STEM Teacher Academy - Maker Spaces

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Resources also available on MakEdu.org

Introduction:

- What are Maker Spaces?
- Why Maker Spaces?
- Engineering/Design Process – Use quick challenges to stimulate creativity

3D Design and Prototyping **Broad concepts/topics that can be taught:**			
Science	**Technology Engineering**	**Art**	**Math**
• Physical/Chemical Changes • Physical/Chemical Properties • Density (if objects are solid or hollow inside the print) • Behavior,specs, properties of different filaments	• 3D Design Software • 3D Printer • Design Process	• Form • Dimensions • Materials	• Geometric Shapes • Scale • Dimensions • Volume • XYZ Coordinates • Transformations • Curves • Calculus (change in volume as item is printed)

Supplies/Tools/Equipment:

- 3D Printer and filament
- Shape-Lock
- Clay/Playdough

3D Printing:

Students can design their own objects using a simple, free online program like Tinkercad (www.tinkercad.com). Tinkercad is a drag and drop interface with great tutorials. Students will need parent permission to set up an account if they are under the age of 13.

123Design is another free 3D design tool but it must be downloaded.

Pre-made designs can be found on Thingiverse (https://www.thingiverse.com/).

Once a 3D file has been created, it is downloaded and imported into the software that controls the 3D printer.

There are many different types of 3D printer filament. The most commonly used types are ABS and PLA. MatterHackers.com has some great information about the different types of filament and how to work with them. You will also want to consult the printer manufactuer's instructions.

The printer shown today is the Lulzbot Mini (www.lulzbot.com) and costs $1,250.00.

Other Prototyping Materials and tools

Shape-Lock is a plastic that has a very low melting point. It comes as pellets that can then be placed in hot water, melted, sculpted and cooled to form a rigid prototype. The plastic can be melted over and over again. This is a great way to test a design or to prototype "curvier" objects.

Clay and play-dough also make great, inexpensive prototyping materials.

This site has some excellent information on other materials to use for prototyping:

http://makingsociety.com/2014/03/modelling-clay-moldable-plastic-for-prototyping/

Basic Hand Tools/Power Tools **Broad concepts/topics that can be taught:**			
Science	**Technology Engineering**	**Art**	**Math**
• Physical/Chemical Changes • Physical/Chemical Properties • Behavior,specs, properties of different materials • Simple Machines • Forces and Motion • Friction	• Power tools • Safety • Design Process	• Form • Dimensions • Materials	• Geometric Shapes • Scale • Dimensions • Volume • XYZ Coordinates • Measurement • Torque (on drills for instance)

Supplies/Tools/Equipment:

- Safety – goggles, gloves, hearing protection, dust mask
- Basic hand tools
- Power tools – Dremel, drill, sander, saw

Safety

Students should always wear Safety goggles when operating power tools – especially ones that cut or may result in flying particles.

Dust masks are helpful when sawing or cutting material that results in fine particles (wood and plastic). They are also great to wear if students use spray paint.

Basic Hand Tools

Stock up on basic hand tools such as screwdrivers, pliers (flat and needle nosed), hammers, and socket wrenches. It is also nice to have an assortment of Allen wrenches/hex keys and small screwdrivers (like the ones used for eyeglasses) for electronic "dissections". Heavy duty tin snips make cutting through thick plastic and metal easier. Most of these tools can be found in ready-made home tool kits.

You may also want to include a small saw (keyhole or pull saw) as well as a hand drill.

Students may not be familiar with basic tool names so take a moment to teach them, for instance, the difference between a flat head and Philips head screwdriver.

There's a fantastic poster called "The Chart of Hand Tools" that would be a great addition to a school Maker Space. It has labeled images of many common tools, organized by their function.

Power Tools

Dremel tools are a great addition to a school Maker Space. They are affordable and can be used in many different ways. Make sure students are trained on safe operation and wear safety goggles.

Electric drills are also fairly easy for older children to learn to use effectively. Again, training and safety are a must.

I've also had students use a palm sander effectively.

If your school is fortunate to have the space and funding, there are also several bench tools that are great for Maker Spaces including jigsaws, drill presses, and table saws. These larger tools require more stringent supervision and safety training than smaller tools.

Electronics **Broad concepts/topics that can be taught:**			
Science	**Technology Engineering**	**Art**	**Math**
• Electricity • Circuits • Physical/Chemical properties • How sensors work • Motors • Batteries (cells)	• Building and testing circuits • Sensors • Design Process • Using instruments to measure electricity • Programming (arduinos, raspberry pi)	• Wearables • Kinetic Art	• Calculations related to electricity (current, voltage, resistance)

Supplies/Tools/Equipment:

- Wire
- Batteries
- Components (motors, lights, sensors, switches)
- Breadboards
- Playdough
- Conductive thread and paint
- MakeyMakey
- Arduinos

Electricity 101 – tools, schematics

Prior to starting to work with electrical components, students should have a basic understanding of electricity. There are lots of great resources – here are a few to get started:

How Stuff Works: http://science.howstuffworks.com/environmental/energy/circuit1.htm

All About Circuits: http://www.allaboutcircuits.com/textbook/direct-current/chpt-1/electric-circuits/

Instructables: http://www.instructables.com/id/Basic-Electronics/

Spark Fun: https://learn.sparkfun.com/tutorials/what-is-a-circuit/short-and-open-circuits

Students should understand the relationship between Voltage, Current and Resistance, how electricity flows through a current and what might cause the circuit to become inoperable – due to be open or shorted.

Basic Components – batteries, LED, breadboard, jumper wires, switches, sensors

Once they have a basic understanding, let students experiment with batteries, wires and lightbulbs to gain further understanding. After that, you can gradually add on more complexity using breadboards and eventually soldered circuitry.

Another way to introduce circuits (especially with younger students) is using "squishy" circuits. These circuits use play dough (conductive made with salt and resistant made with sugar) to manipulate current.

The Makey Makey device is also a fantastic and fun way to experiment with electricity in a tangible way. Students can connect different materials to the device and if that material is conductive it will create a closed circuit, allowing for control of different keys on a computer keyboard. There are links to this on the Makey Makey website. Show students that a Makey Makey is a computer input device just like a keyboard.

Students can also easily create paper circuits using button batteries, LED lights and conductive materials like copper tape, conductive paint, wire, pencil graphite or conductive thread.

Little Bits are kits containing circuit components that students can easily put together (they are magnetic so they cannot be put together "wrong"). You can also add an Arduino type programmable component that works with an iPad to teach basic programming of a circuit. Snap Circuits are similar but are a little more difficult to use.

Programmable Circuits

Once students have a basic understanding of circuits, you can add on programming through devices like

Arduino, Raspberry Pi or Lily Pad. These allow students to control how, when and how long various components of the circuit are active. Arduino is a bit simpler for beginners - for a brief description of the difference between the two most popular, Arduino and Raspberry Pi, read through this article from MAKE Magazine: http://makezine.com/2015/12/04/admittedly-simplistic-guide-raspberry-pi-vs-arduino/.

The Lily Pad controller is specially designed to be used as a sew-able circuit using conductive thread. There are many components that operate with the Lily Pad that have special fasteners designed for the purpose of sewing them to textiles.

Resources for Arduino:

Arduino software (free – you must use it to program the Arduino) - https://www.arduino.cc/en/Main/Software

Arduino Site has lots of information on getting started - https://www.arduino.cc/en/Guide/Introduction

Spark Fun - https://learn.sparkfun.com/tutorials/what-is-an-arduino

Sewing **Broad concepts/topics that can be taught:**			
Science	**Technology Engineering**	**Art**	**Math**
• Behavior, properties of different fabrics and materials	• Sewing Machine • Pattern design • Conductive fabric and threads	• Form • Dimensions • Materials • Textiles • Cultural aspects of textiles and their designs	• Geometric Shapes • Scale • Dimensions • Transformations • Measurements • Patterns

Supplies/Tools/Equipment:

- Needles
- Thread
- Paper
- Fabric
- Scissors
- Pins
- Sewing Machine
- Tape Measure/Ruler
- Fasteners: snaps, Velcro, buttons, hook/eye, magnets
- Grommet tool and grommets
- Freezer Paper (for pattern making)
- Iron

Sewing can be done by hand or machine. Students can learn quite a bit about how different fabrics have different qualities and can be used to "sculpt" garments or other items.

Experiment with different fasteners and how to choose the best one for the job.

Tie in to math by teaching students about quilting and pattern making. How to translate a design into a pattern for a quilt by adding appropriate seam allowances for sewing.

Discuss how quilt designs have been used throughout history to communicate and record information about different societies.

Other Cool Tools, Materials and Links

Broad concepts/topics that can be taught:

Science	Technology Engineering	Art	Math
• Physical/Chemical Changes • Physical/Chemical Properties • Thermal Energy (thermocrhomic pigments, shrink dinks) • Sound Vibrations/Waves • Energy Transofrmation • Light/Lenses • Stereoscopic Vision	• Properties of different materials (ie. which tape or glue to use for which purpose) • Design Process • Which tool to use for which job?	• Form • Dimensions • Materials	• Geometric Shapes • Scale • Dimensions • Measurement

- Heat Gun – melting plastic, thermochromic pigment
- Glue Gun
- Soldering Iron
- Toaster Oven – Shrinky Dinks, Baking Polymer Clay, Melting Crayons
- Blender – can be used to grind up paper and dryer lint with water to make paper pulp
- Hot Plate
- Hair Dryer
- Staple Gun
- Box Cutter and Xacto knife (for use by adult or older students)
- Old Electronics – DVD/VCR players, computers, phones, remotes

Other Cool Stuff:

The Extraordinaires Design Studio – Great little game/kit that can be used to prompt students for design challenges. Comes in a "Deluxe" version for $39.99 or a "Pro" version for $79.99. https://www.extraordinaires.com/. You can also purchase just the sets of challenge cards (Inventions or Buildings) for $19.99.

Screen printing – Speedball makes several different kits for screen printing. The photo emulsion in the kits is a great way to demonstrate chemical/physical changes. Speedball Screen printing information: http://www.speedballart.com/our-products.php?cat=21. Purchase these kits from Amazon or most art/craft supply websites and stores (like Michael's).

Google Cardboard – Make your own VR (Virtual Reality) viewer. Google Cardboard has a downloadable template that students can use to make their own viewer (you will have to purchase the lenses for it). You can also purchase pre-made viewers from many different sources. Videos can easily be found on YouTube (search for Google Cardboard or VR videos). https://vr.google.com/cardboard/

3D Hologram Effect Viewer – Download and print on transparency film (make sure it's for printers) or print on paper and trace onto transparent film (any kind). Cut out, fold and secure the ends. Search for "3D hologram videos" on YouTube, play a video and place the viewer on your phone to experience a hologram effect. Link to the template is here: http://makedu.weebly.com/uploads/3/9/3/0/39300727/3d_hologram_template.pdf

Arvind Gupta Toys from Trash – Arvind Gupta has a great website with all sorts of "toys" created from everyday materials. The site includes instructions and explanations for how they work. He's also done a great TED talk on his work. http://www.arvindguptatoys.com

Landfill Harmonics – Touching story of a very poor town in Paraguay that used trash from the landfill to create musical instruments for their school. Great to tie into studying sound and gives a real world application that students can identify with. Documentary film site: http://www.landfillharmonicmovie.com/ There are also clips on YouTube from news shows like 60 Minutes.

OK Go – This band creates very cool videos – many with easy science tie-ins. One of my favorites is for the song "This Too Shall Pass". The video features s a very complex Rube Goldberg machine. Available on YouTube.

Guitar String Oscillations Videos– There are several of these on YouTube. Basically, a cell phone video camera is placed inside a guitar and is able to capture the vibrations of the strings. This is a great way to demonstrate sound vibrations in a way we aren't able to detect as easily with our eyes.

Shrinky Dink Plastic (Plastic Number 6) – Teach students about the different types of plastic (depending on the recycling number). Plastics have different properties that impact how they can be best used and recycled. Plastic No. 6 is the same as Shrinky Dink plastic. Students can draw a design, measure the dimensions before and after shrinking to talk about scale in math. You can also talk about thermal energy and how/why it causes the plastic to shrink. "How it's Made" has videos on thermoplastic molding that are helpful in illustrating how plastics work.

Build a Light Bulb – You can find tutorials for this several places online – one is on Steve Spangler. This is a great way to talk about conductors/resistors, incandescence, light, chemical/physical changes and

properties and electricity. You can experiment with different filaments for the bulb (just like Edison did) including pencil lead, various wires, conductive thread, cardboard, etc.

Old Computer Keyboard (great to use with Makey Makey and Screen printing) – Take apart an old computer keyboard and you will find that inside are two transparent plastic sheets with circuits printed on them (likely screen-printed as many circuits are). When you press a key, you are connecting the two sheets which closes the circuit, sending an electrical signal to the computer that corresponds with typing that letter or command.

Basic Supplies to keep on hand for all sorts of challenges and building:

Tape: Duct tape, transparent tape, packing tape, double sided tape, masking tape (talk to students about how different tapes have different uses)

Glue: White Glue, Super Glue, Hot Glue, Epoxy

Office Supplies: paper clips, binder clips, rubber bands, index cards, post it notes, brads

Craft Supplies: Popsicle sticks, pipe cleaners, dowels, pom-poms, yarn, string

Other Supplies: cotton balls, cotton swabs, toothpicks, empty cardboard tubes, empty bottles, cans and other containers, CDs, leftover laminating film, plastics.