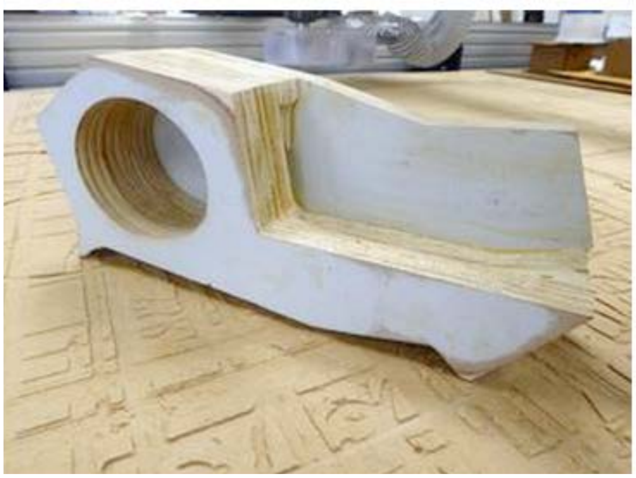


Student orthographic projection

The Mind's Eye

Moving back and forth between 2D and 3D approaches encourages mental visualization and strengthens spatial skills. Providing opportunities to practice translating mental imagery into the physical world empowers makers. An architecture student might undergo this process, accessing the idea in two dimensions by drawing a quick sketch of a structure and developing the visual idea to include floor plans, elevations, cross sections and linear perspective renderings. Eventually the idea is brought into the physical world through the creation of a 3D model. The student utilizes mental visualization moving from 2D to 3D representation first by drawing then with physical construction to execute a design idea. A reverse approach is used in a project designed for Middle School students titled, *"Think like an architect, draw like an engineer"*.





A recent lab project used a 3D entry point as students prototyped iPhone amplifier designs out of foam, cardboard and recyclable materials. The prototypes were tested for amplification. Before moving onto a sketch, students had to translate their design idea into a second prototype using flat material stacked and configured. The material had to be easy to cut build with. Stale toast was our choice for this design challenge! Moving from 3D to 2D, students drew up plans of their designs, considering how each layer would register to create a three dimensional object. They redrew their flat designs in Illustrator and these design files were compiled and cut on the CNC router. The final stage in this project brought the design back to the 3D world as students constructed their amplifiers. The sequence as follows: 3D prototype→ 3D stacking prototype→ 3D drawing plan→ 2D design plan as a drawing→ 2D vector drawing→ 3D construction.

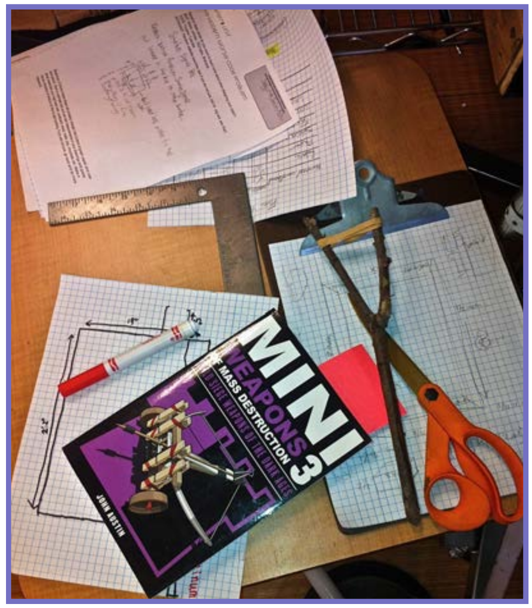
Linking the Eye, Hand and Mind

It's standard teaching practice in the art field to describe the act of drawing as an exercise in linking the eye to the hand. Adding the mind to the mix gives makers access to mental imagery as well. Drawing is a visual language that unlocks student power to bring their ideas into the physical world. The beauty is, the ideas do not have to be practical, functional or realistic. Like Leonardo and his inventions, many of which were precursors to modern designs, students can stretch their imaginations outside of the boundaries of the physical world and imagine what could be possible tomorrow.

To what end is all of this hard mental work of visualization and representing? STEM folks might say *"It's essential to engineering."* Art folks might say *"It's essential to self-expression."* Whether you are couching this question in the context engineering design or hatching an idea untethered to function, we may simply want to frame it as essential to making.

The "Unstructured Classroom" and Other Misconceptions about Constructivist Learning
by Christa Flores

Is *Student-Centered* Code for Lord of the Flies?



Ask any average kid what his or her favorite part of the school day is and you will probably get the answer lunch or recess. Kids love unstructured time because they have the privacy to fail while taking risks or learning how to be a social primate. At recess, kids have nearly 100% choice over what to do with their bodies, with the safe assumption that in case an injury does occur, an adult on duty will be on the scene in due time. Provide kids with a rich, not necessarily antiseptic space to explore and they teach us a lot about ingenuity, inclusivity and learning through play. Whether passionate about the physics of soccer or the game theory involved in the antics the day of a middle school dance, learning is experiential and self-directed at recess. Regardless of what passion takes over their choice time, we as adults trust them to make safe choices for the most part and we respect their individuality. So why does that trust shift when those same children come into our classrooms?

Making is messy. From the outside, making looks unstructured and this disrupts old ideas about what it means to support kids in school and to have good classroom management. In a 100% teacher structured classroom, if a child struggles to learn a curriculum that was picked for his entire class, and not for him personally, the child may be evaluated for having learning differences. If diagnosed with a learning difference, then he will be given an individualized learning plan. While this may sound awesome, in teacher code, it means a set of instructions for the adults to practice with the child to ensure the success of the child in your class. An example of an instruction for the adult might be to write every instruction down for the child. Teachers are asked to be as explicit, regarding the modes for success in their classes to support the child. Sadly, this kind of system is designed to avoid failure more than leverage the individual interests or strengths of a child. While at first glance, this kind of teacher-led structure, which we spare high achieving kids from normally, seems like good teaching. We even have the perfect term for it, it is called scaffolding.

My concern with solutions to support struggling students, is that they attempt to solve a problem that was artificially created by teachers in the first place, leaving the student's self esteem in the wake. Here is where the value of making in the classroom becomes most clearly visible. Having the gift of watching students successfully learning and growing in areas that challenge them, in a student-centered classroom, I fear that scaffolding and interventions are nothing more than a lack of trust for a human's innate desire to learn what matters to her. Thankfully, I am not alone in my uncensored trust of children's innate desire to learn. We need look only at the seminal research of Dr. Mitra, as well as progressive playgrounds in Europe and Berkeley Ca, and TED speaker, author and founder of San Francisco Brightworks, Gever Tulley, to see that the right amount of danger through autonomy and real world manipulatives, like playing with fire, can foster key social emotional skills.

Giving kids agency and designing for self-direction does not come without its criticism however and I urge anyone who is doing this work to take this into account. In the years that I have been teaching science through the lens of making, inventing and problem solving, I have often heard my classroom, also known as the school's makerspace, referred to as "unstructured," by well meaning adults. This harkens back to the discord between what we know progressive education can be, versus what we envision when we think of a "progressive classroom." While working at a school in NYC, that self reported as a progressive school, the term "unstructured" came up a lot about lessons that were not 100% teacher directed. I also learned from our admissions team that families of color shopping for independent schools, rarely hedge bets on their child's education by considering school that label themselves as progressive.

Self-directed learning environments are powerful tools to engage girls and minorities into science, but they also stand to foster feelings of alienation or frustration too if not facilitated well (Martinez). In a blog post entitled *"What a girl wants: self-directed learning, technology, and gender"* Sylvia Martinez, links the importance of the self-directed nature of making in the classroom, while pointing out the challenges they present to fostering confidence in outsiders, such as girls, in science or engineering classes. Sylvia points out that girls, on average, will interact with self-direction differently than boys. This looks like girls tending towards pleasing the teacher (or from my experience their friends or teammates) and avoiding conflict over scarce resources, including the teacher's attention. *"Teachers need to remember that their suggestions carry a great amount of weight. To counter this and encourage self-directed learning, teachers need to train themselves to offer neutral, yet encouraging support for students to think outside the box,"* says Martinez.

With all concerns in mind, here is my response to the claim that a maker classroom is unstructured.

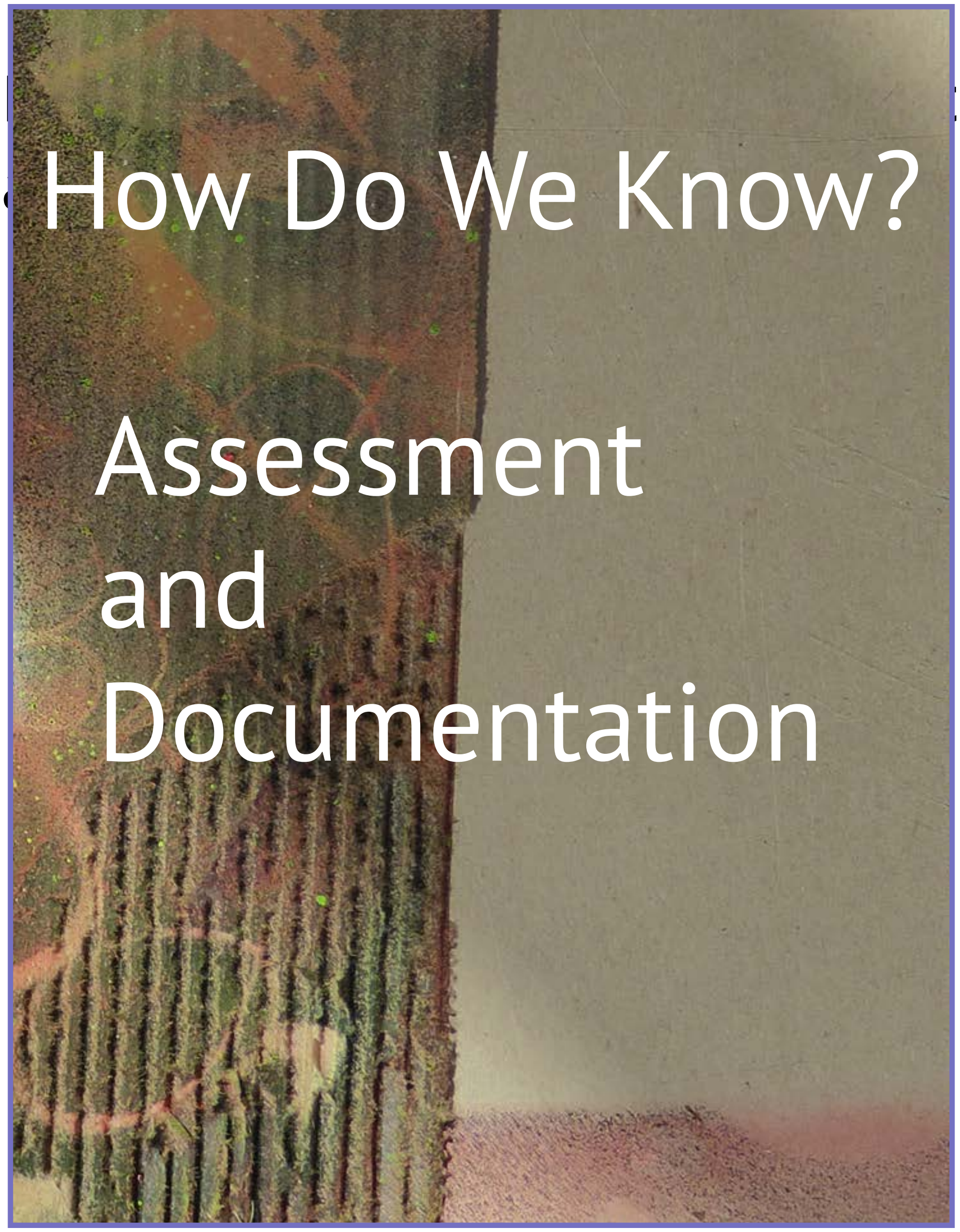
Due to the potentially negative image that the term “unstructured” elicits when talking about self-directed learning spaces, teachers of any discipline using a maker classroom should be ready to document student learning just like an ethnologist. Get creative with your documentation and take time to reflect on what you have seen.

There are skills to be gained in any maker-style curriculum on a spectrum from totally student-driven to totally teacher-directed. In my classroom I lean more towards student-directed with a game-like structure.

For any given unit, either patterns, structures or systems, I give a simple prompt which allows for the most diverse range of solutions for students to discover on their own. In game-like fashion, there are rules about deadlines, how to compose teams and rules about when and how long play takes place (that’s built into the school day schedule). There are “levels” of achievement and complexity of learning embedded into the system. These badges or levels are designed to remind us all to be mindful of safety, and they allow for a mentoring system where knowledge is democratic and passion-based. Allowing students to chose the complexity with which they want to solve a problem is a side of autonomy that we cross our fingers over, but in the end, even when kids pick hard problems, they are experiencing something of value in that path full of potentially frustrating dead-ends.

Having the right amount of chaos and danger is essential for middle schoolers. It addresses social emotional needs, while sparking fierce passions for projects. Lastly, the authenticity of the work that kids do in an environment of constructing, allows kids see themselves as real inventors and engineers. Sylvia Martinez, of Invent To Learn and Constructing Modern Knowledge, read Making Learning Whole by David Perkins and then succinctly compared the kind of work kids can do in a fabrication lab environment to little league baseball. Authenticity bridges mindsets in the fashion that a little league baseball player can imagine being a professional baseball player. It feels real and it’s age-appropriate.

Finally, real science and engineering looks messy when done well. Trusting kids in the classroom, is a good idea. Living with a little discomfort is part of the job description, as it turns out. We model how to live with questions and the unknown for the sake of empathy and democracy in the classroom. For anyone practicing constructionism, you will soon see, there is no such thing as a lack of structure in a learning space. It only takes the eye of a designer and the inquiry of a scientist to see the complexity hidden within. When you find it, you will see that the complexity is deep and beautiful because it exists only when children are trusted to decide.



How Do We Know?

Assessment and Documentation

One of the most common questions about making in education revolves around assessment. How do you know what the students have learned? Can you prove it? Don’t you have to give some sort of test to make sure? What if all the students are making different projects? What will I show my colleagues and administration as evidence of student achievement?

For educators launching a journey into a new kind of teaching and learning, answering these questions with certainty may seem like an impossible task. Yet many educators, such as music or art teachers, are able to evaluate student work even though students may be playing different instruments and painting different paintings. There is a long history and body of research supporting project-based learning and authentic assessment, yet many teachers have not been exposed to these techniques.

The essays in this section attempt to showcase the real ways that teachers are grappling with the questions of authentic assessment in today’s classrooms.

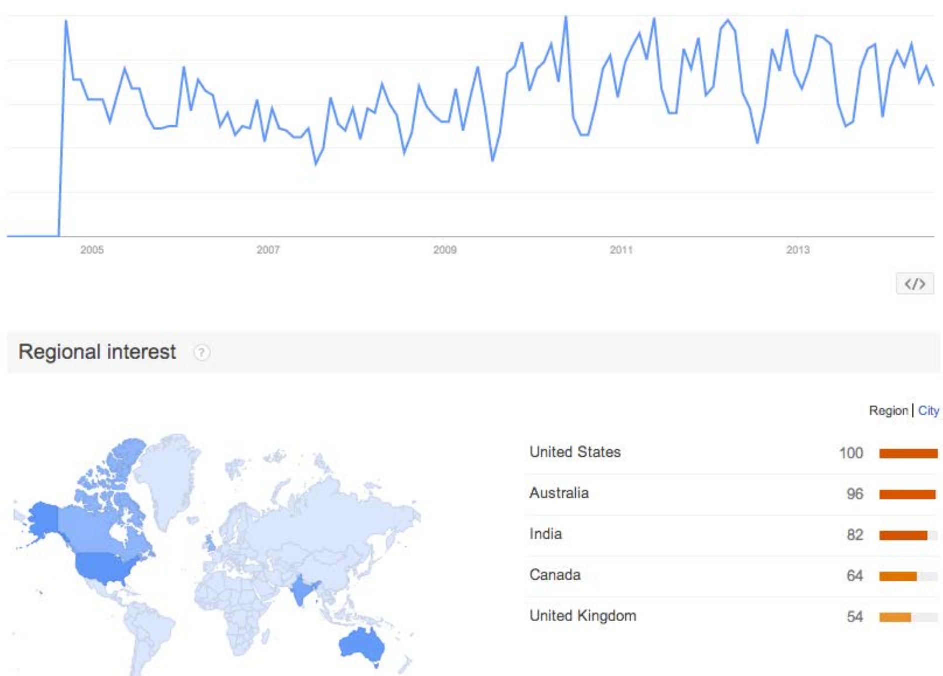
Alternative Assessments and Feedback in a MakerEd Classroom

by Christa Flores

The Rapid Growth of “Maker Education” Programs

Kolb Model

According to Google Trends (see graph below), a new term came into existence and quickly became synonymous with progressive education and a resurgence of STEAM education in America. That term is “maker education”, or makered for short, and can be seen in the graph as “born” according to google searches, around September of 2004. Although the exact number of makered programs is not currently known, schools that employ a progressive pedagogy (insert the word innovative for those working in the 21st century) or schools that make claims regarding the importance of differentiation, constructivism or experiential learning have built or are building makered programs. At first these programs seemed to be



credit: Google Trends

dependent on having state of the art Maker Spaces or FabLabs and high-tech tools, as most were found in well-funded private schools. That picture has changed rapidly in the past ten years since the makered movement has gained popularity, however. More and more public/charter schools and nonprofit programs are building programs for the average American child, that rival many private school programs. In fact, programs with limited budgets and space have reminded us that scarcity or "disability," are invaluable teachers in any good maker culture, as they breed creativity and self-reliance. Many of the makered programs serving lower income communities have access to mentors who never stopped working with their hands, even when it fell out of status in a consumer driven America in the 1980's (Curtis 2002). While lower income mentors may not know Python or what an Arduino is, they are skilled carpenters, mechanics, seamstresses, cooks and know what it means to be resourceful.

As with any progressive education discourse that seeks to reform the current education system in America, maker programs serving public schools are at the heart of this movement. Despite hope driven by the first ever White House Maker Faire and President Obama's declaration of June 17th as the National Day of Making, most public schools still lack access to project or problem based programs. Those working in a makered program, know this kind of work/learning is good for kids, as well as communities and have the energy to fight to keep their programs alive. To support these teachers and to keep makered programs sustainable, i.e. not let them suffer the fate of previous progressive education movements labeled as lacking rigor, we need to be thinking about assessment and we need to be thinking about the following kinds of assessment:

- Assessments used by students for real learning.
- Assessments used by high schools and colleges for enrollment decisions.
- Assessments used by a community norm system to establish authority or job readiness (badge or certification system).
- Assessments used to inform the efficacy of a maker program (research).

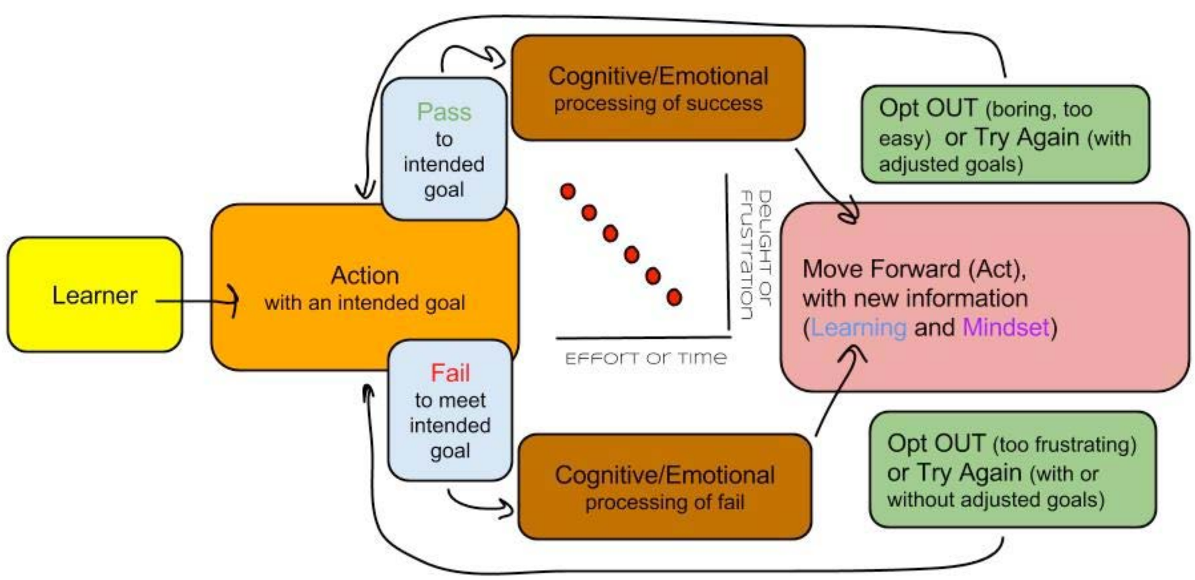
Defining Assessment and Feedback

Discussing assessment and feedback begins with having a conversation about learning in general. Whether an infant, an adult, or a Jack Russell terrier, learning happens every day and in a rich array of ways. Merriam Webster defines learning as *"the activity or process of gaining knowledge or skill by studying, practicing, being taught, or experiencing something."* Albert Einstein described learning as "when you are doing something with such enjoyment that you don't notice that the time passes."

Whether you take the more "traditional school" description offered by Merriam Webster, or the more blissful picture painted by Einstein, learning is a process. It is a process that can be intentional, as when we make a conscious effort to learn Mandarin, or it can be unintended, such as when "mistakes" take us down new and unexpected paths of discovery. For the purpose of this introduction, I will refer only to intentional learning, or events when the learner has a defined learning goal.

While learning is happening, assessment is the cognitive processing of outcomes in an attempt to reach a goal. Assessment is at first a snapshot to determine success or failure, then more deeply, a survey of the factors that led to that success or failure (if done methodically through documentation, this is science). Feedback regarding an action is strongly tied to the physical environment as it reflects the result of the learner's action. Feedback is observed, and it is also felt by the learner. Shame, pride, excitement, shock, etc., about the outcome (pass or fail) of actions drives the motivation to act again, and again, learning through iteration.

Adapted from various learning models, including the Kolb model, the diagram below shows the growth pattern a learner follows when seeking to learn, with an intended goal in mind (Kolb and Fry 1975). The goal may be to walk, make a souffle, or pronounce a glottal stop. If the goal is reached, we call that a pass. If the goal is not reached, that can be called a fail. After the action takes place, the learner processes the outcome or consequences of their actions through two filters; their cognitive self and their emotional self. The cognitive self seeks to diagnose the reason for the failure or the success (note: diagnosing failure for avoidance, especially if pain was involved, can be easier than diagnosing a success for repetition). The emotional self fills a vital role at this point. Classroom teachers call this emotional element of learning engagement or motivation. Studies in behavior and neuroscience have shown that emotional responses to success and failures, as long as a failure does not result in death, are key evolutionary tools driving learning (Arias-Carrión, Óscar; Pöppel, Ernst. 2007).



When failure is tied to a student's actions and they are the only one around to witness that failure (privacy to fail), learning occurs naturally and even blissfully. Learners must experience both aspects of assessment, the cognitive, as well as the emotional, to move forward with intention, purpose and passion towards their learning goal. If success comes too easily, a learner may give up on a task out of boredom. If the task proves too frustrating, the learner may abandon their learning goal, adopt a closed mindset and label themselves as a failure. Finding the perfect balance, a term referred to by some as "funstration" and others as the Zone of Proximal Development, is key.

Student or Teacher Driven Learning and Assessment

When a teacher is handed the responsibility for building the curriculum that his students will be learning from September through June, this is considered a 100% teacher driven learning environment. Often this style of education has pre-set assessment tools made well in advance of their need, in the form of a test or rubric. In contrast, student driven learning would entail students having a degree of choice in the content they will study, the skills they will be building or the assessment used to illustrate their learning. Some combination of teacher and student centered learning is more likely the typical experience, but there are clear differences seen in public versus private school education settings.

In a traditional academic setting the teacher functions as the dark orange square in the above diagram (the cognitive processing of a success or failure). As such, the teacher is entrusted with the wisdom, expertise and fairness to assess each student's level of and potential for learning, at least in one discipline. When the learner is removed from the critical assessment process in this way, they are left with how they feel about a success or failure, but are not encouraged to take part in the empowering aspect of constructing the causal relationships between their actions and their successes or failures. Removing the cognitive from the emotional, for both learner and teacher, creates an imbalance that gives assessment in a rote learning environment a bad name.

> *"[Making] is intrinsic, whereas a lot of traditional, formal school is motivated by extrinsic measures, such as grades. Shifting that control from the teacher or the expert to the participant to the non-expert, the student, that's the real big difference here."*
>
> *- Dale Dougherty*

In a maker classroom, learning is inherently experiential and can be very student driven; assessment and feedback needs to look different than a paper test to accurately document and encourage learning. Regardless of how you feel about standardized testing, making seems to be immune to it for the time being (one reason some schools skip the assessment piece and still bill making as an enrichment program). Encouragingly, the lack of any obvious right answers about how to measure and gauge success and failure in a maker classroom, as well as the ambiguity about how making in education fits into the common standards or college readiness debate, has not stopped schools from marching forward in creating their own maker programs.

Qualitative versus Quantitative Assessment and Feedback

Grades are quantitative, discrete numbers, asked to be a standard language of achievement. Grades are by definition summative, or a non-flexible snapshot of what a student knows and does not know at any point in time. Due to the nature of these discrete, universal numbers they are used to rank children locally (within their classroom or community), as well as globally, and have enjoyed the status of proof of rigor. Whether you are a 10 year old in Santa Cruz, California, or a 10 year-old in Nairobi, an A in math is supposed to mean something. In contrast, formative assessment is a vital element in the process of learning and is best left to qualitative tools; such as oral feedback from peers and adults, narratives and self-assessments. Unfortunately, formative assessments lack the status given to a letter grade. Although new methods for assessing meaningful work and learning through projects are emerging, take Maker portfolios now accepted at MIT for example, we are still working primarily within a grade-based system. As a result, any project can be graded using a clear set of concept or skill related goals in the form of a rubric.

In summary, giving a grade based on a paper test to measure achievement in STEAM still fails to compute in a maker education program, and other quantitative assessments may have a lifespan as well. Neuroscience and educational research assures us that qualitative feedback and self-assessment do more for passion based learning then red marks on a test or high scores on standardized tests. The difference translates to mindsets, argues Mariale Hardiman, professor of education at the Johns Hopkins University School of Education and cofounder and director of the university's Neuro-Education Initiative. *"As the research strongly suggests,"* states Hardiman, *"when students focus on mastery of learning rather than on their performance on tests, they significantly increase their intrinsic motivation for learning."*

Facing Assessment in Public and Private Schools Today

If we look closely at the pedagogical backbone of makered, the lens would clearly reveal experiential learning and student driven projects, which can be more challenging to assess, at its core. That being said, as paid professionals we need to adhere to a few constraints, while we also strive to help kids be their best. Those two main constraints are standardized curriculum, as a result of an industrialized model of education, and current assumptions about college preparation and career readiness. Below is a breakdown of each, as they relate to assessment in public and private PK-12 schools today.

1) Common Core - Described by the well-intentioned as "a common set of rigorous national standards (that) will transform American education, prepare students for college and careers, and allow our nation to maintain international competitiveness," the Common Core is a set of educational benchmarks in math and literacy designed to be taught, then tested for proficiency by schools. Essentially the Common Core is a management strategy to hold schools accountable for their use of government funding. Resulting test scores on Common Core assessment determine how "well" a school is doing at educating America's children. In as simple of terms possible, the Common Core ensures that schools with good test scores are given continued funding for a job well done.

I hope we can all agree that a one size fits all model to force accountability in public schools is an Orwellian and inelegant solution to a systemic failure of industrialized education. That said, its the law of the land for most American children. We owe it to those children to disrupt the system with measurable evidence of how using a makered program to teach math and literacy is better than using a one size fits all curriculum, that focuses on testing versus experiential learning.

2) College Prep versus Life Prep - Just as the Common Core promises to maintain standards in the public school industry, college readiness is the number one claim made by most private schools. After all, any adult life worth having would follow the expected trajectory of college first, then a prosperous career (an assumption worth on average $19,820 a year if your child attends a school within the National Association of Independent Schools). The problem is, college preparatory schools can not guarantee that all of their clients get into top high schools or colleges, only the top performing students will receive those slots, and thus the race begins. Assessment in this environment is driven by raking students rather than focusing on learning and growth, something that can occur in a competitive environment for some, but not others. In the year 2014, some outspoken educational reformers, such as Ken Robinson, are now arguing that college might get you a good unpaid internship, but a well paying career is not guaranteed. Prepping for life, on the other hand, according to Tony Wagner in Creating Innovators, is about cultivating mindsets, especially those that support creative problem solving and entrepreneurialism for a rapidly changing global economy.

Regardless of well intentioned educational reform debates, there are still powerful systems of status quo in the higher education realm that are trickling all the way down to pre-kindergarten pedagogy in ways that would make you cringe. College readiness has become synonymous with stressed out, competitive, over-booked youth that struggle with autonomy and are more “at risk” than their lower-income counterparts. Its not good for kids and its not good for family dynamics either. Assessments used by admissions that support the current status quo in college readiness, good or bad, set the standards for the rest of the independent school industry. Teachers that fall into this category need evidence that making is important for college readiness, as that definition currently stands, in ways that rival standardized test scores. Research and collaboration around best practice for switching from test-based assessments to alternative systems, such as portfolios, is a vital component to keeping makered programs sustainable.

Making is “Just” Arts and Crafts with a Technology Twist - It is not Rigorous Enough

Using pedagogical practices that fall under the title of making are subject to the discourse around how to ensure and measure rigor. The usual answer to the problem of rigor (which is code for college readiness) is to have standardized tests. Tests are reassuring data points that allow administration and parents and admissions officers to feel like we are basing policy on logical and scientific measures. Here is where progressive education loses the fight. No matter how student-centered or innovative your curriculum, if you give a letter grade to students at the end of that course you focus attention, and attention is what we value, on product over process. This imbalance in priorities is beginning to not only confuse constructivist educators, but parents as well. Three events got me reflecting on assessment again and how it plays a vital and controversial role in making in educational settings.

The first event that got me pondering assessment tools, was a conversation between two of my students, who spoke on the student panel at the FabLearn 2014 conference, and audience member and FabLearn Fellow colleague Jaymes Dec. When Jaymes Dec asked my students at the end of their talk how they were graded, there was a pregnant pause. It was at that moment I considered the fact that my students did not have a clear idea of how they were "tested" on their project. Then one of my students said with some reservation, *"We were graded on how we got along."* The second student added with a bit more assurance, *"We were also graded on a pass or fail. If we got the machine to work we passed, it we didn't we failed."* In reality, I graded them on a point system likened to the pass/fail concept, but with room for random point loss to make the system look normal.

They earned points for their work away from school (homework points) and they got points for meeting benchmarks (reflections on peer critique sessions), as well as turning in video or written essays (self-assessments) defending a grade of pass or fail. In the end I am assessing how well they can make a claim, support it with evidence and tell the most accurate and compelling story of a their education. I am training them to think like scientists and to speak like storytellers. Part of me feels a sense of relief that they don't know what part of their year gets the final grade, that way they see all the parts as potentially important, not just the behaviors that can affect their letter grade.

The second conversation I had was with two very intelligent people about the style of assessment I have been testing and using for the past two years in a making centered classroom at Hillbrook. It also happened that the conversation was centered around a narrative report I had written regarding their son. In short I found myself defending how I am able to whittle down all of the learning that happens in a unit which consists of single projects that can last two to four months out of a nine month school year. That is a lot of schools hours to defend to a parent paying a premium for those hours, unfortunately I do not have the test scores to rest my laurels on. The assessment my students experience on a daily basis is formative in nature, on-going and extends outside of the boundaries of a classroom. It can not wait for the end of a unit, it must be happening at every moment.

Formative assessment that does not get a letter grade also allows students to feel assessed more on their collaboration skills, resilience and ability to gain the knowledge necessary to improve the performance of their inventions, the stuff they think is also important to be learning at their age.

The third event that sparked my imagination was listening to all of the dedicated and intelligent offerings at the FabLearn 2014 conference, which had an emphasis on inclusivity and equity. I learned that making is artistic and it is about craftsmanship, so it is definitely arts and crafts, but that is just semantics. Making is also about gaining mathematical literacy through doing and testing. It is about asking questions and collecting information like a real scientist. Making is also transforming kids' experiences of school by teaching them how to think, giving them a sense of purpose and competence that can lead to a lifelong love of learning and problem solving.

Finally, FabLearn 2014 opening keynote speaker Paula Hooper, senior science educator and learning research scientist at the Exploratorium reminded us how constructivism fosters a sense of equity and inclusion for kids. Hooper told us a story of identity through agency and technology literacy. *"You bring who you are culturally and the experiences of your past. Knowledge, that is not just connected to the mathematical concepts at hand,"* Hooper inspires us to dwell on. Making is an outlet for kids to be confident in math, science and technology when they might have felt shut out in a more traditional science and math classroom. Add in the literacy skills needed to tell that rich of a learning journey and you are talking about one of the more engaging, not to mention authentically rigorous, curriculums a school can provide for its students.

But alas...what about the tests? Perhaps Paulo Blikstein said it most wisely, at the close of the short paper share at FabLearn 2014. *"It takes time to find good metrics to assess (making in education), we still keep doing it in the meantime, and document,"* encourages Blikstein. So here I are, continuing to document my thoughts on the state of maker education post FabLearn 2015. Thank you to all of those who made it such a game-changing event in our pursuit of educational reform.

WORKS CITED

Arias-Carrión, Óscar; Pöppel, Ernst (2007) "Dopamine, learning, and reward-seeking behavior." *Acta Neurobiologiae Experimentalis*, Vol 67(4), 2007, 481-488

Barseghian, Tina (July 9, 2014) "A School That Ditches All the Rules, But Not the Rigor" Blog for *Mind/Shift* KQED.org

Borovoy, Amy Erin and Cronin Ashley (2013) "Resources for Understanding the Common Core State Standards" *Edutopia* article July 2013.

Costanza, Kathleen (September 17, 2013) "The Maker Movement Finds Its Way Into Urban Classrooms" Blog for *Mind/Shift* KQED.org

Curtis, Adam (2002) "The Century of the Self" British documentary series on the influence of Sigmund Freud

David Kolb's theory of the "Learning Cycle" http://learningfromexperience.com/

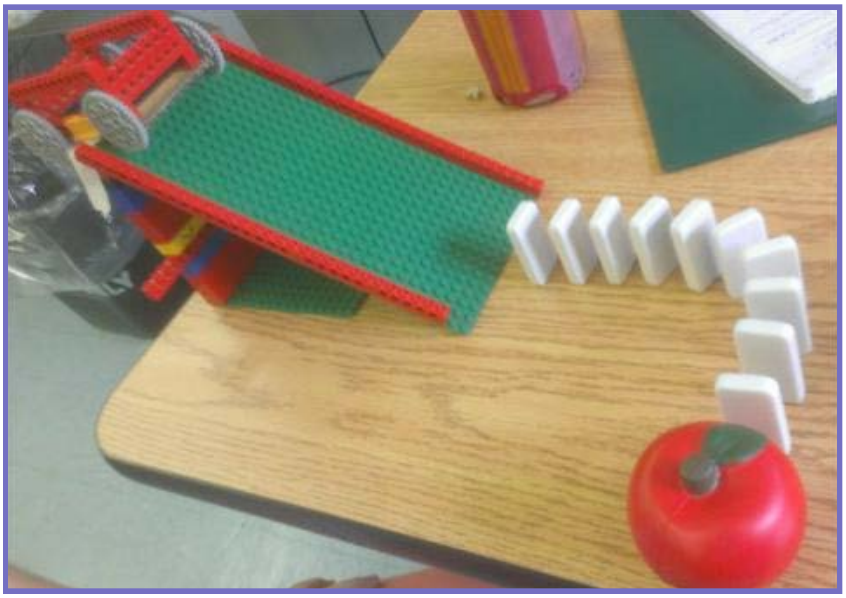
Dougherty, Dale founder of *MAKE Magazine*, from the short documentary "We Are Makers." Google Trends search for "maker education" and "maker movement"

Hardiman, Mariale and Whitman, Glenn (Winter 2014) "Assessment and the Learning Brain What the Research Tells Us" *Independent School Magazine*, NAIS

Kolb. D. A. and Fry, R. (1975) "Toward an applied theory of experiential learning;" in C. Cooper (ed.) Theories of Group Process, London: John Wiley.

Obama, Barack (June 17, 2014) Presidential Proclamation -- National Day of Making, 2014.

Watching Children Learn
by Tracy Rudzitis



One of the most meaningful things that I get to do as a teacher is to watch my students learn. What makes it most exciting and interesting for me is observing this learning through their eyes and their contexts. I have several Flip Cameras located in the classroom long with my Point and Shoot camera and the students will ask me *"where is the camera?" "can we use the camera?" "we just did something really cool, can we record it?"*

The first big project this fall in the STEAM Lab was the construction of Rube Goldberg machines. Students were grouped in teams of 5, not the optimum size perhaps, but based upon 6 tables and 30 students per class and 11 classes in total. You can imagine the amount of activity and experiences happening during any one moment of the 50 minute class period. Often too much for a single person to be able to observe, comment on, and monitor, as well as explain, assist, find materials for, and prompt groups when they get "stuck". Having cameras that could be picked up and used by students at any point in the class gave me a window into the student's work that I might otherwise have missed.

Each project my students participate in has a documentation component. The cameras provide a seamless way for students to document and think about what they are doing. Getting students to document their learning and their exploration of materials, concepts, and ideas can be a difficult task. Using design journals or handouts to encourage students to write and plan is one way to go about it. Planning is an important part of the process, but students (and many times adults) are often impatient and want to just start the project without spending too much time on the "thinking about it first" portion which can take on the characteristics of school that many students have a difficult time with. The sitting still, blank sheet of paper and pencil on the desk, outline of requirements on the board, mind racing with the typical things that occupy a middle school student's mind, these are all in conflict with each other.

There has to be a space where the planning, thinking, design, making, experimenting, testing, reflection, iteration can exist in harmony and equal passion. The other important detail that must be visible is a way for the teacher to be able to get a glimpse of the thinking and ideas that each student is swirling around in their head as they work through the project. Using video and photography has opened up this space and provided an additional format for students.

Looking through the photographs that the students make while documenting their work has allowed for a different insight into their thinking and their ideas. Working with 6th and 7th graders, the expectation when you give them a reflection or a worksheet, is that the teacher provides the questions, or the prompts, the check off list. The adult in the room has decided what is most worthy of discussion, what learning is to be addressed, what questions should be answered. When I look at the projects through the eyes of my students I discover what they think is important, what they are discovering, what is new and exciting for them. I also get to see the focus and concentration in their approach to the work that is often captured unexpectedly or in spite of the enthusiasm that is also displayed. The cameras are available at any time, and students understand the basic expectations, they are documenting their work, their process, their ideas. Pass the camera on to the next team when you are done, don't worry about editing or viewing the photos until I get them uploaded on the Google+ photo album.

- Photographs of Rube Goldbergs by students
- What can happen when the teacher is not looking! (video)

Photographs can tell one part of the story, video can tell another. With the addition of a sound track or voiceover, the students can explain their work and speak about the process and what they have discovered. It offers insight into the project, and can also address some of the more formal learning targets that the teacher might have for the students and the project.

- Makerspace Project Documentation (video)

The documentation of student work can provide evidence of student learning and understanding. Looking at student work is a process that is worthy of exploration. There are several formal methods or protocols that can be used when looking at student work (see http://www.lasw.org/methods.html for more detail). My interest in having students explain and show their work comes from what I often perceive as a tension between the pre-defined expectations often outlined in the rubrics and "students will be able to….." messages that are more often written for administrators then for the students.

Half-way into the first year of the STEAM Lab at my school, I am focused on the need to identify methods of measuring student understanding in ways that are embedded and natural to the hands-on, constructivist learning that takes place in the room. I am looking forward to working with several other STEAM and Maker teachers in the NYC education community over the next few months and seeing where our ideas might take us.

Documenting a Project Using a "Failures Box"
by Susanna Tesconi

At Laboral Centro de Arte y Creación Industrial, I worked with 6 groups this year from primary school to high school, each one with a different project. Consequently a lot of prototypes are hanging around the FabLab. In order to keep the lab not too messy I decided to have each group fabricate stackable boxes by modifying a design from Thingiverse. Modifying and fabricating the box is the first group activity I run with each group, so it also serves as an introduction to laser and vinyl cutting.

After each session the kids put the stuff they make into the box/boxes (depending on the dimensions). The project/prototype "has the permission" to stay out of the box only when the kids consider it shareable. So when we get to that stage, I ask the kids to empty the box and reconstruct the evolution of the project by using the previous prototypes/failures as 'chapters'. They can make photos, videos, write text, dramatize, dance etc. in order to explain what they did and how they feel about each step.

Generally they have a great time doing it, and they understand the importance of documenting in order to tell someone how to do something. Also they became aware of what they have learned. They laugh a lot about the previous failures and dead-end solutions. They seem to be more comfortable about previous feelings of frustration. It makes them more motivated to own their own projects and take risks.

Documenting something you made in order to share it is one of the most constructive practices of the maker culture. Thanks to documentation, a lot of people all around the world can learn, experiment, remix, and re-design building on the base of other people's work. I like to think of knowledge sharing as the action of feeding a global shared brain that makes all of us smarter and wiser.

During an inspiring conversation about hands-on learning activities, FabLearn Fellow Susan Klimczak told me: *"In experiential learning, you know exactly what you have learned when you document it."* Documentation is the missing ingredient in traditional thinking about assessment and self-learning.

Many teachers involved in “maker” programs and schools are familiar with the idea of documentation as base for assessment and formative (pedagogical) evaluation, but I think we can take advantage of the benefits of documentation in more ways.

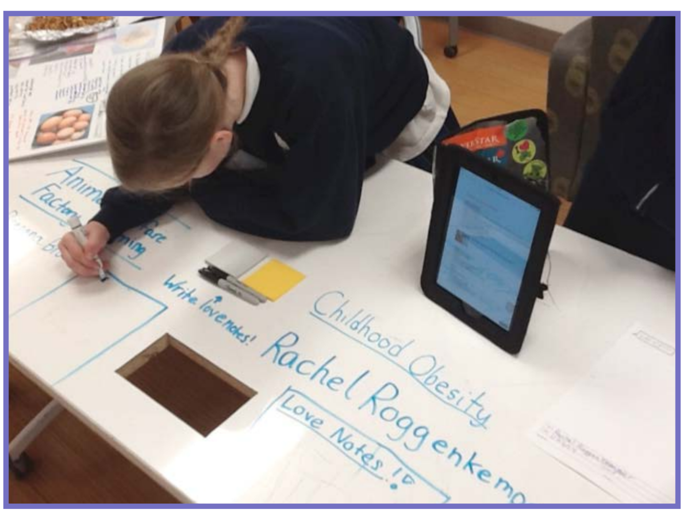
I believe we need to integrate documenting practices as part of making activities as well as designing, tinkering, digital fabrication and programming in order to enable students to document their own learning process and experiment with the beauty of building shared knowledge. Documentation is a hard task even for adult, but it is not so hard if you design a reason and a consistent expectation that everyone will collect and organize the things they will share. This expectation of students contributing to the failure box is that it will help them tell the story, chapter by chapter, of their project.

The “failure box” documenting tool is still a work in progress. The sharing part of it is still not as natural and as integrated into the process as I would like. I hope to continue to experiment with documentation and ways to improve the learning process.

The Role of Peer Assessment in a Maker Classroom
by Christa Flores

Background

When I first started using a problem-based curriculum in science I admit that I had no idea what to expect. Moreover, I had only a vague idea of how I was going to assess my students. As an academic teacher, I am required to give my students a letter grade twice a year. While I am moving more strongly towards the use of portfolios and self-assessment in my classes, I still work within a system that strives to have letter grades accurately reflect a student's level of understanding and or effort in a discipline, in my case 5^{th} and 6^{th} grade science. I work within a system (pre-school through graduate school) that still values grades as an indicator of how to rank children. Ideally this ranking is used so they can be better served, classified and counseled towards the goal of attending college and possibly future career choices. In this system the easy to mass produce and analyze discrete quality offered by tests, makes for a more valued form of assessment. As a result, 5% of the letter grade that I award my students is still the result of paper style tests and quizzes, or what I refer to as, "check-ins."



Beginning with the role of peer assessment, I hope to describe the role of alternative forms of assessment (the other 95%) that I have been using in my problem based approach to science. The other forms of assessment that I use, include self-assessment and assessment by a mentor or adult expert. A fourth form of assessment that I hope to learn more about this year (one which I was first introduced to by Dave Otten of the Athenian School) is the role of authentic assessment in the form of published, or open-source sharing of work. These forms of assessment may be used in conjunction with assigning letter grades, as any are easily adaptable to a rubric, or they can be used in a less formal/grade-less setting. Regardless, they stand alone in value, as they bring a rare opportunity for the following student resume to evolve over time:

- Leadership, through setting higher quality standards of how to do work, the presentation of work and risk-taking by taking on hard problems
- Collaboration, through the sharing of ideas and constructive criticism
- The ability to defend an argument
- The ability to describe a problem
- Developing self-awareness as a learner
- Practicing informed iteration while working towards a solution

Why peer assessment? Can you trust a 10-14 year old to guide another 10-14 year old?

Forgetting for a minute that my students are ages 10 and 11 (as I must to begin to learn their strengths), I researched forms of assessment. I sought out assessment that would be most authentic to a maker classroom. For me, that looked like behaviors (assessment tools) that led to methods (feedback) for offering new ideas, and collaboration on the growth process of designing a product. Peer critique was something that I began last year and I felt it was working with the previously stated goals in mind, but I had no measure to back up my claim. My fear of the image of the blind leading the blind, over a cliff of failure existed at the beginning of the year, as it would for most teachers. I also know that peer review is crucial in science and it works in various design fields, so why not in a classroom? Using peer critique to give rapid feedback on the design process seemed better than trying to filter all student work through the lens of one teacher. Peer feedback was not only useful it was necessary in an open-ended project scenario.

Having taught middle school for fourteen years, I also knew that the role of peer opinion, as it affects some beliefs and some behaviors, begins to supersede the role of parents and other adults at this developmental age (Berndt 1979). Lastly, due to the democratic nature in which knowledge will be accessed in this century, as well as our location in the heart of the technology world, many of my students come to the classroom with valuable insights, experiences and opinions that could inform the whole group. Why not capitalize on these last two assets?

In the end, the blind leading the blind is often how we all embark on an adventure. Every year we have to learn, as a class or team, how to critique the work of others by doing it a few times. It takes modeling comments and questions in the first few attempts at peer critique to get students to make more thoughtful and insightful criticisms of their classmates' work. Students too, will inform the group as to what "quality" looks like, over time. The quality of observations, being made by the audience, also increases over time. This is turn, leads to a higher quality of feedback for the presenter. Presentation styles can also be informed through critiquing the quality of a presentation.

They soon learn from each other two key elements to sharing your work; the importance of a "good story" about your work and that a great data visualization is worth a thousand words.

Formal versus Informal Critiques

Students can earn feedback from their peers in two different ways in class, formally and informally. When we first began the year, all presentations of work for peer feedback were given formally, that is one or two students giving a slideshow aided presentation of the current progress of their work. These formal "crits" (as students call them) were modeled on the first year we used product design in the 6th grade curriculum (2). I soon noticed that the quality of peer feedback grew over several weeks and I began to trust my students to give key feedback I would have been dishing out as the adult in the room. With that role covered by my most ardent student critics, I now reserve my comments to offer clues to a solution or for direct suggestions to deepen their knowledge, as any literacy guru would do.

The problem with formal critiques, is that they are formal. Adolescents hate public speaking, at least some do, and they take days to do properly (allow time for feedback). That is a lot of conference/old-classroom/teaching style information to sit through, no matter how interesting it may be. To add to that, the process of active listening for critical feedback is exhausting. I have to remind myself often, that these students are only eleven. We brainstormed as a class, ways to improve the system and two ideas emerged. Students almost unanimously agreed that peer critiques were valuable. Rather than have every share of work be done formally, they decided to do informal style critiquing, where student share their work more science fair style. For informal critiques, several tables are set up gallery style throughout the iLab. Students can then design their work display using whiteboard tables, rolling white boards, markers, standing their iPads up as displays and displaying their prototypes in an analog timeline.

The second idea to make formal crits less painful came recently when we needed to participate in a series of formal critiques for students to share the results of their testing for product development. This critique needed to be formal as students presented their authentic questions about their work up to this point. This is more like you would see at a scientific conference only with audience critique of work afterwards (This may in fact happen at real scientific conferences, but not at any educational ones I have attended). To help get through the process more easily and effectively, we made sure to schedule only five presentations a day, over a series of days and always indulged in an intermission that required no brain cells (any YouTube video with kittens getting stuck in things will do). The key was to keep the learning process fun, even if it was still formal.

Feedback

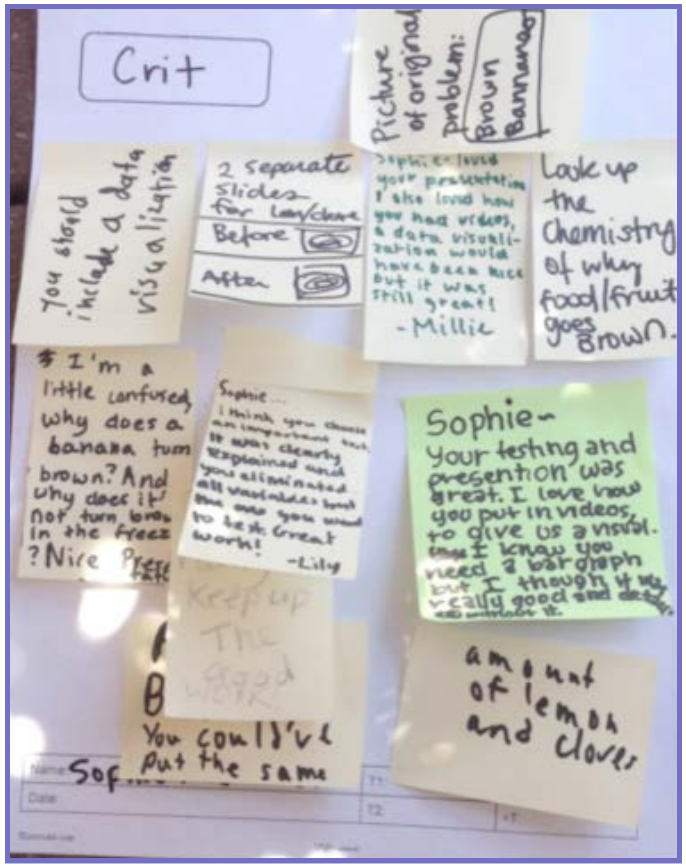
As peers take in the description of work from those presenting, they know that a valuable part of the process is to give real criticism to the presenter. This feedback can be verbal and interactive, such as that given at the end of a formal presentation of work or it can be more passive; feedback in the form of what we call "love notes," or post-its and sharpie marker (see below, students leaving comments for their peers using the sticky note and sharpie model). These brightly colored comments have been deemed "love notes." Love notes can have an effect on a student's project on different layers, emotional, as well as cognitive. The sheer act of getting a paper covered in love notes, still brings a bright-eyed glow of relief to the face of a student, having survived a presentation. My students, seem to genuinely feel rewarded for their intellect and work by the simplest of notes such as those scribbled with the words, "very cool!" or "I liked your ideas." What adult wouldn't want to get that kind of encouragement for their work on a regular basis? The key to using peers to critique student work, is that feedback is immediate and expected by the student presenters, which can be a very powerful motivator to do well (Kettle, et. al. 2010).

Love notes can offer key steps to academic growth as well. As research into effective peer assessment for MOOCs has shown, peer assessment can be as effective as assessment done by a single adult or teacher (Koller 2012, Sadler et. al. 2006). While a maker classroom is not a MOOC, it is a place where student-driven work can seem overwhelming to assess for a single teacher. Using peer assessment, allows for deeper differentiation in the learning process for our students, something we strive for at Hillbrook.

See below, one student's collection of feedback from the formal peer critique of her scientific testing. Her question was whether she could prevent bananas from turning brown in her ice-cream recipe using one of two recipe changes. Her ice-cream was designed to combat depression, the problem she chose to investigate for the year. Once she decided to make a food related solution, she researched micro-nutrients that aid in the relief of depression and invented an ice-cream. Looking at her critique or "love note" form, can you tell which comments came from an adult and which came from an 11 year old?

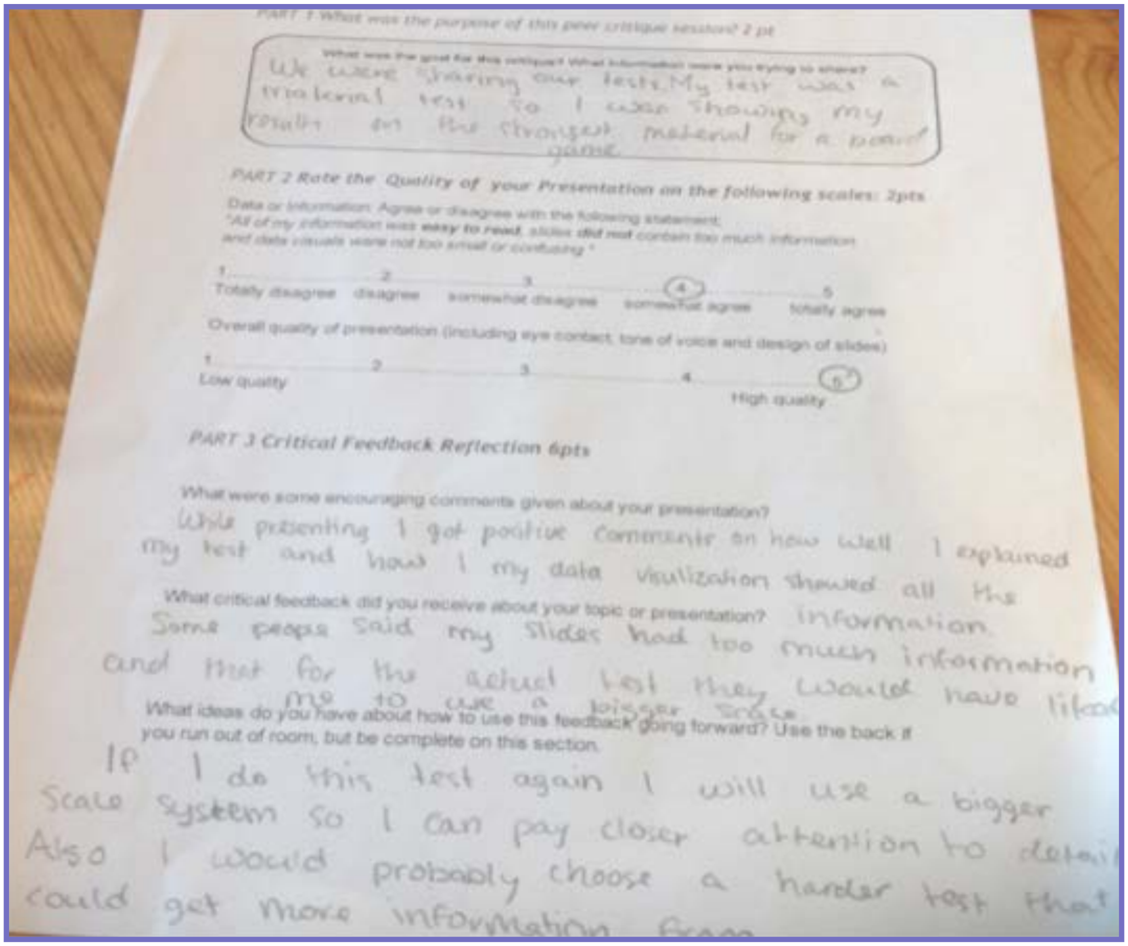
Can we measure the worth of peer critique?

It is one thing to have an intuition that something is valuable in your classroom. It is another to be able to share something of value outside of your classroom using only anecdotal evidence. Isolated in the iLab, I could see growth happening in my students due to the peer critique system we had been using. Still, I struggled with a method of measuring the value so that I could explain the value to others. After deliberation with Hillbrook's science teacher Ilsa Dohman (also our Center for Teaching Excellence research design guru beginning 2014), I began asking students to do a reflection on the peer critique process. I asked them to dwell on the process for a moment while they focused on the following topics:



1. What was the goal of this presentation of your work?
2. Self-assess your presentation in terms of quality (see image below)
3. Tweeze out constructive criticism from the love notes to decide on a plan of action for your next iteration

I wondered if students could keep a better track record of how the comments and feedback they got from their peers was reflected in their iteration process or growth as a student. That way we could all see the value of the process. The analysis of this attempt to measure growth is still pending. Ilsa and I hope to design an experimental assessment that allows students to more actively map the connection between peer feedback and growth (either as a student or of the design or scientific process). In the meantime, we continue to collect data in the form of reflections, as seen below.



PART 1 What was the purpose of this peer critique session? 2 pt

What was the goal for this critique? What information were you trying to share?

We were sharing our tests. My test was a material test so I was showing my results on the strongest material for a board game

PART 2 Rate the Quality of your Presentation on the following scales: 2pts

Data or information: Agree or disagree with the following statement:
"All of my information was easy to read, slides did not contain too much information and data visuals were not too small or confusing."

1 Totally disagree — 2 disagree — 3 somewhat disagree — (4) somewhat agree — 5 totally agree

Overall quality of presentation (including eye contact, tone of voice and design of slides)

1 Low quality — 2 — 3 — 4 — (5) High quality

PART 3 Critical Feedback Reflection 6pts

What were some encouraging comments given about your presentation?

While presenting I got positive comments on how well I explained my test and how I my data visulization showed all the information.

What critical feedback did you receive about your topic or presentation?

Some people said my slides had too much information and that for the actual test they would have liked me to use a bigger scale

What ideas do you have about how to use this feedback going forward? Use the back if you run out of room, but be complete on this section.

If I do this test again I will use a bigger scale system so I can pay closer attention to detail. Also I would probably choose a harder test that could get more information from

REFERENCES

- Berndt, Thomas J. *"Developmental changes in conformity to peers and parents."* Developmental Psychology, 15.06 (Nov 1979): 608-616. doi: 10.1037/0012-1649.15.6.608
- Flores, Christa. *"Authentic Learning and Assessment in the Self-Directed Environment of a Middle School Maker Space."* paper submission for IDC 2013
- Kettle, Keri and Häubl, Gerald *"Motivation by Anticipation: Expecting rapid feedback enhances performance"* Psychological Science 21.4 April (2010) 545-547
- Koller Daphne *"What we're learning from online education"* TEDGlobal talk, filmed June 2012
- Sadler, Philip M. & Good, Eddie *"The Impact of Self- and Peer-Grading on Student Learning"* . Educational Assessment 11.1 (2006) 1-31
- Senger, Jenna-Lynn. *"Student Evaluations: Synchronous Tripod of Learning Portfolio Assessment—Self-Assessment, Peer-Assessment, Instructor-Assessment."* Creative Education 03.01 (2012): 155-63. Print
- Peer Groups. Boundless. https://www.boundless.com/sociology/textbooks/boundless-sociology-textbook/socialization-4/agents-of-socialization-46/peer-groups-285-9603/

The Role and Rigor of Self-Assessment in MakerEd

by Christa Flores

What is Self-Assessment?

The purpose of teacher driven assessment is to measure whether a student is ready to move on to the next topic in a given curriculum. Often this translates to the next chapter of a text book. If the student passes the teacher's assessment, the next step in her education is given to her in lockstep manner. This approach to learning and assessment, while comfortably quantifiable, unfortunately fails to approach the full spectrum of learning that modern day education has to offer children and adults. Throw MakerEd spaces into the mix, and you have a recipe for a revolution in assessment, beginning with handing the right and responsibility of assessment, over to our students.

Dr. Betty MacDonald of the University of Trinidad and Tobago, and leader in the field of using self-assessment to support individualization, describes self-assessment in the following manner; "the involvement of students in identifying standards and/or criteria to apply to their work and making judgements about the extent to which they have met these criteria and standards." When a learner does not utilize the insight of others more their own critical insight into their progress towards a learning goal, they are using self-assessment. **Self-Assessment** is any form of assessment that is undertaken by the learner as a first person. Autonomy to diagnosis one's work (with or without the aid of an expert), can come into play cyclically during a making activity. Documenting that process becomes, by necessity, the responsibility of the learner.

The nuts and bolts of self-assessment? Regardless of how you define it, I have seen in the past three and half years that using self-assessment allows a learner to work towards an ability to:

1. **Critique** Quality of Work (self and others)
   A. Based on principles of design, science, engineering and research
   B. Based on a rubric of pre-selected standards created by students or teacher
   C. Based on peer-feedback and classroom mentoring
2. **Diagnose** and Describe a Problem/Propose Solutions
   Documentation, verbal or written of pass or fail for a given (can be 100% teacher driven or 100% student driven) goal
3. **Communicate** Competence and **Reasoning**
   A. Illustrate knowledge of concepts or skills through application (authentic assessments such as pass/fail) or representation (as in a paper test or essay)

B. Argue for the use of specific materials and design ideas.

C. Mentor others in the use of a tool or technique

Relevance

Need to know how to clean a carburetor, make a souffle or pronounce Dutch words? Students can instantly explore any topic or new skill they are passionate about by browsing YouTube or any other DIY site. Awareness that education, or learning in general will no longer be the proprietary interest of a few elite institutions, Raymond Cirmo of Cheshire Academy (Connecticut) and Vice President of the Connecticut Science Teachers Association, sums up this inevitable shift from teacher-driven curriculum to student-driven, when he says; "*We first need to realize that the students are not in our classroom, we are in their classroom. And the room is not set up for us to teach; it is here for us to be facilitators in the students' learning."* Combine access with motivation and you have an increasingly self-educated population lead by experts and amateurs alike.

With trends towards more differentiation in education, also termed a "student-centered" approach to learning, the teacher no longer defines, or impedes, what students find relevant or engaging to learn. Gary Stager, of Invent to Learn and Constructing Modern Knowledge, describes his tactic for supporting student learning with the following mantra, "Just get out of the a way!" A tactic that works well for encouraging a love of learning, but what happens when you are part of a system that gives students grades?

In the more self-directed learning environments of MakerEd, content knowledge is gained as it becomes relevant to a solution for a problem at hand. Not every student learns the same concepts or acquires the same skills. This presents a major problem for assessing a student on a standardized scale. Consider the alternative; teaching content to assess the retention of content, as the Common Core has left many doing. Assuming you agree, that we are heading in the correct direction in education, you may then wonder; Where does all of this relinquishing of power leave us as teachers? What active role do we take as the champions of our students' passions and pursuits of purpose?

I believe that MakerEd practitioners and champions will offer the best classroom models to answer the above questions. Witnessing the wonders of MakerEd teaches us to foster an environment of growth and self-actualization by using forms of assessment that challenge our students to critique their work, and the work of their peers. This is where the role of self-assessment begins to shine light.

What We Gain from Self-Assessment

Shifting assessment in the classroom from the hands of the adult educator, to the empowered learner can include the following educational benefits:

1. **Assessment Literacy** - Students learn how to critique their work and the work of others for quality, growth and even creativity.

2. **Communicators who Defend a Claim** - Students learn to use argument, logic, evidence-based reasoning, and various literacy (including technology) skills to judge and defend a claim about their work. Students practice making thinking visible.
3. **21st Century Librarians** - Our students are growing up in a world where information is increasingly free and accessible to those with internet access. The ability to navigate one's own learning using the sea of available resources is a vital skill to be cultivated.
4. **Participation in Democratic Education** - Allowing students to have a say in what they learn, as well as how they share, celebrate and give evidence of growth allows for a more empowered learner.

In summary, using non-traditional forms of assessment to support our students can feel risky and more messy. Keep faith, however, as noted in an article entitled "Using self-assessment to support individualized Learning", by Dr. Betty MacDonald, *"The process is time consuming, but the dividends are worth far more than the time invested, especially when you consider the long-term benefits of life-long learning."*

How Effective is Self-Assessment?

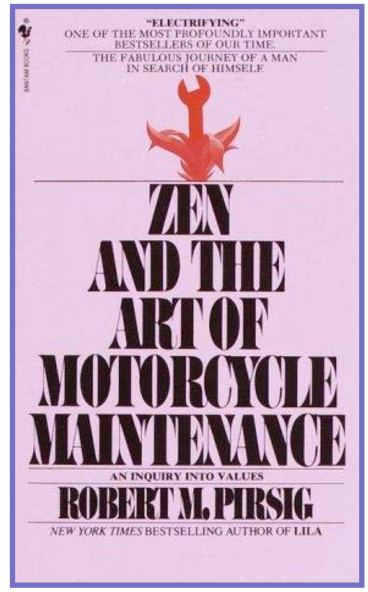
Giving a student a rubric and asking him to grade himself is a form of self-assessment. Expecting that student to be honest (remember grades can be high stakes) or to understand the rubric created by another person, brings to question not only the accuracy of this assessment tool but also the time payoff, especially when compared to quicker or traditional forms of assessment. While rubrics are helpful and make the self-grading process appear more democratic, when not co-created with the student, rubrics may have inherent bias or erred perceptions of understanding built in to them. Studies done at Stanford in 2001 around self-assessment tools in medical school, confirmed that students were inaccurate at assessing their level of knowledge on a given subject (Dunning, 2004).

Stories and studies that paint a positive light on self-assessment argue that the focus of these assessments should be formative, to avoid issues of disenfranchisement or inaccuracy (Andrade, 2009). Formative assessment is process versus product centered as well as more authentic, or embedded into a student's learning. As such, formative assessments foster a growth mindset and a safe space to give and hear critical feedback. The message of a formative assessment is that *"we are all still learning."* Examples of formative assessments can be design or engineering logs that record diagnosis and design ideas, Maker portfolios or informal work shares for peer feedback.

Because formative assessment happens more than just at the end of a chapter or unit, they can be seen as too time consuming. The time used to do these assessments, some will argue, is a vital part of the learning and offers a deeper more holistic payoff compared to the quicker standardized test (MacDonald 2012). Furthermore, self-assessment was found to make students smarter and more motivated according to a 2012 study by Dr. Betty McDonald of the University of Trinidad and Tobago. MacDonald found that, *"students of the experimental group (those who used self-assessment) were able to pinpoint their specific areas for improvement whilst those of the control group took no interest in determining ways for improvement."*

Thankfully self-assessment does not have to be based on content knowledge, nor does it have to be done in a vacuum to be effective. Developing assessment literacy does seem to be key to successful self and peer-assessment, however (Smith et. al. 2011). Combining forms of peer-assessment with self-assessments can help students gain this vital assessment literacy.

In an Edutopia article from 1997, a seventh and eighth grade math teacher using a design based math project, describes assessment literacy as follows, *"We want (students) to be able to judge for themselves whether a piece of work is excellent or falls short of the school's standards. It may seem like a lot to ask of adolescents, but once we started using strategies such as critique circles and portfolios, students quickly showed they were willing and able to take more responsibility for the quality of their work."*



This idea of assessment literacy or quality, as relevant to one's own education and experiences, is one that took time for me to trust. Especially after reading *Zen and the Art of Motorcycle Maintenance,* which dissects the idea of quality ***ad nauseum***. In the end, once I realized quality was relative, collaborative and constructivist, I began to trust the process much more. Now, I ask students to pick out works of quality and to attempt to define the terms for themselves.

Three ideas that seem to point towards effective self-assessment are as follows:

1. Using self-assessment to reach a letter grade that is more summative in nature versus formative can lead to inaccuracies, defeat the goal of the assessment, and give alternative assessments a bad name. Assessment needs to feel safe for students and that is possible when you practice a growth or "maker" mindset around work and assessment.
2. Self-assessment can facilitate deeper learning, as it requires the student to play a more active role in the cause of their success and failures, as well as practice a critical look at quality.
3. The role of peers and the sharing of work leads to a community wide assessment literacy that increases the accuracy of self-assessment, as well as the rewards of using alternative assessments.

The efficacy of self-assessment, as well as return for time spent, is reliant on two factors. First we must create a safe space for self and peer critique to occur by promoting process over product and a growth mindset. Second, we must collaboratively build assessment literacy. As with any kind of literacy, assessment literacy takes time and gets better with modeling and practice. Deeply dependent on collaboration and communication with peers, practicing assessment literacy together leads to more effective assessments, as well as a more democratic and engaging learning environment.

WORKS CITED

Andrade, Heidi, and Anna Valtcheva. "Promoting Learning and Achievement Through Self-Assessment." Theory Into Practice 48.1 (2009): 12-19. Print.

Dunning, David, Chip Heath, and Jerry M. Suls. *Flawed Self-assessment: Implications for Health, Education, and the Workplace*. Malden, MA: Blackwell Pub., 2004. Print.

MacDonald, Betty (2012) “Using Self-Assessment to Support Individualized Learning” Mathematics Teaching. Association of Teachers of Mathematics

MacDonald, Betty (2012) "Self Assessment and Student Centered Learning” Online pdf

McDonald, Betty. (2012) “Gestalt Effect of Self-Assessment” Online pdf

Pahomov, Larissa (December 2014) “What Meaningful Reflection On Student Work Can Do for Learning.” *Mindshift* article

Pirsig, Robert M. (1974) “Zen and the Art of Motorcycle Maintenance: An Inquiry into Values.” New York: Morrow

Smith, Calvin Douglas, Kate Worsfold, Lynda Davies, Ron Fisher, and Ruth Mcphail. "Assessment Literacy and Student Learning: The Case for Explicitly Developing Students ‘assessment Literacy’." Assessment & Evaluation in Higher Education (2011): 1-17.

Yoshida, Clyde (1997) “Creating a Culture of Student Reflection: Self-Assessment Yields Positive Results” *Edutopia* article

Examples of Self-Assessment in MakerEd

by Christa Flores and Carolina Rodriguez

In this article we will get down to business looking at how to use self-assessment in real world project context. Nina Rodriguez, the coordinator of the Innovation and Design Lab at Downtown College Prep (San Jose), will be joining this conversation to talk about examples of self-assessment used in her classrooms.

Example Self-Assessment Tool #1: Student Surveys

6th Grade Project 2014:	"School of the Future"
School:	Downtown College Prep
Curriculum Designer:	Nina Rodriguez

Eight 6th graders at Downtown College Prep met in the Innovation and Design Lab two days out of the week for one hour after school. The 6th graders met a total of 8 sessions to work on the "School of the Future" project, which consisted of students being grouped into teams responsible for designing a specific type of building (e.g. the library, the multi-purpose room, the front office) for a brand new campus. The goal for each team was to create a design that demonstrated empathy towards the needs of the staff and students who would use the facility, as well as to make a unique structure that reflected their own idea of what a school of the future would look like. Prior to starting the program, students filled out a questionnaire with the following questions:

- Why do you want to participate in the School of the Future project?
- What do you hope to learn at this after-school program?
- Have you ever made a model of a building? If you have, what did you build?

When reading the completed surveys I noticed that they had a strong interest in making, as well as a familiarity with the very basics of the design process. As their guide for the project, my goal was to take this knowledge that they already had going into the after-school program and help them determine what aspect of the project they wanted to learn more about. These questions served as an introductory self-assessment for my students, in the sense that they were describing their own motivations for taking the time to work on this project outside of school as well as their expectations for their own learning.

Pre-Project Responses

During the final session of the "School of the Future" project the students completed a survey that complemented the initial questionnaire.

Why do you want to participate in the School of the Future project?

- "Because I want to make new things and to try new things."
- "Because I really like to build stuff."
- "Because one day I can do something and change the world."
- "I want to participate in the School of the Future project because it's a creative group and I like to do creative things like: drawing, inventing, etc."

What do you hope to learn at this after-school program?

- "More about science and designing stuff."
- "How to do step by step things to get to one big thing."
- "How to express myself by being more creative."
- "I hope to learn more [about] how to invent things."

Have you ever made a model of a building? If you have, what did you build?

"I made a model out of pipe cleaners at school with Jasmine and Juan. We made something that looks like the [Eiffel] tower."

My students' responses demonstrated that self assessment makes it easier for them to determine specific interests as compared to when they first started the project. Having a prompt with parameters definitely focuses their attention to certain skills, but when the magnifying glass that is placed over their work is through a student's eyes, they become active rather than passive learners.

Reflection Responses:

Student Feedback: School of the Future Survey

What was your favorite step in the design process?

- "My favorite part of the design was the putting together part."
- "My favorite step was working together."
- "My favorite step was ideate because I got to brainstorm different things."
- "The building part where we made the models."

What did you learn from working on this project?

- "I learned to express my ideas and present in front of a lot of people."
- "I learned that there are a lot of steps in the design process."
- "What I learned from working on the project was to build many things you have ideas on."
- "I learned about measuring and which materials works."

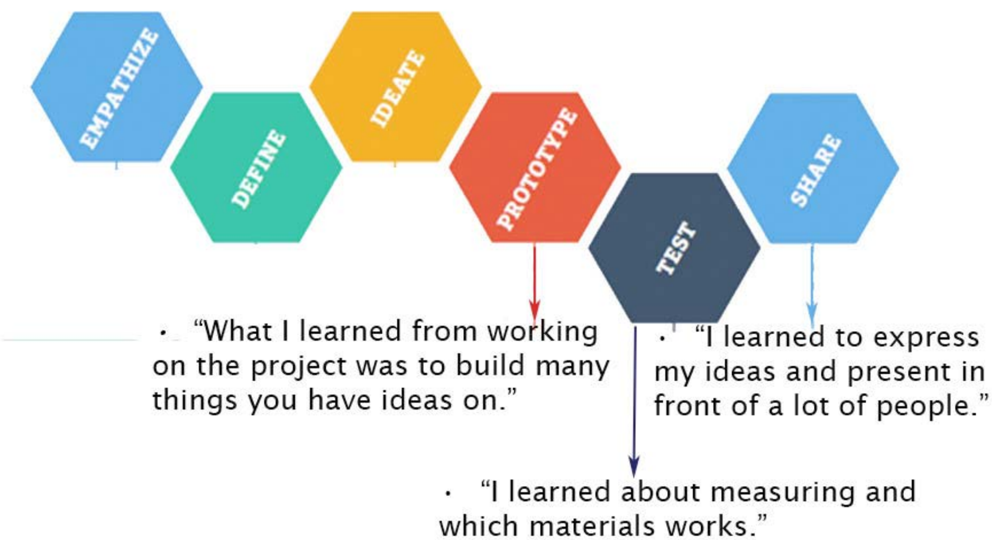
What would you have liked to learn more about?

- "I would have liked to learn more about different designs for the building."
- "Building big things like a tower."
- "Painting"
- "Maybe how many people it took to make a building."
- "How people would like to rate it."

In the pre-survey, students described what they wanted to do ("make stuff", "drawing, inventing"). In the reflection survey, they start to focus on achievements and challenges throughout their design process for their project, such as presenting their work at the school assembly or learning how to determine what materials worked best for their models. In addition, the students also made direct connections to the design process when reflecting on their learning experience, which was the primary focus for the the project.

My students have shown that they can express their expectations for their learning experience as well as recognize the primary concept(s) of a project. Surveys can be used as a starting point for in-depth self assessment, and can also be incorporated to help students when they are struggling to discern the successful aspects of their work as well as the components of their project they need to improve or address.

Design Process by IDEAco, City X Project



Example Self-Assessment Tool #2: Claim for a Grade (Pass or Fail)

5th Grade Project 2013:	"RubeGoldBridge Problem"
School:	The Hillbrook School
Curriculum Designer:	Christa Flores

At Hillbrook we give students grades, even for electives. I teach 5th grade Problem-based Science (PbS) and electives in entrepreneurialism to 7th and 8th graders. In an effort to protect a growth mindset around process and creativity, I base grades not on working prototypes or tests or rubrics, but on a pass/fail point system. I feel comfortable giving points for the written or visual submission of an argument because the only way to lose points is to turn in work late. Self-assessments such as these can be used effectively when the criteria for quality is co-created with the students. Students also feel more comfortable grading themselves when the defense of pass or fail is concrete. Students are asked to show evidence of their own learning, either soft skills or measurable skills.

When I ask my students to list reasons why they earned their grade, I encourage them to list all the things that represented new learning or growth in an area they had been working in. Using this system you can support the wide range of learning that is happening in a self-directed learning space. Students will self-report using above grade level math skills to solve problems, specialized tools for measurement, practicing new leadership skills, learning a new technology like programming or CAD, and the list goes on. The claim/evidence/reasoning or persuasive essay format (sometimes this is a movie made in Explain Everything for students that struggle with writing) is only one form of assessment that encourages a student to defend and reflect on their learning. Public showcase of work also allows students to communicate their understanding of their problem to an audience.

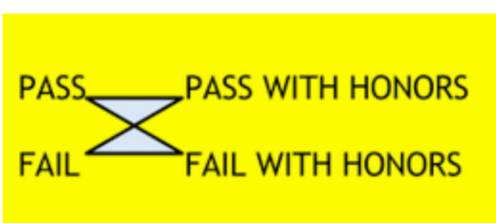
An example of how I do this with my 5th graders can be seen at the end of the four month long "spring hard problem." The project is based on a prompt of 3-5 rules, such as: 1) Do work on a 75 gram steel ball (move the ball from position A to B) 2) with an input and output that connects to two other teams' machines 3) and bridges two or more forms of energy. After months of trial and error, design and redesign and team building, I knew that my students were having a very rich experience, but accessing it and getting out in the open or even on paper was a huge challenge. That's when I decided to start looking at self-assessments.

Here is the first one I presented to my 5th graders:

Dear 5th Grade,

I am so proud of all of you. You survived PbS 5 iteration #1 and Maker Faire 2013! I know that I had some fails this year and I know I had some successes. Thank you for all of your hard work this year, especially the last four months during the Rube Gold Bridge problem. As many of you might feel that more time would have been better, I hope that you still found deep satisfaction with what you did accomplish.

While I am very sad to leave you at this important time, I am also looking forward to spending a week with the 6th grade in Yosemite this week to rest from Maker Faire and Maker Faire rush week. While I am gone, I need you to do something for me. I won't have time to grade you on your work for the RGB problem. I need you to decide what grade you should receive for this project. Only you can do this now. Only you know how hard you worked and how much you learned. Please choose ONE from the following grades. You must give me three pieces of evidence to support this grade claim. You can ask for help from anyone if you need to get mentored doing this. You have one week from today to complete this task. Please bring your grade and all evidence to school to share with me on Tuesday after Memorial day.



Your Fan,

Christa

My 5th graders had no problem telling me what they had done to support their team, or the way they took risks or problems they had solved. Their ability to make a valid argument was so impressive, I continue to use this form of assessment at the end of all of my projects, including my electives. Below is an example of one student's self-assessment for the RubeGoldBridge problem. This style of assessment allows students to use argument and communication skills that are appropriate for that student. It also shifts the role of assessing progress from the adult to the learner, a goal we are striving for in the Middle School at Hillbrook.

May 20, 2013

The Rube Gold Bridge Problem

By: Olivia [redacted]

For the Rube Gold bridge Problem, I fall into the "Fail with Honors" category. My design failed in some places, but I put a ton of team effort into this and rarely ever was working on something else. At some times my teammates weren't the best of partners and occasionally left me to work on the design. Here are three pieces of evidence to support my claim;

*I worked really hard on a star structure that was later incorporated into our design. I nailed it into my structure so that it would be easier to transport. In this star, I used both mechanical and electrical energy. The spinning movement of the star uses mechanical energy. The NXT robot the star ran on used electrical energy.

*I came up with the idea of making the ball go down tubes while an underwater movie was playing. Although we never had a movie play, we drew an underwater scene on the backdrop. Later on, we changed the backdrop completely and I helped make it, design it, and put the tube on. At MakerFaire, the tube came off and I taped it on.

Making it Happen: Society & Inclusion

Making in education is not about having the coolest, most expensive tools or the fanciest makerspace. Making is a way to empower people to solve their own problems and develop the skills and mindsets to do so.

At its essence, the Maker Movement is about sharing ideas and access to solutions with the world, not for money or power, but to make the world a better place. It's about trusting other people, many times people you don't know, to use these ideas for good.

Making in the classroom is also about power and trust, and perhaps in an even more important way, because it's about transferring power to the learner. Young people who are the ones who will take over the world in the not too distant future. And in giving the learner agency and responsibility over their own learning, they gain trust, not just the trust of the adults in the room, but trust in themselves as powerful problem-solvers and agents of change.

Making is not only a stance towards taking that power back, as individuals and communities, but also trusting ourselves and each other to share that power to create, learn, grow, and solve problems. Empowering youth is an act of showing trust by transferring power and agency to the learner. Helping young people learn how to handle the responsibility that goes along with this power is the sensible way to do it. Creating opportunities to develop student voice and agency takes skill and determination. Inspiring them with modern tools and knowledge needed to solve real problems is part of this job.

STEAM, de Trojan Horse for Making ”Inclusivity”
by Christa Flores and Patrick Benfield

Many years ago when one of us (Christa) was looking at undergraduate programs in anthropology and paleontology, a UC Berkeley graduate student, who happened to be white and male, snickered at the suggestion that it would be “fun” to work on a campus with so many fields of science to learn from. *“Its way too competitive for collaboration,”* he scoffed, half disgusted, half proud to be surviving in such an environment. As a budding anthropologist, I knew humans for their ability to collaborate. Forming alliances to solve problems was a key survival strategy for early humans. Female humans, especially, have enjoyed evolutionarily success solving hard problems in this manner (Fukuyama), so that grad student's description of how science was done really struck a chord.

Fast forward to the year 2015, and growing concern has mounted for attracting females and minorities to the STEM fields. Counterbalancing past bias (by creating “unfair” advantages) to bridge the gap in college and STEM fields, continues to be a messy road, however. Once attending top STEM schools, women still face constant doubts about whether they belong in their programs. Competitive language from peers such as *“they (MIT) are turning away qualified applicants in favor of less qualified female applicants,"* creates an environment of doubt (Selvage) and does little to attract those to STEM already feeling less armed to compete.

Toy companies riding the wave of interest to close the gender gap in STEM have seen some success in sales, but simply adding storylines, and product lines which “feature girls in settings including a shopping mall, a beach house, and a pet salon” feel bereft of the kind of substantive changed needed. Getting more women to participate in the creation, versus consumption of their lives, through STEM careers is a conversation that can be easily lost in arguments for economic success. Take the “Case for Gender Equality” statement put out by the World Economic Forum for the 2014 Global Gender Gap Index which says: The “consumer case”, “talent case” and the “diversity case” are all reflected in the findings around a growing business case for gender diversity. As women become more economically independent, they also become more significant consumers of goods and services, including for the majority of purchasing decisions of the household (7).

Sylvia Martinez links the importance, as well as challenge, of using self-directed learning environments to support more outsiders, such as girls, in engineering. She also points out that girls, on average, will interact with self-direction differently than boys. This looks like girls tending towards pleasing the teacher (or from my experience their friends or teammates) and avoiding conflict over scarce resources (that includes the teacher’s attention). *“Teachers need to remember that their suggestions carry a great amount of weight. To counter this and encourage self-directed learning, teachers need to train themselves to offer neutral, yet encouraging support for students to think outside the box,”* says Martinez. Furthermore girls need to be given strategically “unfair” advantages by being invited by the adult to learn technology first, leading to leadership roles in the classroom as mentors.

Blikstein reminds us to invite access by creating Gender Neutral Learning Spaces: Super Stoked, this high skilled young lady made her first vintage re-design in the iLab's textiles section!

More hope for closing the gap between STEM interest and underserved populations, can be seen in the work of the non profit Maker Education Initiatives in schools. Due to their extensive work with public schools, the target audience for Maker Education is often low income or minority students. In a news article targeting Latino families describing the role of creativity and how traditional schools fail to teach or preserve it, Maker Education was mentioned as a potential cure. In the article, Nirvan Mullick, a U.S. documentary filmmaker and founder of the Imagination Foundation says the emergence of these new educational initiatives *"shows we're going through a period of transition, of changes in which we're experimenting and re-imagining the way in which young people learn."*

Similar efforts to combine issues of gender and income, can be seen by the fact that over 50% of graduating engineering students are female at Harvey Mudd College. Why? *"Simple,"* says president Maria Klawe, the first female president of Harvey Mudd, in this Huffington Post article. Female students are thriving in newly designed environments for collaboration and creative team projects. Avoiding lecturing helps too, notes Klawe, that way you avoid only two or three students dominating the dialog.

Most importantly Klawe adds, *"What we see happen when we (change teaching styles) is that it not only increases the number of women in those classes, it also increases the number of students of color and others who don't often feel like the dominant group in engineering or computer science."* Good learning environments support more students period.

We like white coats too, in a gender neutral (outside) classroom!

If STEM is experiencing a new pushback for its competitive nature, as well as a peeling back of the layers of authority coded by the "white coat," then what does **STEAM** (insert MakerEd if you will) offer this conversation about change? (Erickson, et. al.)

If STEM is still tied to marketability and the Arts are stereotypically not marketable, then what can be the result of such a hybrid between the Arts and STEM and Making?

As far as inclusivity, when it comes to using STEAM as an argument for Making in schools, we get to decide and define for ourselves exactly what “A“ means. We can tailor it to match the skills, interests, and passions of our students. “A” could be someone’s cultural heritage, their native language, customs, or gender identity. It also increases the umbrella of interested students, who, for a variety of reasons (low self-esteem, fear of looking smart and or nerdy and so forth) might be willing to participate in making activities because they can express themselves in a way that connects with them. The “A” in STEAM is the wild card that gives a voice to our students in ways that a metric-driven focus on STEM can not. That voice can and should be the seed of inclusivity at schools.

WORKS CITED

Blikstein, Paulo (Oct 24, 2014) *“I Have Guts Too”* FabLearn 2014 Opening Keynote. Stanford University.

Bouza, Tereasa (November 26, 2014) *“Initiatives seek to tap into children's creativity”* Fox News Latino Link: http://latino.foxnews.com/latino/news/2014/11/26/initiatives-seek-to-tap-into-children-creativity/

Erickson, F., Kneller, George F. (Nov 2002) “*Comment: Culture, Rigor, and Science in Educational Research”* EDUCATIONAL RESEARCHER vol. 31 no. 8 21-24 http://edr.sagepub.com/content/31/8/21.short

Fukuyama, Francis (Sep. - Oct., 1998) *“Women and the Evolution of World Politics”* Foreign Affairs Vol. 77, No. 5, Published by: Council on Foreign Relations

Issacson, Betsy (July 2014) *“Why Most Of This College's Engineering Students Are Women”* Huffington Post http://www.huffingtonpost.com/2014/07/31/women-in-engineering_n_5631834.html

Martinez, Sylvia (November 3, 2014) *“WHAT A GIRL WANTS: SELF-DIRECTED LEARNING, TECHNOLOGY, AND GENDER”* blog from www.sylviamartinez.com

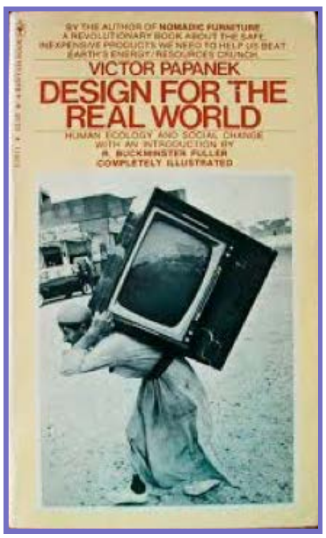
Selvage, Jennifer (Novenber 2014) *“Pushing Women and People of Color Out of Science Before We Go In”* Huffington Post Blog http://www.huffingtonpost.com/jennifer-selvidge/pushing-women-and-people-_b_5840392.html

The Global Gender Gap Index 2014: The Case for Gender Equality (2014) World Economic Forum http://reports.weforum.org/global-gender-gap-report-2014/part-1/the-case-for-gender-equality/

The young Papaneks: In face of a Problem, a Project

by Gilson Domingues and Pietro Domingues

Brazilians live in a county with a lot of problems and as a result, we've developed many ways to solve them, not all of them "orthodox". Of course, having flexible rules can lead to ethical problems, which must be corrected. But the good side about this adaptative characteristic of Brazilian people is that we are "natural born designers". The important thing is to see the real problems, and solve them in a way that benefits all the community (and this community is global). Because of the importance of this ethic, our work is inspired by architect and designer Victor Papanek.



Solution created by our students for garbage trouble in community without urban

Victor Papanek was a designer and educator who believed in inclusive and responsible design. In 1960, he was already working on what today we call sustainable design. His work permeates our activities not only conceptually, but also in the modus operandi, giving importance to low-cost materials and simpler solutions.

The advantage in using this kind of material isn't just about cost and access. We avoid trash accumulation, and when reusing the resources, the students learn about reverse engineering and how to adapt any part to our objectives.

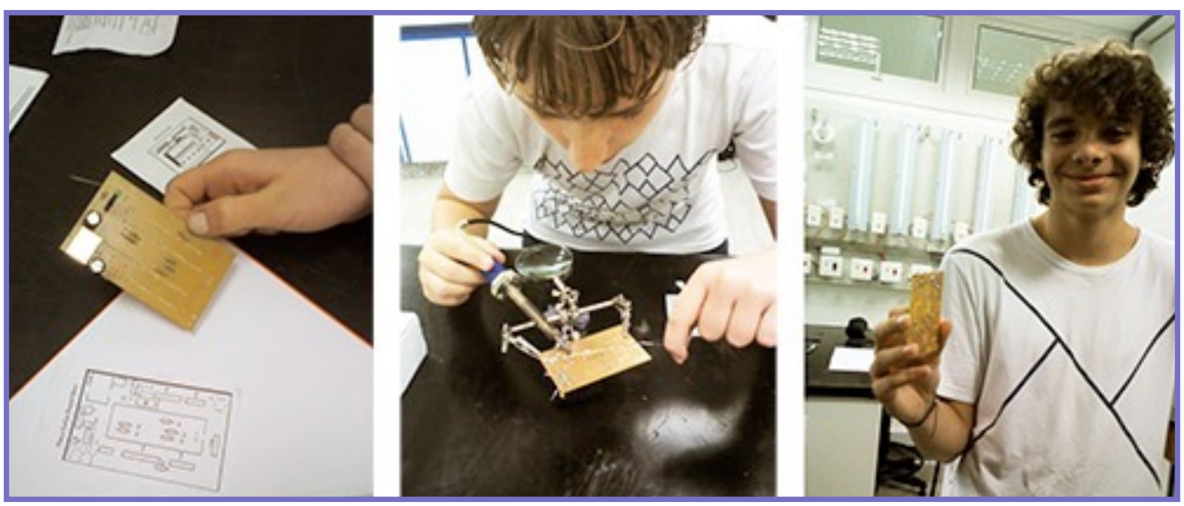
Designers at all ages

It's clear that for each age range there is a different mode of reading the world, and because of this, a child has a different agenda than an adult or a teenager.

Child designers

Design is always centered on human beings and what they do. For children, this is often play. Because of this, at the Alef School we created a course called ***Arte, Tecnologia e Design (Arts, Technology and Design)*** where we worked with toys and fabrication in two situations:

- In 8th grade, each student made his or her own GoGo Mini (a low cost robotics board) and in groups they built a robot using the board. They learned how to program and at the end they used the robot as a basis for a big kinetic and interactive toy.



- In 6th grade, the students made a simple kinetic toy, using things like cardboard boxes and other discarded materials plus motors and in some cases the GogoBoard. They also created curious interactive experiences, for example, a mirror that answers whether the user is beautiful. Video: https://youtu.be/1_d3gMAKt2g

This experience of making toy is really very motivating. In Colégio Santo Américo, the students created their own oscillator toy and then modified them. The toys move on their own due to the motor oscillations.

Using a variation of this oscillator, children can build a piano using multiple buttons:

555 Piano - http://fablearn.stanford.edu/fellows/project/piano

The young Newtons: Reading the world with scientific experiments - high school

Students learn that building things can help them understand scientific principles to build things even better.

Unfortunately, in Brazil scientific education is very deficient, especially in public schools. Colégio Santo Américo, an important private school in São Paulo, created in 2003 a digital inclusion project aimed at needy communities at the region. The project gained strength with the support of Dr.

Blikstein in 2004. In 2007 he implemented an introductory scientific program for the students. In a spontaneous way, the students started to research about subjects of their own interest (global warming, earthquakes, volcanos, etc.) and they made scale models to validate their knowledge (obtained from books and internet).

Naturally the models not only helped them understand abstract concepts, the models helped them articulate these concepts in a creative way. In addition they felt excited to solve both technical and scientific problems.

Teenagers

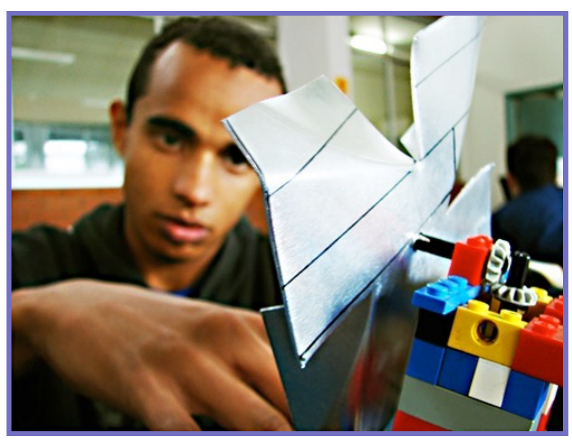
While younger children see the world with imagination and in a ludic way, teenagers use their creativity associated with their incipient critical vision of the world. In Colégio Santo Américo, we had the opportunity to work with students to find solutions that would be important to the world.

For example, students designed a telepresence system in which the operator uses a manipulator that move the arm over long distances.

We always try to encourage the creation of new ideas. Every idea is good, it just needs to fit to its place and moment. Then we create a "bank of ideas", where students can store their ideas and share them or use them later.

Projects:

Air-cooled clothes



Wind car

The young Platos, Socrates, Aristotles and other philosophers on the Agora of science fairs

Participating in Design praxis (the application of design to real life) is captivating and offers great experiences. Many of the students who experienced this process solved problems and developed social projects even without knowing it explicitly. All these projects showed:

- Social relevance
- Economic viability
- Technical and scientific tradition based projects
- Generation of innovation

These elements were important criteria for science fairs in Brazil. The consequence is that these projects participated on these fairs and one of them even was selected to participate in INTEL-ISEF in 2006:

Ergorelhao: Public telephone that adjusts itself automatically to the user's height. It allows kids and wheelchair users. It made tremendous success in Brazil and USA.

Link: http://www.csasp.g12.br/conteudo/oColegio/projetos/responsabilidadeSocial/tecnologia/robotica/projetos/ergoOrelhao/Default.aspx

The best thing about these fairs is the possibility that these students have to interact with other people that develop the same kind of projects.

In this moment they can share and talk about their ideas, as philosophers from ancient Greece did in Agoras.

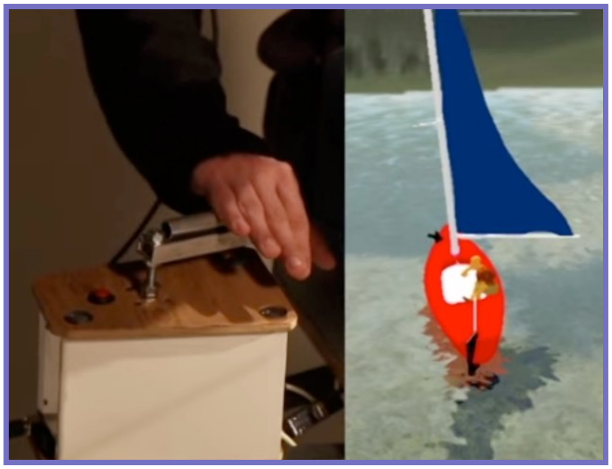
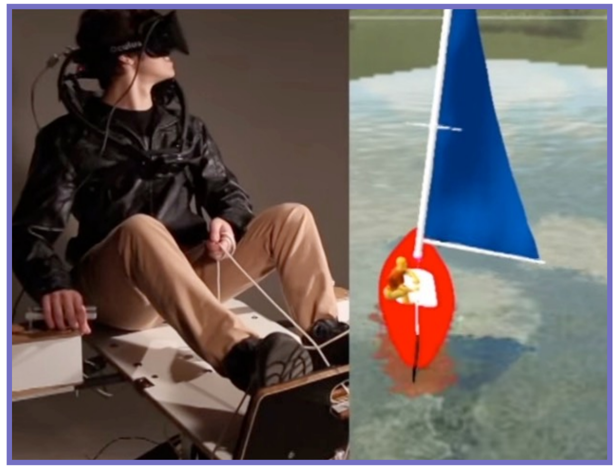
Creating designers – undergraduate design course

The maker culture is not limited to the school. There are professional activities that have the maker culture as its kernel. Using the prototyping process creates better projects and better designers. This is how the maker culture contributes to Design, Architecture and Engineering.

At Universidade Anhembi Morumbi, in Brazil, I have been working on many aspects of the maker culture. One part is related to prototyping and digital fabrication in an undergraduate digital design and architecture course, which uses 3D printers and laser cutters.

The other part is related to game design where the students also learn how to prototype electronic circuits and microcontroller based devices.

- Students make a lot of projects with computer and joystick interaction. Here is a tutorial on how to use Arduino as joystick to communicate to Unity (a game engine): https://guiaarduino.wordpress.com/2015/04/09/joysticks-especiais-integrando-jogos-eletronicos-e-arduino/

Sail Simulator prototype with Occulus Rift https://youtu.be/fOLRmziBTEU

- As part of the design, they make other devices using basic electronics, as in this tutorial teaching how to make a sensor: Force Resisting DIY -http://fablearn.stanford.edu/fellows/project/force-resisting-diy

- Here is another project using Arduino and communication modules. This project is a robot controlled by cellphone via bluetooth: Bluetooth Robot - http://fablearn.stanford.edu/fellows/project/bluetooth-robot

Makers forever

As we have seen, being a maker is not limited to an age range. Many professionals are learning continuously about what is new in the market and because of that, a lot of people are starting to embrace the maker movement.


When we ran a 3D printing assembly course that was open to the public, and we saw that a lot of participants were adults of all ages. People of many different professions were very interested in the potential of this new technology and culture of the maker movement. That just shows us that being maker has no limits!

"Making" in California K-12 Education: A Brief State of Affairs
by David Malpica

In schools, “maker” education has been typically known for many years as hands-on project based learning (PBL). While “maker” education continues to deepen its roots in small pockets of the nation’s private education, the introduction and implementation of “making” into California public education still has a long road to go. Efforts are underway to provide access to “making” opportunities to more and more students.

Some of these efforts are underway in the bubbling California charter school movement, with the most well known and established programs running in the High Tech High network of San Diego, the LightHouse Community Charter School of Oakland, and a few of other public schools (including my employer, Bullis Charter School) spread throughout the state. In district managed schools, Fab Lab Richmond (to open in March of 2015) will be the first full blown digital fabrication space to serve a large public school community: the entire PreK-12 population of West Contra Costa Unified School District. Also funded by Chevron and designed in cooperation with the FabLab foundation, another FabLab of similar magnitude is planned for Bakersfield. Castlemont High in Oakland has opened a FabLab this year. Ravenswood City School District in the Bay Area peninsula has an ambitious plan to set up seven MakerSpaces. All these bits of information account for clustered efforts undergoing in a handful of school districts out of over a thousand in CA. The construction or setup of dedicated project based learning spaces is by no means a perfect metric for this daunting task as many other programs subsist without them. However, at the current rate, and with a growing K-12 student population of over 6.5 million, MakerEd’s inspirational motif *“Every child a maker”* will take an indefinite amount of time to achieve in California.

Speaking of MakerEd — the two year old non-profit running out of its headquarters in Oakland — it is the biggest player in efforts of supporting maker education in and out of state. MakerEd has released information claiming to impact more than *“140,000 youth and families”* through a diverse set of *“youth serving organizations”* across 24 states. When asked about their impact in the CA public school arena, Steve Davee, Director of Education at MakerEd had the following to say: "*The best number based on events, our PD, and Maker Ed direct relationships is at least 64 public schools, with easily hundreds more schools benefiting in other ways..."* It is clear there is growing interest in the adoption of "maker" education practices by teachers representing many schools in California.

Teacher preparation and pedagogy

Meanwhile, it seems that California is behind in offering credentialed teacher preparation dealing with innovative hands-on subject matter and curriculum. It is unclear how many graduates out of California undergraduate STEM and graduate education programs head into the field of project based teaching and learning as opposed to educational app entrepreneurship, MOOCS, or even traditional textbook classrooms. Another concern has to do with the focus on STEM, which alone may be too narrow to solve the challenges of engaging diverse populations in the state. The first experience of making most children live is art; why is it being left out later in life? Some of the most astounding contemporary art is enabled by STE(A)M. Furthermore, curriculum designed largely by a homogenous population cannot truly serve a heterogenous one.

The researchers, ideological parents and advocates of PBL have stated that while introducing any kind of “making” into education is a positive move forward, said move would be better served by being accompanied by a shift in pedagogy. The typical practices of textbook and worksheet instruction, student grading and testing are known to contribute to the development of fixed mindsets, the opposite desired outcome of “maker” education in youth. A welcome development in teacher training is being spearheaded at Sonoma State University with its Maker Certificate Program. With a clear and sound set of educational values, it stands apart from the sea of typical Math and Science education and teacher preparation designed to be instructed, graded and tested.

Another pedagogical challenge is that of finding the right balances. Any kind of truly deep project based learning takes significant time and multidisciplinary facilitation. This means teachers of different subject areas need to collaborate on unit integration. A true innovation in education would be to acknowledge the need for time and expertise brought in by teachers with a growth mindset, which goes beyond the standard fragmented curriculum of Math, Science and ELA. Making in the classroom will not get the time and attention it deserves while Math and ELA still occupy most of the curriculum time. This is unfortunately still an effect left behind, almost ironically, by “No Child Left Behind” practices, which emphasized math and english.

Standards and assessment

Another push that opens up “making” opportunities in the California public school system has to do with the newly adopted Next Generation Science Standards, part of the Common Core Standards. While pedagogically, standards are a divisive issue, the NextGen standards actually do a good job of adding engineering practices into the mix of science while leaving the field very open for content development. Currently, there seem to be no plans to add specific engineering content into the CST examinations (and these won’t be dramatically changed in four or five years). We can only be pro-active in addressing California education leadership to see the benefits of keeping it grade and test free, allowing opportunities for different kinds of making and engineering to be taught and in order to meet and make use of local needs and expertise. A very worthwhile effort of developing alternative assessment in the shape of open portfolios is being conducted by MakerEd in partnership with Indiana University. Friend and FabLearn fellow Christa Flores, has compiled and constructed important recommendations in this area. Another alternative method of assessment comes from Stanford University: choice based assessment. When confronted with problems, do students persevere or find creative solutions instead of giving up? A new framework of assessment is important, as research and data from longitudinal career paths has shown interest to be a more powerful and enduring driving force than concrete skillset building.

Conclusion and some suggested next steps

Only through a concerted effort of state and federal government, non-profits, institutions and industry, redesigned pedagogy and assessment methods, and teacher collaboration, curriculum integration and compromise, will it be possible to reach the California student population in the short amount of time needed to build a homebrewed generation of empowered and innovative makers, engineers, artists and designers. With the current momentum and excitement around "maker" education and with the state of California carefully recovering from years of deficit, there are opportunities to regain funding for education. Said funding would be well used to propose and execute student centered programs designed to build agency, interest and growth mindsets as core 21st century skills. Colleges and universities would do schools and families a big favor by accepting portfolios (in addition to essays and perhaps in place of grades and test scores) and looking out for students demonstrating strong interests and good choice making. If this was a statewide (and why not nation wide?) policy, schools and government policymakers would adapt and teach what matters most instead of falling into the grade and test score games. Ultimately, it is the stakeholders who would benefit the most from becoming active in recognizing and demanding an education centered around what matters most.

Making for Change
by Roy Ombatti

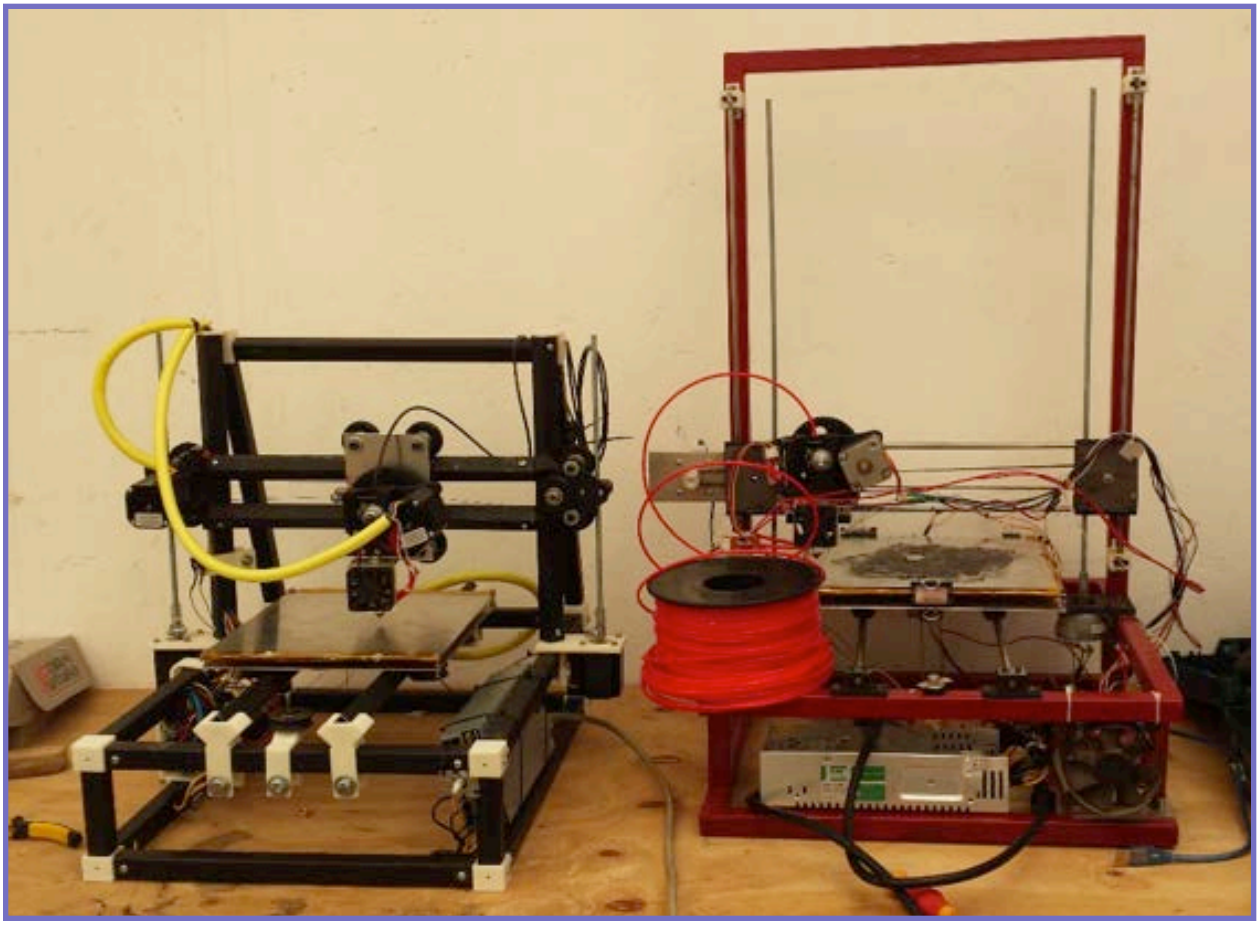
In the Nairobi Fablab, I have personally seen that hands-on making is life-changing. However it can be difficult to measure impact and as such it is difficult to quantify the successes of the process. But I am particularly curious about the making in the context of the developing world. I feel the impact of the change effected by making is most significantly felt, and needed here. But then how do we ensure that making is exploited to its full potential?

With developing world challenges such as reliable connectivity and off-the-grid access to electricity, there is a tremendous need for ingenuity and. The issue is how to provide making experiences to those brilliant young minds. From my travels around East Africa, I am amazed at the number of small creative and innovative spaces. Africans have clearly seen the need for the local solutions to local problems. And the making scene has become really vibrant in the last few years. The potential and need for African makers is tremendous, and makerspaces are popping up, including in schools.

I was very impressed by the Accelerating Innovation and Social Entrepreneurship (AISE) space in Arusha, Tanzania. AISE is a local innovation space where the community is empowered to design and create their own solutions and technologies. It is a space where creative ideas come to life. I spent 2 months working with them earlier this year. Their scope recently expanded to hosting workshops for school children teaching them skills required for making as well as getting them involved in project-based learning.

I believe that the focus on children is so important to improve education and lives around the world, but especially in the developing world. There is a need for similar spaces all over Africa in order to ensure the systemic and sustainable development of Africa.

3D Printing in Kenya
by Roy Ombatti



AB3D's 'Retr3D_V2' Printer (left) alongside Retr3D_V1 (right)

3D printing in Kenya is slightly over 2 years old now with the Nairobi Fablab having had the first 3D printer in Kenya. Since then the trend has caught on to the point of people owning personal printers. I know the world is years ahead in terms of 3D printing but be sure that Africa, in general, is full of surprises!

In early December this year I made a presentation at a conference on Footwear Health Tech in Eindhoven, Netherlands. This was due to 'Happy Feet': a project involved with the provision of footwear for people with foot deformities. During the conference, 3D printing featured prominently as the value of the custom fit and personalization of shoes has become the new fad. Anyway, during my presentation, I mentioned that as a result of my research, I had concluded that it wasn't yet time for 'meaningful' and sustainable 3D printing in Kenya. Especially for what I was trying to do and on such a large scale. One of the questions I was asked by a certain lady is why this is so, yet 3D printing (printers and filament) had become very cheap. I answered that the affordability of the printers was relative and the Kenyan context is a different scene altogether. But then the lady still didn't seem to understand why it still wasn't affordable. I was surprised by her persistence and this got me thinking of a way of making 3D printing affordable for an African context.

Firstly, this is something I have been trying to do for a while now because for a long time my project relied highly on 3D printing (plus it's one of my most favorite tools to be honest). I had thought of how to recycle certain plastic waste materials to extrude plastic filament. From my travels, I saw that there's already so much going on out there in this field. And I am happy to say that I shall be setting up our own extruder in January next year here in Nairobi.

And then there's brilliant African ingenuity such as this fellow right here. Such stories give me renewed hope in the maker culture in Africa. Our circumstances give us new ways of thinking and I am looking forward to what this amazing continent has to offer. Unique situation calls for a unique solution so watch this space in the years to come! I can assure you that you will not be disappointed.

So why not do the same in Kenya? Challenge accepted! I have made significant strides towards realizing this goal…enter AB3D (African Born 3D Printing). AB3D is a social enterprise involved with the production of local and affordable 3D printers as well as 3D printing filament from waste materials. The 3D printers are made from electronic waste parts while the filament is extruded from recycled PET plastic waste. The goal is to alleviate poverty, make 3D printing more reachable and affordable to makers in Kenya as well as hopefully make high quality products that could be sold to the international market. Part of AB3D's agenda is also to set-up makerspaces in schools centered around though not limited to 3D printing. Check out the progress in terms of our printer design pictured above.

Technologies of the Heart: Beyond #BlackLivesMatter and Towards #MakingLiberation
by Susan Klimczak in collaboration with Adia Wallace and Nettrice Gaskins

One 2015 collaborative project at the South End Technology Center @ Tent City (SETC) was supported by the Harvard Graduate School of Education (HGSE) Dean's Equity Project. The goal was to create a safe and creative space for high school and college youth to explore their identities and their relationship to issues that have come up in the #BlackLivesMatter movement through activities based on Hip Hop Culture. Then, using the design engineering process, the youth imagined a world that would work for everyone by creating participatory art and technology projects and activities that engaged them in #MakingLiberation. These were shared during demonstrations and workshops for the HGSE community and served as inspiration for other youth during the 2015 Learn 2 Teach, Teach 2 Learn (L2TT2L) program.

> *If we want a society and culture that works for everyone, we need innovation in our relationships along with innovation in the STEM fields and STEM education.*
> *- Mel King, Activist and Founder of South End Technology Center @Tent City*

In our 13-year-old STEAM maker program at L2TT2L, we most often start designing teaching activities by identifying the big ideas and skills connected to a technology we teach, be it computer and physical programming, electronics or digital design and fabrication the “technologies of the earth”. Then, we work to create a "cool" culturally relevant activity that engages the youth in those big ideas and skills.

What excited me about this project is that we were "de-centering" or taking these "technologies of the earth" away from the focus of activity design and putting them in the service of "technologies of the heart” –those technologies that are necessary to bring out the best in us and enhance our relationships with each other.

What has most engaged me as an educator for the past few years is a participatory research project with youth teachers and college mentors that seeks to document how the technologies of the heart support the STEAM education of our Boston youth of color. I've addressed my thoughts about this in some of my blog posts: Some thoughts on technologies of the heart while thinking about Seymour Papert and Making justice - youth restoring their own humanity.

At SETC during the school year, we have two small after-school programs for teenagers: our Eek! Electronics Explorers Klub and our Fab Stewards program. During circle-up sessions, the teen participants expressed how they were discouraged (and even banned) from talking about #BlackLivesMatter at school or participating in the nationwide school walkout. Some spoke about how their parents were fearful about talking about #BlackLivesMatter and asked them not to participate in any activities. Their lack of meaningful opportunities at school or at home to explore and express their ideas and feelings about the #BlackLivesMatter movement concerned me because the courage and ideas of youth have historically been at the center of social movements here and across the planet.

I am also beginning to understand #BlackLivesMatter as a maker movement that indeed is seeking to create new technologies of the heart (and the earth!) to address social justice issues. So, in collaboration with graduate student Adia Wallace from the Technology and Innovation in Education program at the Harvard Graduate School of Education, we developed a successful proposal to the HGSE Dean Equity Fellowship to address this question:

How can Science, Technology, Engineering and Math enrichment help youth of color meaningfully express their feelings and address issues related to #BlackLivesMatter in historically and culturally relevant ways in Boston, Massachusetts?

> *"Our ultimate end must be the creation of the beloved community."*
> *– Martin Luther King Jr.*

Engaging people from the local community in maker education projects enriches education for our youth and brings fresh vitality into the programming. Visiting educators can serve as role models and expose youth to possible STEM career paths. Many talented people are also seeking ways to give back to their communities and have creative outlets for their talents beyond work. The question often is, how do educators go about "making" these relationships?

At SETC's L2TT2L program, we used a number of practical strategies in developing collaborative partners for "Beyond #BlackLivesMatter and Towards #Making Liberation: Using STEAM to provide opportunities for Boston youth to explore and express possibilities for change." (Read our successful proposal.)

STRATEGY #1: Seek role models who look like our youth

As a white education organizer working for over a decade with 90% youth of color in our L2TT2L, I know I bring much love and skill to our youth. However, I feel it is particularly important for them to experience role models who not only look like them, but have developed effective and

2014 Youth teachers with LLK Graduate Student Abdulrahman Idbli in Chain Reaction Workshop at MIT Media Lab interesting STEM skills and exemplary achievements in the community as well as in higher education. So, I work hard to find those community members who look like our youth and can share their talents and stories through social media and networking.

STRATEGY #2: Cultivate long-term relationships with local programs and individuals in higher education institutions

Over the past 12 years, Learn 2 Teach, Teach 2 Learn has developed a lively and deep relationship with the MIT Media Lab, including the Lifelong Kindergarten Group (LLK) and the High-Low Technology Group. Our youth have been among the early testers and adopters of LLK technology education tools such as Scratch, PICO Crickets, MaKey MaKeys, and Chibitronics Circuit Stickers.

Dr. Karen Brennan with L2TT2L youth teachers Cynthia Johnson & Naeem Wilson at Harvard Graduate School of Education

STRATEGY #3: Youth are the best ambassadors for developing community relationships

When LLK researcher Dr. Karen Brennan moved to the faculty at the Harvard Graduate School of Education (HGSE), she asked Dr. Amon Millner and me to serve as guest speakers about our work with L2TT2L in her T-550 course called Designing for Learning by Making.

Amon and I decided that we could have the most impact on the Designing for Learning by Making graduate students at Harvard by bringing youth teachers as guest speakers and by having them showcase some of their projects. The adults provided some history and a few contextual comments here and there, but made sure that the youth teachers were lifted up as the main speakers. Technologies of the Heart can involve giving youth opportunities to experience and communicate what is significant to them about learning by making.

We recruited 3rd year youth teacher Naeem Wilson and 1st year youth teacher Cynthia Johnson to speak to the class. I contacted the headmaster and principal at their high schools, as well as their parents, to explain how this opportunity could enrich the education of the youth AND the Harvard graduate students. This allowed us to get written permission for them to miss school one morning. We also packed up some of the youth projects to showcase at their Harvard talk.

Naeem and Cynthia were "rock stars" at the class and our guest speaking time was extended well beyond what had been planned in order to accommodate the many questions from the Harvard graduate students. It turned out that Cynthia and Naeem were not just the only youth to speak to the class; they were among the very few people of color guest speakers. Their impact was palpable, especially on the graduate students of color.

STRATEGY #4: Mentor local education students and community members

As a result of this Harvard visit, I received many emails from graduate students. One, Adia Wallace from Mississippi, visited our technology center and began hanging out with our youth in her “spare” time. Adia even participated in our Digital Embroidery and Sewing Group and helped out with our youth teachers' holiday Pop-Up Store. Her infectious enthusiasm made developing relationships with the youth come quickly and easily.

Adia Wallace with youth teacher Tyla in a playful moment during Eek! Electronics Explorers Klub

STRATEGY #5: Participate in local STEM professional networks

Practicing technologies of the heart involves creating caring community connections that support the maker activities of youth. Adia wanted to have local STEAM educators participate in our collaborative Beyond #BlackLivesMatter and Toward #MakingLiberation project. So, I began to connect her to people in our local Race, Education and Democracy STEM network that seeks to provide meaningful STEM opportunities for educators and youth of color. This network grew out of the wonderful Simmons College Race, Education and Democracy Lecture and Book series directed by Professor Theresa Perry.

In the fall of 2014 the RED STEM Network held an event that featured a Makerspace Panel for local educators and parents at the SETC. One of the most engaging speakers was the new STEAM Lab Director at the Boston Arts Academy (local high school), Dr. Nettrice Gaskins. (See this FabLearn blogpost for more information.)

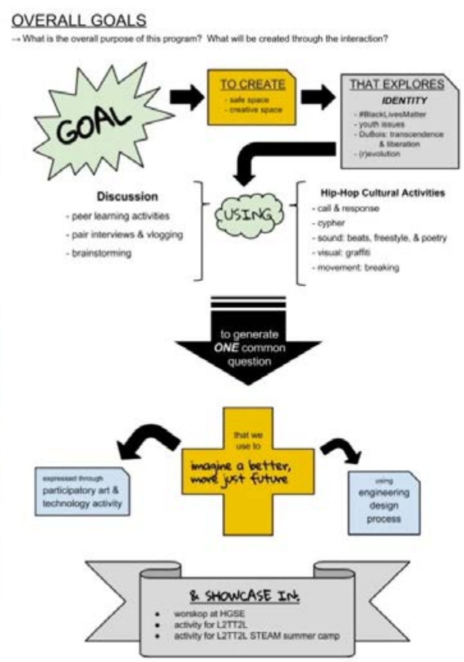
Adia, Nettrice and I met together several times for lively conversations, imagining how hip hop culture and AfroFuturism could be incorporated into the project. Nettrice generously offered to participate as a collaborator. Her unique approach to maker education helped both Adia and me to expand our own understanding and practice of culturally responsive making, breathing a new vitality into our work!

STRATEGY #6: Use design-thinking for planning with hiphop culture as a framework

To plan, Adia and I gathered interested people from our support network over an after-work take-out dinner to imagine what we could do with youth in the #Making Liberation activity. Using ideation techniques from design thinking, we asked them to write all their ideas on sticky notes. Then we

The Poem, "Let's Show Off" was discussed with activist and center director Mel King

Organizing the ideas imagined on sticky notes into a map to create a clear goal for the activities



arranged the sticky notes into categories on a whiteboard, until an activity plan emerged!

This lead us to define what the youth would do:

- Use hip-hop expressions, such as cyphers, graffiti, spoken word, to engage in authentic conversations regarding identity and bigotry
- Expose youth to hip hop maker culture and its techno-innovations
- Build knowledge together through constructionism, a theory of learning through making developed by Seymour Papert
- Use technology as both the medium and the message

Graffiti created by youth participants

STRATEGY #7: Spend significant time exploring the issue and what is important to the youth

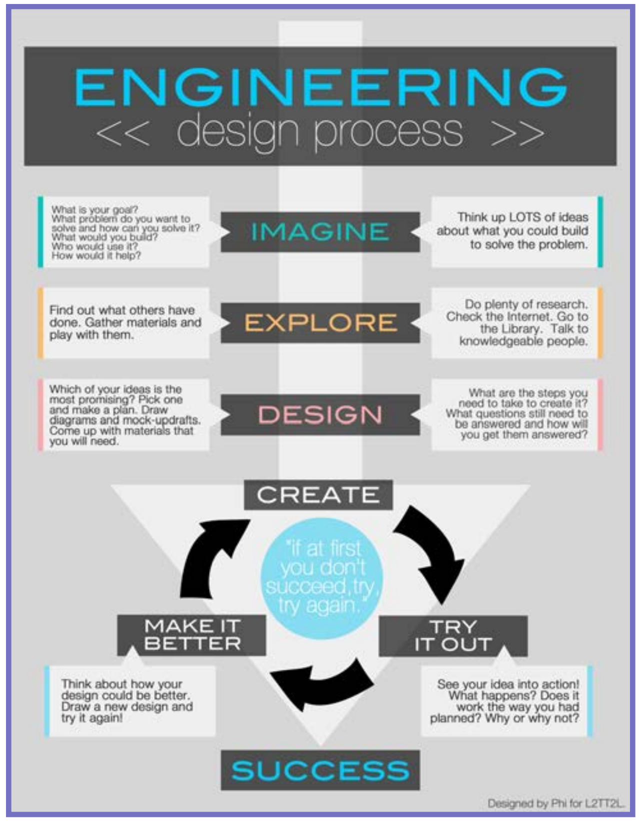
One important decision we made was to spend about half of the sessions exploring #BlackLivesMatter before beginning project design and building. Nettrice Gaskins lead discussion "cyphers" about the often overlooked maker geniuses of hip-hop. Technologies of the heart can involved helping youth to develop relationships between a culture in which they participate and its history of making and electronic innovation. As Nettrice explains,

> *"Hip-hop artists Grandmaster Flash and Afrika Bambaataa, along with a few others, pioneered what we now know to be hip-hop music and culture. Grandmaster Flash is credited with the invention of the first cross-fader or audio mixer by reclaiming parts from a junkyard in the Bronx. Flash also advanced the technique of scratching, which is a DJ and turntablist technique used to produced distinctive sounds. Scratch programming was inspired by this method of music production.*
>
> *Africa Bambaataa created "turntablism" as its own sub-genre and helped to make electronic music a popular trend in the late 1990s.He picked up on sci-fi imagery and cosmic ideas from the 1960s and 1970s including the style of Jazz maverick Sun Ra who is known as the grandfather of Afrofuturism, which is a style of storytelling that treats African American themes and addresses African American concerns in the context of 20th century technoculture."*

Nettrice helped youth explore hip-hop as a responsive and improvisational musical and sociopolitical movement for change. The youth participants also engaged in hands-on activities to explore the creative possibilities of expressing their thoughts and feelings through hip-hop culture including graffiti and poetry. We ended this imagining part of #Making Liberation by having youth generate ideas for their own manifesto that would guide project building and appear on the #MakingLiberation workshop poster, seen later in this article.

STRATEGY #8: Use youth-generated engineering design process steps to imagine, explore, design, and create projects

Technologies of the heart can involve helping youth to transform their relationships with maker education methods. A few years ago, I heard the youth teachers at L2TT2L having a conversation about the educational poster of the design engineering process that hung in our Fab Lab. They said, *"This doesn't make any sense to us!"* So, we gathered a group of experienced youth teachers and college mentors and had them research and evaluate about a dozen engineering design process diagrams that were used by groups as diverse as PBS Design Squad Nation and MIT graduate engineering classes. They decided that none of them really worked. So they generated their own. One of the youth who was interested in graphic arts turned it into a simple and elegant infographic.



We have successfully used this to guide our project building activities for the past six years. Each year, in our evaluation survey, the youth have given us feedback that this version of the engineering design process works for them.

For #Making Liberation, the youth generated project ideas and then formed small groups to rapidly prototype their ideas with materials we had on hand, have a design review to get feedback, then begin building their projects. The two projects that came out of this process were a United Voices Sequencer and the Rainbow Glove.

United Voices Sequencer. Tyla, Naeem and Simon decided to use the idea of the sequencer, ubiquitously used in Hip Hop music production, that uses words and sounds to convey a personal message about why the voices of all people matter. They designed and coded two Scratch programs for people to test (code for test program) and then play (final Scratch program) their messages using a MaKey Makey controller.

Rainbow Glove. Mariela, Antwain and Steven were newbies to electronics and coding, but were inspired by a project they saw at Adafruit called the "Piano Glove," that converts color to musical sounds. They decided to put their own spin on the glove by remixing it into a "Rainbow Glove" that would demonstrate *"It's OK for people to be different"* and *"Things are better with many colors and cultures of people."* They also decided to use the "Let's Show Off" poem they discussed with Mel King as a basis for their activity.

Technologies of the heart often involve helping youth articulate relationships between the ideas behind the technology they use and what they are up against in their own lives.

Mariela, Antwain and Steven produced their own short video about the Rainbow Glove. (Youtube Link)

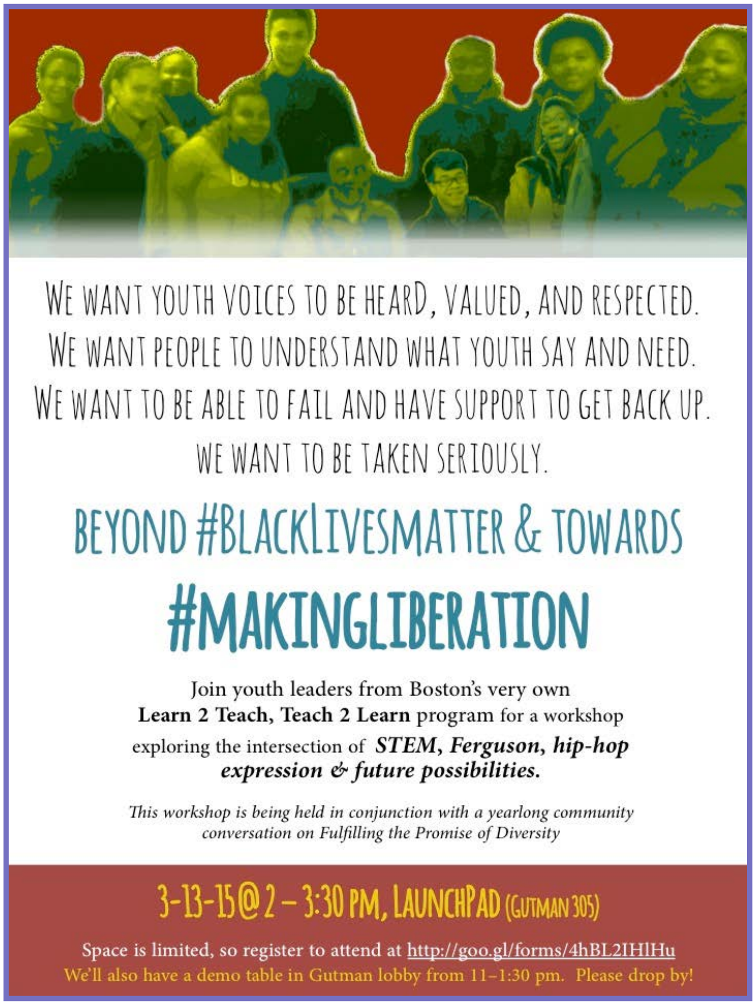
One of the most powerful parts of the Rainbow Gloves project was the connection that Mariela made between the science of color and the impact of racism in her own life:

> *"To see color, you have to have light. When light shines on an object some colors bounce off the object and others are absorbed by it. Our eyes only see the colors that are bounced off or reflected.*
>
> *Racism works that way too. People only see what's reflected back, not what is absorbed.*
>
> *In my own life, I absorb people's criticism of me, I absorb the negative feelings when they don't see who I really am and when they don't believe I am capable or smart."*

STRATEGY #9: Create meaningful ways for youth to "Show Off," taking a page from constructionism by making projects truly "public entities"

Cultivating technologies of the heart means developing opportunities, especially for youth of color, to take what they create into the community to "show off" what they have accomplished. The poem, "Let's Show Off" says, I believe *"helps diminish the misconceptions of [our youth] and the life that they* *lead."* Making projects into what Seymour Papert called "public entities" also gives opportunities for youth to develop a belief in themselves — self efficacy — and to learn more by explaining their projects and their process of designing, building, troubleshooting and improving.

For #Making Liberation, our Eek! Electronics explorers presented their projects through demonstrations and a workshop for faculty and students at the Harvard Graduate School of Education and made a video (see on YouTube).



Poster for #Making Liberation presentations at the Harvard Graduate School of Education that includes part of the manifesto that the youth generated.

Final Thoughts on #MakingLiberation

Adia Wallace has some reflections to offer on our #MakingLiberation experience:

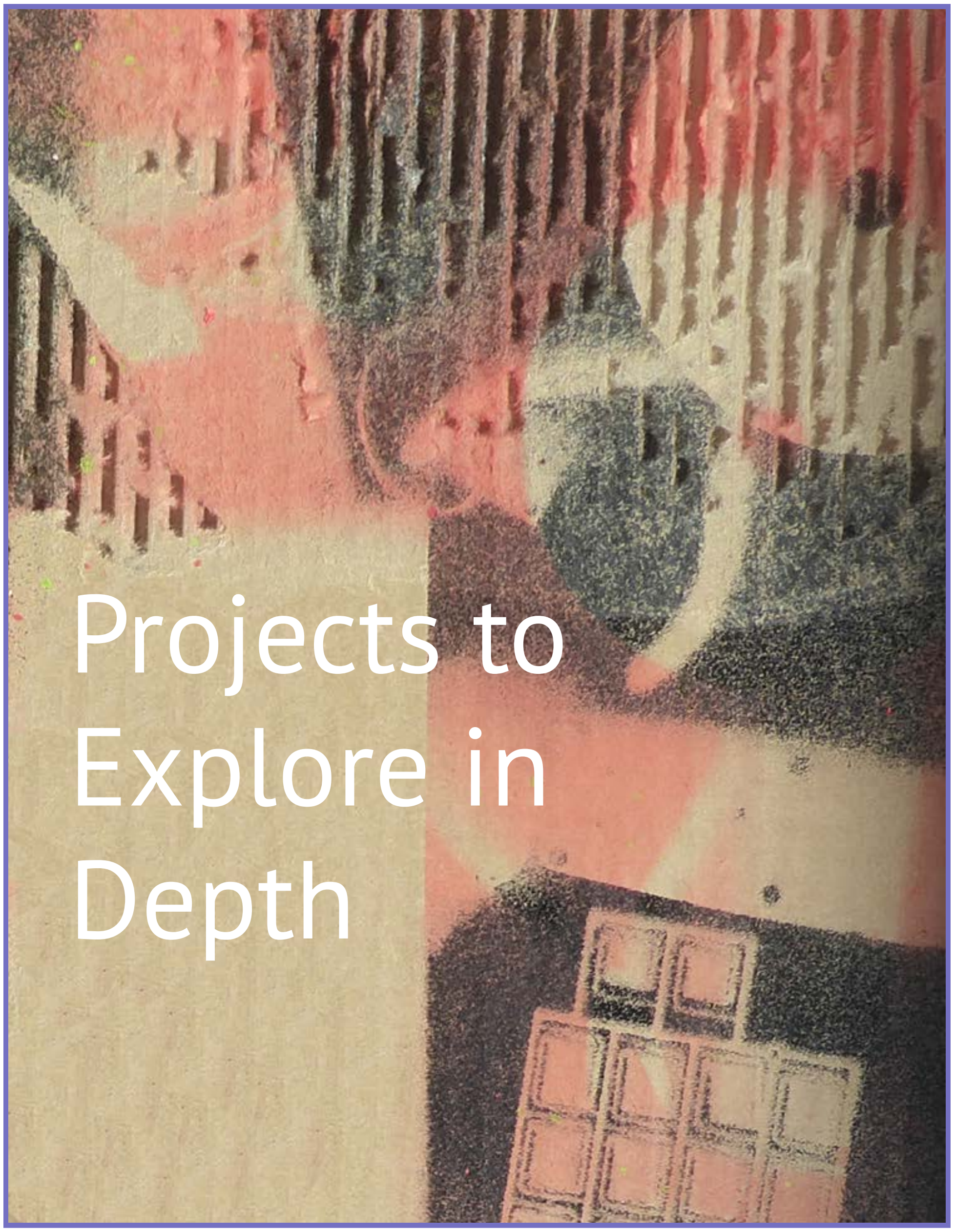
> *Susan and I witnessed struggle firsthand: the youth leaders struggling to understand where we were trying to go with our wrap-up lessons in history, sociology, and politics; the youth struggling to identify the problem first and imagine the solution second; the*

youth struggling with creative confidence. And the youth also witnessed our struggles: struggling to make sure that we can afford the technology kits with our budget; struggling to help them make connections – both in our wrap-up lessons and in teaching the new youth leaders how to solder small circuits; struggling to push them to realize their potential the same way we did.

The best thing about presentation day was not only about the technologies of the heart, but also about how seven uniquely amazing Boston youth could touch the hearts of fifteen attendees from the HGSE community through their love for technology. The youth captivated this audience by sharing their stories and by incorporating rhyme, culturally-responsive techniques such as call-and-response and hip hop (in addition to trap music influences), and demonstrating their diverse interests from graphic design to circuitry.

There was much laughter in the room and tears of joy. Our workshops received several mentions and retweets on Twitter, and I had several peers either email me directly or tell me in-person how much they'd thoroughly enjoyed the youth leaders.   One of the HGSE staff members, a man of color, broke down after the workshops ended expressing that L2TT2L is how his sons can flourish. The youth leaders were telling me even prior to the workshops that it was the best day they'd experienced that school year based on how excited the HGSE community was about the demo table. I could not agree more with the L2TT2L youth. Why? Because #YouthVoicesMatter."

Because #TechnologiesoftheHeartMatter. The center of my practice as a maker educator is reminding myself daily to not only focus on engineering skills and ideas, but to focus on those technologies that are necessary to bring out the best in us and enhance our relationships with each other.



The projects in this section give the reader a lot to think about, try, and adapt for your own situations. In contrast to the Project Snapshots in the final section of this book, these projects are more fully described, and often feature interesting reflections and course corrections from the authors.

Of Feet, Fleas, and 3D Printing
by Roy Ombatti

I have been involved in many projects during my time at the Fablab in Nairobi and I personally enjoy those that leverage technology for change and development. I am most interested about the space for technology in development because I feel it is in this space that making is most needed. I believe very much in empowering people, primarily the poor, with the necessary knowledge and skills to make them problem solvers. Hailing from a developing country, this has never made more sense to me than it does now. Gone are the days of handouts and donor funds. That technique is clearly not working in the fight against poverty. If you ask me, the approach should be more practical as well as personal. The 'poor' should be taught how to solve their own problems and supported through this process rather than throwing money at them. And this is where making comes in; be it high- or low-tech type of making. I look up to Amy Smith, founder of MIT's D-lab, which is building a global network of innovators to design and disseminate technologies that meaningfully improve the lives of people living in poverty. She said,

> *"We need to think of poor people not as vulnerable, but as capable. We have to think of it not as a billion mouths to feed, but two billions hands to engage."*

With that being said, I would like to talk about a personal project of mine that I have been working for the past two years called 'Happy Feet'. It involves leveraging 3D printing to fight jiggers that cause foot deformities and sometimes death.

The jigger is a small flea measuring about 1mm in size that is found in dirty environments. It feeds on the flesh and blood of its warm-blooded hosts. The female jigger buries itself in the host's flesh and lays eggs. This results in a black spot that is typically itchy and painful. Scratching raptures the sac and spreads the infestation. There is stigma against the infection and it affects millions of people, most of whom are children. There have been 265 reported deaths as a result of the jigger menace in Kenya alone.

Besides poor hygiene, the common denominator among the people who are affected by jiggers is abject poverty. They cannot afford water for cleaning as it is not a priority. This contributes greatly to the spread of the jigger menace. Many people cannot afford shoes and the infected cannot fit into conventional shoes. The infected use needles to dig out the jiggers but this option is painful and contributes to the spread of diseases such as HIV/AIDS through the sharing of needles. Shoes are thus necessary in stopping the infection as the jiggers are poor at jumping.

As a solution I propose 3D printed, affordable, customized, and medicated shoes.

This will involve setting up mobile shoe centers, tapping into the networks of Ahadi Kenya Trust (the only organization in Kenya tackling this issue), where people can come in and have their feet scanned and have part of the shoe printed for them. [For more about my research and the shoe project kindly check out this article. The project is still on-going and I am happy to answer any questions].

The magic of making comes in in these shoe centers. This is not just about giving people shoes, but I also see them as spaces where the youth can be taught about basic shoe-making skills. The printed parts of the shoe will be used as a frame around which a classical shoe can be constructed using locally available materials. This is because using 3D printing for the production of these shoes will be expensive as well as very time-consuming. In time, I'm sure these hurdles can be overcome, and I have a few ideas about working around this. Consequently, there will be teaching about 3D printing technology. This encompasses teaching the youth about some basic CAD design principles as well basic computing and designing. But I already have their attention, so why stop there?

From my research, it is evident that the solution to jiggers cannot be just shoes. The crux of the problem is poverty and so something needs to be done to address this directly. I hope to do this through the maker education. With continued support and uptake, I see the shoe centers serving as small-scale/mini Fablabs where the youth are taught skills and introduced to making. With these skills, the youth will certainly have a better chance at life as they not only feel like they are part of the solution, but they are also empowered to do more…much, much more. The people who are affected by jiggers are typically very poor and so this community space will serve as a second chance at life for them.

I am currently at the proof of concept stage of the project where I will be catering primarily to children as they are the most affected. The teaching will at first be limited to basic computing and design, all the while printing to fight the jiggers. Ideally, the space will be a community-led initiative to ensure the sustainability of the project. Again, if the community feels like they own the solution then they will certainly protect it and ensure its success.

This is an on-going project and although I have come very far, there is still a lot to be done.

Think Like an Architect, Draw Like an Engineer
by Erin Riley

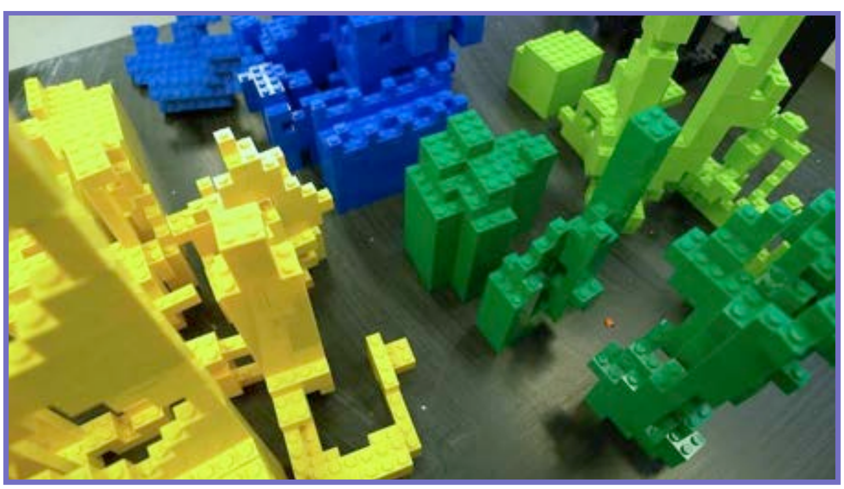
Experience: Intermediate
Age Group: 12-15 (8th grade)
Group Size: 12-18
Time: 5-7 days, 50 minutes sessions
Tools: LEGOs - just bricks, doors and windows

This unit was designed for a Group VIII Art elective at Greenwich Academy exploring the intersection of building, 2D and 3D visualization and representation through drawing. The original idea for this project was inspired by a conversation with Colin Callahan at St. Paul's School in Concord, NH based on some of the wonderful work they do in their Architecture course. In *Think like and Architect, draw like an Engineer*, students build LEGO models, create multiview plans and rebuild and review peer plans. The sequence of activities builds spatial skills and helps create a foundation for architectural and technical drawing as well as understanding points of view in CAD applications. The plan acts as a prototype, going through a peer review and revision process.

Lesson Sequence

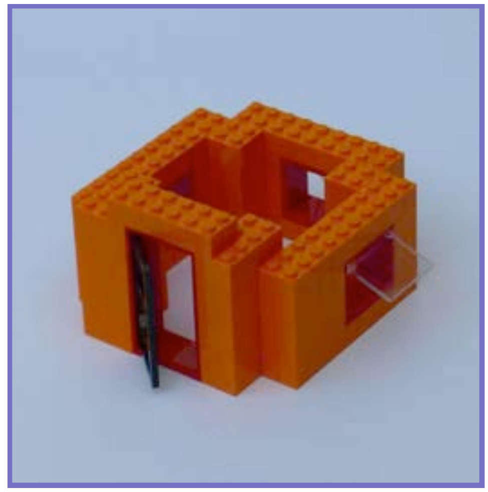
Day 1: Exploration with building

I store the bricks in a huge utility bin and the first order of business is to clump the bricks by color. I couple this organizational moment with a day of building and playing.



Days 2 and 3: Build a four-sided structure

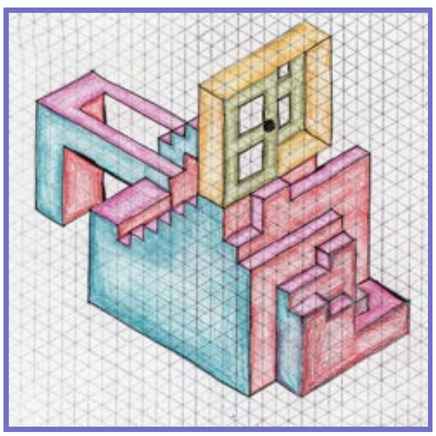
Students are given a piece of foamcore for a base and set of guidelines. They choose their brick color and start working. The guidelines place constraints on the building size to ensure there are enough bricks for everyone. Other guidelines include a projection, windows and doors so structures have a baseline level of complexity.



[Download building guidelines]

Students hand in their buildings. They will take 360 photographs of the structures next class.

Day 4: Thinking in three dimensions — Isometric drawing



This is an exploration day. Students are given isometric drawing paper and asked to create free form drawings based off of a cube unit. They are asked to identify an X,Y and Z plane and differentiate the planes with shading or color.

During this period students also take turns photographing their work.. I upload the photos into a master class folder in Google Drive. Builders will compare the final peer-built piece to the photographs.

[Example: Elizabeth's building- 360 view.]

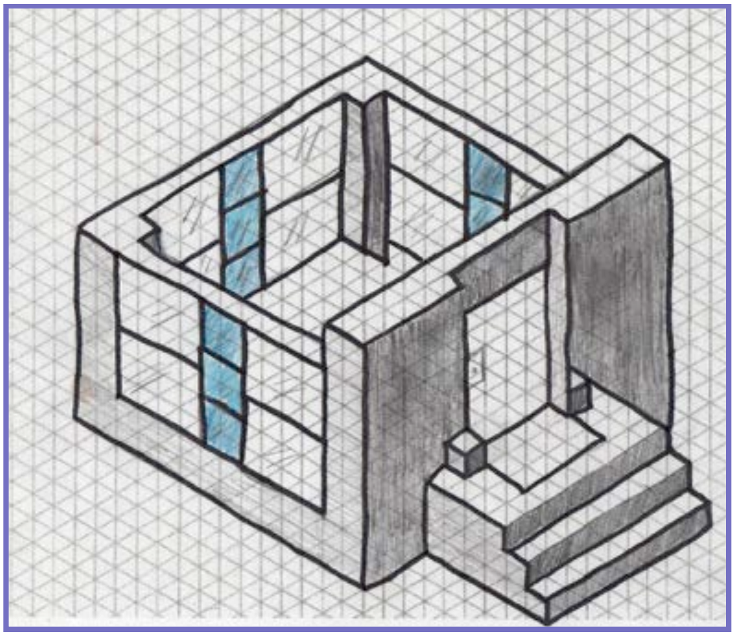
Days 5 and 6: Make the building plan

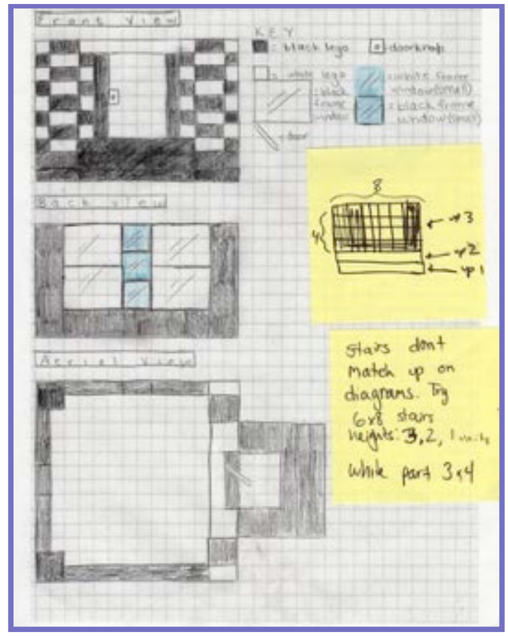
Students have access to standard quad and isometric graph paper as well as mechanical pencils, fine point graphics pens and colored pencils to represent their building. I supply an architectural drawing reference page that can guide them in representing floor plans, elevations, sections, and isometric views.

Printable isometric graph paper:

https://docs.google.com/file/d/0B9ac7pP-TB5eamg3bVJ6d0RNRlU/edit?usp=sharing

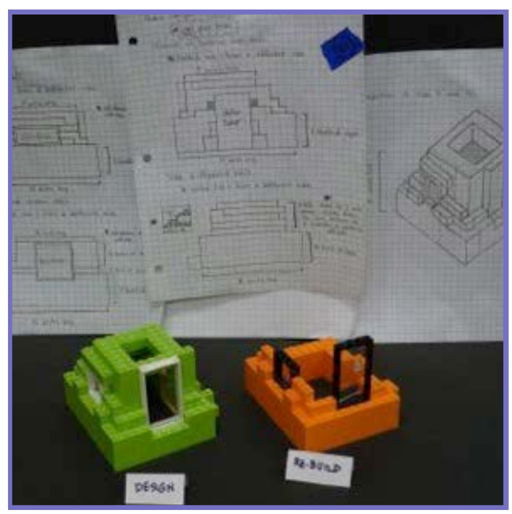
At this point if you have students who are done with their drawing (while others are still working) and you have access to a large format printer you can print 18 x 24 isometric paper. This is an excellent lesson in scale.





Days 7 and 8: Switch and build

The original builder takes apart their creation and hands the pieces to a peer builder/ reviewer. The peer builder builds according to the plan. Once finished, the 360 view is shared and the peer reviews the plan by adding suggestions and improvement ideas to sticky notes.



Day 9: Revision and reflection

Peer build and revision suggestions are returned to the original builders. Students make final revisions. Class reflection and share.

RESOURCES and TIPS

- **Slideshow**
  Showing different ways building plans are represented

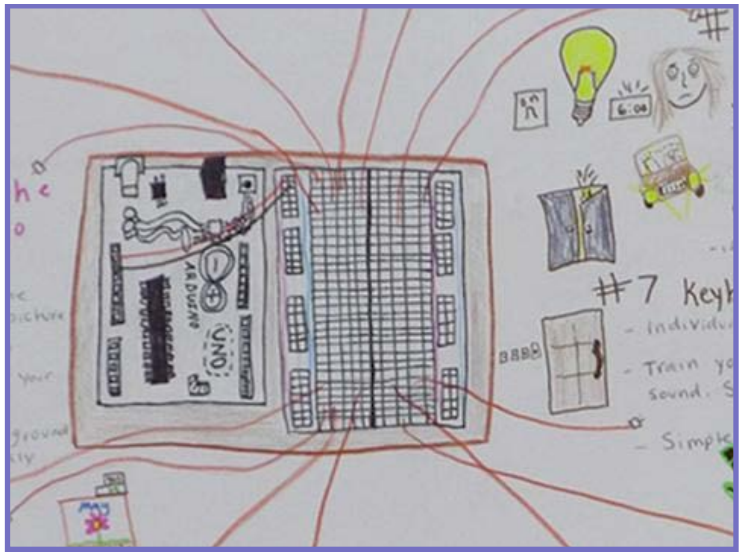
- **LEGOs**
  These are links for the LEGO bricks I purchased for this project. I used one box of bricks per three students and three boxes of doors and windows for the class.
  Just bricks
  Doors and Windows

- **Storage**
  I store the bricks in a large bin and stash it safely away from other LEGOs and robotics parts.

- **Good Reading**
  Super article on the importance of teaching drawing to develop spatial skills for art and technical fields:
  Sorby, S. A. 1999. Developing 3D Spatial Skills. Engineering Design Graphics Journal, Michigan Technological University http://www.edgj.org/index.php/EDGJ/article/viewFile/126/122.

Drawing: a Visual Language for Makers
by Erin Riley

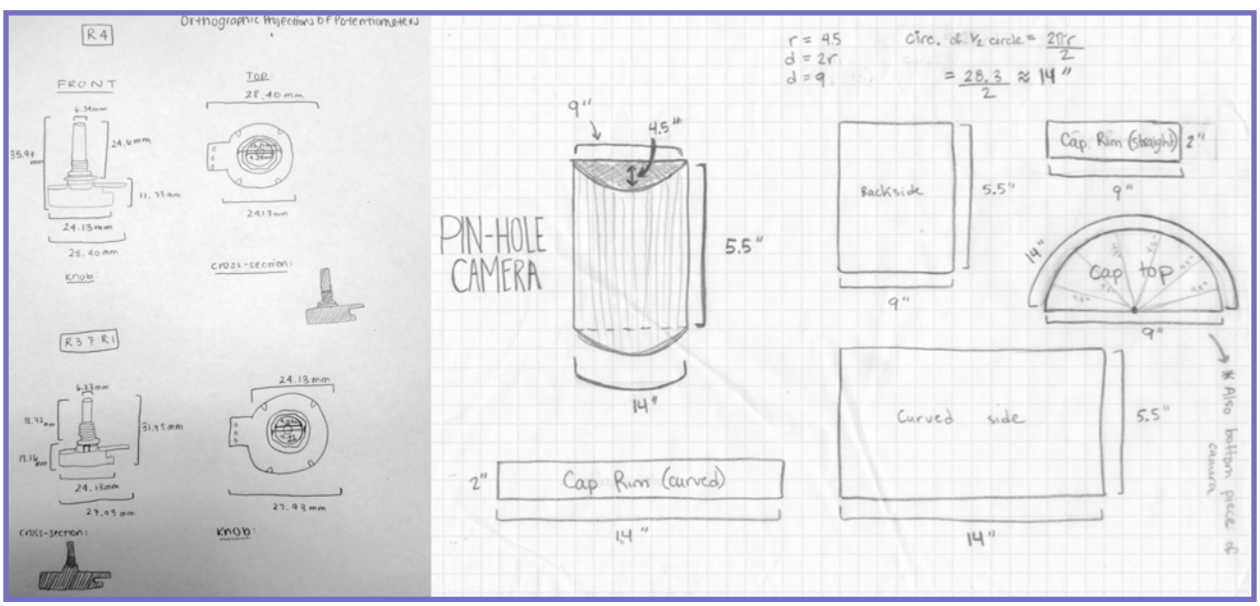
Drawing is like writing, using pictures instead of words. It is a form of communication that can be useful, expressive, descriptive and observational. It provides form to visual ideas. Including drawing as part of the process of making things is fun and provides a good framework for understanding two dimensional (2D) and three dimensional (3D) design.



This is a list of drawing approaches that are used most in the Engineering and Design lab.

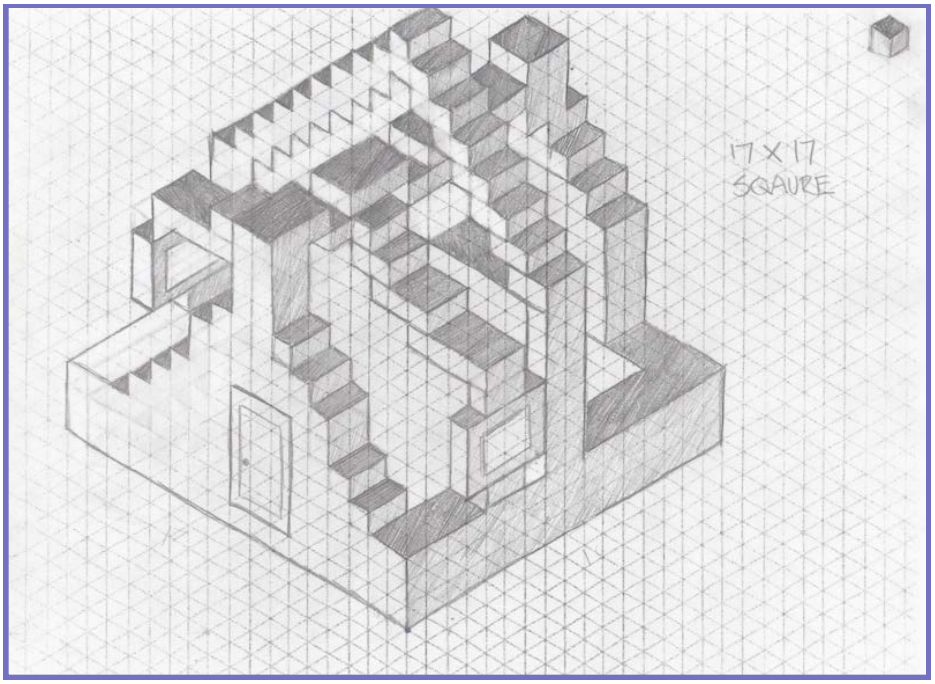
Orthographic projection

Orthographic projection presents multiple 2D views of a 3D object. It's used in [architecture](#) and [engineering](#). Critical information could include measurements. This type of drawing is an excellent exercise leading up to [3D modeling](#). It provides a framework for students to understand how to work around a three dimensional object.



Isometric projection

Isometric projection is artificial 3D representation using x,y,z axis and 120 degree angles to produce a 2D picture that looks 3D. It's great for communicating 3D ideas quickly and an excellent precursor to linear perspective. The artist MC Escher used it in optical illusions. Check out how it can depict impossible objects.



Building plans

Building plans can include all of the above. Think LEGO instructions or Ikea furniture.

Mind map

This is a great way to express ideas in graphical form.

Arduino Mind Map project. Use a mind map to brainstorm all the possible projects and inventions to build using an Arduino.

Descriptive drawing

This kind of drawing is very useful as a record of your observations. Think Lewis and Clark journey log or Albertus Seba's Cabinet of Natural Curiosities. Annotate with notes for even more detail. Great for sketchbook or journal entry.

Schematics

Drawings of systems using symbols. Think subway map or circuit diagram.

The stuff to make drawings

A lot of the drawing that happens in the lab is preparatory work for 2D and 3D design for fabrication. Precision matters here so students need access to good measuring and drafting tools.

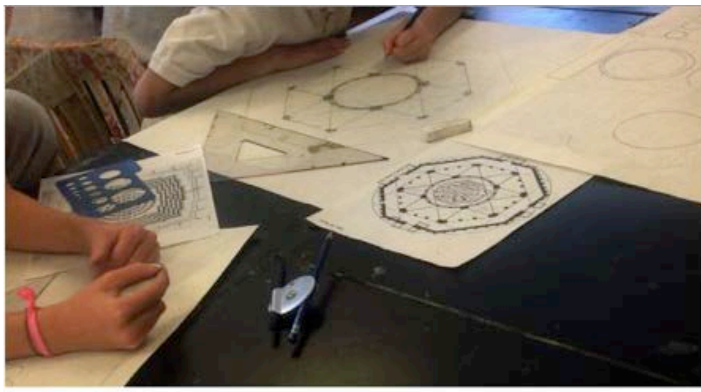
- Calipers
- Tape measures
- Different types of rulers (clear, cork bottom, various sizes)
- T-squares
- 45/90 and 30/60 Triangles
- Compasses
- Drawing paper
- Different types of graph paper (cartesian, dot, isometric)
- Graphite and colored pencils
- Sharpies
- Grey graphic pens
- Brush markers
- Industrial pencil sharpener

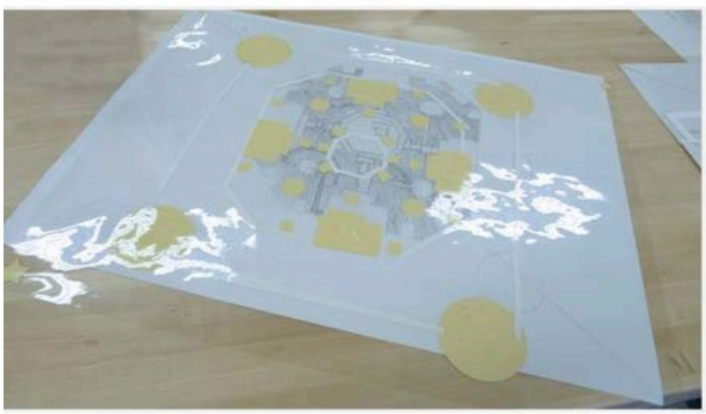
More thoughts on drawing....

A maker with a literacy in drawing can feel confident about representing their ideas visually. Whether they are communicating an idea for self-expression or for a technical end, these drawing methods can work together and provide a powerful tool for bringing the ideas of one's imagination into the world. There are many more types of drawing than what I have listed here and ultimately we develop hybrid styles that best reflect what we are trying to communicate.

Cyanotype Blueprints
by Erin Riley

Experience: Intermediate
Age Group: 10-14
Group Size: 12-18
Hours: 8 days - 40 minutes periods






Overview

This project was designed for sixth grade students at Greenwich Academy to bring together ideas from history, art, science and technology. History classes study world religions and do research on significant buildings within religious traditions. In art they made drawings from architectural plans of the historic building using compasses, straight edges and triangles. On acetate they used tape and shapes they generated on 2D vector software on the vinyl cutter in the Engineering and Design Lab. The final step in the art process was to produce blueprints of their buildings the old fashioned way...Cyanotype solution A+B and 20 minutes of winter sun!

Leading up to the project

The lead up included a joint art project with art and technology helping the students gain an understanding of 2D design space and vector drawing, an essential lab skill for digital fabrication. Students created geometric collage designs that they translated into vector designs using the pen tool in Adobe Illustrator. These were made into linoleum block prints in art class.

Student vector drawing and linoleum block prints

Big learning goals

To learn through history, art, science and technology. Explore the science and art of sacred geometry and cyanotype blueprint techniques. Use graphic tools and drawing to create blueprints. Use 2D and 3D design for fabrication.

The sequence in Studio Art and the Engineering and Design Lab

1. **Graphic tools-exploration of making shapes.** Students spent one class period exploring making shapes in their sketchbooks with graphic tools like triangles, compasses and rulers.
2. **Creating a floor plan.** The structures they researched in history become a springboard for a newly interpreted floorplan in graphite. Art students were encouraged to pull out the shapes and profiles that were most appealing visually to create a design.
3. **Masking:** In the cyanotype process a mask is created to block out the sun. The students designed vector shapes that they cut out on the vinyl cutter combined with tape to create a mask design.
4. **Cyanotype:** Students mixed up the cyanotype chemicals, treated paper,exposed their designs to the sun. The final step was to rinse and dry the prints.

What followed

The cyanotype blueprints provided a framework for students understanding of basic CAD drawing principles of 2D - 3D through the representation of the floorplan. In Sketchup they built the footprint of their designs and used the Push/Pull tool to create their 3D models.

Where is the line? Telegraph Construction with Specific Instructions

by Heather Allen Pang

Reflection Before the Lesson

Every teacher in every classroom contemplating a project plan faces the question of how much guidance, how many constraints and how much help to give students. I have been thinking about this problem in particular for history projects where the content is specific, for example the invention of the telegraph and the beginning of the revolution in communication and technology that brought us to take cell phones for granted. I have also been thinking about this question in terms of the larger movement, and the role of kits in teaching and learning.

One way to think about this is skill building. I have no problem teaching a specific skill, such as soldering, or correct formatting of a bibliography, with very specific teacher instructions. These tasks are ones that students are going to do many times, and learning to do them the right way and practicing that is not a moment for individual exploration. If everyone solders in their own unique way people get hurt and connections do not get made. If everyone formats their bibliography in their own unique way then it is not, really a bibliography, and students do not get to participate in the scholarship of history.

At the other end of the spectrum, even if I am specifying some part of the content, there are times when I want students to have pretty free range about what they do, how they show that they have mastered some subject or task, and the only constraints I might have to put on that kind of project is time and materials. Students can design any kind of monument they think represents the woman they pick, they may write any type of reflection (poetry, prose, fiction, nonfiction) in response to their reading of a historical novel, and when they pick a 19th century technology to explain to the class they can do whatever they think will help their classmates understand.

Most projects, however, are not that simple. So back to the telegraph. I spent some time at Constructing Modern Knowledge summer institute (CMK) during the summer of 2014 summer learning to build one. And it worked, sort of, if you were not too picky about being able to distinguish between dots and dashes. (Dots were good, but when you held it down a bit longer it tended to get stuck, so the dash never ended.) I am planning on having students, in pairs, build telegraphs that will allow them to send their dots and dashes at least from one end of the classroom to the other, and maybe farther. When I did it, the biggest challenge was finding the right parts. Some of that was being at a hotel in Manchester. While CMK has an amazing amount of stuff, there was nothing wood that would make a strong base, so I found myself at CVS buying a picture frame, and then back at CMK cutting it up with a Dremel tool. I have no problem saving my students from that part of the task by pre-cutting the bases on the laser cutter. That is a good use of my time and a very bad use of their time.

But then things get tricky. If all they do is put together what I have assembled following my instructions, then that inhibits their learning. If I hand them a base and tell them to go searching the internet for instructions on how to make a telegraph and then have them searching all over school for the right kinds of metals (need to be magnetic) nails, (iron) wire (right gauge, covered, etc), then how much of that learning is about the technology and how much is about bothering the maintenance staff and running around getting frustrated?

After spending a bit of time worrying about this, I decided that I would start someplace in the middle, and try it this year, and then ask the students what they learned, what they liked, and what might make the lesson better. I will provide the supplies, but not sort them out into kits, and links to basic instructions, a brief framework for discussion of the historical circumstances of the invention as it happened in the 19th century. Students will take it from there.

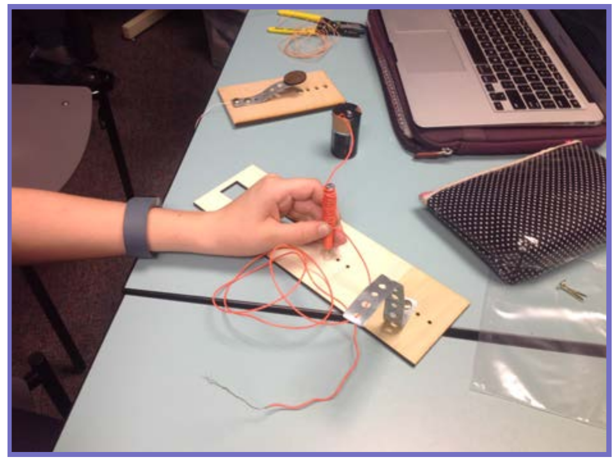
After the lesson

I started with a design meeting with Angi Chau, our lab director and Diego Fonstad, our tinkerer in residence (yes, I know, it is so cool that I work at a school that has both of these people, and I know I am super lucky), and tried a few variations. We settled on a base for the key, a base for the receiver, and the different types of wire we would have the students use. We cut the base parts out of wood on the laser cutter to make things go more quickly. Diego figured out how easily we could have the students put things together if we used metal brads. Angi wrote out some instructions, and we shared those with the students.

I put the girls in pairs, showed them the supplies, and told them to follow the instructions. I added a rule they already know: before they ask me a question they have to show me where on the instructions document they are. Most of their questions can be answered by figuring out where on the instructions they are.

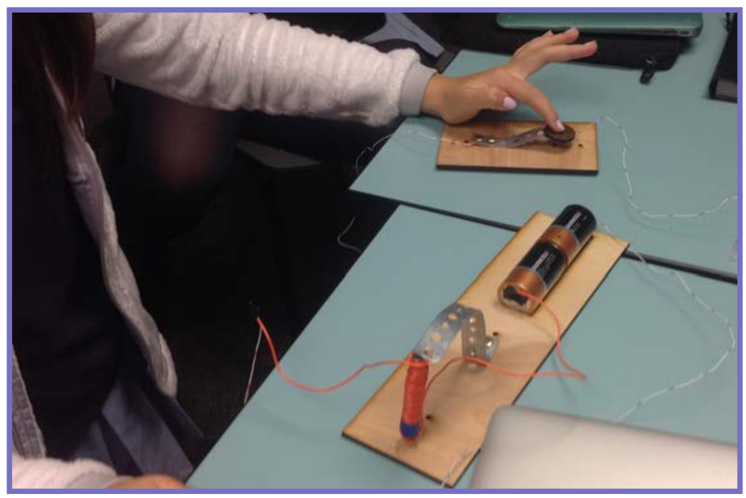
We were trying to use up some wire we had in the lab, so the first thing they had to do was untwist it. That was both fun and frustrating. Some girls were much better at it than others.

Some observations:



- Wire strippers are hard to use. A student who is rarely an expert in history turned out to be a pro at stripping wire.
- It was not clear to all students that the connections had to be metal touching metal for the telegraph to work.
- Following instructions is not easy.

At the end of the first 50 minute period I got a great statement from a student. *"Mrs. Pang, this project is fun! It is really hard, but it is fun."* (I wish I had that on video.)



"It works!"

Most students finished the basic instructions early on day two, but then they had to start trouble shooting, since very few of the telegraphs worked on the first try.

I don't know if we struck exactly the right balance on instructions vs. exploration. The lesson did achieve several of my goals. The students created a working telegraph machine, and demonstrated their understanding of the basics of how the 19th century version worked. They had the chance to trouble shoot their own creation, and I gave almost no help, other than to remind them to check the connections and keep trying. Our conversation about invention, the role of instant communication in the 19th and 20th centuries, and how much we take it for granted was rich and thoughtful.

The student reflections highlighted the importance of checking the connections, how hard it is to untangle wire, and how wire strippers work. These lessons are not part of the history curriculum, but they are certainly part of life's curriculum.

8th Graders Design Monuments to Historic Figures

by Heather Allen Pang

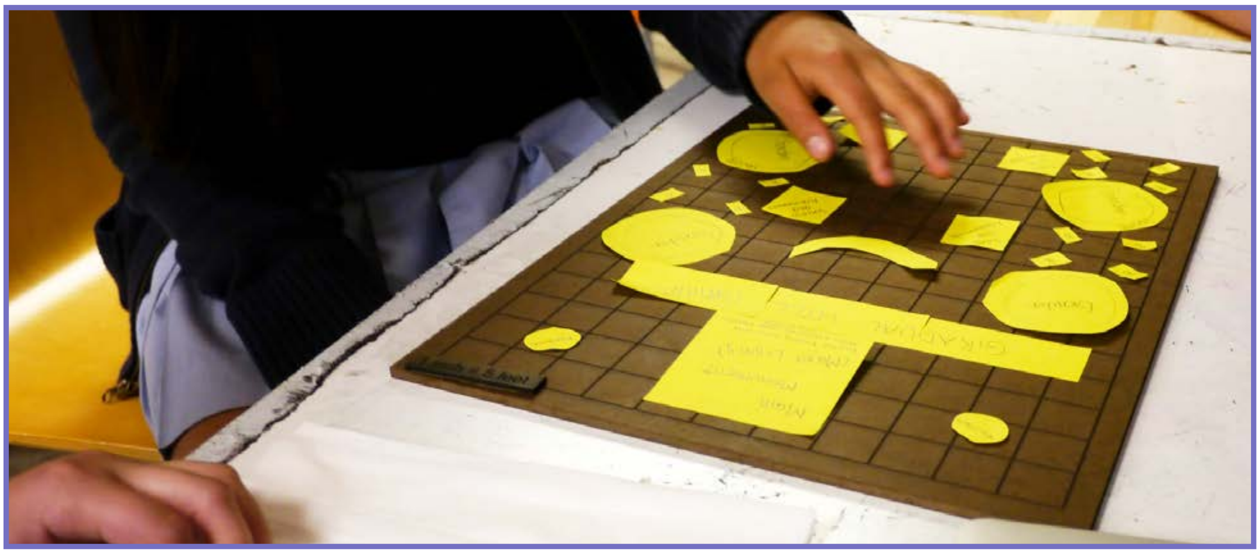
For several years, I have ended 8th grade history with a project that brings together two themes we have looked at through the year: individuals who make a difference and historical monuments. The students have finished their research and class presentations on the 1950s, 1960s, 1970s, and 1980s. The pick one of the important women, or women's issues, from their group research projects and design and build a model of a monument they would like to see to that person on the National Mall in Washington DC. I only grade the presentation of that monument to the class. The students needed to be able to explain how the parts of the monument would make a visitor feel and learn, how the monument reflected the life and values of the person, and how their design and building process had worked.

These presentations, on the last day of school, are a fantastic way to hear from the students, and they enjoy the chance to show off their work. We don't do a peer critique at that point, because the year is over; they couldn't change anything.

I ask them to pick their subject from the work they had already done on women in the 20th century; I tell them to think big, but keep in mind that they would have to figure out how to build it. They have two weeks in the lab to design and build the models.

When I designed the project I had two goals. The first was to create an engaging, thoughtful, and challenging project to end the year thinking about important themes from their studies. The second was to stretch students to think more critically about using history as they had to become the active designers of historical works, rather than as consumers of other people's created histories. This project achieved those goals. It also presented some new challenges for me and the preparations I need to make for the students to engage in this type of historical practice. We also have a great deal of fun.

I was asked by a prospective parent who came into the lab while we were working, why would you take so much time from "real history" to build things. The question is an important one, and I described some of my observations to the visitor. Students were debating the merits of representing historical events literally or metaphorically. They had long discussions about the need to include negative information in a monument for historical accuracy. They discussed the need to present their subject as a hero, a role model without flaws. They had delved deeply into their historical knowledge to find ways to show a modern visitor the historical realities of the lives of their subjects. I had seen more "real" historical thinking in the project up to that point than even I had expected.



The Monuments project brings together several threads from the 8th grade year, including the ways we memorialize history, the importance of women in American history, and the ways in which students are themselves practicing historians, not just consumers of information. The students used the tools in the Fab Lab at school to realize their designs, primarily the laser cutter, the foam cutter, and the 3D printer.

This project requires students to think about what important aspects of their subject they want to show in the monument, how literal or symbolic they want their monument to be, and how to design the best user experience. It also requires them to do a great deal of math to get the proportions and scale right. All group projects require collaboration, but one of the benefits of building something physical turns out that it is much harder for a student to hide and let her classmates do all the work. It also requires a different kind of collaboration because no one is sure of the "right" thing to do.

After the students had successfully presented the projects to the class, we talked about the challenges of the project. Some of these challenges are the same in any group project, time management, delegation of work to group members, and resolving differences of opinion about creative or technical issues. But they also talked about challenges that only came from actually building their monument models, or that came out very differently because of the making process.

First they talked about skills: they had to learn new software and improve their skills on the machines in the lab, which are important challenges in their learning process. These challenges brought out leadership in some students in ways that they would not have done in other settings. They also talked about the interdisciplinary nature of the project, not the way teachers sometimes do, fitting one subject into another because it is a current trend, but authentically, because they could not possibly build what they imagined without using math. They talked about working out issues of scale and understanding how people would react to their presentation of historical material in physical and symbolic ways. The students also talked about how to take an idea, for example, *"what if we had lights on our fountain?"* through the process of design and creation.

Other students described the benefits of doing a new type of project. They said (I am paraphrasing), we really had to think through what an architect thinks about, for example thinking about a fountain going down into the ground and not at ground level, and how we would build that. We had to think about constraints, for example, we can't just put up a facade and need to think about struts for supporting the façade, and how that might work for someone visiting the monument. My favorite comment: "Something that's unexpected during building can actually work out!"

Bringing fabrication tools into the history class opens up ideas about the role of making in all academic subjects. When students experience history through the process of fabrication they become the historians and they have to come to a deeper understanding of their subject. This opens up a wider variety of project based learning for social studies and humanities classes, and brings students and teachers more options for creativity and deeper investigation of core academic topics and skills.

This project also reflects an ongoing and evolving interdisciplinary collaboration between me, Yvette Yamagata, the Algebra teacher, and Angi Chau in the fab lab.

Each year I have increased the collaboration with math. We noticed the scale issues, and the students did too, so now I work with the math teacher and she designs some indirect measurement activities to support the project. When we go to monuments in DC they do indirect measurements, record their data in their journals, and we will save that material for the spring project. We will also have them record their reactions to different monuments in terms of the scale, structure, and style of the places they visit. They have already done a sample activity measuring buildings on campus. The idea came from some of the students last year, who figured out that if they wanted to know how a 30 foot tall monument would look, they needed to find something that was 30 feet tall and stand next to it. They started out measuring the lab itself to compare, but I like the idea of building that measurement process into the curriculum, and so does the math teacher. In addition, the math teacher has come down to the lab while they are working and observed them doing the scaling and she intervenes in their discussions, or pushes their thinking a bit further. They have been creative about how they tried to imagine scale, and we don't want to interrupt that process, but we do want them to apply skills they have learned in other places.

The collaboration with Angi in the fab lab has been a huge part of the project. I developed it with Diego, and refined it the next year with Angi. The girls get more comfortable asking for help, and working together with another expert adult in the room, and that allows for greater creativity. Students who want to go further with one of the tools can do so, since sometimes Angi is able to spend significant time with one group, working on some technical challenge; that would not be possible without two people in the lab at least some of the time.

Bringing the history class down to the lab to build monuments is one more tool we can use to expand what we think of as history instruction, and introduce students to how history work happens in our culture. After building their own monument prototypes, students are more likely to think critically about historical monuments they see, and they are more likely to feel that they have the ability to present historical material in creative ways. Doing history in the lab fosters making, and making in the lab makes them better historians.

Silhouettes – Old and New Technology of Portraits

by Heather Allen Pang

In August, while I was thinking about for a simpler laser cut project to teach Inkscape and the laser cutter in my 8th grade history class this year, I happened upon two things at about the same time. One was a blog post by Sylvia Martinez about starting the year with making (http://sylviamartinez.com/back-to-school-start/) and the other was the image of a page of silhouettes of the family of John Quincy Adams (yes, the one who became president). So I decided to start with the students themselves, using new tools to create an old-fashioned silhouette or profile.

John Quincy Adams silhouette image is from the Massachusetts Historical

The process starts with a backlit photo (taken in a dark room against a light curtain, I taped paper on the window in my classroom). The photo needs to be edited it in the basic iPad editing software to make it a black and white image against an even lighter background. This introduced the students to the photo editing tools they all had on their devices, but many had never explored.

Importing the photo into Inkscape, using the paint bucket tool to fill the shape of the head, and deleting the fill leaving only the stroke line creates a clear vector line for the laser cutter.

Completed student profiles hanging in the classroom

The students enjoyed creating their profiles, even as they expressed some frustration with the tools (Inkscape is sometimes difficult to download and install on a Mac, and if the image is not dark enough the shape is not clear, but these challenges allowed for some useful discussion about how to figure out what had gone wrong, and how to troubleshoot our technology and our projects). They learned several of the editing tools in Inkscape, and they will be well prepared to do more complicated projects using the software later in the year. These are all things I expected to come out of the project.

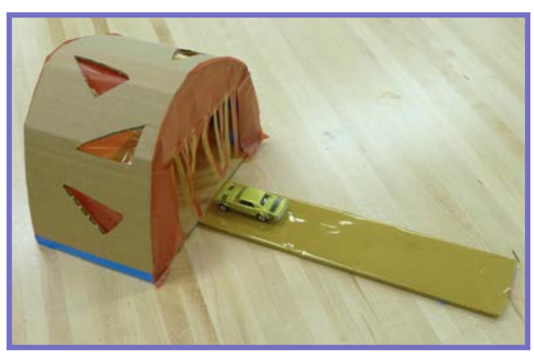
What I was not so sure about was how well they would see the historical issues involved, but I should not have worried. I showed them the John Adams profiles and several other late 18^{th} and early 19^{th} century examples, and then we talked about what it cost to have a profile cut (25 cents for two copies in 1808, according to one source I found), and why these images were so popular. They could clearly see how important it would be to families to have an image of a loved one, especially if part of the family were moving away, or going to war. They talked about how many photos we have today, and how different it would be not to have those images to look at. We also talked about when photography was invented, and when it became available to ordinary people. In the course of a short discussion we covered economics, settlement patterns, and the human desire to have images of ourselves. Not bad for a simple laser cut project.

I hung the silhouettes on the wall of the classroom, and the students had fun recognizing themselves and their friends. At back-to-school night the parents loved seeing their own children, and I had to laugh at the sight of them using their smart phones to take photos of the silhouettes, somehow bringing the idea full circle, and proving the point that today we cannot possibly have enough images of ourselves or our children.

Story Architects: Reflection on an Integrated Project
by Erin Riley

Sarah Holzschuh's English XII class, New York State of Mind, worked in the Design and Engineering lab on a two-week interdisciplinary project bringing together the concepts explored in literature and translating these ideas into the visual language of architecture. Students selected one of six texts they had studied throughout the year, and over the course of several class periods, worked to construct a building model based on the themes, character trajectories, or the experience of reading the work they'd chosen. Inspiration for the collaboration came from a project between Creative Writing and Architecture graduate students at Columbia University. You can learn more about the project here: [Writers as Architects, NY Times](), August 3, 2013.

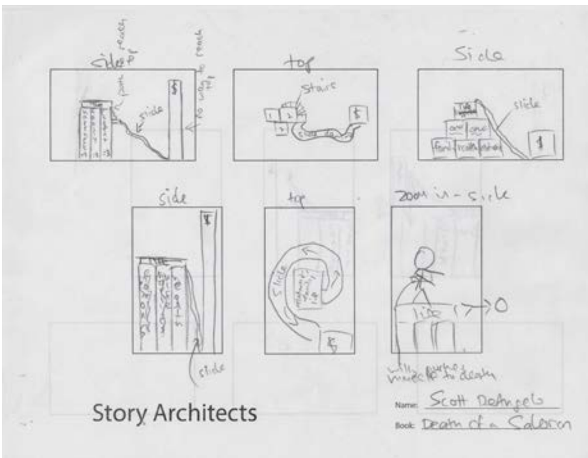
Day 1 — Design challenge and exploration of materials

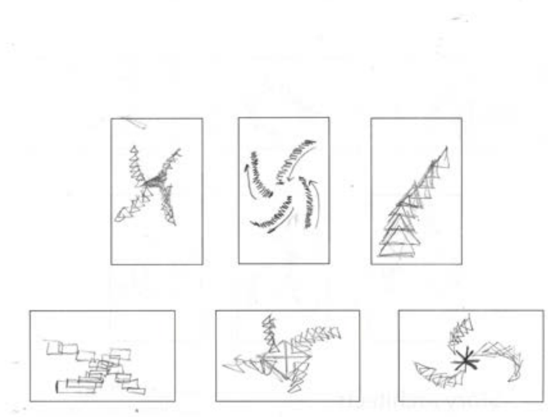


Before being introduced to the project, students were given a one day design challenge to create a carport for a toy car. This activity was specifically designed to get the students thinking about scale and the nature of the materials they were using from both an engineering and aesthetic perspective. This challenge also offered them time for exploration and reflection within the group. The solutions were varied and the students were inspired by the wide range of visual and structural possibilities with cardboard, tape and translucent materials.

Day 2 — Book selection and thumbnails

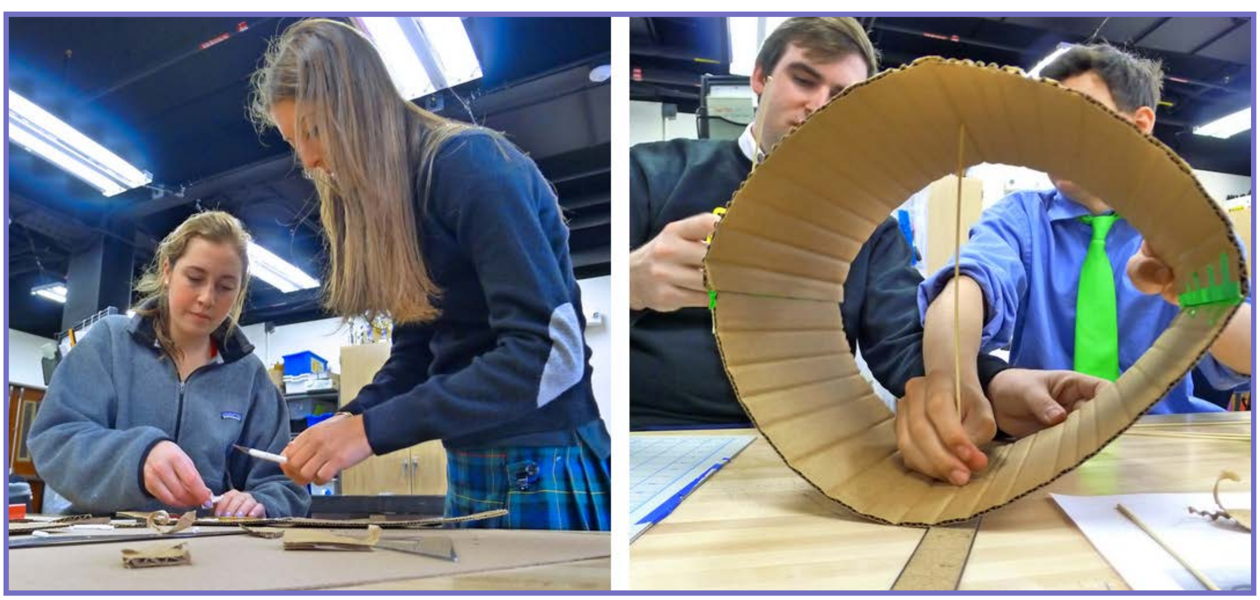
After being introduced to the Story Architects concept, English students took time for written exploration, reflecting on a series of questions designed to get them thinking about literary concepts in structural terms. Each student then created a series of thumbnails, quickly sketching visual ideas from the book they had chosen. Many students moved on to a more detailed thumbnail in preparation for building.





Days 3 through 5 — Building

Each class had three days to build their structures. Guidelines were loose; they were given an 8 x 8 inch laser cut platform to build the structure and could expand the air space to fit within a 10 x 10 envelope. Their only other limitation was a designated collection of building materials, including cardboard, wooden dowels, and transparent and translucent paper. The class was familiar with the materials having used them in their one-day carport challenge.



City Planning

Students put forth proposals for how to organize the structures for the final exhibition. They ultimately decided on a grouping of structures into 'neighborhoods' organized by book. The pockets were engraved on the ShopBot and students installed the work in the gallery and reflected on the process.

View: Luchsender Gallery

Design Explanations

Student writer/architects explained their process and design choices. Here's one:

by Kate S.

> *At its core Colum McCann's Let the Great World Spin is a book about hope. While the immediately apparent themes in the novel seem to be hardship, loss, filth and destitution, there are continually moments in which the characters find happiness and light in the midst of all the darkness. My architectural piece is an attempt to emphasize the importance and centrality of the character's search for something beautiful in their lives. At the base of the structure there and many short buildings of various heights, seemingly oppressed by three taller buildings in the center. Some of the small buildings are broken, missing large pieces from their sides, whereas some are even collapsing onto each other. None of these buildings have roofs for coverage and protection. These structures are symbolic of the difficult situations that many of the characters find themselves in during the novel. The most important part of the piece however is the beams that connect these buildings to each other, as well as to the increasingly taller buildings in the center. These beams*

symbolize the ability of anyone to move away from the darkness and find moments of joy or happiness in their lives. The rising beams represent the characters ability to "rise" up from their situation and find beauty in their lives, if even for a short time. The beams also reflect Phillipe Petit's tightrope walk between the Twin Towers, which is a recurrent theme in the novel. I think that Petit's tightrope walk is so central to this book because most of the characters find themselves in horrible situations that they cannot control, whereas Petit places himself in a dangerous situation by choice and ultimately makes something beautiful out of it instead of focusing on the danger or potential outcome of his endeavors.

The three taller buildings in the center of the piece represent the happiness and light that the characters can find in their lives if they simply look for it. The area higher up is less crowded, and the buildings are covered by roofs which represents a safer and more protected place. In this piece my goal was to create a structure that would reflect the hope in this novel, and focus on the search for occasional happiness instead of oppression by constant sadness.

Reflection

Sarah Holzschuh and I have plans to continue to develop and improve Story Architects for the Spring of 2015. Our goal as facilitators of this project is to enrich students experience as learners. We hope that their understanding of literature is enhanced by the opportunity to express ideas through making and designing an artifact that has personal meaning to them. Built into this experience were design and structural challenges that students solved with limited resources and time.

The project itself is a prototype and the collaboration we have forged is the start of what we hope will continue to grow with our students. This group is a particularly interesting one to study as the bookend of a collaboration. Not only is it the final year at Greenwich Academy, but students of this class (2014) contained some of the original members from the inaugural year of our Middle School FLL Robotics team. Since then, STEAM education and curricular integration of “making”, engineering and design into every girl’s experience at the school has gained institutional support. Through the course of their education, all of our students will continue to get a rich experiences with the visual arts, woodworking, computer programming, physical computing, electronics, 2D and 3D digital design and fabrication and the engineering design process. This project will undoubtedly evolve as students will be able to draw upon more tools and experiences in the Engineering and Design Lab, in their time at Greenwich Academy.

Story Architects 2.0

Sarah and I collaborated on a second version of Story Architects in the Spring of 2015. The concept of mapping was introduced and a large scale map was printed and installed in the gallery. Students identified a location for their structure using map pins and string. Material choices expanded with the second iteration of the project, and the variety of design ideas was evident.

The Techie Ugly Christmas Sweater Project
by Mark Schreiber

Ugly sweaters seem to be pretty hip these days.

Wal-Mart sells them, Target sells them. There's even a shop in my town where you can "uglify" your very own Christmas sweater. And yes, we have an ugly sweater contest at our school (that I plan on winning by the way). Last year I made a pretty nifty one and this year I made final unit out of this idea. Yep, my advanced engineering class is pushing toward the completion of some pretty sophisticated ugly sweaters. Some blink, some play music, some might even look like the Grizwolds house. One has car horns on it and yet another, a Christmas trivia tree!

One might ask, *"Why would you do such a project?"* and I might answer with a Christmas quote like, *"Bah humbug!"* I mean do you all know that, "*The best way to spread Christmas cheer, is signing loud for all to hear."*?

The truth is that this has been an amazing project. Students, driven by the desire to create something amazing, have learned a ton. MaKey MaKey, Soundplant, Scratch programming, more Arduino lines of code than I can count, flashy LED, e-textiles, laser cutting, soldering, I could go on and on. The room is abuzz with excitement - the warm smells of gingerbread being cut on the laser cutter fill the air. Kids helping each other, sound bites of various Christmas music and movie clips playing in the background, and students helping each other troubleshoot their projects.

All I can say is that well… it's a wonderful life, really wonderful.

So, how can you create your own interactive techno ugly Christmas sweater? Well, here are my recommendations for a simple but effective techno sweater. (Part 2 will show you how to make it even more like the Griswold's but let's start with the basics.)

- Get a really ugly sweater
- Get a laptop that you can carry with you (if you want to go completely mobile).

- Get a MaKey MaKey and some conductive ornaments, or other conductive bling for your sweater.
- Download Soundplant or use Scratch to map keyboard keys to soundclips, songs and such. (See resource section below.)
- Layout your sweater and glue down conductive elements to the front.
- Turn your sweater inside out and mount your MaKey MaKey to the inside, run wires to each conductive element on the front of your sweater. -Just duct tape them to the inside since this is probably temporary.
- Link your favorite audio clips or songs to the A, S, D, F, W, SPACE, and arrow keys in SoundPlant or on Scratch.
- Connect yourself to the MaKey MaKey ground (I used a gator clip running down my sleeve to my wedding ring but you could also connect to a metal bracelet, watch, etc.)
- Test your sweater. It should play clips or music when you touch your various conductive elements on the sweater!
- Go mobile! Just make sure your computer doesn't go to sleep when the lid is shut, keep it attached to the MaKey MaKey with SoundPlant or Scratch open and then put it in a Christmas gift bag. Run the USB cord up inside your sweater, add some gift tissue around the top and you are ready to go.
- Have a fun time!
- If you want to add twinkle, try adding some LEDs, or some blinky LEDs with a LilyPad or Gemma. Cotton balls make nice snow and diffuse the light very well while hiding your LEDs a bit.
- Look at my next blog post on how to make your sweater beat the Griswold's house with your Arduino timed light display! Oh ya, it's going to be fun!

RESOURCE LINKS

- MaKey MaKey plus Soundplant - This combo is the one-two punch of an awesome interactive ugly sweater. If you really want to go crazy, put in 2 MaKey MaKeys (just have to reprogram the keyboard map on one of them).
  http://soundplant.org/
  http://www.makeymakey.com/
- If you are using a Mac you might want to download NoSleep too. This way you can close the Mac, and still have it run Soundplant.
- Add some basic twinkle - check out Adafruit's Gemma or SparkFun's LilyPads.

- The Adafruit sequin hat will get you a nice start.
- Or SparkFun has preprogramed Tiny Lilypad that can add some dazzle in minutes.
- Want a working fireplace? Download the Digital Dudz app for multiple Christmas sweater movies that can play on your phone.

Ugly Sweater Part 2

Let me let you in on a little secret... that ugly sweater from the Part 1 guide was my sweater from last year. Yup, that right. I've had a year to refine, learn and hack a new sweater. And I have to say that I'm pretty proud of this little project. And, I want you to be able to make one as well!

Here is the executive summary of the project along with a video of my upgraded (read "awesome") ugly sweater. The core of this project is a cool sequencer called Vixen, an AdaFruit Flora (with a FastLED library), and a bunch of NeoPixel stips (or other digitally addressable RGB LEDs) Grab a gift bag, load your laptop, some speakers and tissue paper - you are set!

The Theme

What says, "2014" more than the Frozen soundtrack? I wanted to make my sweater the epic ugly Christmas sweater for 2014 and when I found this rendition of Frozen I knew I had the makings of a winning sweater. I used the free version of WavePad to edit the song to a shorter length. I loaded the code on my Flora so that it could receive serial communications from Vixen, set up the NeoPixel elements for the different zones of my sweater and then imported the song into Vixen (see the full tutorial below).

You'll have to let me know but I think I might have even beat the Griswolds this year. I'm thinking that I should go stand on my street corner and broadcast my own house light display channel. Dancing sign guy, prepare to be bested!

Check out the video: https://www.youtube.com/watch?v=f09do0DjQAY

Follow the steps and have a great ugly sweater party of your own. And hey, "Do you wanna build a snowman" on your sweater? Well, that will just have to wait for another blog post..

Here's the step-by-step

- Collect your parts - Flora, Neopixels, wire, cotton balls, laser cut snowflakes, ugly sweater bling.
- Download and install software - Adafruit's Arduino IDE, FAST LED library, and Vixen (see resources below)
- Upload sketch to Flora (remember USBTinyISP programmer, and remember you COM port too)
- Close out of your Arduino IDE
- Configure Vixen for Generic serial port using the same COM port as your Flora was using. (see blog link below)
- Setup Vixen Displays - I suggest breaking your full strand of NeoPixels into small sections/ segments so that you can do different effects on each segment. I used about 80 pixels on my sweater with 8 different segments (also called elements in Vixen).
- Connect your NeoPixels to Pin6, Ground and VBatt on the Flora (make sure you put a 330ohm resistor on the data pin of your first pixel so you don't blow that pixel and kill your whole setup!).
- Close Vixen and the Flora.
- Turn on your devices in this order: Plug in the Flora connected to the Neopixels (you should see a green light and yellow RX LED on the Flora flash.
- Open Vixen (you should now see a solid yellow light on Flora if all is configured correctly if not, make sure that your display is set up to receive the same COM port as your Flora is using)
- Open a "New Sequence- Timed sequence" in Vixen.
- Drag an effect to the pixel segment you'd like to test and click the "play" arrow (green play button). I like to use the "chase" effect to test out the whole strip at once.
- Build your sweater: cut strip into segments, run wires, and resolder to chain your strip segments all the way around your sweater to different locations (I started at the bottom left, then up the zipper, around the collar, down the right zipper, to the bottom, up to the left middle, left pocket and finally around the back to the right pocket.) You can power pixels from anywhere the beginning, the middle or the end (or all of them) just make sure your data pin wire is 1 continuous strip)
- Test it again. Once your strips are installed on your sweater check all connections and retest.

- Take a break.
- Spend way too long syncing music to your lights in Vixen audio track. Click here for my synced version of the Frozen remix.
- Decorate and camouflage your LEDs with cotton balls, or laser cut felt, or other fun stuff.
- Tweak, troubleshoot, and repeat.
- Hook it all up to your computer, hide your computer in a gift bag, put on your sweater (or vest) and head out to your Ugly Sweater Christmas party.
- Enjoy, have fun and remember, *"The best way to spread Christmas cheer, is signing loudly for all to hear"*

ADVANCED RESOURCES

- Vixen and Arduino - This website has the perfect "how to" to get some RGB LEDs strips up and running with Vixen. I've uploaded the code to Adafruit's Flora E-textile board and it runs just fine. Just make sure you have the FAST LED library installed and you should be great! http://blog.huntgang.com/2014/11/08/vixen-lights-3-x-arduino-pixel-controller-ws2812b/
- Vixen - (only available for Windows but I run it under a virtual on Mac just fine too) http://www.vixenlights.com/
- AdaFruit Flora - You can use an Arduino Uno but I wanted to go mobile so I choose the Flora for some mobile horsepower. https://learn.adafruit.com/getting-started-with-flora/overview
- WavePad Sound Editor - Just a nice little slim sound editing tool. Make sure you get the free trial version and watch out for that pesky Ask toolbar checkbox too! http://www.nch.com.au/wavepad/
- Hip Frozen Remix – Thanks Mr. Fallen Super Hero for the awesome groove. It really makes for a great lightshow. You can find it on SoundCloud. Every time I hear it I just want to dance. https://soundcloud.com/fallensuperhero/frozen-let-it-go-fallen

The Molds of Civilization

by Gilson Domingues and Pietro Domingues

This article will introduce the molding process, including utility and the current methods used in this process. We will explain step-by-step how it is possible to make these molds and how to use the molding process in many types of materials.

Reproduction by molding

It would be very interesting to think about something and it appears magically!

However, according to the laws of physics, it's easier to make things messy instead of getting some well defined shape. Actually, shaping something is fun, even if it takes a long time. When we want to make one single part, we can spend hours and hours, and it might even be pleasant to work on it. But what if we want to reproduce a lot of something, keeping the same quality without having to craft every one with the same care? This is a challenge that the mankind has been facing for a long time.

(Photo: http://www.manutencaoesuprimentos.com.br/conteudo/4372-quais-sao-os-diferentes-metodos-para-a-fabricacao-de-tijolos/)

To solve this problem, we can use molds! There's a very simple way to make mudbricks using molds.

The process allows us to put a pliable or liquid material (such as liquids) in a cavity called mold, and after being transformed, we obtain a solid part.

An everyday example is the ice cube: it's made putting the liquid water into the ice cube tray, and after some minutes, it turns into solid in a cubic form. Chocolate truffles are made this way also. This transformation is the main idea of metallurgy since the beginning of civilization.

The photographs above are examples of molding where liquid metals are cast into rock molds.

(Photo: http://magodafloresta.blogspot.com.br/p/obra-do-gamarra.html)

Since antiquity, mankind has been making products based on the molding process. Jewelry, weapons, domestic utensils, tools, etc. were already made this way.

Currently, big industries as well little communities and artisans still make products through molding and casting.

If we pay attention carefully, we will see that many objects of our everyday life are made by molding. As an exercise, identify 5 objects made through this process. Try to find out how each object was manufactured and projected. Taking a look on everyday objects, you will see that this process allowed engineering and design to develop new technologies over history.




Museum of Anatolian Civilizations – Ankara, Turkey. Photos by Gilson Domingues

How to Make Silicone Molds
by Gilson Domingues and Pietro Domingues

Silicone molds are excellent because they can be used to make objects with complex geometry at a low cost.

In this article, we will see how to make a silicone mold.

Materials:

- Liquid silicone + catalyst
- A container to mix up the silicone
- A stick
- Another container, if necessary, to retain the silicone with the original workpiece
- Original workpiece (Any kind of object to reproduce, the workpiece can be some 3D printed part, or a sculpture, etc.)

There are two kinds of Silicone:

On the right side of the image we can see the white silicone. It's made to mold materials at room temperature, while the brown silicone, on the left, is made for high melting temperature materials.

Silicone comes from the factory in liquid state, and it is sold in small containers (1L or ¼ gallon).

The two workpieces on the left are produced by melting them at high temperatures in the brown silicone mold. The white one is Paraffin wax and the other is Tin.

The next four workpieces are made of Plaster of Paris (the white one) and resin (the other three). These were made at room temperature in the while silicone mold.

Before putting into the small container, it is recommended to stir with a stick to ensure the homogeneity. Next, drop the catalyst (the right amount is usually indicated on the manual) in the small container. Stir the mix completely for the recommended time.

Next, place the workpiece you want to reproduce in a container and pour the liquid inside. Fill so the workpiece is completely covered.

It may take about 30 minutes to many hours for the silicone to cure (it depends on the amount of silicone). Touch the silicone, if it sticks to your fingers, it is not cured yet.

When the silicone is cured, carefully remove the mold.

Now the mold is ready to use! Let us reproduce the workpiece!

Reproducing Workpieces

by Gilson Domingues and Pietro Domingues

In the previous article we learned how to make molds. In this article we will see how to reproduce workpieces using many materials. This is a fast technique used to replicate complex parts that would take a long time to be made in a 3D printer.

Some materials we can use at room temperature, such as Plaster of Paris and resin. Other materials must be melted at higher temperatures, such as Tin and Paraffin wax.

We will cover:

- Plaster of Paris
- Polyester resin
- Parafin wax
- Tin

Plaster of Paris

Materials

- Plaster (dry powder)
- Container
- Stick

1 – Drop water and dry plaster powder at the same amount in the container.

2 – Stir the mix (Just a little)

3 - After getting a good mix, drop it into the mold. If necessary, forces the mix against the mold to ensure that the mold is filled

4 – The setting of unmodified plaster is complete after 30 minutes, and the workpiece is ready.

Polyester Resin

Polyester resin is great to make low cost reproductions, keeping the same quality. Although the mechanical resistance of this material is not high, it can be used in some mechanical applications.

It's often used by artisans to manufacture fridge magnets, miniatures, keychains, etc. As with silicone, resins are manufactured in liquid state. We need a catalyst to change the liquid to solid and give a shape to the object.

Warning: It’s highly recommended to work in a place with fresh air, using gloves, glasses and if possible, an air-purifying respirator.

Materials:

- Resin (liquid)
- Catalyst (it comes with the resin)
- Small container

1 - We must drop the catalyst and the resin in the container according to directions in the manual. Mix well.

2 - Pour the resin into the mold.

3- Let the resin cure. It takes 30 minutes to 2 hours. It depends on climate conditions.

Now it’s ready! In this example, the resin was prepared without any pigment. We can usespecial pigments (made for this application).

Using Pigment

The pigment is manufactured as a paste. It's added in the resin according to the concentration of the color desired.





Conserving Resin

To use less resin, there are some aggregates that can be added, such as Talcum powder, marble powder, wood flour, etc.

The addition of aggregates modifies the viscosity of the liquid and the color of the workpiece. Here is the difference between the two methods (on the left, just resin, and on the right, 30% of talcum was added)

This is a fast technique used to replicate complex parts that would take a long time to be made in a 3D printer, at the same time that the workpieces reproduced seem like the 3D-printed one. On the image, the red workpieces were 3D-printed, and the yellow were made with this process. We used spackling paste and using a sandpaper, we obtained a smooth and flat surface, ready to make a mold.

With the molds, four parts were replicated, and so we assembled a Gear Cube. Actually with these techniques, it's possible to build anything at home.

Reproducing using melted materials

Tin and paraffin wax are materials with a low-melting temperature. Because of this, they can be melted at home with a cooker, a Bunsen burner, etc. In this experiment, it's highly recommended to use adequate personal protective equipment, such as gloves, glasses, adequate shoes.

Paraffin wax

Paraffin is derived from petroleum, and candles are made of paraffin. To get paraffin we can melt candles, but it is also available commercially in small grains.

Materials:

- Paraffin
- Metal container

1 - Drop the paraffin into the metallic container and burn it to 60°C. You can use a frying pan, in this case you'll need to heat it carefully and if necessary ask someone to help. If you use a cooker and a pan, the flame must be low. Avoid moving the pan abruptly and do not put the paraffin directly on fire - it is flammable! In case the paraffin is on fire, cover it with a lid bigger than the pan.

After all the paraffin is melted, drop it carefully into the mold.




 The solidification is slow, it takes 15 to 45 minutes depending on the size of the workpiece. As the material solidifies, it gets an opaque appearance. We can see on these photos.

Even if the workpiece is entirely opaque, it's recommended to wait for more 30 minutes, because the center may still be liquid.


Tin

Using a similar method, but at not so high temperature, we can melt tin and lead (the last one is not used for obvious reasons!). Tin can be obtained from hardware shops (it is sold as bars, used to solder copper tubes).

Warning: There is another kind of tin, used to solder PCBs, but its composition is different, and when it is melted, it releases a toxic gas and should not be used.

The method of melting the tin is the same as the paraffin. You can use a cooker as well, and the same care is needed.

Cut the approximate volume that you will need to fill the mold, and melt it in a metallic container or a frying pan. The melting process can take some minutes.

After completely melted, pick small amounts of tin with a spoon and drop it carefully into the mold. Repeat this until the whole mold is complete.

It's recommended to wait for 30 minutes before touching the mold. Even after it solidifies, it's better to not touch it directly. To guarantee the workpiece is ready to handle, the best is to contact the mold with water.

Make a Silicone Protector for Soldering Irons
by Gilson Domingues and Pietro Domingues

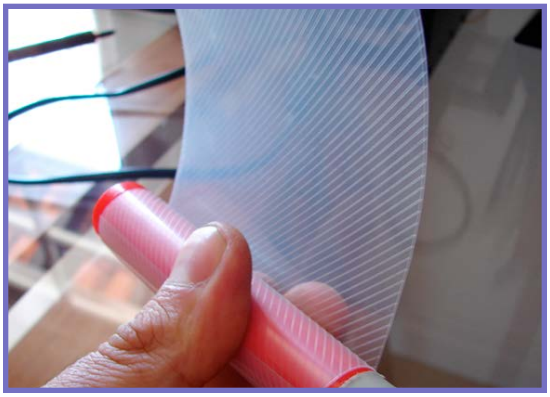
There are many ways to construct electronic circuits quickly and safely by using conductive inks, kits with magnetic contacts, breadboards, etc. However, the soldering method is still indispensable to create robust circuits at a low cost.

Handling the soldering iron may offer some risks to the user, mainly to children. To avoid these risks, it is recommended to use PPE (Personal Protective Equipment) such as gloves and safety glasses. Even with protection, the metallic part of the soldering iron is too long (especially for small hands) and offers risk of burning some part of the body.

Based on this, we developed a Silicone protector...

...that can be made following the 10 steps below:

1 – Cut a semi-rigid plastic film (such as obtained from folders, cards, packages in general, etc). The length must the same as from the metallic part of the soldering iron

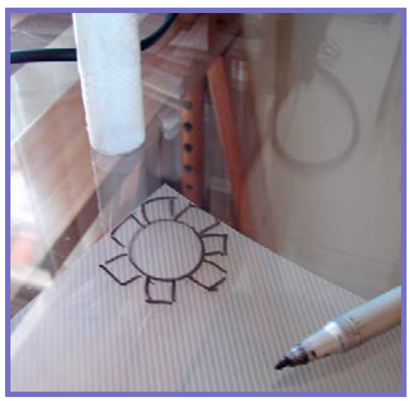


2 – Wrap the plastic film

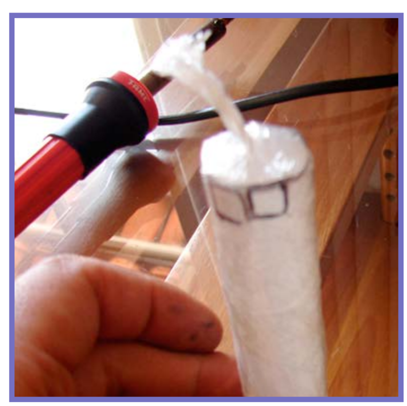
3 – Glue the tube with adhesive tape.

4 – Now make a lid for the tube. First, draw a circle of the same diameter of the tube on a piece of the plastic film. After this, cut the plastic film as a flower (like the image).

5 – Glue the lid on the tube.

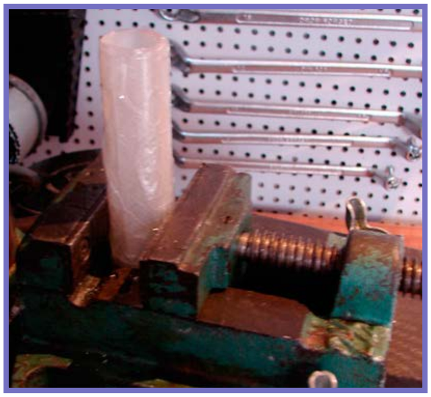


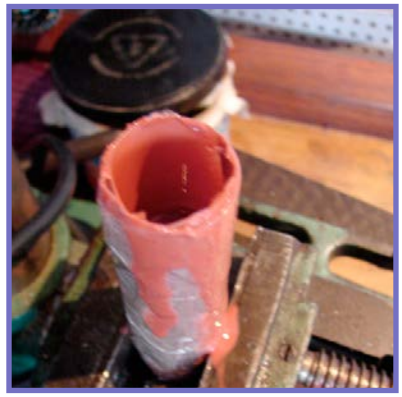
6 - This is a very important step. This tube is a mold for the silicone, so if there are any gaps, the liquid silicone will leak. A good solution is to wrap a thin PVC film around the tube, so it covers any possible gap.



7 - Fix the tube rigidly at a vertical position. (The lid must be at the bottom)

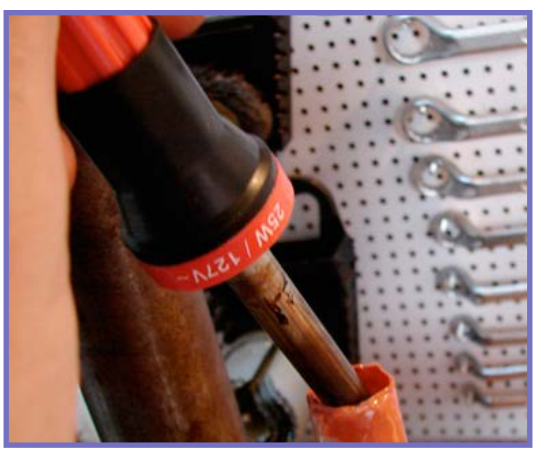
8 – Put the silicone in the tube. Notice that the silicone must be suited for high temperatures (See tutorial). Fill just the half of the tube (because of the soldering iron).

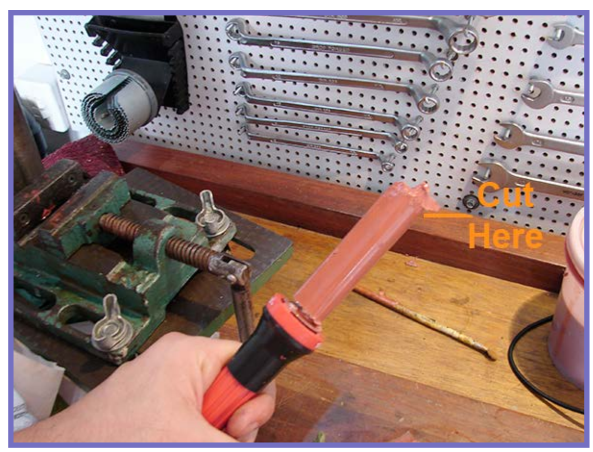




9 – While the silicone is still liquid, put the cold soldering iron inside the tube, concentric to it.

10 – Wait about six hours, and the silicone will be solid. After checking it is solid, take the soldering iron off of the mold and cut the silicone, exposing the tip of the soldering iron, ready to be used.





Final considerations

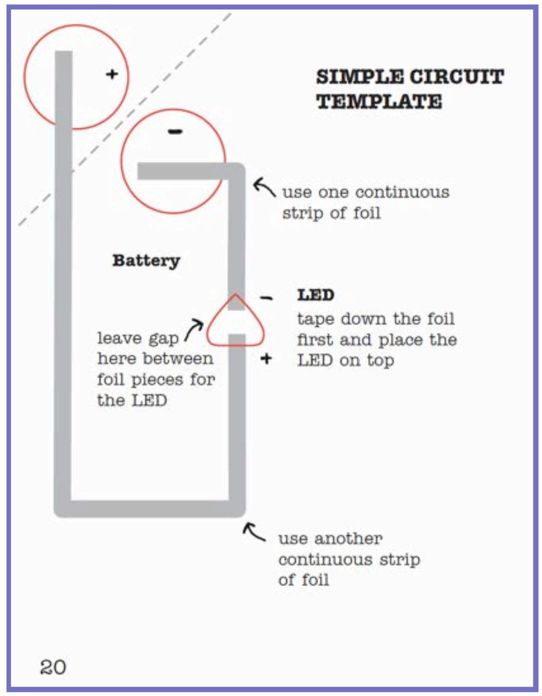
The first time it is used, the soldering iron may smell of silicone due to the heat. It is recommended to use it at a fresh and ventilated location. silicone is an excellent thermal insulator, but after many minutes of use the silicone may get hot. Nevertheless, this heat is not harmful. (The unprotected soldering iron can really injure the user).

Learning to Debug Circuits with CircuitScribe
by David Malpica

Last year, we took upon the challenge of teaching basic circuitry to my 6th grade students for our first time. As part of our skillbuilder activities, we used a variety of kits and tools to learn how to use circuits, including: paper circuits, soldering materials and CircuitScribe, a conductive ink kit that also has an online circuit simulator.

One common pitfall when studying circuits is to create short circuits, which leads to many problems including non-working circuits (and frustrated students) and possibly damaged and non-reusable materials (and frustrated teachers).

When we first started using paper circuits we used templates from the "Circuit Sticker Sketchbook" created by Jie of Qi in 2014.



Students were extremely excited to create their first working circuit with lit LEDs and moved on to more complex series and parallel circuits. As you may notice, with the template it's very difficult for students to accidentally create a short circuit.

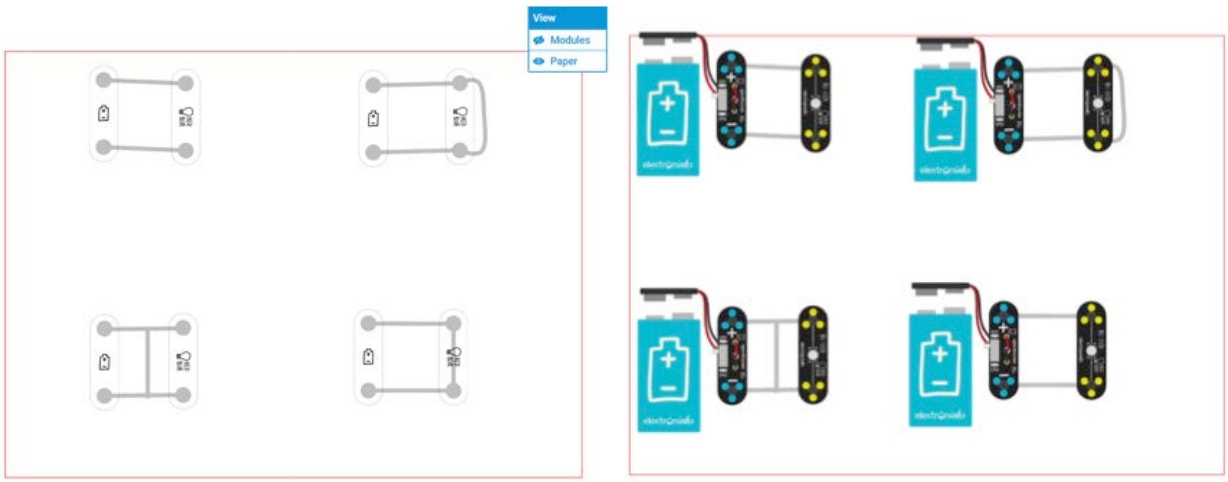
We then taught the students to solder leads on to the paper circuits. This was also extremely engaging for students.

While we ran a soldering station with half the class, the other half was trying out the CircuitScribe kits. The free flow nature of the conductive ink pen allowed students to create networks of ink in any shape. While the freedom could be felt in the room, this allowed students to create short circuits without knowing. The CircuitScribe modules are protected to prevent damage and show short circuits through red LEDs, a good reason to use it.

It became clear that at least part of the underlying theory had to be explained in order to quickly have all kids be able to identify short circuits.

We designed an online CircuitScribe showing four circuits, one working and three non-working ones. By going into “editing mode” of the software, there are tools available to quickly visualize the underlying ink. Borrowing on a water flow analogy, we explained that electricity likes to travel through the path of least resistance and that ink would such path, in spite of its location in relation to the LED.

See the graphics below (note the graphics on the right hide the modules partially and let the user see the ink underneath):



Once kids understood these topological differences, they were better equipped to design circuits on their own. After circuit and control (Arduino and mBot) skillbuilder activities were done, kids were able to make artifacts controlling LEDs, buzzers and other components.

Sensing the Physical World Around Us - An Introduction to Sensors using Scratch for Arduino

by Tracy Rudzitis

Inquiry Question: What is a Sensor?

These tutorials can be used for student's to develop an understanding of how sensors can be used to detect the physical space around us. Using the block-based Scratch4Arduino (S4A), students who have experience with Scratch can work independently and follow the tutorials provided. Students should be encouraged to modify the blocks and experiment on their own as directed by the challenges in each tutorial. (http://s4a.cat)

Understandings

- Input & Output: have students identify which device is used for input and which for output.
- Students will develop an understanding of the logic flow of both information and electricity through the Arduino as they wire and test individual sensors (and LED's) to the Arduino through the use of a breadboard.

Learning Targets

- I can create a program that lights up a RGB LED, and understand how to program a variety of colors
- I can write a program that returns the Analog value of the sensor that is connected.
- I can play a melody using a Piezo speaker
- I can write a program that uses an IR sensor (input) and based on the changing values of that sensor, will play musical notes.
- I can write a program that uses a PIR sensor (input) and uses an LED or a Piezo buzzer (output) to indicate what the PIR sensor value is.
- I can create a program that demonstrates Analog In/Out (examples: potentiometer; fading LED; light sensor; thermal sensor; Piezo speaker)

Using S4A (Scratch4Arduino)

Students will use the S4A program and the accompanying tutorials to help guide them through their investigations. S4A is a block-based program that makes the transition from programs such as

Scratch to programs that are entirely text-based, such as the Arduino IDE, easier to understand. For information on installing and using S4A please see the S4A website. Firmware needs to be installed on the Arduinos before S4A will recognize the board. (Easy!)

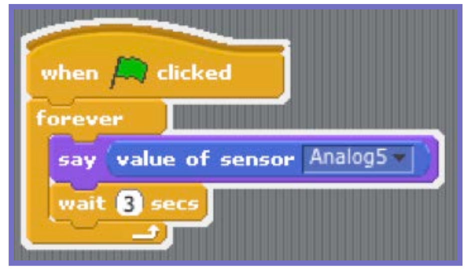
Tutorials (next pages)

- Testing Sensors With S4A
- S4A - How to Light Up an RGB LED
- S4A - Piezo Buzzer
- S4A - Piezo and PIR
- S4A - Making Music With Sensors

Testing Sensors with S4A

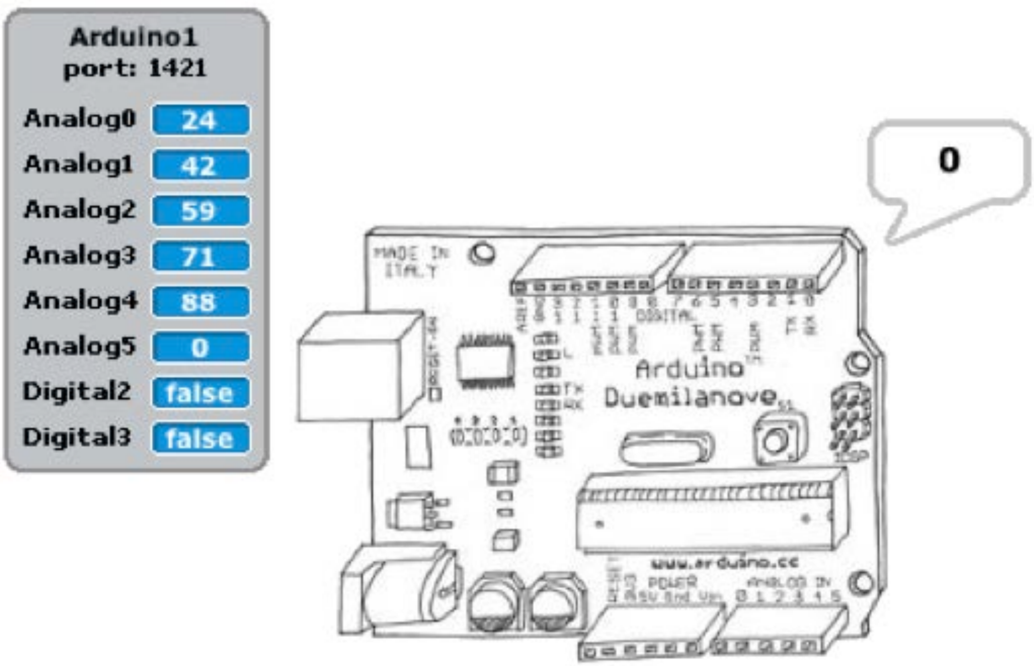
1. Set up the Arduino so the ground pin of the sensor is going to GND, the VCC pin of the sensor is going to 5v, and the Out (Signal) is going to the A5 pin.

2. Create a program that looks like this:



3. When you click on the Green Flag, you should be able to read the value the sensor is sending to the Arduino on the screen.

Test some different kinds of sensors, how do they sense? What kind of readings do they give you?



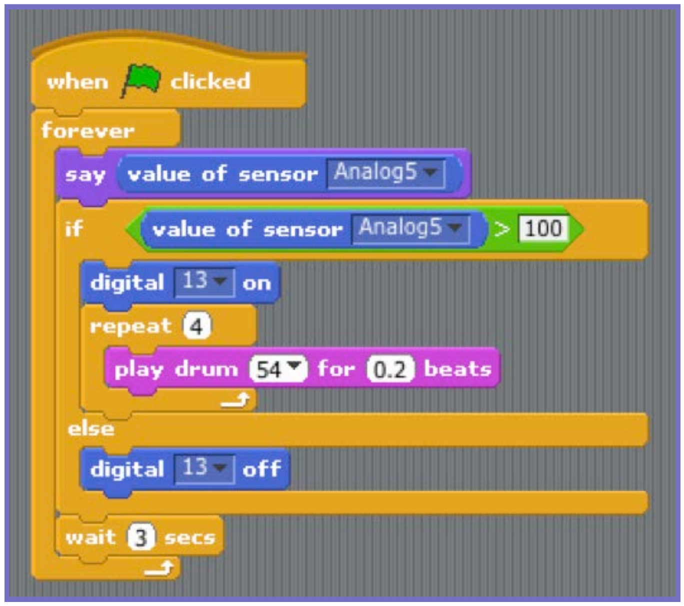
What kind of sensors can you use?

Flex Sensor, Touch Sensor, Light Sensor, IR Distance Sensor

Links to More Information About Sensors and Arduino

- Sparkfun Sensors
- Adafruit Sensor Pack

Try this code... What happens? How can you modify this to do something else?



Extensions

- Try adding LED's to add some bling to your tunes.
- Set up a PWM LED and use the sensor values to change the brightness of the LED
- How can you use the modulo operator?
- What other operators can you use to make sure that your sensor values can play notes?

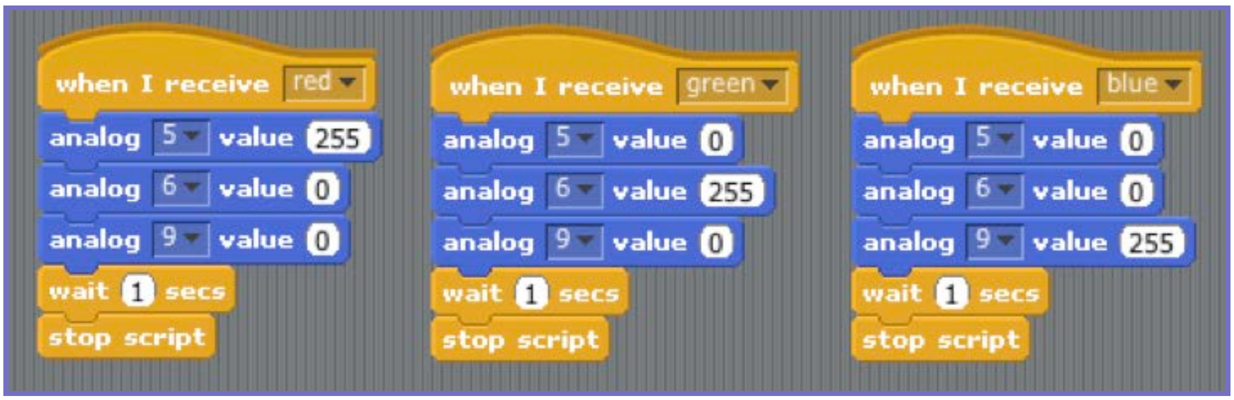
How To Light Up an RGB LED with Scratch 4 Arduino

What kind of RGB LED do I have?

Cathode? the long leg is negative

Anode? the long leg is positive

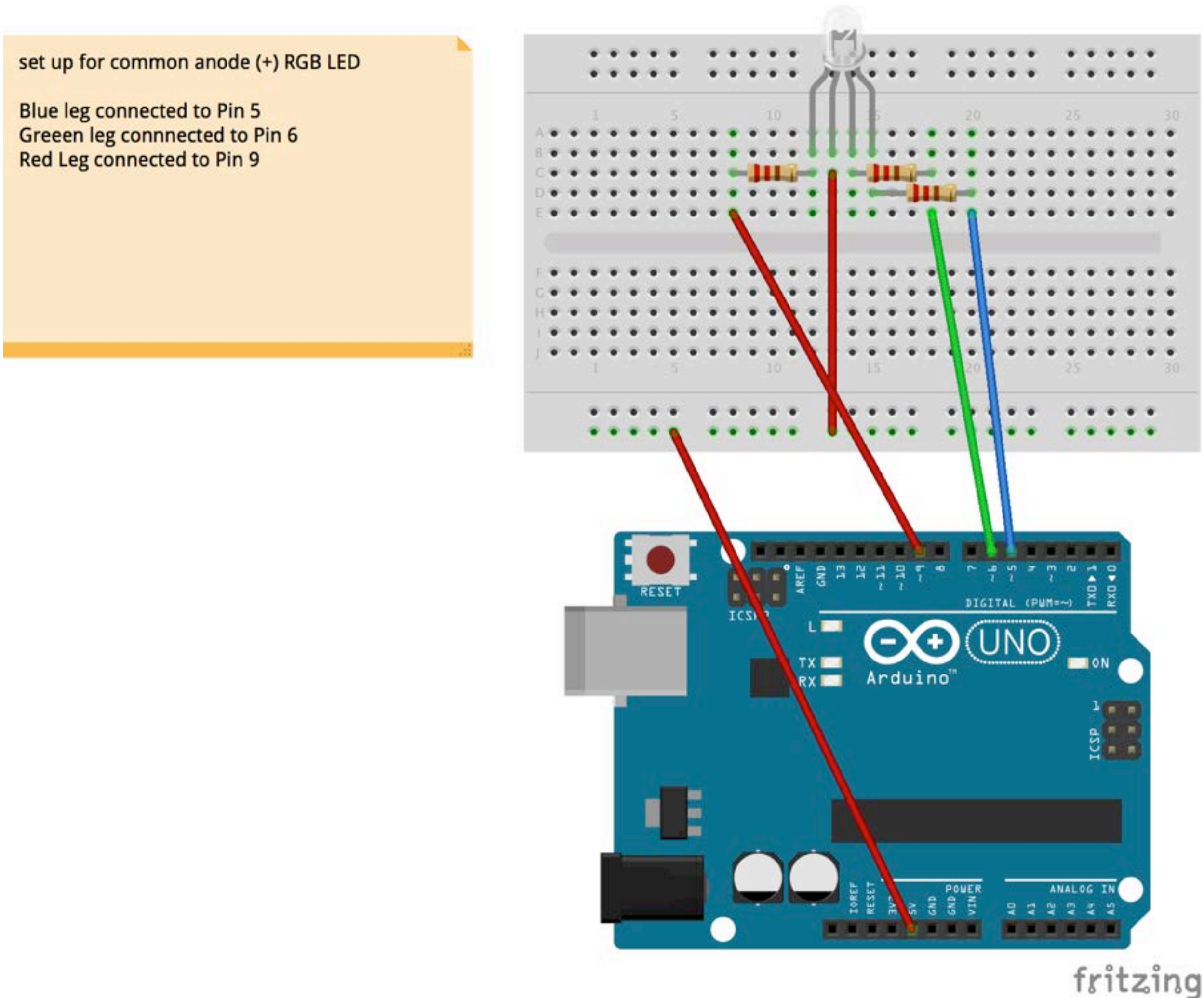
To set up a test, create this program in Scratch4Arduino:



This will give you Red, Green and Blue colors. To create different colors you need to change the values of each of the individual colors. Can you make Magenta? Orange? Teal?

- Try making new colors and test them out.
- Add additional Broadcast blocks to trigger your new colors.
- Change the order of the broadcast blocks to create a flashing sequence of party colors.
- Change the wait blocks to create a Morse Code effect.

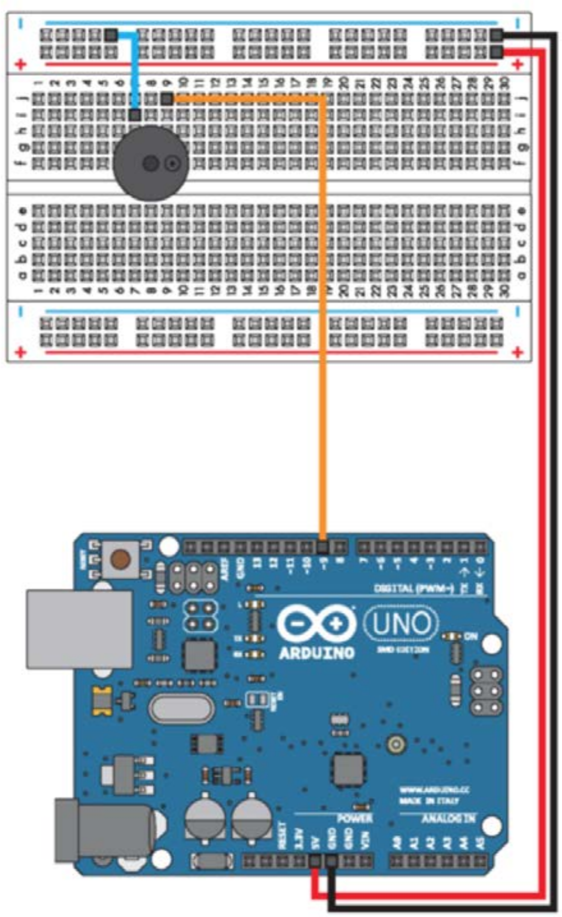
Use this diagram to set up the Arduino and the Breadboard

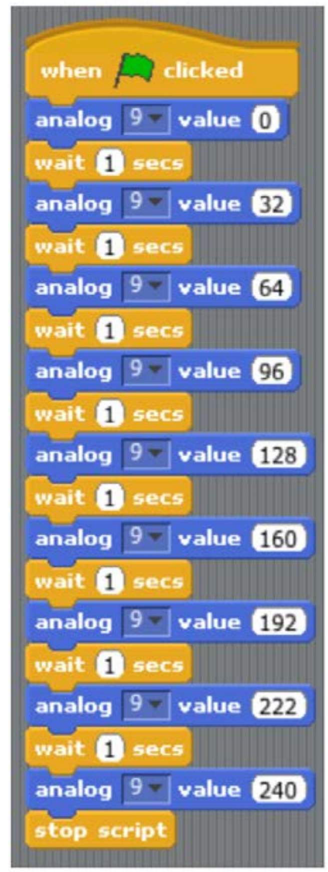


FOR FURTHER INFORMATION AND IDEAS:

- http://www.instructables.com/id/RGB-LED-Tutorial-using-an-Arduino-RGBL/
- https://learn.adafruit.com/adafruit-arduino-lesson-3-rgb-leds
- http://arduino-info.wikispaces.com/RGB-LED

S4A - Piezo Buzzer





Materials

- Arduino Uno
- Breadboard
- 1 red wire
- 1 black wire
- 1 orange wire
- Piezo Buzzer

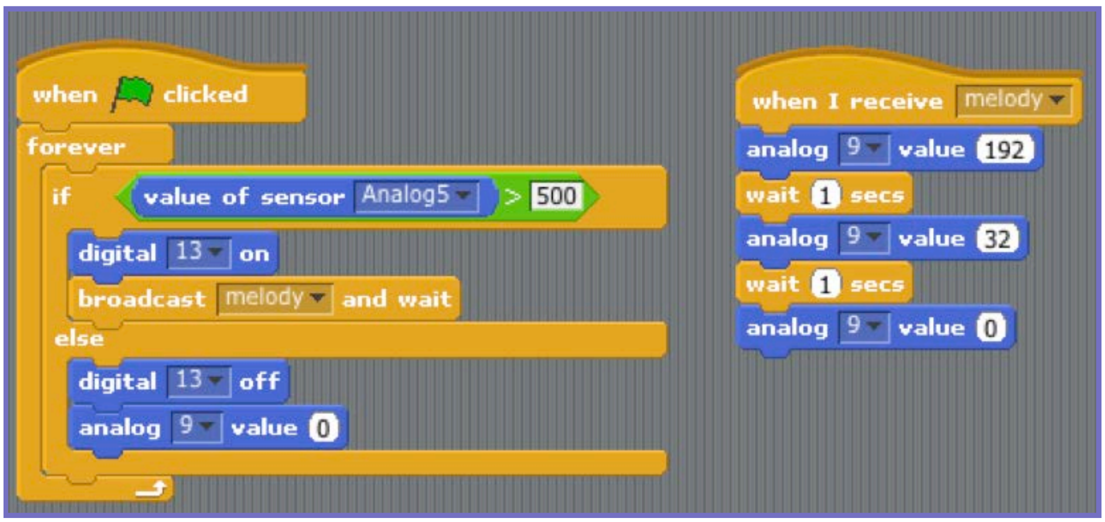
The color of the wires doesn't really matter but you should get in the habit of using red for the positive, and black for the negative. The orange wire is used here for the "signal".

Connect the orange wire to Digital Pin 9 (Analog outputs limited to 5, 6, 9 pwm pins)

S4A Piezo Buzzer & PIR Sensor & LED

Use a Passive InfraRed Sensor and a Piezo Buzzer to warn when someone approaches!

Scratch Blocks



The LED is connected to digital 13 pin (digital output)

The Piezo is connected to the analog 9 pin (this is the PWM Digital 9 pin on the Arduino)

The PIR is connected to the analog 5 pin

The PIR detects motion and when it does the value of the signal that is sent changes. You can read the value using the screen on the stage. -------------->

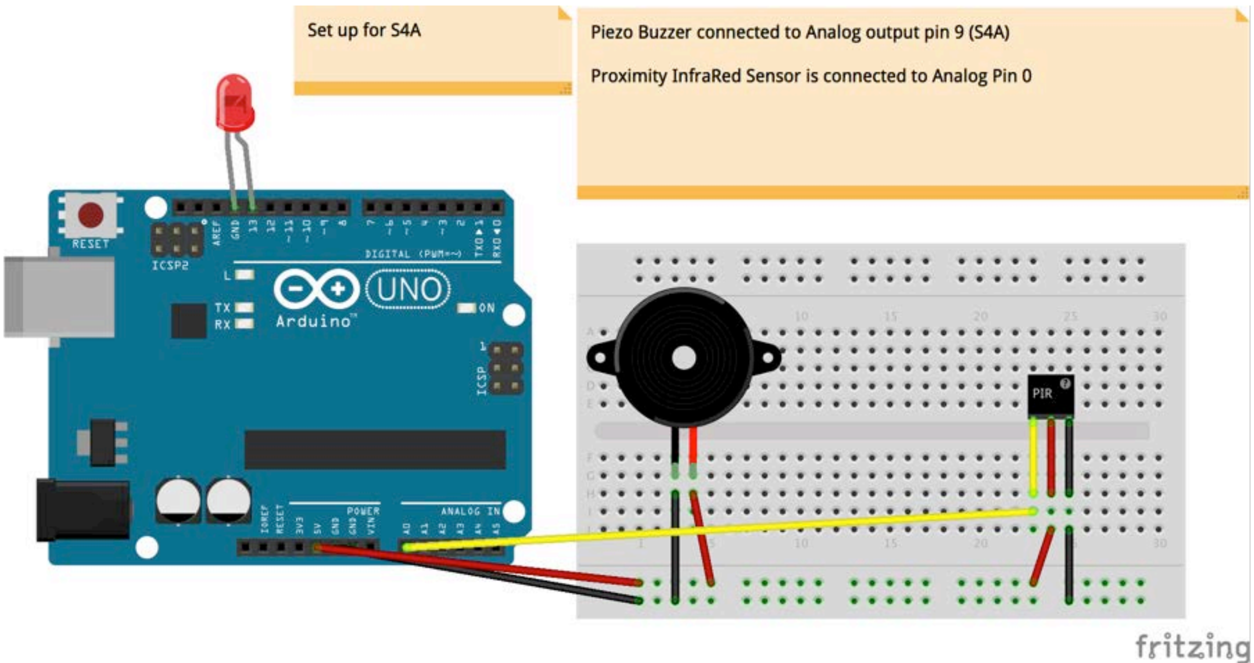
Once you determine what the value is when motion is detected, you can write a conditional statement that plays the melody and lights the LED when the value is greater than the number.

The Piezo plays a melody to based on the voltage being sent to the pin, the value determines the note that is played.

Modifications:

- Can you create a different melody to play?
- Can you add more LEDs (use the breadboard) and program them to flash in a pattern?

Arduino and Breadboard Circuit



FURTHER READING

- http://www.arduino.cc/en/Tutorial/PlayMelody
- https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor

Making Music With Sensors

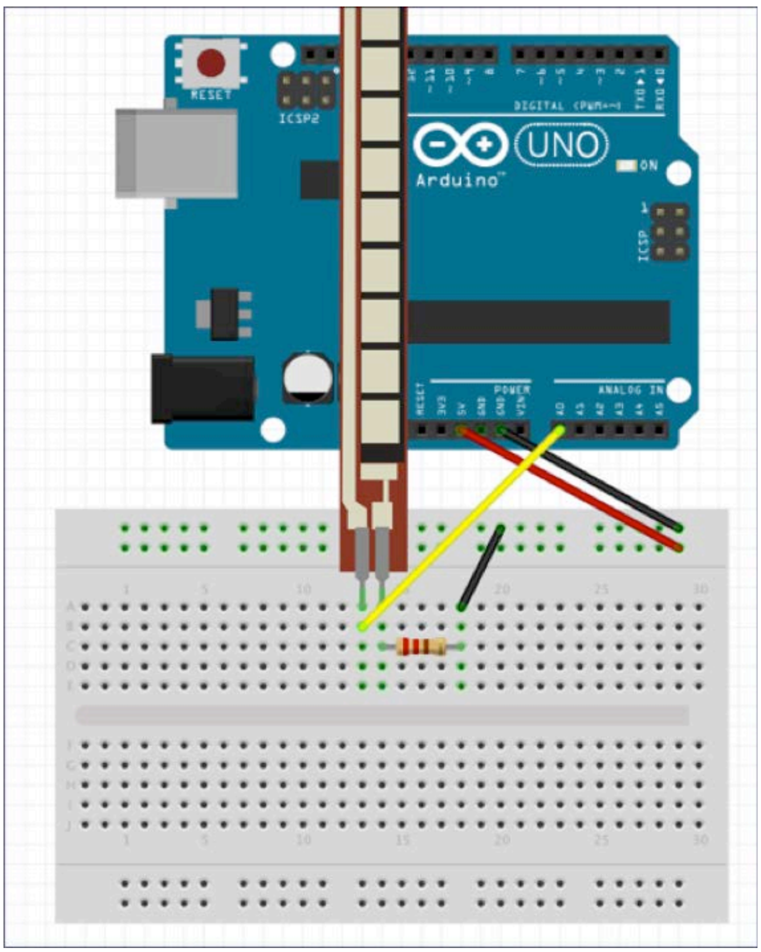
What Kind of Sensors Can We Use?

Flex Sensor Photocell (light)Tilt Sensor Touch Sensor Distance Sensor

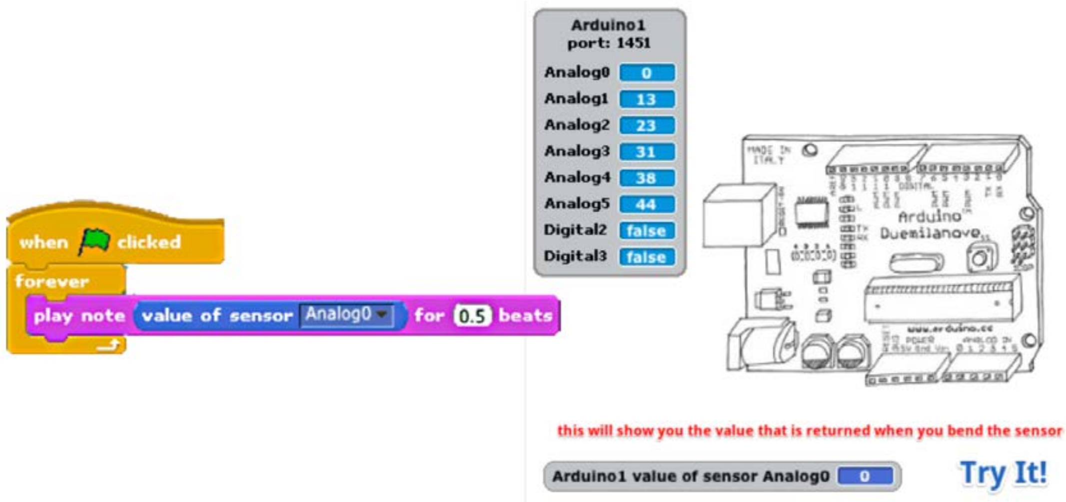
Setting Up the Arduino

Use Analog Pin 0 and connect that to the positive pin of the flex sensor

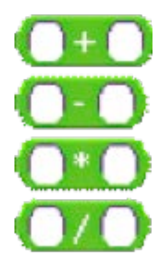
Experiment with different sized resistors, what happens? (the resistor shown is 220Ω)



Setting Up the blocks in S4A



Add these Blocks and see if you can make different notes!



Operator Blocks

What is happening and why?

What operator block would you use to get a note to play to get if your sensor was returning the value above?

- Read the code carefully. What do the Green Operator blocks do?
- What other operations can you use and get different results?
- Do other sensors return different Analog values?
- Can you create an orchestra with a classmate?

Making Stuff Light Up and Move!

by Tracy Rudzitis

My sixth and seventh grade STEAM students immersed themselves in the wonder of electricity this school year. They started out by exploring basic circuits, using blocks that I constructed using the Exploratorium's ideas from their electricity exploration curriculum.

The overall learning targets for this unit were:

- Students will learn how to handle and connect components without overloading, damaging, or destroying them
- Students will learn what an electrical circuit is
- Students will learn how to understand and measure electricity and resistance
- Students will draw, build and identify the characteristics of a series circuit and a parallel circuit
- Students will construct a circuit of their own design using a variety of conductive and non conductive materials that includes a switch, an output device, and a sensor (input device).

Tinkering and exploring how circuits and electricity works generated many questions from the students. In each of my 10 classes we wrote down some of the questions so we could use these ideas to drive the projects that students would immerse themselves in to really develop their understanding of electricity.

My approach to student inquiry into content is that it should be directly related to questions they have about how and why things work. Without providing all the answers upfront first, students will choose ideas to work on that might answer some of the questions they have about what ever the subject is we are in the midst of.

I wanted my students to think big about what they wanted to "make" so I provided some very big prompts:

- Build something that can see
- Build something that can talk
- Build something that makes sounds and responds to touch
- Build something that makes art
- Build an interactive toy
- Build something that performs a simple task that makes life easier

- Build something that helps people
- Build something that you can wear
- Build something that makes music
- Build an interactive house
- Build something powered by the sun

I didn't want students to think about the tools or materials that would be used in the projects at first, I wanted them to think about ideas and what they were curious about. Once the students (and I teach 300 of them!!) decided upon an idea, I was able to direct them towards the kind of materials or possible existing projects (Instructables is a great resource for ideas), that they may use as resources and reference for their own work. Students who were perhaps a little overwhelmed at all this could choose from some ideas and examples I had in the classroom. Simple soft circuits or paper circuits that could be made with simple materials, yet still allow for these students to demonstrate their understandings of the learning targets that make up a middle school science class.

I wanted students to be using a range of materials. This is the first year of the school's STEAM lab and in the back of my mind I also saw this project having potential for showcasing the different materials and electronics that are available in the lab. I pointed students in the direction of the Arduino, the MaKeyMaKey's, the Make!Sense boards, Hummingbirds, NXT Bricks. I provided solar panels, various DC motors and servos, LEDs and batteries and lot's of wire and copper tape. The student's imaginations and creativity fill in the spaces and the results were pretty spectacular.

Students documented their work, and they wrote up instructions that we published as PDF files on our STEAM Lab site so that other's could share in the experience of making and learning and exploring electricity.

Take a look at the awesome and amazing things that were dreamed up and made. The pdf files can inspire and provide some instructions and ideas so that others can make these projects. The photos and videos that students took of their work, as it was being made or as finished products, give you a glimpse into the process, the thinking, the questions, that happen as the project unfolds.

When students are engaged and motivated by exploring their own questions, their own ideas, their own interests, they are learning so much, and better yet, really retaining so much of what it is that we want them to learn. By embedding the learning in rich and sometimes difficult and complex activity, they student comes away with a deeper understanding. Sharing in these experiences and wonderfully creative ideas and inventions that only middle school students can have, the teacher comes away with new ideas, deeper understandings, and admiration for the amazing minds that these students possess.

Advanced MaKey MaKey: Remapping Pins
by Jaymes Dec

The MaKey MaKey is a popular microcontroller that makes it easy to use any conductive object as an interface for a computer. When you plug a MaKey MaKey into a computer, the computer thinks you plugged in an external keyboard and mouse. So triggering the sensor inputs on the MaKey MaKey just sends keystrokes or mouse commands to your computer.

The MaKey MaKey has 18 inputs that it can use to send those keystrokes and mouse commands.

"Out-of-the-box," the device comes pre-programmed to trigger:

- **keystrokes**: w, a, s, d, f, g, up, down, left, right, spacebar
- **mouse commands**: left click, right click, scroll up, scroll down, scroll left, scroll right

Careful readers might note that there are only 17 commands listed above. That is because left click is used twice, once on a female header pin and once on an easier to access mount for alligator clips.

So what can you do with the MaKey MaKey?

You can type. You can move your cursor around and click. You can play video games. You can play digital music instruments. You can navigate the web. You can trigger a webcam. Anything that you might do with a keyboard or mouse, you can do with a MaKey MaKey.

But there are two limitations to keep in mind:

- You can only trigger the keystrokes or mouse commands that are programmed on the device.
- You must be touching the earth (or ground) part of the board to trigger these keystrokes or commands. I'm going to address this second limitation in another blog post.

So what if you need the MaKey MaKey to trigger different keystrokes than the ones that are preprogrammed on the device?

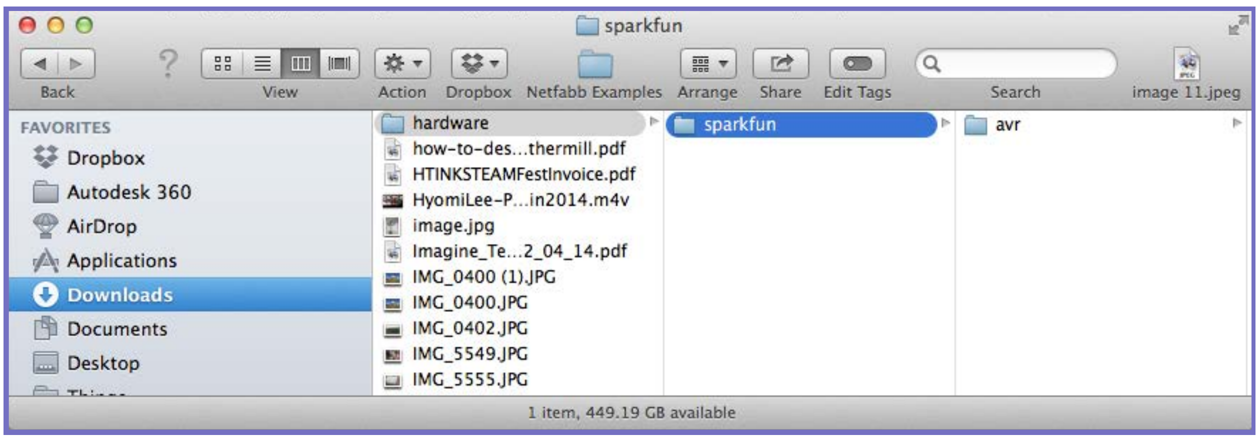
Well, I'll let you in on a secret...

The MaKey MaKey is really an Arduino! Actually it's a special Arduino called an Arduino Leonardo. The Leonardo is a bit different from other Arduinos. It's processor has built-in USB communication capabilities so it appears to a connected computer as a mouse and keyboard. This means that we can reprogram the MaKey MaKey to trigger any keystrokes or mouse commands that we want. This tutorial will show you how.

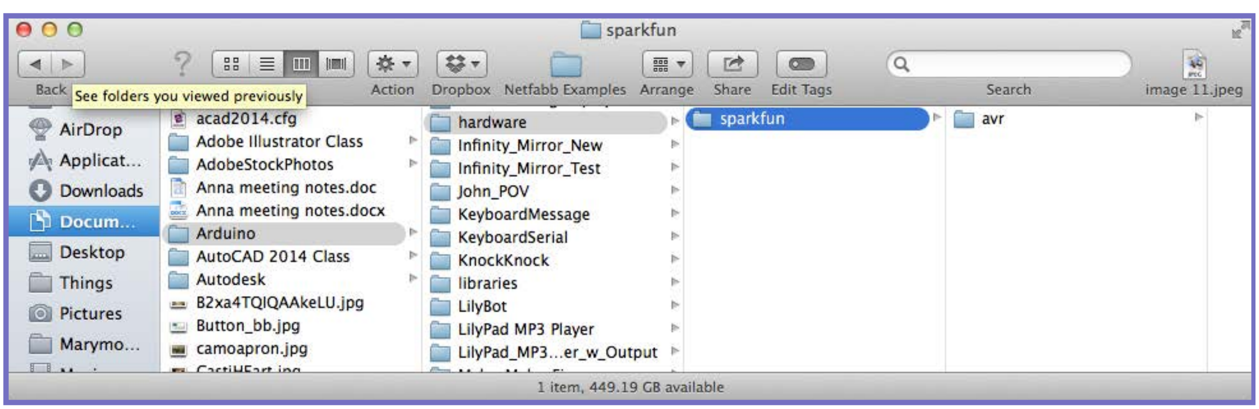
Please note: *if you re-program your MaKeyMaKey, I highly recommend re-programming it back to factory default settings when you are done with it, so that nobody will get confused later on when the device they are using is not behaving the way that they think it should.*

You are going to upload a new “sketch” or program into the MaKey MaKey. If you have not worked with Arduino code before, see this tutorial.

1. Download and install Arduino 1.5 or greater if you don’t have it already.
2. Don’t start the Arduino IDE yet. If you do, make sure to Quit the program before you do the following steps.
3. Download the hardware Addon file for the MaKey MaKey here: https://cdn.sparkfun.com/assets/learn_tutorials/1/9/1/1.6_32U4_Addon.zip
4. Unzip that file. Inside you’ll find a folder called hardware and inside that will be a folder called Sparkfun.

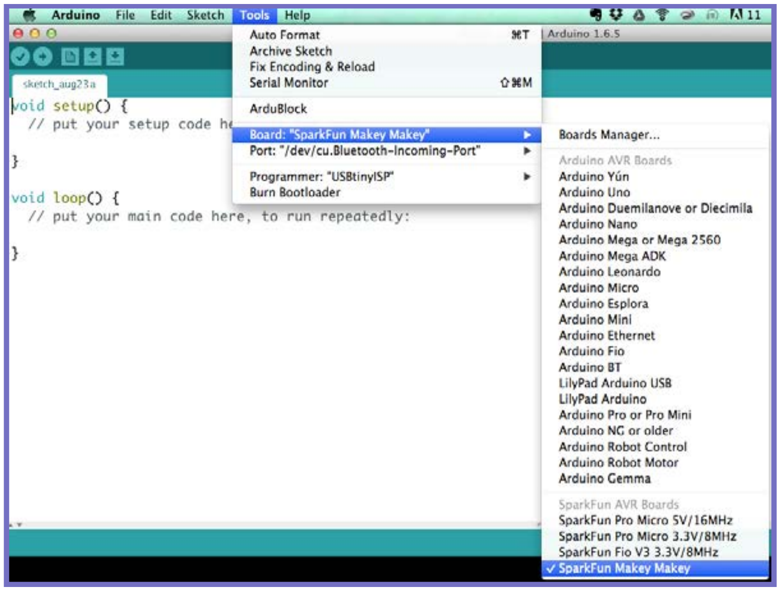


5. Copy the Sparkfun folder highlighted in blue above.
6. We need to paste that folder into our Arduino hardware folder.
   a. On an Apple computer, navigate to Documents - Arduino - hardware. Paste the Sparkfun folder there. If you can’t find the hardware folder, you may have to create one.
   b. On Windows you need to go to My Documents - Arduino - hardware. Again, if you can’t find the hardware folder, you may have to create one.

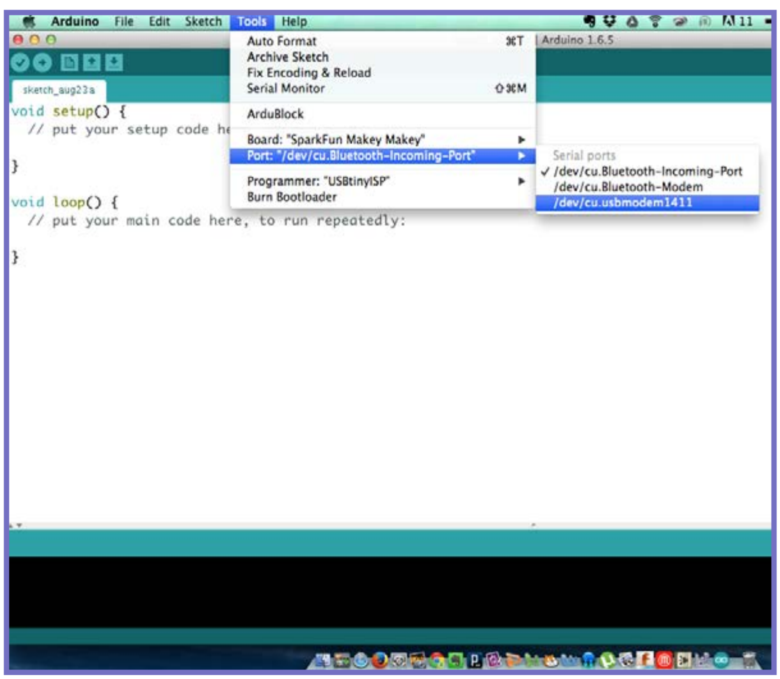


7. Open your Arduino IDE. In the top menu bar, go to Tools - Board - and then choose Sparkfun MaKey MaKey.

Note: If that board is not in the list of boards, you may have missed a step above. Double check that the Sparkfun folder is in the correct place in the Arduino hardware folder on your computer.



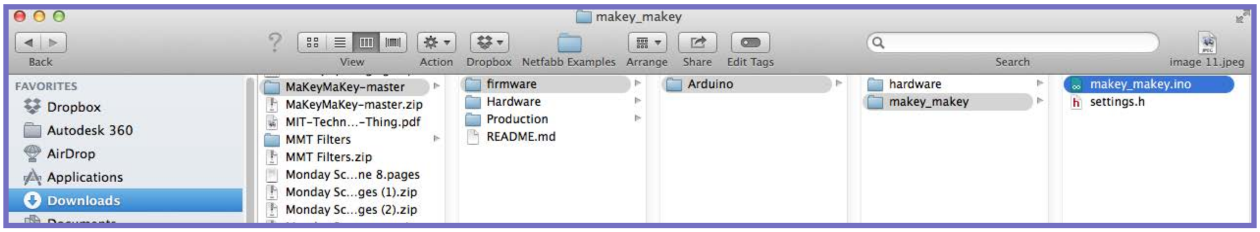
8. Plug your MaKey MaKey device into your computer with a USB cable.
9. In the top menu bar, go to Tools - Port - and then choose the last port listed.



On Apples, the port name will include usbmodem. On Windows, choose the COM port that appears when you plug in your MaKey MaKey.)

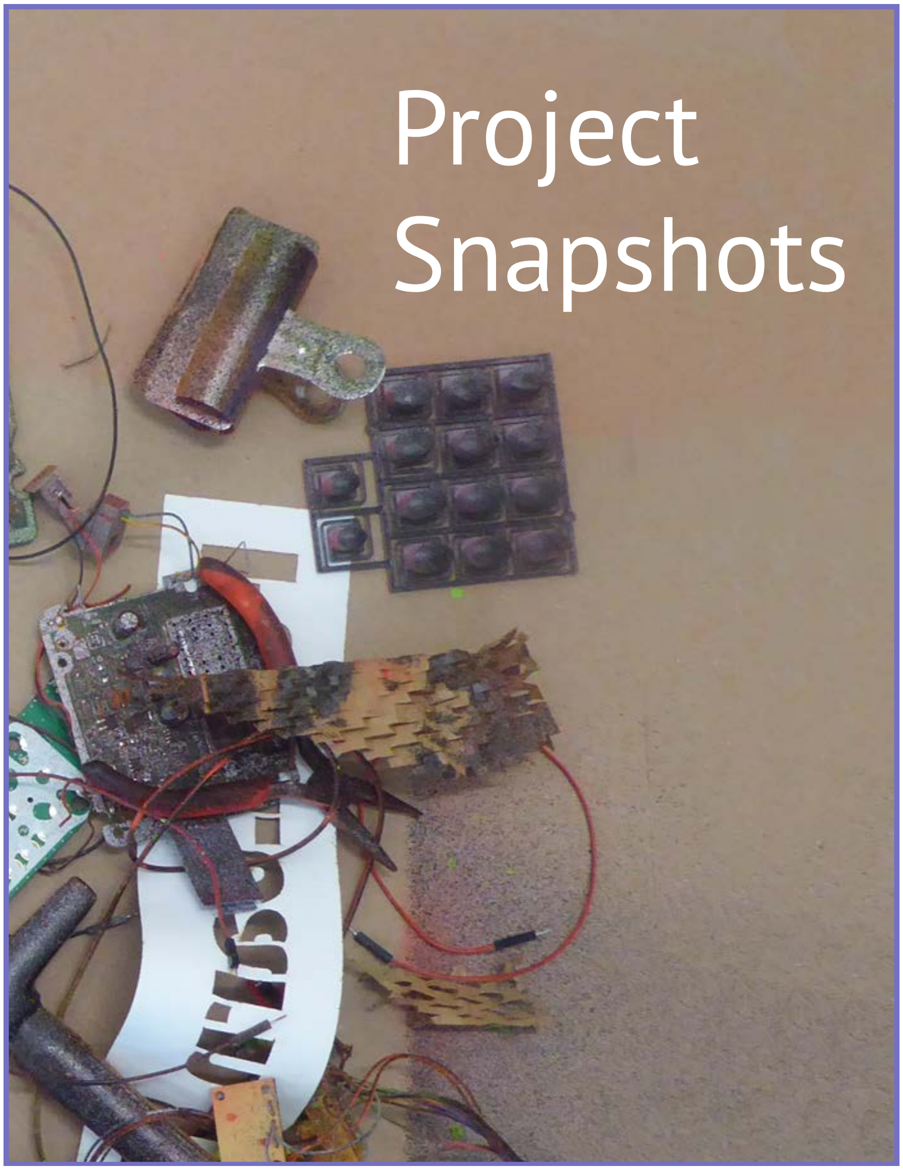
10. Now we have to get the default MaKey MaKey firmware sketch from Github.
    a. Go to https://github.com/sparkfun/MaKeyMaKey
    b. Click on Download ZIP in the lower right corner
    c. Unzip that file

11. In the MaKeyMaKey-master folder, navigate to firmware - Arduino - MaKey_MaKey and then open the MaKey_MaKey.ino file.



12. The MaKey MaKey firmware will open on your computer. This is the default firmware for the device, so you should save a copy to your Arduino sketch folder and then when you make edits, make sure to save it with a different filename so that you can always reprogram the device back to factory settings.
13. From the top menu bar, go to File - Save As, and then save the file in your Documents - Arduino folder.
14. Click on the tab near the top of the IDE that is called “settings.h.” This is where you remap the keystrokes and mouse commands on the device.
15. Read the comments at the top of the settings.h file to see how to change the keystrokes. You change the values listed in the int keyCodes[NUM_INPUTS] array. For instance, if I want my MaKey MaKey to trigger numbers instead of letters and , I could change my array to [EXAMPLE CODE]
16. To upload the new code onto your MaKeyMaKey, just make sure that you have the correct Board and Port chosen from the Tools menu (see steps 7 and 9). Then from the top menu bar, choose Sketch - Upload. Wait a few seconds while the sketch compiles and uploads. You know it it finished when the Arduino IDE says “Done uploading” in the bottom left corner.

Congratulations! You’ve remapped your keys on the MaKey MaKey. When my students re-program a MaKeyMaKey, I ask them to reprogram it back to factory default settings when they are done. Otherwise someone else might have a hard time using it!



Project Snapshots

This next collection of projects is meant to give a quick introduction to some of the FabLearn Fellows' favorite projects. It started out as a simple challenge to quickly share favorite projects, either "go to" projects that always work, projects that were especially engaging, or tried and tested projects that showcase thoughtful educational practice and student-centered learning with modern materials. The goal was to keep them short and free-form, capturing the essential heart and soul of the project instead of trying to make the projects fit into a one-size-fits-all "lesson plan" template.

These project snapshots accommodate a wide variety of grades and experience levels, vary in length and expertise needed, and use many different tools, materials, software and hardware. This wide variation may seem too random to be useful, but is deliberate. One of the challenges of

trying to create a coherent set of resources about "making" in learning spaces is simply that there are so many variations in tools, spaces, time, subjects, experience levels, etc. So we decided just to embrace the chaos and create a grab bag of favorites to share.

These projects are presented as simply as possible, showcasing the remarkable variety and range that happens in student-centered environments rich in materials and imagination. They are organized solely by the author, as this helps communicate what kind of learning space the project is situated in. The context of the author, whether in a traditional classroom, museum, community organization, or other learning space can make the projects more understandable and hopefully more useful to the reader.

We invite you to view these projects as starting points, rather than complete recipes. Browse and find the ones that speak to you. Many are works in progress, but that's how making works! (Iterative design isn't just for kids.)

Many projects have links to read more, and every FabLearn Fellow has a page on the FabLearn site **where they can be contacted.**

Aaron Vanderwerff

Lighthouse Community Charter School

Curriculum Integrated Projects

Mousetrap Car – Physics

In our high school physics class we ask students to build a mousetrap car at the beginning of our motion and forces unit. Our students return from winter break with a semi-functional car (it is supposed to move 2" at that point) – their prototype. From that point forward, we collectively use students' cars to drive the curriculum; inevitably we talk about how we measure motion, forces like friction, the elastic force of the spring, and gravity, and mechanical advantage. The difference is that students are the ones who are pushing us to study these topics so they can use physics to improve their designs. In addition, students isolate a single variable (wheel diameter, mass, etc.) and present their results to the class.

Building a mousetrap car is a time-honored tradition in high school physics, but by starting with the building of the car instead of using it as a capstone project, we find it gives a great context for learning about motion and forces.

Wind Turbine – Physics

Students in our physics class built their own wind turbines including winding their own coils for the generator. Using the initial design, they then test the output of the turbine and modify the wind turbine in some way to see if they can increase its output. Students modified the generator, the turbine shape, the turbine size, etc. Anecdotally, students understood power generation much better through this lesson then they have using more traditional lessons.

Turtle Art – Introducing Cartesian coordinates (5/6th grade)

During this mini-unit, students learned basic programming skills, deepened their understanding of angles, and were introduced to the Cartesian coordinates all using Turtle Art (free by emailing the software's authors). For the first week, students learned to draw shapes and use the various blocks through investigation. During the second week, students were asked to make their favorite shape and then repeat that shape many times on their screen. This prompted students to explore a variety of blocks including set x y, which gave the class an opportunity to 'discover' the Cartesian coordinate system that is built into Turtle Art.

Character Study Puppets (2nd grade)

In second grade our students study character traits of the main characters in books folk tales and books they are reading. In this project, students sew puppets to represent these character traits using felt, thread, buttons, and found objects. They go through a simple design process to think about how they will represent the character trait they are trying to capture.

Elective and Enrichment Projects

Chair (7-12)

In high school, we have students complete a set of skill builders. Their first is to redesign and build a chair. We set a student sample from the previous year in front of the students and then ask them to improve the design. When students get to a step they don't know how to do (like use a circular saw) we coach them through it in groups of 2-4.

Materials are all inexpensive (dimensional lumber and drywall screws) and our workspace is a few picnic benches outside. At the end of the project students are comfortable drilling, sawing, and measuring and the chairs are used for the year!

Sewing Pillows (5-12)

Similar to the chairs, we have our high school students sew pillows to learn to embroider, use a sewing machine, and create a plush object. Students start by embroidering a design on a piece of fabric, sew the side of two squares of fabric together to make a pillow, and then stuff the pillow. The pillows are then used with the chairs.

Woodworking (Kindergarten)

In the woodworking project, students learn to safely use tools and eventually design and build a toy for one of their classmates. The class starts by learning to sand and file and then work with the teacher in small groups to learn to use a small hand saw. The hot glue-gun, hammer, and drill are all added to their repertoire throughout the quarter. Kindergarteners build their tool literacy during the first quarter, which allows them to independently create projects throughout the year. Students have built houses as tall as themselves, a table for the class kitchen, and have fixed toys using what they have learned.

Mini-Makerspaces (7-8th)

Students in our middle school elective worked together to create classroom based mini-makerspaces for a couple of our elementary classroom using the design thinking process. The middle school students interviewed our kindergarten teachers and observed the kindergarteners making. They then created designs for the mini-makerspaces and asked the students and teachers for feedback. Finally, using found objects (dressers) they built mini-makerspaces to help organize materials, tools, and projects.

Robot Petting Zoo (7 – 12)

In collaboration with the TechHive at the Lawrence Hall of Science, our students have built an interactive petting zoo. The animals were built from cardboard, and use Hummingbird Robotics Kits that are programmed using Scratch. Each animal has sensors (mostly motion, but some use sound), that allow the robots to react to a stimulus. When students feed the animals, they are actually triggering motion sensors, which then causes the animals to wiggle their ears, or shout "Yum!"

Independent Maker Faire Projects (6 – 12)

The project with the longest track record (since 2011) is having students create independent, student driven projects, which they showcase at the Maker Faire. Students come up with a project (we lead them through a weeks-long ideation process) after completing some basic skill builders in the fall, create a prototype to share with the school community mid way through, and then display their project at Maker Faire.

Example projects: a motion sensitive LED tutu, a recycled plastic-bottle chandelier, a redwood bench for the schoolyard, and an EV truck conversion.

David Malpica

Bullis Charter School

Engineering Design intersession (7th grade)

Challenge descriptions written by colleague, Sarah Watanabe.

In between trimesters, seventh grade students get three weeks of focused project based engineering design. Students pick from a pool of challenges gathered by the teachers from our local school community. Below are a couple examples from our pool of challenges:

Problem: The crows on the BCI campus are food ninjas! They easily get into the trash cans and lunchboxes removing food and packaging, making a mess of our beautiful school.

Your Job: STOP THOSE CROWS!! Figure out a way to prevent the crows from making a mess. Make sure to interview people to see what their biggest crow concern is and then get to work preventing our bird burglars from striking again.

A Heart Wrenching Situation

Problem: In the Fab Lab, they have a set of 22 wrenches that they need to store on the pegboard and easily transport. However, the wrench holder was made of cheap plastic and broke. Oh-No!!!

Your Job: Create a sturdy wrench holder that can be hung on the pegboard and easily moved from place to place (safely) with the wrenches still on it.

Design the School of the Future competition (8th grade)

As one of the 8th grade intersessions, students are tasked to submit models for the "Design the School of the Future" competition organized by CEFPI. Students carefully balance pedagogical models, environmental factors, and architectural design based on a real plot of land (our school campus). In June of 2015, a team of BCS 8th graders reached the final stages of the competition. The final verdict will be decided on October 23. A jury will judge from a pool of four teams from the USA and Canada.

Redesign of 3D printed Robohands (5th grade)

Part of a larger unit on learning about the human body, students were given 3D printed components of the snap-together Robohand. They were given the tinkering challenge of putting them together and observing problems with it. They were then introduced to the use of digital calipers (be careful, these are sharp!) to take measurements and use those to rebuild 3D models of components of the hands. Finally we went through a design thinking exercise, where they thought of improvements for the robohand (with a user in mind), and modeled those in TinkerCAD.

Laser cut habitat animals and mythological creatures (component of 4th grade PBL unit)

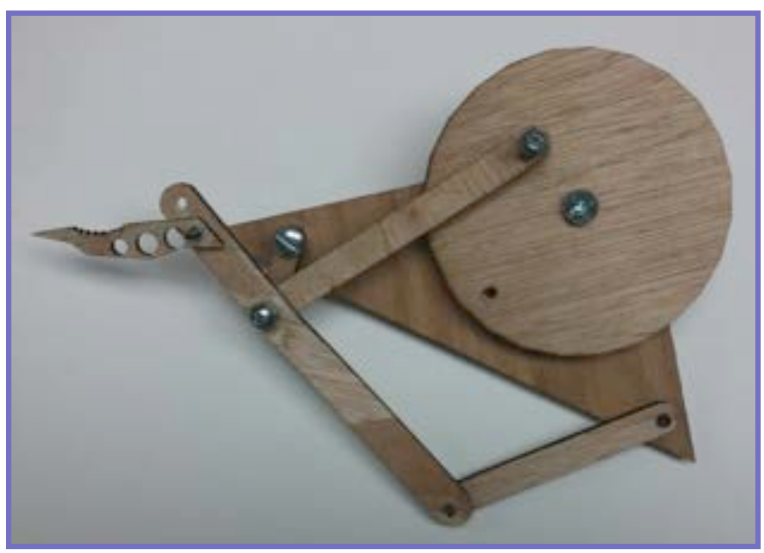
Part of a larger PBL (Project Based Learning) unit, students learned how to take Omni-Animal templates to create fantastic and real world beasts and animals. Students learn to precisely design parts to fit with the template. The larger PBL is about designing a zoo habitat that would house a protected mythological creature. The habitat is designed in the homeroom classroom using low cost prototyping materials.

3D Gnomes skill builder (3rd Grade)

This is something I did with 3rd graders back in December of 2013. At the time, we didn't have good internet at our new site so I was forced to use 123D Design instead of TinkerCAD. Because it's a less intuitive software, teaching 123D Design to 3rd graders was HARD! However, the kids showed incredible resilience in the face of crashes and not-so-intuitive tools. Kids who finished early had to create a musical instrument for the gnome. Overall, the results were pretty impressive.

This skill builder was a preamble for a more in-depth project based learning unit where students had to 'redesign' inventions in history (wind turbines, telephones, and cars). It is worth mentioning that while we were doing the skill builder I showed them different CAD tools (extrusion, revolve, sweep, mirror among others, loft) and had them look for or think of real world industrial designs that use those techniques. Since the gnomes were practice projects, they weren't 3D printed. Furthermore, many of these had unattached components and they would have come apart if printed. That was a concept that had to be constantly revised.

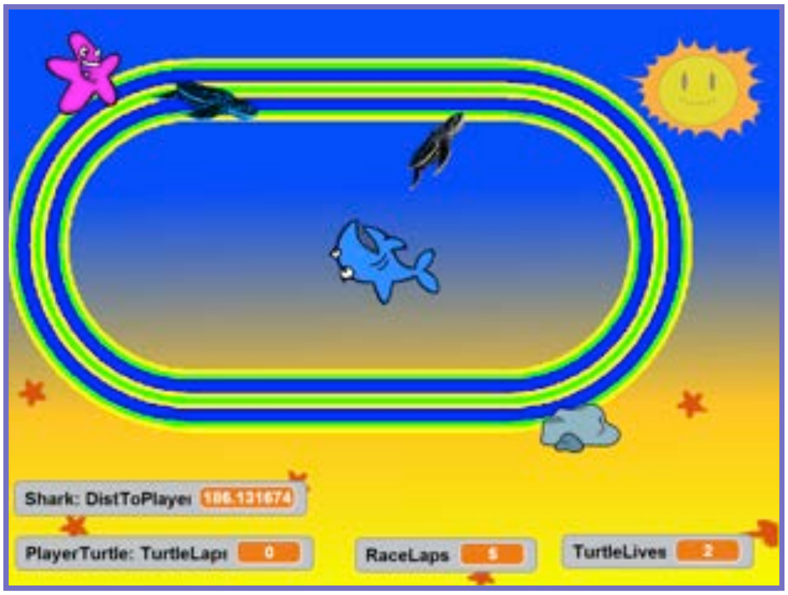
Kinetic Sculptures (8th grade STEAM unit)



In collaboration with the art teacher, eighth grade students designed kinetic art sculptures in the FabLab. Kinetic sculptures are a perfect way for students to be engaged in S.T.E.A.M. (Science, Technology, Engineering, Art, Math) integration. The students' work was inspired by artists and designers such as U-ram Choe, Doris Sung, Theo Jansen, Reuben Margolin, and Alexander Calder.

Turtle Racing (6th grade Engineering Design)

Students are introduced to coding through a series of TurtleArt or PencilCode graphics coding exercises. The students use their graphics as part of a larger Scratch project in which they are challenged to create a game where sea turtles race against each other through sand and water and avoid opponents such as sharks and crabs.



Costa Rica eco-tourism experience PBL (6th grade)

After visiting a sea-turtle research and protection station in Costa Rica, students are tasked to design an eco-tourism experience that will protect the environment, its inhabitants, help the economy of nearby town Tamarindo. In the lab students used software such as 123D Design and 123D Make to design cardboard structures representing their eco-tourism experiences.

Erin Riley

Greenwich Academy

Marble Run

I first did this on the fly with a camp using flexible tubing, molding and pegboard.

The campers had a ton of fun, but the materials were really limited. Later we tried it on a larger scale with the entire 6th grade as part of a Creativity Day event.

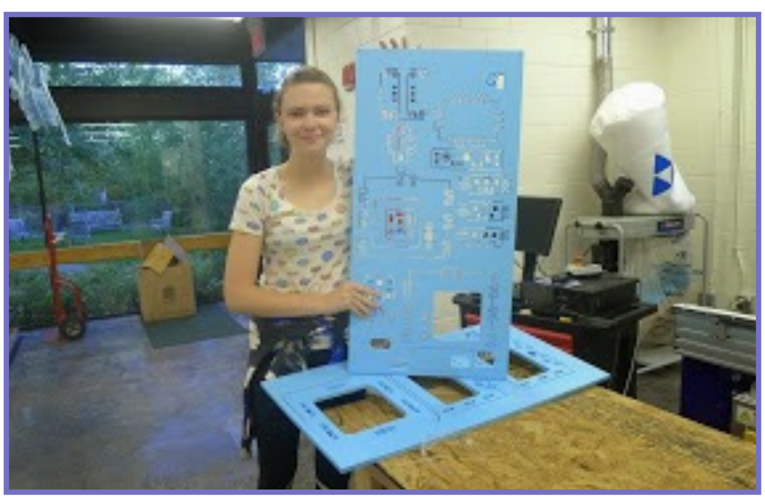
Marble Run Resource from the Exploratorium

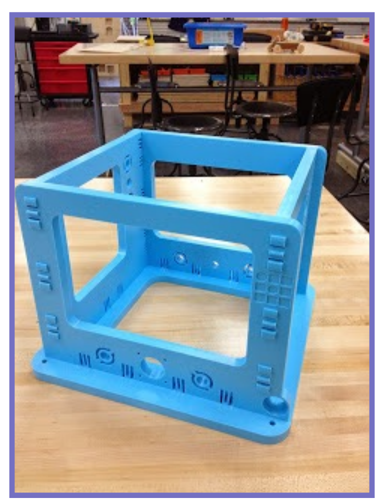
Building with cardboard

Flat and flexible. Strong. Cheap. Beautiful.

Independent projects

Student summer project made in the lab: http://mtm.cba.mit.edu/machines/mtm_snap-lock/build/





Adobe Illustrator

I teach Illustrator for vector design. It produces clean, precise graphics for 2D design and can be used for outputting in the engineering lab. It is my favorite 2D design program for the laser cutter and CNC machines.

iPod Amps designed in AI and cut on CNC

Cardboard keys designed in AI and cut on laser

Alternative photography cyanotype

Art and science come together in the beautiful medium of cyanotype. It produces Prussian blue, turning simple positive/negative images into moody, high contrast artistic statements. Great for making blueprints!

Printmaking

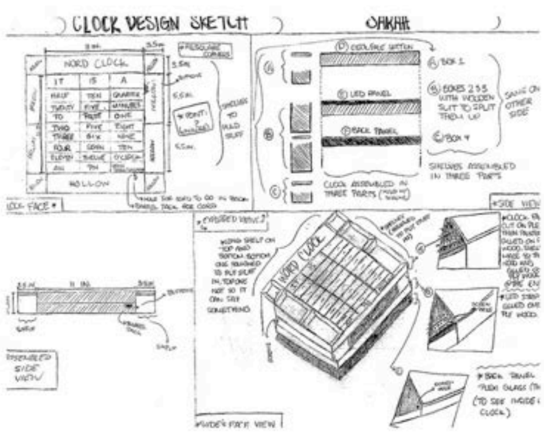
Printmaking can be a very controlled. I enjoy turning it around by introducing messy, unpredictable, painterly elements into the mix. Chine colle, splashy watercolor, and off-registration not only create beautiful objects, but also encourage creative thinking. This year we used the laser cutter to create plates (wood-cut and etching).

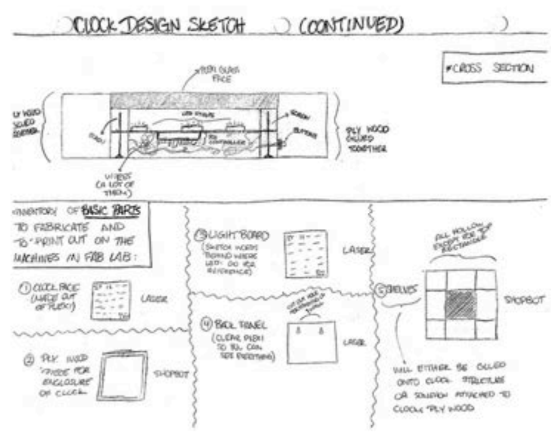
Laser cut plate (wood)

Laser cut plate (etching)

Drawing from observation, architectural drawing, isometric and linear perspective

The visual recording of ideas is invaluable in making. Problems can be solved before an idea is built by hand, on the computer, or outputted to a machine for fabrication. Drawing helps us become better at observing and understanding the structure of the three-dimensional world. Architectural drawing and linear perspective enable artists, designers and engineers a language for describing ideas and plans.



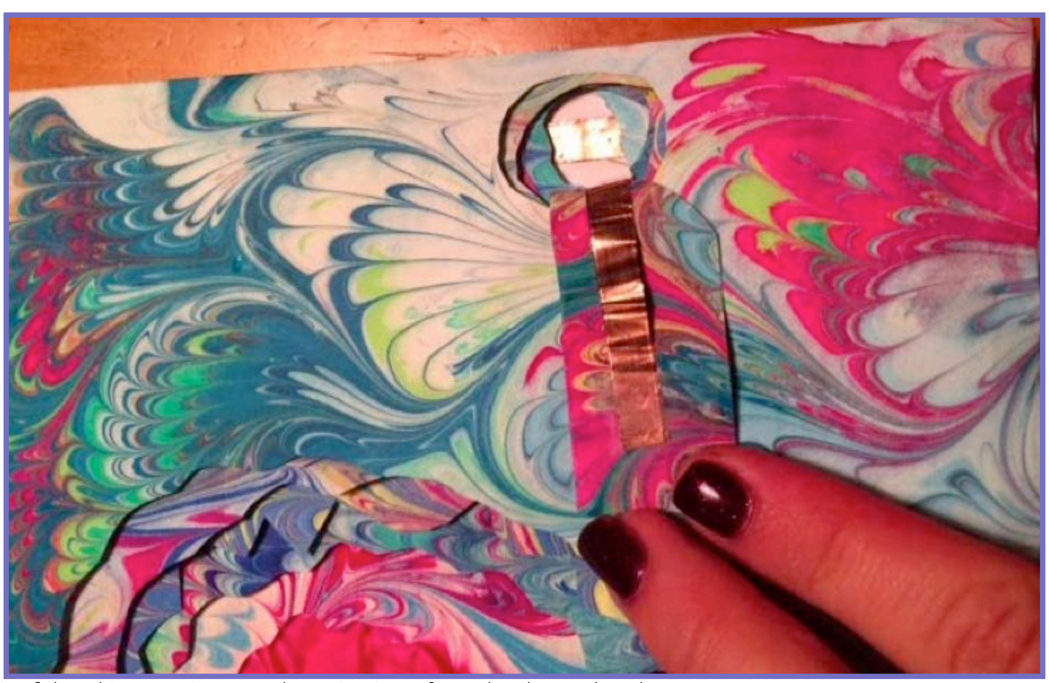


Related blog post: [Drawing: a visual language for Makers]()

Paper Circuits

Enhancing paper engineering, pop-ups and 2D design by introducing paper circuits adds a magical quality to the work.

Paper circuits resources: http://highlowtech.org/?p=2505

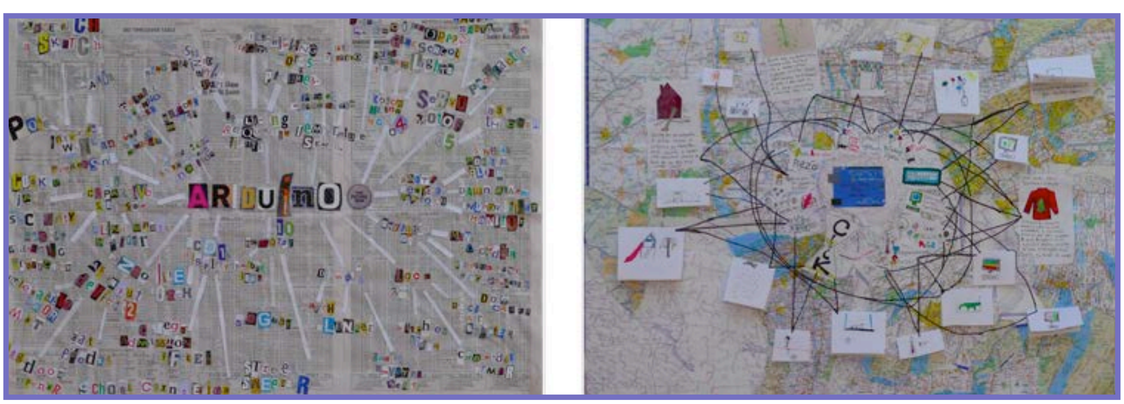


Sketchbooks/book binding

Bookmaking can be incorporated into all disciplines and can be customized for all subjects. It might be a sketchbook in art class, journal in English or maker's lab book in the engineering lab. I also introduce papermaking, marbling, paste paper into book making — it's a bit of science and art and definitely magic. When students bind their own books, collect special materials and even make their own paper, the investment is huge and they pour their heart and soul into the pages.

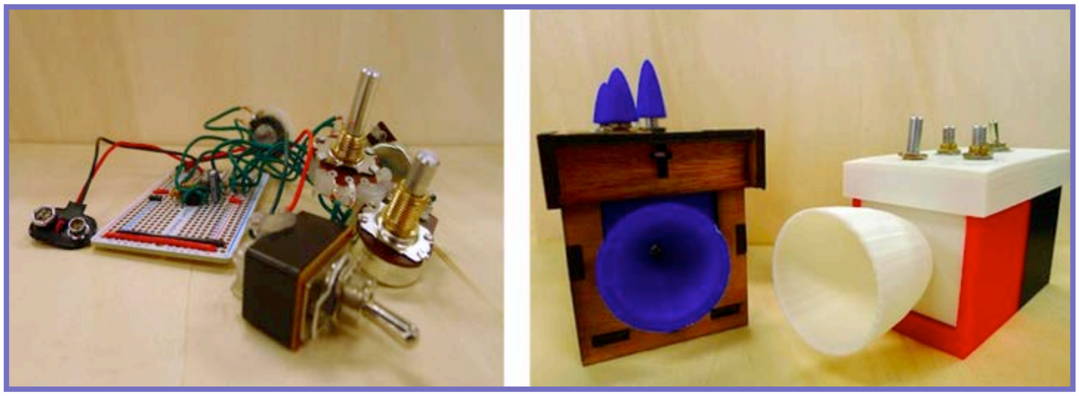
Arduino Mind Map

Our Engineering and Design class spent a couple of weeks working through the Arduino Starter Kit. The culminating project was a Mind Map--a brainstorming art project of sorts showing how these projects acted as a springboard for new ideas. We hope some of these become future makers projects!



Atari Punk Synthesizer

This project was designed for a circuits unit for an Upper School Engineering and Design elective at Greenwich Academy. Project details are here.



Gilson Domingues

Anhembi Morumbi University - Design and architecture school

Assisting Gilson with these projects:

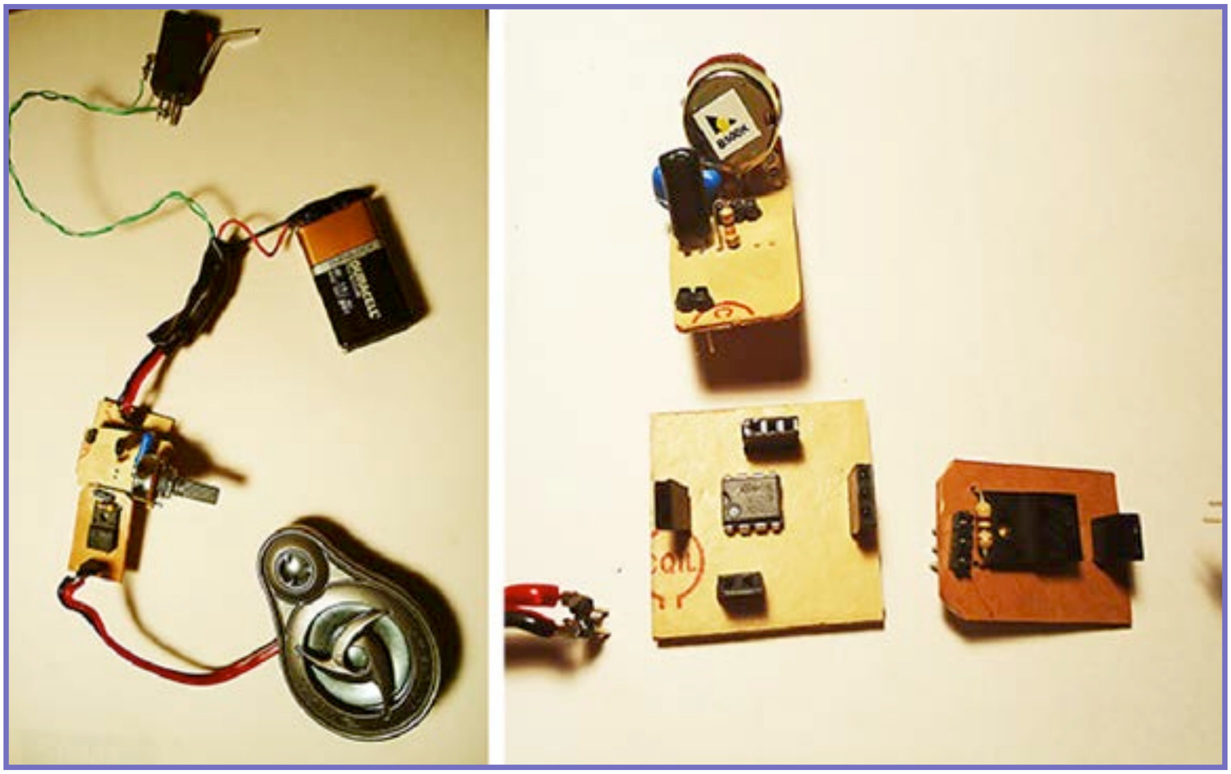
Pietro Domingues – Mechatronics student in University of São Paulo. Currently working on projects related to rapid prototyping on engineering, design on engineering. Member of PET (Programa de Educação Tutorial – Automação e Sistemas), where develops projects relating education, research and extension inside the mechatronics undergraduate course. Contact: pietrodomingues@gmail.com

Little Tomas Edisons – Assembling and Inventing from 6th grade to High School

The students learn how to build little mechanisms and how to automate them with GoGoBoard and Arduino. They also learn how to make basic electronic circuits and PCBs and how to adapt other existing designs. In these activities they learn basic concepts about electromagnetism, electricity and electronics (transistors, capacitors, resistors, relays, etc.).

The mechanisms and circuits building allow them to understand and experience the electronics and mechanics principles, but they can be understood with metaphors as well. For example, to explain the concept of oscillators we show the "Monjolo" mechanism (which is a water-powered mechanical oscillator).

In another activity they are allowed to manipulate circuits involving a 555 chip, changing resistors and capacitors values to obtain changes in oscillation.



LED Flasher with relay

- http://fablearn.stanford.edu/fellows/project/led-flasher-and-electric-bell-relay

The monjolo and the pulsating universe

- http://fablearn.stanford.edu/fellows/project/monjolo-and-pulsating-universe

Monjolo mechanism video

- https://www.youtube.com/watch?v=oGLaTd264Dw

Oscillator circuit in blocks

After this basic experience, the students are able to assembly more complex circuits. They assembled their own GoGoBoard at Colégio Santo Américo and Fundação Pedreira.

To make the assembly task less complicated, we developed a simpler version of Gogo Board, called GoGo Mini. And then students from 8º Grade of school assembled this version over one semester.

More details about the GoGo Mini (and how to build your own) :

GoGo Mini: http://fablearn.stanford.edu/fellows/project/gogo-mini

Little Turings – Programming robots and other devices

With the GogoBoard, Gogo Mini, and Arduino, students can build their own devices and robots. In our experience, we realized that when the students learn basic notions about programming, their understanding about mechatronics is better.

To learn programming, the students are challenged to program little robots to execute tasks such as walking until some objective is met, or to follow a black line on the floor, etc. This helps them understand sensor reading, conditionals, and computer programming workflow in general.

Robots worked so well that we developed a lot of versions using the GogoBoard. These versions interested many students and teachers, so the project "Robô barato" (cheap robot) was launched in 2013 on Catarse (crowdfunding platform on Brazil), and has succeeded very well.

Link to the Robô barato project: www.catarse.me/robobarato

Link about robot building: http://luthieriaderobos.blogspot.com.br

In 2014 we developed a cheaper and simpler model that can be made in a laser cutter and assembled by school students. We tested this robot with the same students in 8th grade at the Alef school.

Low cost robot

http://fablearn.stanford.edu/fellows/project/low-cost-robot

This robot model allowed them to program their own robot and learn the principles of programming.

Heather Allen Pang

Castilleja School

National History Day Exhibit Boards

This is not really a maker project but rather an extension of a more traditional project that is much better since we have started making. Students do an extensive research project related to the National History Day theme (for 2014 it was Rights and Responsibilities in History). They have several options of how to present their research, including making a museum style exhibit. Students at first think this is a traditional poster board, and then they look at some of the projects from previous years and realize what a building project it is.

Next year I hope we will be using the lab to make the projects more interactive.

Advisory project modified for laser cutter

I have done this before with charms from the craft store but it would be much better with a trip to the laser cutter.

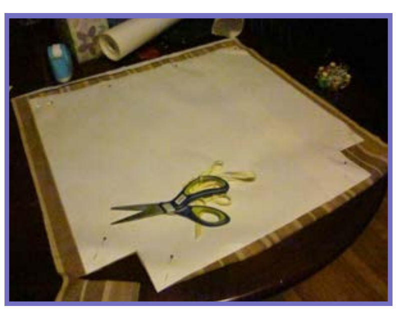
Students in advisory have a conversation about what matters to them and how they might want to remember things they want to accomplish during the day or the week or the school year. Students come up with words to stand for their goals, like "friendship" "courage" "creativity" and then they make a necklace, bracelet, or backpack decoration with one of the words. But before I have been limited to the words I can find at the local craft store.

I am going to do the exercise to create the word list, and then either take them down to the laser cutter, or if the timing won't work, do it myself, and cut the words on the laser cutter. They can then have any word they want on their "word reminder."

Introduction to sewing by machine

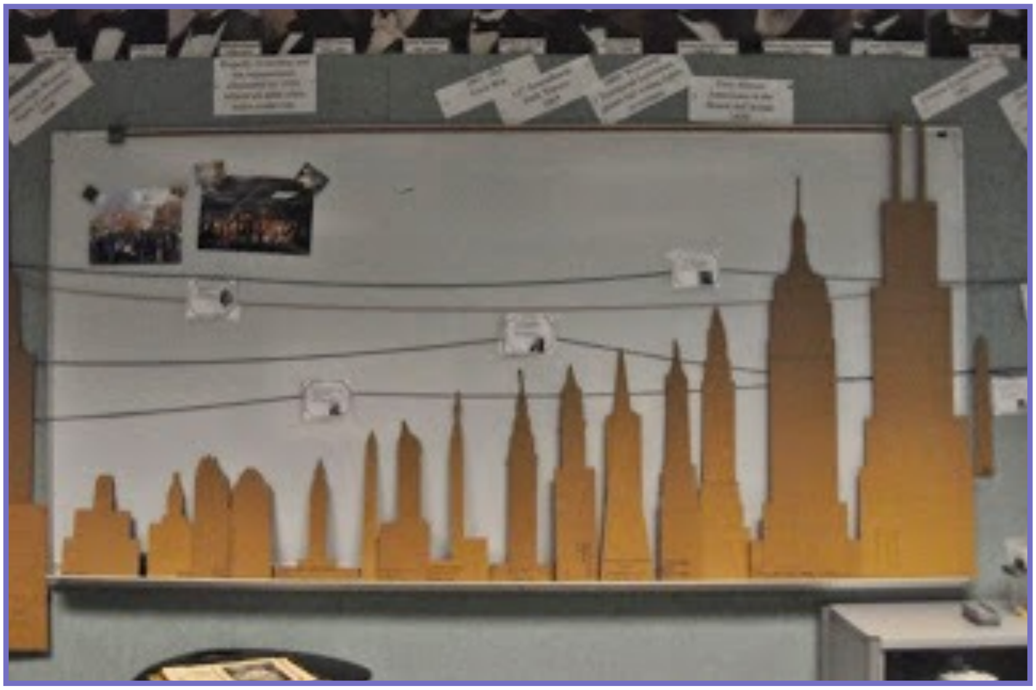
This is the first project in a 9 period sewing elective. It is challenging, but doable for students who have some experience, but not much. It is also useful for showing how 3D objects are made from flat cloth.

Students create their own patterns (if you are short on time you can make the patterns for them). The bags are lined, so you need 4 cut pieces of the pattern, and then we talk our way through sewing each step, and leaving a bit open to turn the bag. Students may add a strap if they want. We use recycled fabric from FabMo (http://www.fabmo.org/fabmo/Home.html)


Skill builder: Inkscape Buildings

The students in the monument project two years ago said one of the biggest challenges was getting their ideas drawn in Inkscape to cut out on the laser cutter. So I set up a skill-builder project to get them using the program earlier in the year.



I assigned each student an American skyscraper or tall building, ranging in height from about 300 feet to over 14,000 feet. I gave them each an image of the building, and they had to import the image, and trace the shapes. I reminded them that breaking something down into shapes was a 7th grade math skill, so that part was a good review. And Angi wrote very detailed instructions. I learned early on that to get them to follow the instructions I would not answer questions that did not start with what step they were on (that cut down on the questions considerably).

After I hung them up in the classroom we had a great conversation about how the skyscraper changed cities, and what technology was needed to build these things, and the problems of urbanization.

18th Century version

We have also done this project with 18th century buildings from Colonial Williamsburg and discussed the architecture and working of colonial cities. The variety of small houses and the grand scale of the Governor's Palace inspired observations about class difference, slavery, and status. Students asked who cleaned all those windows? who took built these buildings, and what kind of technology they had to build with.

Laser cut Williamsburg. We are still working on some issues of scale

Jaymes Dec

The Marymount School of New York

Environmental Concern Project

GreenFab was an NSF funded Fab Lab program for high school students from Hunts Point, South Bronx. Students attended morning classes on digital design, fabrication, computer programming, and physical computing all explored through the lens of sustainable design and green technologies. During the afternoons, students had an opportunity to tinker and explore with technologies, host visitors from environmental organizations, and go on field trips to local eco-friendly manufacturers and museums. For six weeks each semester, students worked on their own projects. The prompt that we gave them as to make something that addressed some environmental concern that they had about their community.

I think because we left it up to the students to come up with their own definitions of environment, concern, and community, students came up with great ideas. They made many amazing projects including: a machine for drying nail polish, an aquaponics window farming setup, an data collecting setup to test the effectiveness of green roofs in the summer, a mold for casting bricks from dirt and grass, and a solar paneled park table that charged USB devices.

Some of those projects and more: http://www.nsf.gov/news/newsmedia/greenfab/

Make something that makes art

This is one challenge that I gave to students last year that worked well during the second semester (after they had learned how to use most of the tools in the lab). It's pretty self-explanatory. I like to give kids access to tools and then these sort of vague challenges that put some constraints around the ideation process.

Interactive Dioramas

For this project, students build interactive data visualizations and/or museum type diorama displays that address some issue around biodiversity. They start the project by visiting a local Natural History Museum to observe different types of museum displays. Then they choose an issue (e.g. deforestation, pollution, invasive species, etc) that they want to highlight. Then they design an interactive display that addresses that issue. They use tools and materials like the 3D printers, laser cutter, vinyl cutter, Arduino, Scratch, and MaKey MaKeys. More on the project here.

Nerdy Derby

This is an annual week-long integrated project that we do with our 6th grade each year. It is a collaboration between Science, Art, and Technology. Students spend half the week doing experiments that allow them to discover some of the variables that affect the speed of a vehicle on a track. Then they spend the rest of the week designing and building cars to compete in a derby competition for fastest car, slowest car, and the Queen of the Hill.

See http://nerdyderby.com/ and https://www.edsurge.com/n/2013-04-24-nerd-derby-rules for more info on that project.

High Contrast Portraiture

Many of my students seem to enjoy portraiture projects. I'll sometimes ask them to take a high contrast picture of their head and manipulate it on a computer so that they can use the image to make vinyl portraits or laser cut stencils.

MaKey MaKey Instrument

Many of my students enjoy the "low floor" and "wide walls" of the MaKey MaKey microcontroller. One project that is popular is to make a novel music instrument using the MaKey MaKey and a computer. I had one team of students build a piano out of marshmallows and brownies. When they realized that they would run out of inputs on their controller, they learned how to reprogram and change the keys on the MaKey MaKey.

Light Up Bracelet

This past year I had a lot of students enjoy making simple felt bracelets with an LED, a battery, and snaps for a switch. This is based on The Sparkling Bracelet project in the book Sew Electric: http://sewelectric.org/diy-projects/sparkling-bracelet/

Make Your Space a Better Place

This is a semester-long project where I ask students to start with a public space in the school building and come up with an interactive installation that changes how people behave in that space. Some resulting projects have included: light up signs that encourage hand washing in the bathroom, a staircase that plays music, a motion-activated device that plays music in the elevator, and an RFID Card reader that dishes out compliments.

Project ideas from Constructing Modern Knowledge 2014

I thought that this list might be helpful here. It's a list of all the ideas that teachers had for projects at the beginning of CMK 2014, a summer institute for educators (http://constructingmodernknowledge.com).

These are just ideas. Some of them won't make sense out of context, but others might trigger an idea. Not all of them were built, but many were. Special thanks to Brian Smith for typing all these up. By the way, you can see some great video documentation of the final projects here: https://vimeo.com/tag:CMK14

- Tennis tracker app
- Musical dance shoes
- Noise activated event
- Wearable mouse
- Motion sensor camera for race cars
- SmartPhone Zipline [building to building]
- Wearable Speakers
- Housing Furniture
- Flocking and/or swarm robots
- Rockets!
- Giant Cardboard Robot
- Critter Detector
- Animatronic Crochet
- Giant Drawing Robot
- Drones
- Helio Tracker
- Conductable Fountain (Bellagio)
- Exercise Reminder "Get-up +Move"
- Magnets!!!
- Fly on the wall shirt (kid follower)
- Tesla (mini) Coil
- Choose your own adventure
- Levee system
- Rube Goldberg Machine
- Automated Chicken Coop
- Virtual Orchestra Conductor
- Talking & Self Watering Plant
- Phone Tracker
- Remote sprinkler system
- Interactive Wallet
- Smart Compost bin
- Perpetual motion machine
- Visual Voice meter
- Voice Pitch Meter Device
- Sand sculpture
- Jewlery
- Jumping bot
- Airplay receiver
- Paper speakers
- Programmable inflatable
- Robotic creatures
- Wearable Greenhouse
- Interactive Art Installation
- Stress reducer/tester
- Robot class pet
- Gloves that translate morse code to sign language
- Program to generate stories
- Weather data art generator
- Data Art
- Animatronic Parrot
- Robot Head Massager
- Wearable Space Invaders
- Twitter (stats) meter
- T-shirt that plays music
- Interactive Sound Sculpture
- Musical instruments
- Stroboscope
- Interactive Tree sculpture
- Interactive coffeepot
- Model Town
- Interactive Recycling bin
- Interactive soft book
- Robot High Five Machine

Juliet Wanyiri

Foondi Workshops

Redesigning our cities

We asked kids to design a futuristic Nairobi (Kenya's capital). This three month project was spread out so that the children were able to build projects on architecture and design as well as tinker with electronics in transport, security and funtomatics (a word we coined to mean fun electronic projects and games) . It's a great to get to engage students on physical programming, 3D printing, laser cutting, and e-textiles. Want to know what the future will look like? Ask your students to show you!

Video games & Virtual Worlds | Programming with Scratch

A great way to introduce software programming and gaming is by having the kids experiment on building their own virtual world. It gets more interesting when the kids are able to build games around themes that engage them in a fun and creative way.

Tutorials and sample games: www.teach-ict.com/programming/scratch/scratch_home.htm

Intelligent House and Car

This is one of the best ways to really get kids dive into an electronics kit. Ask them to imagine what their dream house or car and let them go out and make it. It gives them a great chance to use sensors: lights, motors and Legos to re-imagine the world around them and see themselves as positive change makers.

Building a Bike-Powered Smoothie Maker (Bici-blender)

This project is ideally better for older kids to learn about mechanics and how to use pedal powered machinery. There are several adaptations of this, each made to suit the materials available and the user needs.

Here's the link: http://fablearn.stanford.edu/fellows/blog/buiding-bici-blender

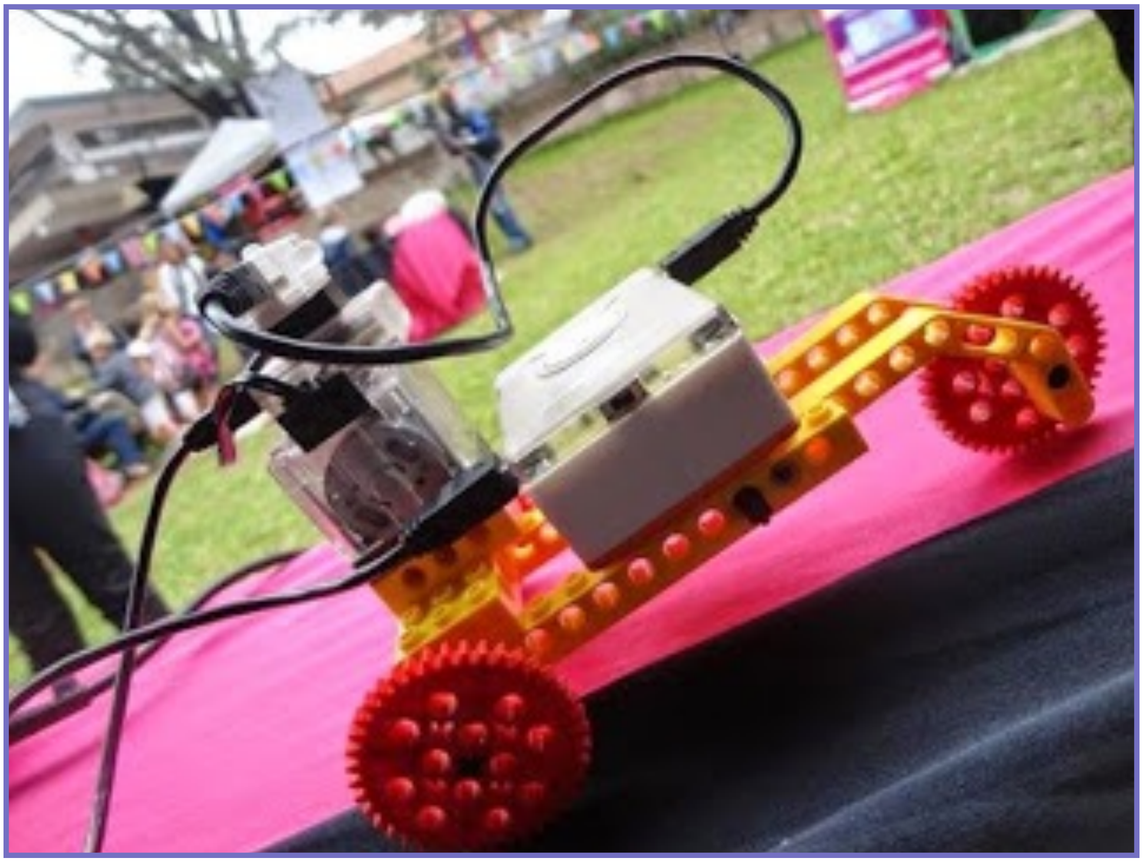
3D printing meets paper electronics

Trying to have a simple start for 6 year olds to 3D printing? Why not have the kids 3D print their names and their favourite super hero logo. Then make a paper circuit, and a LED, coin battery and Voila! You have a cool electronic name tag for your kids to wear during the maker sessions!

The Clapping Car - An introduction to artificial intelligence

Using the sound sensor, motor and Lego pieces in the Picocricket kit, the students are able to build a sound controlled car that begins motion when the kids clap (or any other loud sound is made) and moves in the opposite direction when the kids clap again. This project always works as a great way of introducing the concept of artificial intelligence incorporated in normally functionality of a simple car.

From here, the kids are able to build up even more creative, intelligent electronics projects on home automation, security and amazing automated games.



Electronic Quiz Board

We realized that the kids loved the quiz game we made using the Picocricket. So we decided that it would be great if they could make their own quiz boards now that the Picocricket was no longer in the market and electronic kits are hard to ship to Kenya. The way this works is that the students need to link each word with the corresponding correct answer. If a correct match is made, the light goes on. If not, they will need to try again until they get it right.

Here's what we used:

- A bulb & a bulb holder
- One 9v battery
- Screws (for each question and it's corresponding answer)
- Alligator clips
- Cardboard to act as the quiz board

The kids had lots of fun testing their knowledge on everything from the animal kingdom to countries and their respective capital cities. Using the quiz board, they were able to create their own learning environment that was built based on the electronics and maker classes they had previous had.

Simple Origami Lights

This project is a great way to incorporate science in art and this way build functional art.

Here's what you need:

- Paper to build the origami
- one LED
- Coin battery
- Wires

This project is a fun way of teaching kids how LEDs work, the basis of a simple circuit design while incorporating art.

Keith Ostfeld
Children's Museum of Houston

Cardboard Automata

This is a truly wonderful activity and one of the first ones from the Playful Invention and Exploration Network that we implemented in our own maker space. We've made multiple variations on it that we've done in the Museum, Outreach work, and the Houston Maker Faire.

From the PIE Institute:

http://www.exploratorium.edu/pie/downloads/Cardboard_Automata.pdf

Light Painting

This activity was first introduced to me by the staff at the Exploratorium when I was part of the Playful Invention and Exploration Network. It takes a bit of investment in terms of a good camera, but we had the kids make their own LED devices or they could use one of the light sources we provided.

Light Painting with PIE Institute:

http://www.exploratorium.edu/pie/library/lightpainting.html

Zoetrope

This animation activity is a lot of fun to make. Generally, we have kids first make one that works using our pre-made strip, then encourage them to try to create their own strip to animate. http://www.instructables.com/id/Make-a-Zoetrope-21/

Duct Tape Making

We do lots of making with Duct Tape. Wallets is one of our go-to items, but we also have done belts, superhero masks, and bags/purses.

Wallets: http://www.instructables.com/id/Duct-Tape-Wallet-14/

Bag/Purse: http://www.instructables.com/id/Duct-Tape-Bag-okayPurse/

Top Making

Another fairly successful activity is top making. We've had lots of variations and have reached a point where it has become an engineering sort of activity. We provide lots of materials as well a circle templates and safety compasses. Here is one of my favorites that we created - the chop top: http://www.instructables.com/id/Chop-Top/

LED Bling

A few other people mentioned this one, but we do a very open-ended LED jewelry-type activity with kids including rings, bracelets, glasses, etc. that the kids make. We usually start off with several examples around the room as inspiration, and encourage the families to create their own design.

Susan Klimczak

South End Technology Center @ Tent City

Computer Programming Game Making with Scratch – Flappy Bird

This year our youth teachers decided that we would teach children how to program their own Flappy Bird type games. The youth teachers made their own Flappy Bird games with physics simulations for gravity, but we needed a much simpler version to teach with children in a 2 hour block.

To do this, we use a starter game, with many choices for flappies, tubes and backgrounds that children remix: http://scratch.mit.edu/projects/22357673/

Then we have a two page single fold guide with hints for the children to scaffold the game building.

The youth teachers have an explainer guide and a cheat sheet to help them prepare for teaching and to consult if they run into problems while teaching.

- Flappy Bird Guide Page1
- Flappy Bird Guide Page2
- Get Flappy Explainer Guide
- Get Flappy Cheat Sheet

Musical Scratch

Our beginning Scratch tutorial activity this year for the children is called Musical Scratch, where in each step of the game they learn some new technique in Scratch while creating an interactive character.

There are something like 8 steps and in between the steps they play musical chairs at the computer and switch to someone else's creation. It's kind of like that children's game where you fold the paper like an accordion. The first child draws the monster head and folds it over before passing it to the next child who draws the body without seeing the head, then folds it over before passing it to the next child who draws the legs without seeing the head or body.

We tested out the Musical Scratch with children and they loved moving around and dancing to the music. We just used smartphones to play their favorite songs to do the musical chairs part.

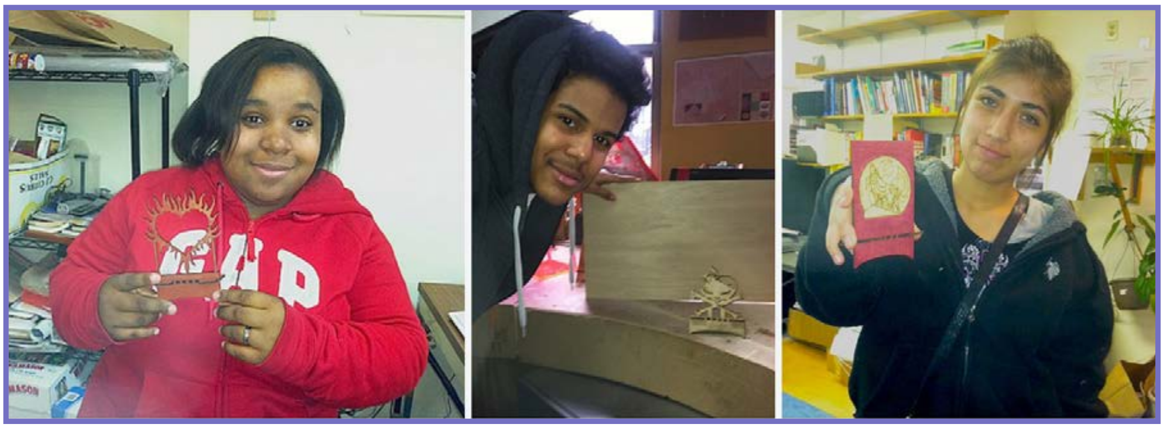
Cell Phone Holders Fabricated with Wood

This year, our youth teachers suggested that we make cell phone holders fabricated in wood and acrylic as an Introduction to Digital Design and Fabrication Project. One of our experienced youth teachers made a press-fit demonstration template that the new youth teachers could build upon.

The project allowed the youth teachers to learn the basics of formatting bitmap drawings into vector drawings while designing with Inkscape and LibreDraw. It was a great success!

Photos of what they made:

https://www.flickr.com/photos/28629285@N02/sets/72157644116128155/



MaKey MaKey game controllers

We like having youth make conductive MaKey MaKey game controllers and find some way to personalize games.

One example is a Scratch "Rock, Paper, Scissors" game. We found a version that featured white hands, but since most of our youth are youth of color, we substituted hands of color. We also personalized the game and created laughs by making versions with college mentors and in a recent case, featuring the principal and science/math department head at a local middle school where we taught.

- College mentor Xia: http://scratch.mit.edu/projects/23582670/
- Ms. Davis, Math/Science Coordinator: http://scratch.mit.edu/projects/23581911/
- Principal Brewer: http://scratch.mit.edu/projects/23578541/

Having the children both personalize the Scratch program and construct a game controller (we bring a variety of conductive materials from pencils to fruit) is very very engaging.

Another example that is popular is the Whack a Potato game from bluntbody. We create a pack of possible "moles" that range from popular cartoon characters (Spongebob, Hello Kitty to music stars like Beyonce). We also use GIMP (a free image editor) to take photos and encourage youth to put themselves or their friends into the Whack A Potato game.

MaKey MaKey Conductivity Activities

We use MaKey MaKey in many ways, but one of our favorite activities is having a "Battery Battle." Last year, a group from the Netherlands came to visit us and shared a Scratch program they used as a competitive game with MaKey MaKey. The idea is to break up the group of youth into two groups Team Blau and Team Rood. There is a table of many different kinds of things --- some conductive, some not, the sillier the better --- and each team has to choose one item they think is conductive. If they are right, a battery on the screen gets a "bar." The first team to get 5 bars wins!

Here is the activity plan we use (Google Doc)

Here is my edited version of the Scratch program that makes it much easier to set up

Squishy Circuits

We have been developing activities with squishy circuits for many years and I count AnnMarie Thomas (the inventor of Squishy Circuits) as a friend!

Some interesting things we have done:

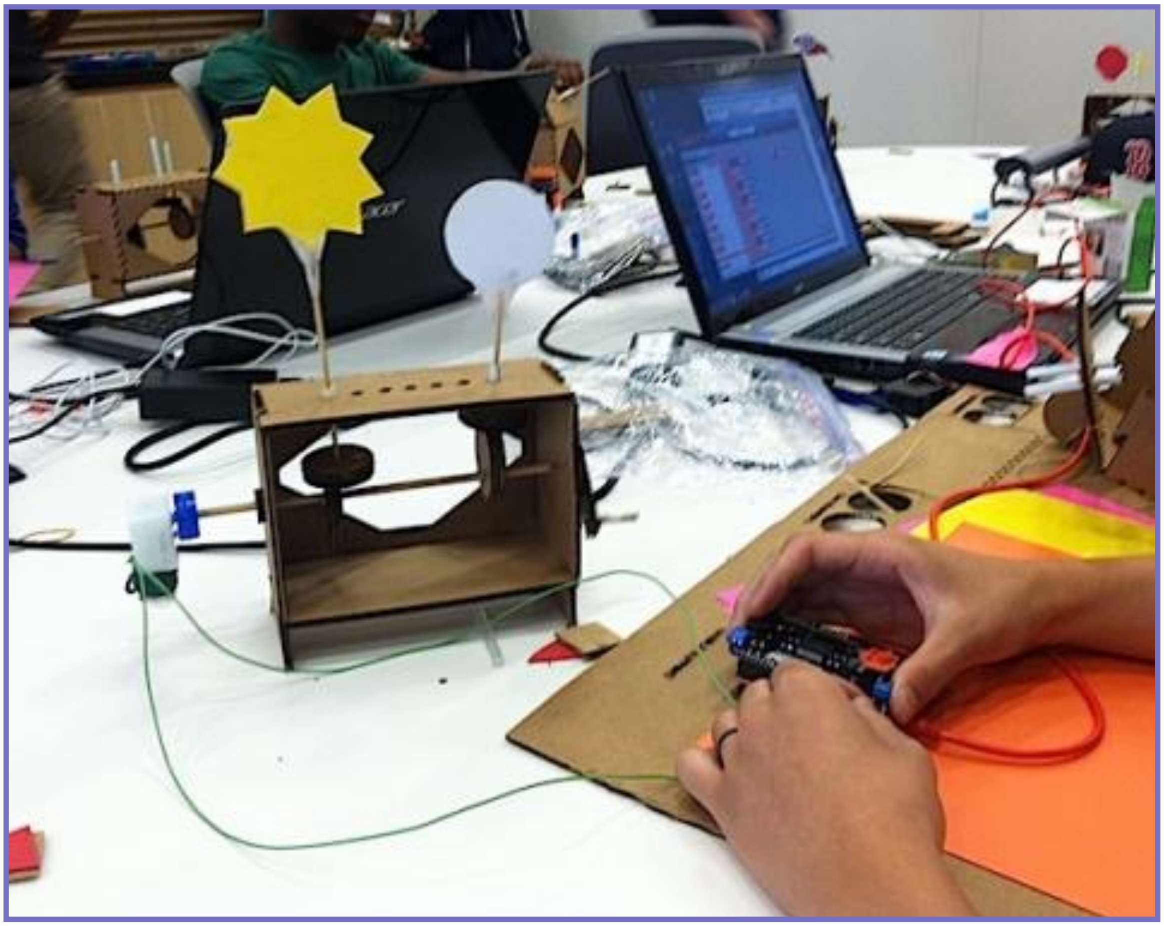
- Make buzzers buzz with both battery pack and a solar panel to highlight that there are sustainable forms of energy
- Create solar spin art by making a squishy motor circuit powered by a larger size solar panel; we use watered down tempera paint in nozzle bottles and have them sprinkle sparkly glitter while it is spinning and then hang them up with clothespins on a string line to let them dry.
- Make funny sculptures

This year we also added RGB LEDs and the youth at a local middle school where we piloted the activity with just loved it! We also created a variation on the Operation Game activity called Rescue Me! that focuses more on building a circuit from a diagram, then on the design of their own "operation," but it is very transportable for the activities we do at community organizations all around Boston.

Here is a little blogpost I did about this year's Squishy Circuits

Machines Gone Wild! Physical Programming with Cam Mechanisms

Here's the little blogpost I did about our new physical programming activity with Cam Mechanisms. We are excited to take it out to 600 children this summer! We used Arduino, a Modkit MotoProto Shield, fabkit plug-in components (LEDs, potentiometers, button, geared motor) and Modkit Micro as our graphical interface programming environment.



Paper Electronic Storytelling

For the last several years, we have worked with Jie Qi at the MIT Media Lab on paper electronic storytelling, both letting her try out things she is developing and also helping her figure out the best ways to teach them. Our youth love making electric cards and returning youth teachers even offered a workshop for youth teacher applicants this year that took the circuits 3D! Just last Saturday, we were the first group to try out Jie's programmed and programmable circuit stickers that allowed both led effects like heartbeats and fading, but also had sound and light sensors.

Here's a video about the paper electronic storytelling workshop from last year

Here's how the returning youth teachers built on what they learned with Jie Qi last year in their own paper electronic workshop

Here's a little video from the Circuit Sticker Storytelling workshop we did with Jie Qi last weekend!

Electric Friends Soft Circuit Activity

Last year, we wanted to develop a soft circuit activity for children that did not involve sewing. We created digital fabrication files for the slot and tab design and fabricated the "bodies" out of felt. The circuits are fixed to the felt with masking tape. Two dangling legs or arms with sticky copper tape form the "switch" to turn the light on.

Here are some photos at different stages of activity development.

https://www.flickr.com/photos/28629285@N02/8508940579/

https://www.flickr.com/photos/28629285@N02/8508107652/

https://www.flickr.com/photos/28629285@N02/sets/72157632299420424/

https://www.flickr.com/photos/28629285@N02/sets/72157638207166305/

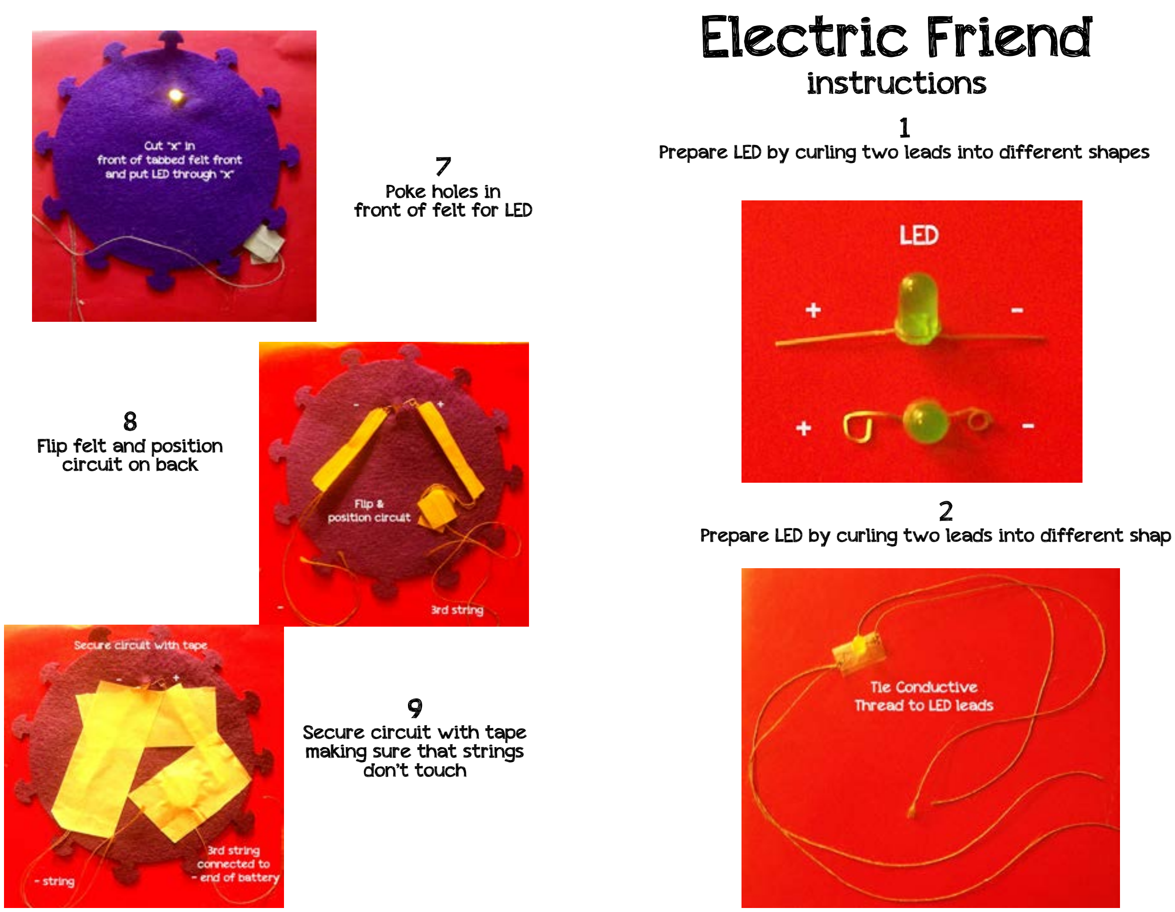
Here are some photos from a teaching session we did in the summer with the Boston Refuge Youth Engagement group:

https://www.flickr.com/photos/28629285@N02/sets/72157638207862166/

https://www.flickr.com/photos/28629285@N02/8508107652/

[Here is a rough activity plan, created by our teenaged youth teachers (Google Doc)]

Here is a PDF of a single fold handout the youth teachers and children used to make the electric

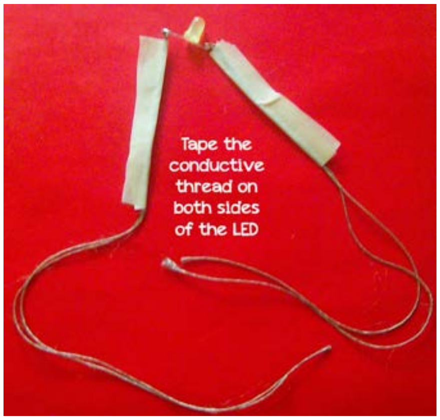


friends. Print two-sided and fold down the middle.

[Page 1 (outside)]

3

Put tape over conductive threads on both sides of LEDs

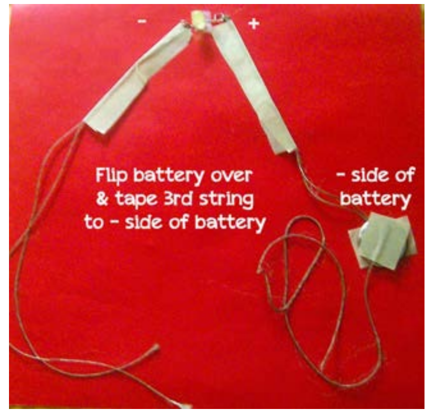


4

Tape threads from + side of LED to + side of battery

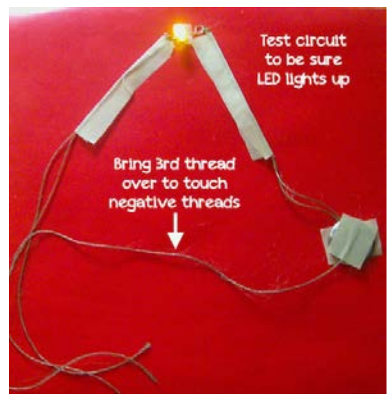
5

Flip battery and tape 3rd string to - side of battery



6

Flip battery and tape 3rd string to - side of battery



Page 2 (inside)

RoboPicasso - Physical Programming Activity with Vex Robotics using Modkit Micro

For several years, we have been refining a "RoboPicasso" physical programming activity in which youth "teach" a robot to draw. In previous years, we fabricated simple drawbots using lego motors: https://www.flickr.com/photos/28629285@N02/sets/72157634266667681/

This year, we got some Vex Robotics Kits donated and were able to make some more sophisticated DrawBots so that the "pen up" and "pen down" could be programmed and a gear train that allowed much more precise design. The activity featured a kinesthetic exercise called "Moving Like a Robot." The Modkit Micro graphical interface programming environment (developed by one of our longtime staff and L2TT2L contributors Ed Baafi), lets us scaffold the learning of coding.

https://www.flickr.com/photos/28629285@N02/sets/72157644424122964/

Chain Reaction with WeDo and Scratch. . . Physical programming!

Thanks to the Fab Learn Fellows program, I received some WeDos and we have spent the spring developing a Chain Reaction activity our youth teachers are about to take out to 600 elementary and middle school youth in 20 Boston community centers for our free 3-week STEAM camps next week!

This is the footage from the "spring training" activity at the MIT Media Lab with Abdulrahman Idlbi, a doctoral student who developed the Scratch/WeDo plug in. The WeDo kits have two sensors and a motor. If you use the WeDo Plug In on Scratch, you can "sense" the external sensors and "start" the motors from Scratch! The plug in only works in the Scratch online version (not the remote desktop downloadable version) and you can't use it on those Chromebooks that are so popular in schools. Otherwise, it's super easy!

Link to video: https://www.youtube.com/watch?v=l6gYRjOCIoc&feature=youtu.be

Starter project templates for Scratch game-making

We find youth get interested in computer programming when they have early successes with cool projects. While youth love drawing in Scratch or editing imported cartoon characters, for short game-making sessions (as a second Scratch lesson), we have developed an approach where we use starter games with lots of sprite choices. We usually only have 1 1/2 - 2 hours with the youth we teach in summer STEAM camp sessions.

For instance, last year, we taught Pacman and had a pack of different Pacmans, ghosts and coins that they could design their games with:

http://scratch.mit.edu/projects/11132470/#player

This year, we are teaching Flappy Bird and are using a pack 'o flappies and pack 'o tubes to get them started: http://scratch.mit.edu/projects/22357673/

Soft Circuit Pins using Lasercut Felt

One of our tried and true activities to introduce both youth and adults to soft circuit electronics is sewing circuits into pins designed and fabricated in felt on our lasercutters. It takes about 4 hours.

For this project we also fabricate and sew up the battery holders to get folks started. I have a little felt panel that show the stages of building the circuit and attaching the battery holder, which I find to be much more helpful than any written documents. The participants can actually see what the circuit looks like. We use regular through hole LEDs and tiny pieces of copper taper, as well as conductive thread for this activity which makes it affordable. It's important to have lots of craft materials for embellishing!

The youth teachers also designed a workshop for L2TT2L applicants this year where they made felt light up cellphone holders.

Here are photos from one we did with folks from the MIT OpenStyle Lab who are designing and making clothes and accessories for folks living with disabilities:

https://www.flickr.com/photos/28629285@N02/sets/72157645249332458/

Here's some other photos from workshops we have given for youth teachers and families:

https://www.flickr.com/photos/28629285@N02/sets/72157642729929725/

https://www.flickr.com/photos/28629285@N02/sets/72157632198771889/

Nalin Tutiyaphuengprasert

DSIL Bangkok Thailand

Darunsikkhalai School for Innovative Learning (DSIL) has established our Fablab with the support of Stanford's Tranformative Learning Technologies Laboratory in 2013. Fablab. Our Fablab is a part of FabLab@School program. DSIL is an educational initiative since 2001 that aims to provide a learning laboratory that allows educators in Thailand exposed to project based learning and innovative learning tools and ideas. We hope that this small school project will inspire and provoke thoughts and effort to develop more meaningful learning experiences for Thai students.

We kicked off in 2013 with some teacher training program. As a Constructionist school since 2001, DSIL has some experiences in making for learning in classroom by using paper and craft materials. Introducing Digital Fabrication to Thailand is another big step to make learning especially in Math and Science more concrete and interesting to students.

After some basic training to teachers and lab staffs, we have been developing curriculum and activities from scratch. In our Fablab, we have team of freelance designer(Sangaroon Jiamsawadi), freelance programmer(Meechai Junpho) and myself as a teacher. Three of us are interested in developing a curriculum and program that allows K-12 students to access to variety making tools and aims to develop agency and trigger our students to become proactive learners.

In this blog, there are some activities that we had developed and applied in our FabLab class and also some activities that we work with teachers and parents to help them understand the new learning environment that the children will be exposing to. We believe that developing common understanding and believe in adults both teachers and parents would enhance the children's learning experiences and become a sustained learning environment in the long term.

Parents Maker Day

The objective is to give the parents the direct experience of making something in the FabLab. This is a good strategy to introduce the FabLab to parents, so they get to see it, use all the devices, and ask questions. I wrote a blog about this event here.

The activity is to make the lamp that parents can take it home. The parents get to use Illustrator, the laser cutter, and assemble all pieces together.

At the end we have a reflection discussion with parents, introduce the parents about Constructivism, and Constructionism learning in making experiences.

A video conference (get the student’s ideas on stage)

We have done this once in the past year. We tried to connect to other school outside Thailand and would like to get the kids to share their projects together. But with the time difference challenge, we still could not match the other school yet. But we did one sharing session with Paulo Blikstein and Roger (Lecturer from Chiangmai University) and get the students to share their individual projects and get feedback from people outside the school. The students were so excited and proud of their work. This activity can lift the motivation to make things very well. We're still looking for a school to do this project together. Thai kids are ready to stay overnight at school to do a video conference with any school on other side of the world. Let me know if you're interested to join this with us.

Exhibit box (for new makers)

This is the exhibit box that the student will make for the class exhibition. They will use the box maker, design the pictures on each side of the exhibit box that will represent ideas of their topics. The students know how to make the box already, this is to introduce them how to apply the skills gained from FabLab class to their regular classroom.

FabLab in Your Class Project (for teachers)

The idea is to think of strategy how to promote the making for the teachers in the regular classroom.

We invited different groups of teachers to have meetings. The FabLab team will discuss with teachers, provide ideas of what are the cool things we can make in each particular topics. The FabLab team also worked together with the teachers running the class not just providing ideas.

This strategy works well, this term there are more classes involve making into the classrooms. The students can get to make things both in the regular class project and the FabLab class.

FabLab Training (student & teacher workshop)

This is very helpful to get the lab started. Paulo, Brogan and team from Stanford together with the Thailand's team designed a 4 day workshop for 15 teachers and 5 students at our school in Bangkok. This workshop gave the guidelines of how to use the facility safely and how to make things. Brogan introduce the design thinking process to all the participants and we get the participants to create the projects and at the same time introduce the project based learning styles to the teachers. Teachers get to discuss together about the design of activities and share ideas of how to incorporate making experiences in the regular classrooms.

Design your house (For beginner makers, age 7-8 yrs old)

After the little kids make the boxes in the box maker challenge, we provide them a bit more complicated task. We assign them to make the house. We create the template of the house and teach them how to use the basic tools of Illustrator and let them design the house. They will be guide through the process of designing, laser cutting and assembly the product. Kids are more confident to make and use the equipment in the lab after this activity.

Mini Sculpture Project (Good for little kids, grade 1-2, first time makers)

We encountered some challenge when the little kids came up with brilliant ideas but they couldn't really make things by themselves. We designed the activities to help them practice and strengthen the hand muscles and also expose them to the basic forming and structure of the object they would like to make. We provided the kids clay, wire and construction paper. Show them some guideline how to form the shape from each material and let them design and make their own sculpture.

Box maker challenge. (Good for first time makers, age 6-8)

We created this activity for the new maker to enjoy making experience instead of getting so overwhelming by the lab and other experienced makers.

For the Box Maker Challenge, we provide the kids age between 6-8 years old with cube box plates. We made the plates simply by using the Box Maker Software http://www.makercase.com. The kids were assigned to assemble them, glue them and make it strong as much as possible. After they finished assembled the box, we will test them by throwing them up in the air so they drop on the floor (1.5 meter high). The task is to make a box that will not fall apart.

There are 3 stages, each group has to pass each stage one by one. Each stage introduces the kids the new way to structure the cube box which they will be using a lot when they're making projects.

Pop-pop boat competition (grades 4-5)

We had found that for the new makers, they need something to start off their making experiences. The FabLab can be so overwhelming to new makers. This is one of the starter classes that we designed.

The task is to make pop-pop boat for the competition. This boat will make from the trash only. It can be the can, milk carton, straws, etc.

This project is 3 classes long of 1 hour each.

- **1st class:** Introduce pop-pop boat, kids work in groups of three to make their first pop-pop boat with the materials that we provided (can, straws, glue)
- **2nd class:** In groups of two, make their version of the boat. The task is to make the fastest boat. They can think of other materials and designs to make it faster. How can they make the boat float and move fast? They learn new techniques from each other.
- **3rd class:** Finish the boat and competition. Discuss: what makes the boat fast?

The boat design can be found here: https://www.youtube.com/watch?v=0ki9Kta8g14

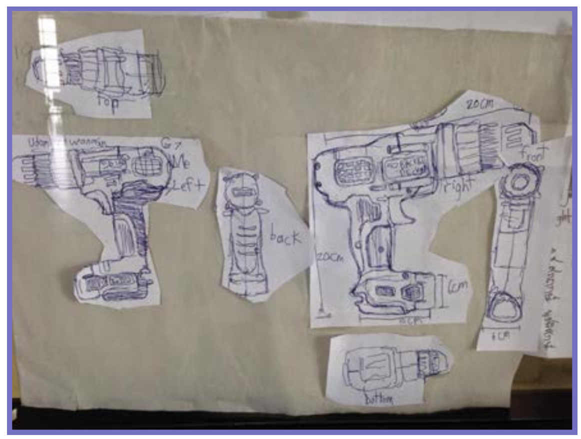
(The gluing part is not as easy as it looked on the video though. We did some trials by our team first, but this is so much fun for the kids and us. Leave some space for the air and water, glue them well and have fun with pop-pop boat.)

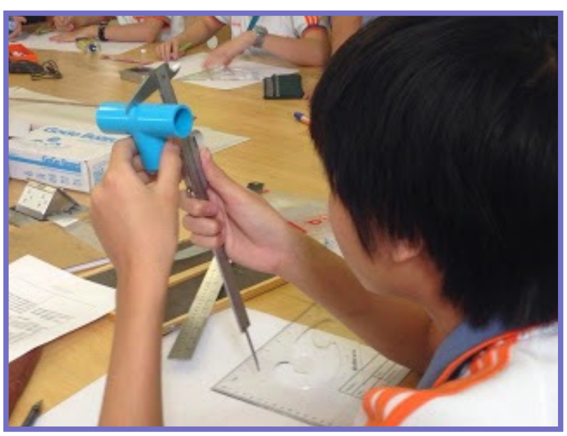
Elevation Drawing - Becoming professional maker part 1 (grade 5/6)

This class was introduced to grade 5-6 students after they had made a couple of things earlier. So the kids get familiar with the equipment and basic tools in the Fablab.

This will get the kids to see the benefit of this drawing and put effort to these tasks.

The objective is to introduce them the 6 perspectives drawing from different point of view. (top-bottom-left-right-front-back) This drawing experiences gets the students familiar with dimensions of the object, and will be helpful once they work with the computer. This is useful for the first-timer getting into 3D graphic design on computer.



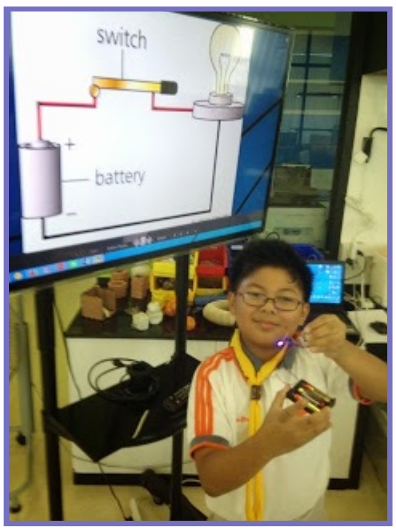


The kids spent about 30-40 minutes drawing an object in different perspectives. The class is simple and straightforward, no fancy design, but the students are so into the task. They want to be professional designers and know that this will help them communicate their ideas to others what they actually want to make. The kids get to use the vernier caliper. This activity can get the kids to work in the millimeter units and slows the kids down a lot. This also helps improve the focus and concentration for many active students.

Mother's day pop-up card - basic electronic circuit for g2-3 class

In Thailand, August 12 is the national mother's day. We have 2 groups of grade 2-3 students making pop-up cards for moms. The students get to make and learn the basic circuit: batteries, switch and LED. There are 3 different classes of 45 mins each.

- 1st class: pop-up card (individual task)
- 2nd class: make the light up! get the kids to connect the battery, wire and make led on! (groups of 2 kids)
- 3rd class: combine all tasks, making popup card with one led in their own design.



Mark Schreiber

American School in Japan

Squishy Circuits with Arduino

I still love making play doh circuits and so do the kids. They really get to explore how a circuit can work and how it can short out. Once they have the basics we hook them up to small Arduinos (Usually Adafruit's Gemma) and add in a simple blink code that they can continue to tweak and change thinks like how fast it fades or how long it stays on and off. It's a great introduction to electronics and Arduino. (Squishy Circuit Dough Recipe)

Aerial Photo-Weather Balloon

Aerial Photography is a great activity. It costs a bit to have a helium tank but if you do it right you can re-use the weather balloon. It's nice to build a rig that can hold at least 2 cameras (if your balloon can lift that) then you can do two groups at a time.

It is a great design challenge for most age groups as the rig to hold a camera is pretty easy to design and create. Then I do a safety check on it and away they fly. Next time I do it I'm going to put my kite string on a modified bike rim. Then I can just crank in the balloon with the pedals and let it fly away with the freewheel. That should help things go faster and get more rigs flying in less time.

Also, I plan on doing the Global Space Balloon challenge this year with my advanced class. It looks pretty cool. Basically you let the balloon/camera rig go up to burst altitude and then retrieve it once it parachutes down using a GPS signal (maybe AdaFruit Arduino module or a Raspberry Pi USB device..)

Here's a great video of one launch. https://www.youtube.com/watch?v=iOyZoch_hb4

Monster Scribble/Art Chalk Bots

I know a lot of people have added their Art/Scribble bot ideas. I love doing these too. I think it is one of my favorite tinkering activities for sure. If the kids are older or get bored with the small scribble bots (or toothbrush bots are fun too) then challenge them with a larger bot. We use 5-gallon bucket and cordless power tools to make monster chalk drawing bots.

Materials

- Sidewalk chalk
- Duct Tape
- Cordless drill (with off balance weight)
- OR try another power tool like an orbital sander
- 5 Gallon bucket or other big super structure object.
- A clean fairly smooth sidewalk

Water/Air Rockets

Water rockets have been around for a long time but I still find them as a great activity for students. Get a 2-liter pop bottle, some materials for fins, foam core is good and easy to cut on the laser for various designs. We pump them up to 90-100 PSI on using a rubber stopper, a PVC launcher, and a ball valve. If they are created right they can easily go 100 meters. We've also done payloads, parachutes, as well as coupled 2 bottles together for a longer "burn" (look up Robinson couplings).

Upcycling

I think upcycling is a great and low cost way to get kids into design. I walk kids through the basic design thinking and iterative design cycle by having the come up with ideas based on a material, location, and activity. Once the mini group settles on the idea they have to rapidly prototype it. In other classes we refine the ideas using Method 635, give and get feedback and then make a final prototype and "pitch" to the class. Whichever idea wins gets to do a small 1-class production run of their idea.

We've created bike tube coffee cozys, wallets, bracelets, hair clips, utilitarian hooks, firehose belts and guitar straps and more. It was such a hit that I actually created a side curriculum with the concept called DesignCase. (See www.designcase.co for more info.)

IKEA hack-a-thon

My advanced classes do a hack IKEA unit where we use small objects (usually LED lamps and such) and repurpose them or combine them with other IKEA objects (typically kitchen wares). One that I'm doing next week as part of a maker camp for 8 -14 year olds is going to involve hacking a nightlight, changing the LED out for a different color, replacing the lens with a laser-cut design of their own for making shapes and patterns on their ceilings.

Edible phone cases

Using rice crispy treats we learn molding and casting techniques, vacuum bagging, and what makes a good design.... (then we eat the cases)

Upcycling

I walk kids through the basic design thinking and iterative design cycle by having the come up with ideas based on a material, location, and activity. Once the mini group settles on the idea they have to rapidly prototype it. In other classes we refine the ideas using method 635, give and get feedback and then make a final prototype and "pitch" to the class. Whichever idea wins gets to do a small one-class production run of their idea. We've created bike tube coffee cozys, wallets, bracelets, hair clips, utilitarian hooks, firehose belts and guitar straps and more. It was such a hit that I actually created a side business with the concept called DesignCase. I'd be happy to send the (mostly finished) curriculum to any fellow interested. www.designcase.co for more info.

Shake it up

Have students create parts of a mega-metropolis city out of paper, foam-core, etc. Using Inkscape or Adobe Illustrator and the laser cutter. Once the new city is assembled, on a rocker platform (a piece of wood on rollerblade wheels with places to insert a jig saw to make it shake) we turn on the "earth quake" and see how well their buildings hold up.

Open Source Pinball

This is kind of like the marble wall but instead we made a pinball machine that can be easily reworked. Basically it is a slanted pegboard, some bolts or dowels with rubber bands, a couple flippers with push rods, and at the bottom a slanted rail that funnels the balls back to the shooter. (rubber bands and pvc/rod or just pvc on a slope).

It's been a fun project for kids to tinker with for sure.

Susanna Tesconi

Laboral Centro de Arte y Creación Industrial

Hidden sound: Experimenting with piezos, vibration and amplifiers

This is one day workshop. Create a circuit with a 9 volt battery, 1 piezo, mini jack connector, speaker, amplifier. There is a simpler version just with the piezo and the connector, but you need an external amplifier.

The piezo placed on the wood allows you to "hear" the hidden sound produced by the vibration of material you stick to it. The complex version is a stand-alone sound object, the simple version need to be plugged to an external device.

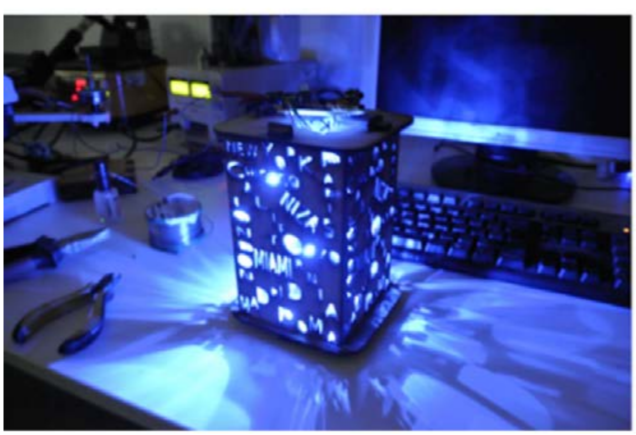
The kids enjoy very much making noise and noisy story telling. If you have a multi channel DJ mixer you can plug several instrument and set up a noisy orchestra.

Advice: the kids love to bring the instruments home and make some experimental electronic music so: the parents will hate you!

More photos at:

http://susannatesconi.net/post/66284747826/workshop-hidden-sounds-at-fundación

Video: https://vimeo.com/13122229

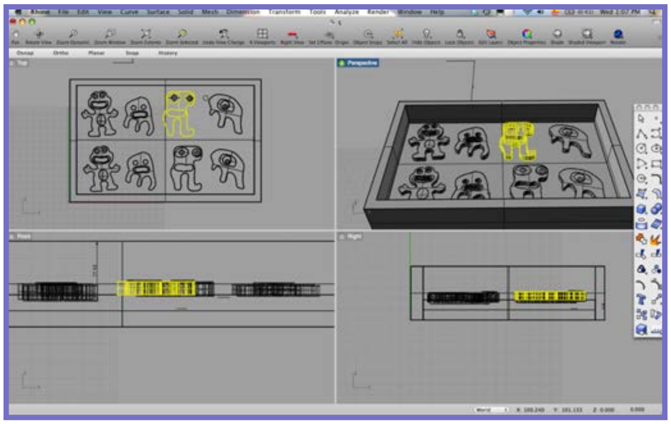


Playing with light: lamps design

This one school year long project has been realised by a small group of high school students in a special program against school dropout. We asked them to research about light, its everyday use and application to opaque projectors and other similar devices. Then we focused on lamps design and production. They worked with Inkscape and laser cutting to make prototypes using different materials and techniques. At the same time they experimented with LEDs, colours and circuits.

Making candy monsters

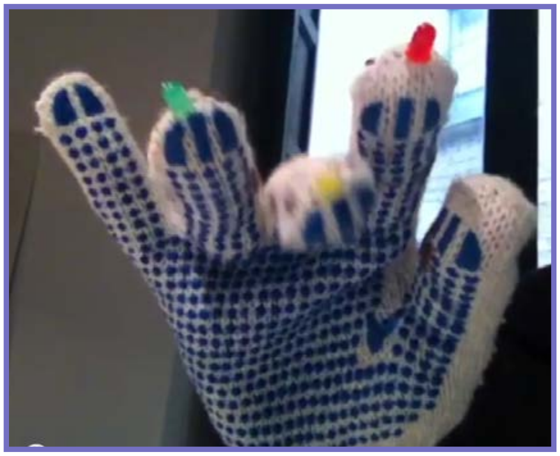
This is a weekend project for primary school kids. We created candy molds from 3D models using a milling machine (a 3D printer works as well). The pictures are from 2009 so the modeling was made in Rhino...using some tricks in order to allow the kid starting from free hand drawing to surface extrusion. These days using Tinkercad is obviously easier.



Light gloves and light fingers

This is a scalable e-textile project. The idea is to build wearable devices for light painting. Depending on the age and expertise of the group you can use different designs for the circuit and the object. You can start with a simple "finger" made with foam, copper tape and a single LED (no sewing) or realize a more complex device, like the 3 LEDs glove with an embedded sewed circuit. Simple and complex devices work well for light painting.

Watch the video here: https://www.youtube.com/watch?v=u6ohyXgB8Dc



Make your own Trivia game

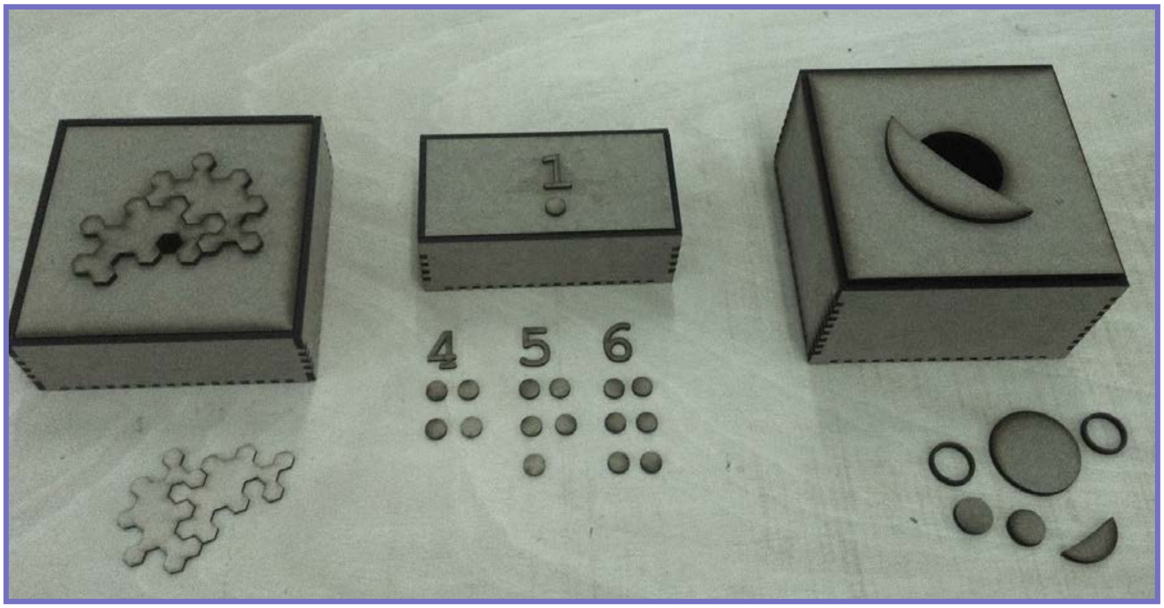
This is a semester project in middle school. We asked the kids to design and build a Trivia game. Each part of it was re-thought and re-designed: board, symbols functions and logos, subjects, cards, questions, dice, etc. The games passed through several design cycles.

Teacher training: no-battery lab

This is a week-long workshop with middle school teachers. I asked them to design and build devices producing energy without battery. We made 2 wind generator models and water power generator optimised by a Joules Thief circuit.

Teacher training: design and build your own Montessori-inspired material

This is a one-week workshop for primary school teachers. After running a set of introductory activities to the FabLAB I asked them to use the lab in order to produce material they need.



Make it big: scale up a Scrabble game

This is a semester project for high school students in a special program to prevent school dropouts. The project is the design and fabrication of a SCRABBLE® game. Students were asked to investigate about the game and find technical solutions to build a 5:1 scale real prototype they can use at school.

What do elderly people need?

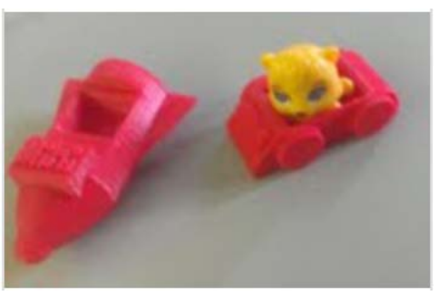
This one school year long project has been realised by a small group of high school students in a special program to prevent school dropouts. We asked them to design something that can help senior citizens in their everyday life. They first researched the needs of elderly people and then they design and fabricate several prototypes of ROSE (from Recoge Objetos Sin Esfuerzo - easy pick up tool) a shoehorn that also picks up shoes.

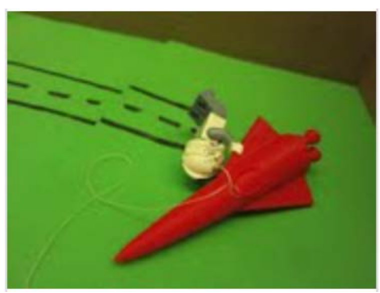
Tracy Rudzitis

3D Printing Characters & Props for Stop-Motion Animation

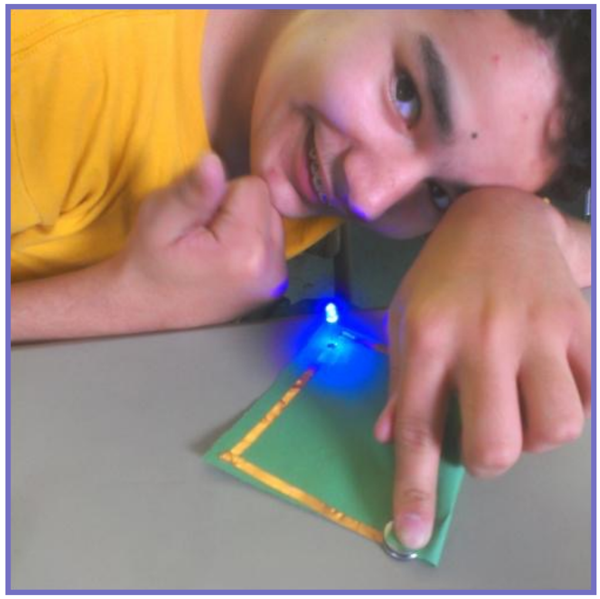
My 6th and 7th grade class work on a stop-motion animation as part of the larger animation unit they study. This year I suggested that they could use the 3D printer. The students came up with some brilliant and creative ideas.

They had to work with scale and measurements to get the props to fit with the non-printed items they were using. Typically the students design, draw, paint, the backdrops and scenery, this was the first time that students created 3 dimensional objects and this really opens up such a new range of possibilities for what students can do and the kinds of tools and technologies they are starting to have made available to them.





Very Very Simple Circuit - Copper Tape & LED & Battery & Paper



I did a hands-on workshop in circuits with our 12-1 Special Ed class. They were absolutely thrilled to get some making experience. It truly is a shame how little hands on activities take place in the typical NYC Public Schools.

Although the activity is simple, the learning and understanding is not, none of these students knew about negative and positive and electricity and how it works, so it was all so magical to them.

After we built paper circuits I hooked up a MaKey MaKey and was able to demonstrate how we can use our bodies (holding hands) to conduct electricity.

Here is a link to a video I made from the afternoon activity, I think I enjoyed it at least as much as the students did!

https://vimeo.com/96956333

Jitterbugs

My student LOVE this project. This is an excellent project for beginners, and when you may not have a lot of time to help out.

- DC motors
- Hook up wire
- CD-ROMs (or other material for the robot body)
- Arts & Crafts materials to decorate
- AA batteries
- Battery holders (not necessary)
- Masking tape

Extensions - use this project to teach soldering to kids, or have them teach it to each other. 3D print the parts or the entire robot (see green robot in photo),

This is where I first read of the Jitterbug

There are a number of resources I have found that describe this project or google Jitterbug robot.

There are kits, but it's more fun to make your own and be creative.

Make Something Happen

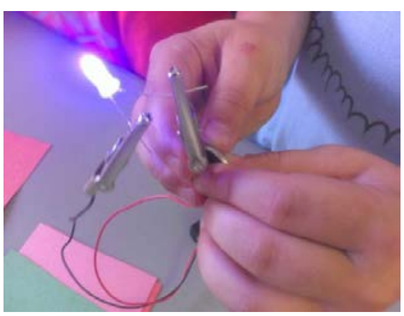
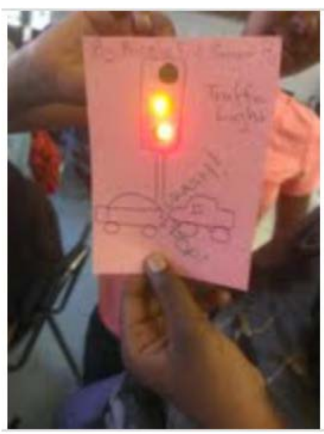
For the end of the year introduction for the current 6th graders who will be having our new STEAM Lab next year, I had 45 minutes with each of the four classes, 34 students in each class. I sat them at 4 tables, had a basket with construction paper, markers, various lengths of hook up wire, wire, pipe cleaners, alligator clips, assorted LEDs, coin cell batteries and AA battery packs (the plastic ones with a negative and a positive wire coming from the terminals.)

They played around with a variety of ideas, after 30 minutes or I asked them questions like:

What did you notice about the LED's? Were you able to make the lights light up? Why? Why not, asking them to see what the others at the table were doing, asking them to notice how the coin cell battery was able to light up an LED....

Some of the students are my Makerspace kids, but for many it was the first time in their life they had touched something electrical like that!!!




Tables of project snapshots, materials, supplies, age/grade ranges (including projects from all sections)

Note that all these are approximate, accommodations can often be made for different ages. Use your own judgement to decide if these projects are appropriate for your own environment and participants.

Refer to each project snapshot for more details about the supplies and materials needed.

Legend	Grade	Age
Lower elementary	< 6	< 7
Upper elementary	Grade 3-6	8 - 10
Middle School	Grade 6-8	10-13
High School	Grade 9-12 (and up)	13 +

Materials & Supplies	Details
Conductive fabrication	LEDs, copper tape, conductive thread, batteries, battery holders
Sewing	fabric, sewing supplies
Papercraft	paper, glue, tape
Craft	tape, glue, scissors, cutters, clips, decorations, cardboard, recycled materials
Electronics	resistors, small motors, capacitors, breadboard, wire, potentiometers, buttons, switches,
Building	nuts, bolts, screws

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Aaron Vanderwerff							
Chair (7-12)			x	x	hand tools, power tools	wood, building	
Woodworking (K-4)	x				hand tools, power tools	wood, building	
Wind Turbine – Physics					hand tools, voltmeter	craft, building	
Sewing Pillows (5-12)			x	x		craft, sewing	
Character Study Puppets (2nd grade)						craft, sewing	
Sand and Water (Kindergarten)	x					sand	
Independent Maker Faire Projects (6 – 12)			x	x			
David Malpica							
Engineering Design intersession (7th grade)			x		hand tools, power tools, computer controlled machines		CAD, Arduino
Design the School of the Future architectural models (8th grade)			x		laser cutter, knives	glue	CAD
Kinetic Sculptures (8th grade STEAM unit)			x		hand tools, power tools, computer controlled machines		CAD
Redesign of 3D printed Robohands		x			3D printer	calipers	CAD

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Laser cut habitat animals and mythological creatures (component of 4th grade PBL unit)		x			laser cutter	nuts and bolts	Meshmixer
3D Gnomes "Skill Builder" (3rd Grade)	x	x					CAD
Turtle Racing (6th grade Engineering Design)			x				PencilCode, TurtleArt, Scratch, Pixlr
Costa Rica eco-tourism experience PBL (6th grade)			x		laser cutter, knives		CAD
Erin Riley							
Marble Run	x	x	x	x	hand tools	tubing, pegboard	
Building with cardboard	x	x	x	x		cardboard, craft	
Adobe Illustrator			x	x			Adobe Illustrator
Alternative photography cyanotype			x	x			
Printmaking			x	x			
Drawing from observation, architectural drawing, isometric and linear perspective			x	x			
Paper circuits		x	x	x		papercraft supplies	
Sketchbooks/book binding			x	x			
Arduino Mind Map				x			
Atari Punk Synthesizer				x		electronics	

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Gilson Domingues							
Little Tomas Edisons – Assembling and Inventing from 6th grade to High School			x	x	Gogo Board, Gogo Mini	electronics	
Little Turings – Programming robots and other devices			x	x	Gogo Board, Gogo Mini	electronics	
Heather Allen Pang							
Inventions from history - the telegraph			x	x	lasercutter, hand tools	wood, wire	
National History Day Exhibit Boards			x	x			
Advisory project modified for laser cutter			x	x	laser cutter		
Introduction to sewing by machine			x	x	sewing machine	sewing	
Skill builder: Inkscape			x	x			Inkscape
20th Century Women Leaders Monuments Project			x	x	hand tools, laser cutter, 3D printer	wood, cardboard, craft	Inkscape
Jaymes Dec							
Environmental Concern Project				x			
Make something that makes art		x	x	x			
Interactive Dioramas		x	x	x			
Nerdy Derby		x	x	x		wood	
High Contrast Portraiture			x	x	vinyl cutter		

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
MaKey MaKey Instrument		x	x	x	MaKey MaKey		
Light Up Bracelet		x	x	x		conductive fabrication, sewing	
Make Your Space a Better Place	x	x	x	x			
Project ideas from Constructing Modern Knowledge 2014							
Juliet Wanyiri							
Redesigning our cities	x	x	x	x			
Video games & Virtual Worlds | Programming with Scratch		x	x				Scratch
Intelligent House and Car		x	x	x			
Building a Bike-Powered Smoothie Maker (Bici-blender)				x	hand tools, power tools	pedal powered machinery	
3D printing meets paper electronics	x	x			3D printer	conductive fabrication	
The Clapping Car - An introduction to artificial intelligence	x	x			Picocricket kit		
Electronic Quiz Board		x	x		Picocricket kit	craft	
Simple Origami Lights	x	x	x			conductive fabrication	
Keith Ostfeld							
Cardboard Automata		x	x	x		cardboard, craft	
Light Painting		x	x		digital camera	conductive fabrication	
Zoetrope		x	x			craft	

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Duct Tape Making		x	x			duct tape	
Top Making		x	x			craft	
LED Bling	x	x	x	x		conductive fabrication	
Susan Klimczak							
Computer Programming Game Making with Scratch – Flappy Bird		x	x				Scratch
Musical Scratch		x					Scratch
Cell Phone Holders Fabricated with Wood			x	x		wood, acrylic	Inkscape, LibreDraw
MaKey MaKey game controllers		x	x	x	MaKey MaKey	conductive, craft	Scratch
MaKey MaKey Conductivity Activities		x	x	x	MaKey MaKey	conductive, craft	
Squishy Circuits	x	x	x		homemade dough	conductive, craft	
Machines Gone Wild! Physical Programming with Cam Mechanisms			x	x	Arduino, MotoProto Sheild	electronic components	Modkit Micro
Paper Electronic Storytelling		x	x	x	Circuit Stickers	craft, LEDs	
Electric Friends Soft Circuit Activity		x	x	x		fabric, craft, conductive fab	Modkit MIcro
RoboPicasso - Physical Programming Activity with Vex Robotics using Modkit Micro			x	x	Vex Robotics	pens	
Chain Reaction with WeDo and Scratch. . . Physical programming!	x	x	x		WeDo Building Kit		Scratch

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Starter project templates for Scratch game-making	x	x	x				Scratch
Soft Circuit Pins using Lasercut Felt		x	x	x	Lasercutte r	Conductive fabrication, sewing	
Nalin Tutiyaphuengprasert							
Parents Maker Day	x	x	x	x			
A video conference (get the student's ideas on stage)		x	x	x	video		
Exhibit box (for new makers)		x	x		hand tools	wood, craft supplies	
FabLab in Your Class Project (for teachers)							
FabLab Training (student & teacher workshop)		x	x	x			
Design your house (For beginner makers, age 7-8 yrs old)	x	x			laser cutter	hand tools, craft supplies	Illustrator
Mini Sculpture Project (Good for little kids, grade 1-2, first time makers)	x					craft	
Box maker challenge. (Good for first time makers, age 6-8)	x	x				craft	
Pop-pop boat competition (grades 4-5)		x	x			craft	
Elevation Drawing - Becoming professional maker part 1 (grade 5/6)		x	x		calipers	craft	
Mother's day pop-up card - basic electronic circuit for g2-3 class	x	x				conductive fabrication	
Mark Schreiber							
Squishy Circuits with Ardunio			x	x	Squishy circuit dough, Gemma	conductive fabrication supplies	

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Aerial Photo- Weather Balloon			x	x	camera, GPS enabled Arduino or Raspberry Pi, balloon	electronic	
Monster Scribble/Art Chalk Bots			x	x	power tools	craft	
Water/Air Rockets			x	x		craft	
Upcycling	x	x	x	x		craft	
IKEA hack-a-thon			x	x		craft, building	
Edible phone cases			x		Rice Krispy treats	craft	
Upcycling		x	x	x			
Shake it up			x	x	laser cutter	craft	Inkscape or Ilustrator
Open Source Pinball			x	x		craft, building	
Susanna Tesconi							
Hidden sound: Experimenting with piezos, vibration and amplifiers			x	x		electronic, craft	
Playing with light: lamps design				x	laser cutter	craft, electronics	Inkscape or Illustrator
Making candy monsters			x	x	miller, 3D printer		Tinkercad
Light gloves and light fingers		x	x	x		sewing, conductive fab	
Make your own Trivia game			x	x			
Teacher training: no-battery lab						craft, building	

Project title	Approximate Grade				Tools	Materials/ Supplies	Software
	Lower elementary	Upper elementary	Middle school	High school +			
Teacher training: design and build your own Montessori-inspired material					laser cutter	craft, building	
Make it big: scale up a Scrabble game			x	x	laser cutter	wood, building	
What do elderly people need?			x	x			
Tracy Rudzitis							
3D Printing Characters & Props for Stop-Motion Animation		x	x	x	3d printer, camera		
Very Very Simple Circuit - Copper Tape & LED & Battery & Paper	x	x	x			papercraft	
Jitterbugs	x	x	x			electronics, craft	
Make Something Happen	x	x	x			electronics, craft	