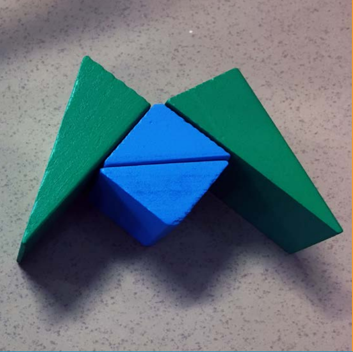
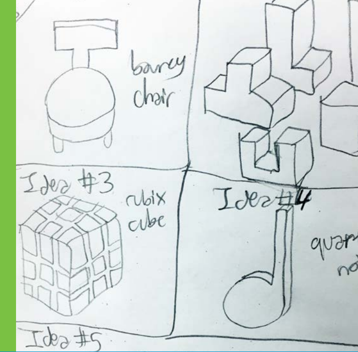
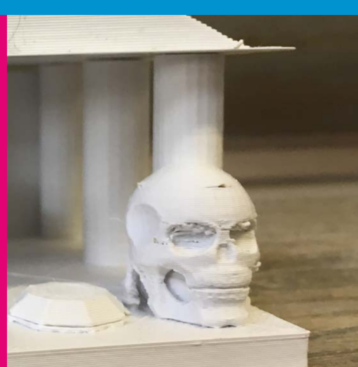
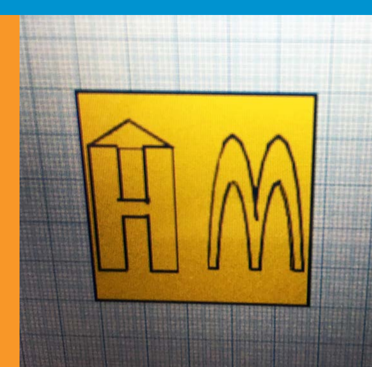





# IDEAS

## (INVENTING, DESIGNING, AND ENGINEERING FOR ALL STUDENTS) MAKER PROGRAM



Education Development Center

New York Hall of Science

NYU TANDON SCHOOL OF ENGINEERING

NYU STEINHARDT

ASD Nest Program

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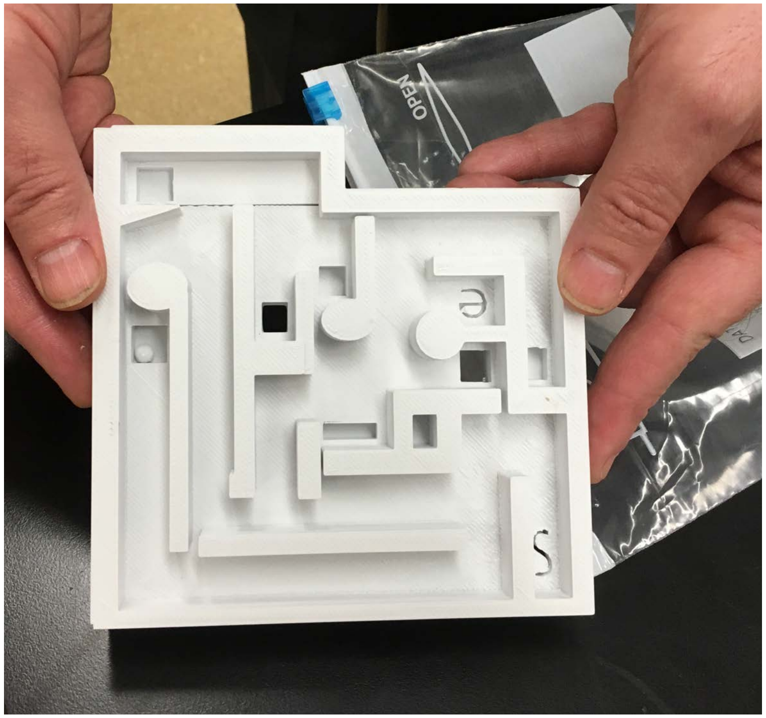


# An Introductory Guide for Facilitators Participating in the IDEAS Maker Program

## Introduction

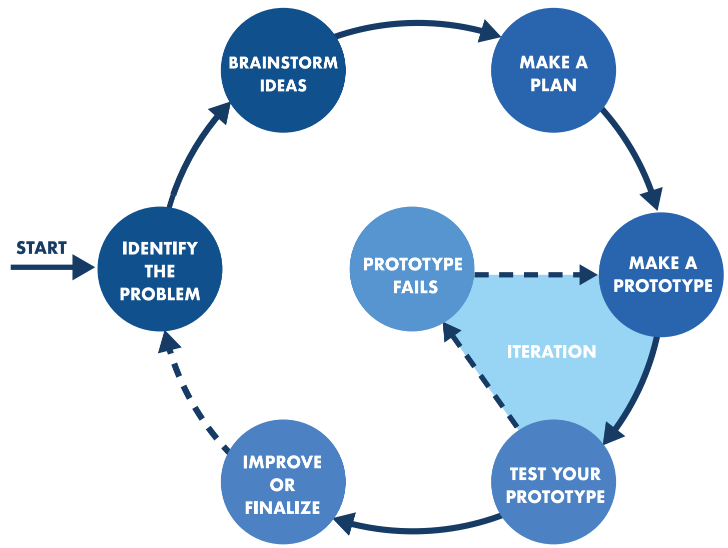
Funded by a grant from the National Science Foundation (Award# DRL 1614436), the IDEAS Maker Program was developed by a team of researchers from Education Development Center and SRI International, experts in autism support from the ASD Nest Support Project at New York University, Maker Space program developers at New York Hall of Science, engineers from Tandon School of Engineering at New York University, and teachers who work with students on the spectrum in New York City middle schools. The core belief of this program is that, by giving students on the autism spectrum a chance to pursue their interests as they engage with peers in the engineering design process, they will develop confidence in their abilities, awareness, and motivation to pursue higher education and careers in engineering and design.

The group adapted a Maker Space program called 3D Design and Fabrication from the New York Hall of Science and modified the curriculum for an after-school or lunch-time "Maker Club," which teachers can run in autism inclusion schools. The following guide is designed as a tool for teachers who will facilitate this program in their schools. The curriculum is meant to be flexible and open to modification depending on the resources and challenges of each school. Please feel free to exercise your creativity when implementing this program.

## The Engineering Design Process (EDP)

The IDEAS Maker Program takes participants through the **engineering design process (EDP)** multiple times, first by doing hands-on skill-building activities and then by applying those skills to create their own 3D design project from ideation to fabrication. Following is a visualization of the EDP for middle-school audiences. This diagram is used throughout the program and is referred to as the *EDP*.

**The Engineering Design Process Diagram**




## Format of the Program

The IDEAS Maker Program is approximately 16 hours in length and is composed of a variety of activities that can be adapted for implementation in an after-school club once a week for 2 hours or as a lunch or extracurricular club two to three times a week for 45 minutes. Each activity can be split into two or three sessions if time is an issue. If you choose to split the activities, then you will need to meet more often to make sure there is ample time for students to complete each activity. Students will probably finish at different times, which can be used as an opportunity to allow students who finish earlier to go back to past projects and iterate or finish them.

## The Curriculum

The curriculum of this program is divided into two different sections. Section 1 includes skill-building activities that encourage tool and material exploration and creative problem solving. Each activity is designed to accommodate different teaching and learning styles as well as different implementation situations, materials, and time constraints. Teachers are encouraged to modify and adjust the activities as needed for their specific circumstances. Section 2 is the application portion of the program, when students will apply the skills they have learned to a personal project.

### Skill-building

Skill-building activities afford students the time to explore tools, materials, and processes in order to create projects and acquire new making skills. Throughout this process, students will gain confidence in using tools as each activity introduces tools, materials, and processes that build off the previous activity. The skills they build will be useful when they are designing and creating their final projects in the second half of the program. The skill-building activities are One Sheet of Paper, Journal Making, Intro to 3D Printing, Wooden Blocks, TinkerCAD, Paper Circuits, LED Greeting Cards, and Motors.

### Application

In the second part of the program, students apply the skills they learned in previous activities to design and build their final project. During the Final Project Planning, students will participate in group brainstorming sessions to create a list of project possibilities. During the brainstorm, you should encourage creative thinking as well as student's personal interests and support all ideas that come up. Once students have listed their ideas, they will focus on feasibility, answering questions such as *How will you make this? What materials, tools, and processes will you need?* The final projects typically vary in focus and content, but they all use similar skills and require an understanding of the materials.

## The Facilitator Role

Facilitating a Maker Club will likely be different from teaching a class. While there is a "curriculum" made up of a series of activities, the focus of the facilitator should be on providing students the time to play, explore, and test things out. We recommend at least two facilitators when running the club. In the curriculum below, there are descriptions of roles for a facilitator who leads the activity and one who supports by assisting with materials and helping students. Facilitators can alternate between lead and support roles for different activities.

During the Maker Club, students will encounter a variety of challenges, and how they interpret those challenges will differ from student to student. Things may not work out the way they intended. As the facilitator, it is important to see this as part of the process as well as a learning opportunity. Making mistakes and getting unexpected outcomes will provide students with more information that will help them decide how to move forward with their projects. When you see a student struggling or getting frustrated, it is good to give them support but not to solve the problems for them. Instead of focusing on the mistake, encourage them to define the problem and focus on how they might fix the mistake or build off of it to redirect the project.

Facilitation throughout this program is about asking questions rather than providing answers. This helps students find answers through making and discussion, which in turn helps them understand what they are doing and why they are doing it. By doing this, you are modeling how to manage mistakes and challenges in a productive way, and it provides a chance to learn alongside your students.

Once the students start their final projects, encourage them to take the lead, make mistakes, and figure out solutions with less guidance from you. Of course, you know your students best and can assess what strategies work best for each one. Following are things to think about that will help guide the facilitation process as well as some questions to ask to help ignite conversation.

## Facilitation Guidelines and Questions

- **Do all the activities in the curriculum yourself before you teach them.** This will provide you with the opportunity to experience them and see first-hand what potential obstacles may arise.
- **Lead with questions:** Ask, don't tell.
- **Allow students to do all making themselves** rather than you picking up their projects and doing them for them. One strategy you can use is called "Hands in Pockets." When you approach a student to help them with their project, keep your hands in your pockets and refrain from physically interacting with their materials.
- **Build confidence step-by-step.** Offering a platform for minor accomplishments will help them become more confident in their abilities.
- **Try to step outside of your perspective** as often as possible. Can you see this another way? Why might they be feeling this way?
- **Remember that things take time.** Balance expectations with resources. Plan according to how much time you have.
- **Have multiple entry points:** Provide as many ways into an activity as you can.
- **Make personal connections** to your students' interests and experiences.
- **When you see a mistake happening or feel you know the outcome,** PULL BACK, and allow things to happen. If challenges arise, you can ask questions such as, "What happened?" "How might you fix that?" or "What could change to try to make it work?"
- **Increase confidence:** Allow students to lead the conversation. Refrain from "filling in the blanks" if they are not 100% sure how to explain themselves. Use a variety of questions to help guide their expression, such as "What do you mean by that?" or "Can you tell me more about...?"
- **Increase trust:** Allow students to make the decisions. You may feel differently than they do, but allowing them to make their own decisions will enhance and encourage their understanding while developing their own approach.
- **If a student is struggling and requires feedback,** offer *What if...* questions to reveal the possibilities they may not be thinking of. For example: "What if you tried...?" or "If I was making this project, I might try..." Such questions allow you to offer suggestions without telling the student what to do.

### Facilitator Entry Point Questions:

**How's it going?**

**What are you up to?**

**What's going on?**

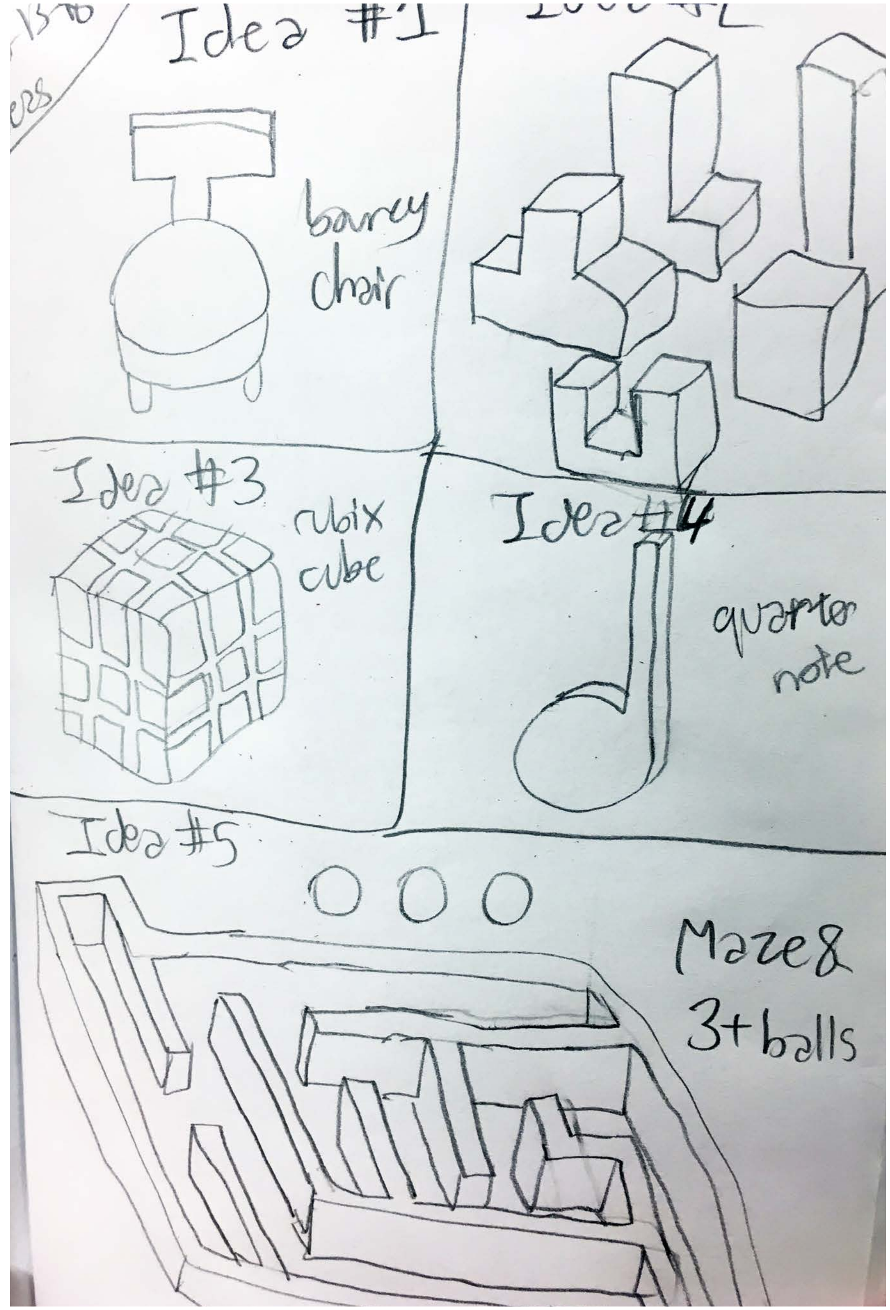
These are good questions for starting conversations. They will open up a casual platform and promote discussions. You are encouraged to create your own questions and try them out. If your question can be answered with one word (i.e. yes or no), then think of ways to ask the question that requires a full response.

## Facilitator Probing Questions:

- **What do you notice about…?** This question gives students the opportunity to observe the situation judgment free and express what they are thinking.
- **What do you think?** This question probes deeper than the previous one, affording an opportunity for students to express how they see what is happening.
- **Why do you think that?** After students have expressed what they think, you can dig deeper. This will provide a stronger understanding for you and the student about how they got to their conclusion.
- **How do you know this?** This question is to inspire students to explain the steps that went into their thinking process.
- **Can you tell me more?** This question encourages the student to dig deeper to explain their ideas as well as build off what they have already said.
- **Do you have any questions about…?** This question encourages students to ask about anything else they are wondering and to seek advice on their terms.

## Reflection and Documentation

- **Reflection and journaling are important.** This gives students time to think about what they are learning and what they want to do next. It also creates a record of what the students plan to make and what they think about the process. Activities include sample questions to start the reflection conversation.
- **Build in time for reflection and journaling** when designing a learning experience.
- **The facilitation questions can also be used to discuss and reflect** on the students' process: "What did you do? Why did you do that? What tools did you use? Would you change anything?"



## Outline of the Activities

**The program is divided into two phases:**

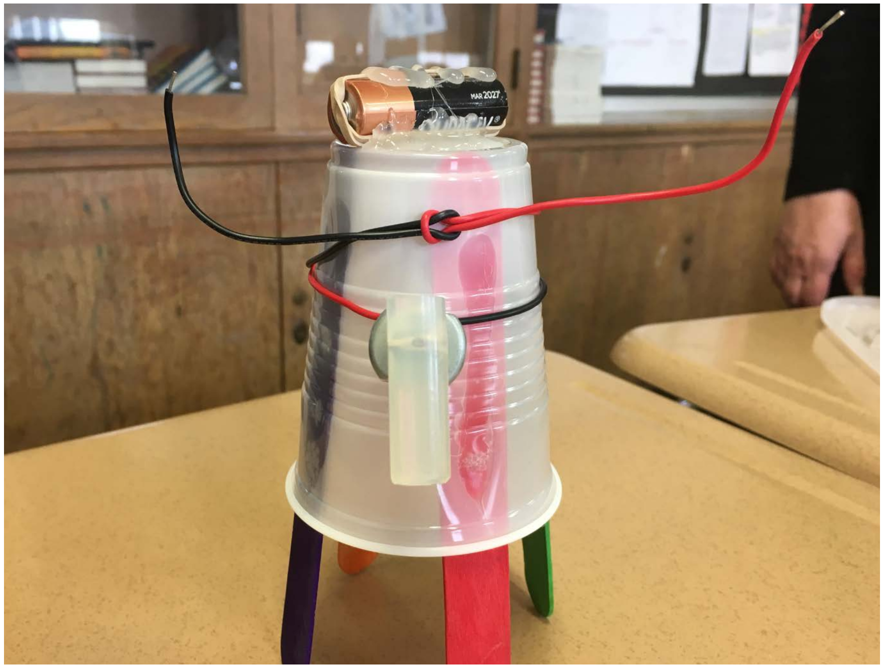
- **Phase I: Skill Building** is focused on helping students gain knowledge about materials and tools and build the confidence to go into a more open-ended project.
- **Phase II: Final Project** is where students will create their own 3D design project.

### Phase I: Skill Building Activities

- **One Sheet of Paper Activity** – Make a 3D shape using a piece of paper and discuss the properties of 3D objects.
- **Journal Making** – Create and personalize a journal using everyday materials and tools and discuss the importance of documenting the EDP.
- **Intro to 3D Printing** – Use a variety of activities and materials to understand how to design for a 3D printer; and learn how a 3D printer works and explore its limitations.
- **Wooden Blocks** – Understand how to create a 3D object by creating initials using simple 3D blocks.
- **TinkerCAD** – Understand the basics of CAD design software and digital 3D design by transferring wooden block designs into a digital format.
- **Paper Circuits** – Create a paper circuit to light up an LED; develop a basic understanding of the flow of electricity and LEDs.
- **LED Greeting Cards** – Apply the paper circuit to a greeting card for a special occasion.
- **Motors** – Expand circuit knowledge and create objects that move by using a motor.

### Phase II: Final Project

- **Final Project Planning** – Brainstorm ideas for the final projects, discuss their feasibility, and create spec sheets detailing students' ideas and how they will make their projects.
- **Prototype 1** – Create the first prototype of the project using materials such as cardboard or other physical materials.
- **Prototype 2** – Iterate the prototype with the option of transferring the design to TinkerCAD and printing it out.
- **Final Poster** – Create a poster to present all of the different objects created during the club, as well as the final project; present the poster at a culminating event.



# Activity 1: One Sheet of Paper

**Complexity Level:** ● ○ ○ ○ ○

**Pre-activity Preparation:** ★ ☆ ☆ ☆ ☆

**Duration:** 30 min

**Key Vocabulary:**

- 3D
- 2D
- Height
- Width
- Depth
- Design
- Process
- Volume

## Objective

Create a 3D object from a sheet of paper

## Learning Objectives

**Students will:**

- Understand and express the difference between 2D and 3D objects.
- Learn what defines 3D: height, width and depth
- Understand that there can be many different outcomes when designing a project
- Learn the process of sharing projects and explaining ideas

## Materials Needed

**Materials (Per Student):**

- 1 sheet of printer paper

## Pre-Activity

Prepare students for what they will do during the lesson. After students sit down, distribute one piece of paper per student on each table.

Explain: "Today we will design and make a 3D object out of a piece of paper with only one tool—our hands. Later we will learn how to make our own journal, which we will then use to document our ideas throughout this program."

If you are unable to do both of these activities in the same session that is okay. Modify as needed.

## Introduction and Activity (10 min)

This is a quick introductory activity for you to assess students' understanding of what 3D objects are. Provide them with a single sheet of paper and ask them to make a 3D object out of the sheet of paper. Give them 10 minutes to design the shape. This could take less time, so if students finish early you can start sharing out with the entire group.

### FACILITATION

| Lead | Support |
|---|---|
| "Make a 3D object out of your piece of paper. The only tool you can use is your hands. When you are done, you will share the reasons you think your object is 3D." This activity is meant to have students express dimensions: height depth width etc. | Hand out a sheet of paper to each student. Assist as needed.<br><br>Check in with the students as they are making their 3D objects. Remind them to think of reasons why they think their object is 3D. |

## Share-Out: Comparison of Solutions (10 min)

After 10 minutes, prompt students to take their hands off the table and look at you. Ask 2–5 students to volunteer to share their 3D object. The goal is to get students to understand and express that a 3D object has height, length and width. Write these 3 words on the board for reference if it helps.

| Lead | Support |
|---|---|
| Ask, "Who wants to share what they built?" After each student shares, ask, Why do you think this is a 3D object?"<br><br>Write the key vocabulary words on the board and discuss them. | For students who may not feel comfortable sharing what they think about the activity, have them share what they made with those at their table. |

## Reflection: Engineers & Makers (10 min)

Provide the students with an overview of the program and what they will be doing over the next few weeks. You should have some example projects from your own exploration of the curriculum. It is a good idea to share those as context for the students.

Explore students' existing knowledge about engineers and ask them what comes to mind when they think of an engineer. You can write what the students say on the board. The answers will vary. The objective is to have students understand that engineers design objects that help solve problems or challenges people have. There are many different types of engineers, and they design things from buildings and bridges to computers and apps.

Ask students to write their names on their 3D objects. Collect the objects and put them in a labeled box. Another option is to give each student a bin in which they can store their own projects.

### FACILITATION

| Lead | Support |
|---|---|
| "What comes to mind when you think of an engineer?" | |

# Activity 2: Journal Making

**Complexity Level:** ●●●○○

**Pre-activity Preparation:** ★★★★☆

**Duration:** 1.5 hours

**Key Vocabulary:**

- Documentation
- Binding
- Sewing
- Hammer
- Needle eye

## Objective

Create a handmade journal out of paper using a needle and thread

## Learning Objectives

**Students will:**

- Design and fabricate their own design journal
- Learn bookbinding techniques
- Learn and use the basic hand tools to complete the project

## Materials Needed

**Materials (Per Student):**

- 1 sheet of cardstock for cover
- 10 sheets of printer paper
- Glue gun
- Embroidery thread/yarn
- Binder clips
- Foam block
- Regular tape
- Pencil/pen

**Tools:**

- Scissors
- 1 hammer per 2 students
- Embroidery or tapestry needle
- Needle threader
- Large nail
- Magnetic tray

**Personalization Materials:**

- Markers
- Washi/colored tape
- Adhesive vinyl
- Colored beads
- Buttons
- Ribbon
- Other decorative material

## Pre-Activity

**Prep: (1–2 hours)**

**Before you begin the activity, review the journal making guide.**

1. Create at least one journal sample per table. Creating your own journal is important so you understand the process well enough to troubleshoot problems that students may run into.
2. Make sure you sort all the materials listed above beforehand and have them ready to be set up quickly on a table right before the activity starts.
3. Create space in the classroom to store the students' journals. We recommend a journal box that the students can access to get their journals when they come in and put them back at the end of each day. Another option is to have an individual bin for each student to store all of the objects they make.
4. In this activity, there are two different methods to make the journal. For a step-by-step description of each method, see the instructions at the end of the activity.

## Setup

This is a materials-intensive activity. Create stations in the classroom for each set of materials and a station for glue guns. Providing different stations will allow for a better flow through the room, and students can access materials and tools as they need them.

Have one journal on each table for the students to look at for reference throughout the activity. The materials can be distributed in 3 phases.

**In Phase 1, they will need:**

- 10 sheets of paper
- 1 sheet of cardstock for the cover
- 1 foam block
- 2 binder clips
- 1 hammer and 1 nail

**In Phase 2, they will need:**

- 1 needle and thread (or just thread if doing the no-sew method)
- Scissors

**In Phase 3, they will need all the personalization materials.**

## FACILITATION

### Lead

Prepare stacks of paper: 10 sheets per student.

Prep all materials for both phases of the journal project.

### Support

Place materials in labeled bins.

If necessary, prepare a demo table:

- 10 sheets of paper + 1 cardstock
- 1 foam block
- 2 binder clips
- 1 hammer and 1 nail
- 1 needle and thread
- Scissors
- Tape or a glue gun

A demo table will let you walk students through the process first, and then they can do it on their own.

## Introduction (10 min)

Begin the activity by asking students, "What is a journal?" and "Why do we use journals?" This will open up the group for discussion, and allow the students to discuss personal and shared experiences.

Explain: "Journals provide scientists, engineers, artists, and many other people a place to record their ideas, to plan, and to draw diagrams to reference later. Journals should be personal and contain information that will help remind you of certain ideas and projects."

**Pass around the sample journals. Ask students:**

- What materials are these journals made of?
- How do you think they were made?
- Do you think you can make one?

Point out the sewn binding, and ask students how they think that was done: "What tools and materials would you need to sew a binding?"

**Go to the board and write out the action plan for the activity:**

1. Pick a color for the cardstock cover.
2. Prepare the sheets for binding by folding them all in half.
3. Sew the binding of the journal.
4. Personalize the journal.

### FACILITATION

| Lead | Support |
|---|---|
| "What is a journal?"<br><br>"Why do we use journals?" | Stand by and be ready to assist any individual students that may need help participating in the class brainstorming. |
| "Journals provide a place to record ideas, plan for cool things we want to make, and document what we did so others can make it themselves if they want." | Pass around sample journals, and tell students to pass them on to different tables after looking at them. |

## Demonstration (if you feel it is necessary, 10 min)

Gather students around a table and tell them you'll now do a demo to show them how to prepare their paper for binding. Do steps 1–4 of Method 1: Sewn Binding, then stop.

Tell students that there are many different ways to bind journals and that you will demonstrate two ways. Demonstrate both options from the binding methods at the end of this activity.

Show students the hammer. Ask them if they know what it is and what it's for.

Explain that a hammer is used to drive nails, and today they're going to use the hammer to drive nails to make holes in order to sew the binding of their journals.

"What are hammers typically used for? (Driving nails into wood). Today we're going to use them to hammer through paper. Which material is harder: wood or paper? Do you think we need a lot of force to hammer a nail into wood? Do you think we need a lot of force to hammer a nail through paper? Paper is soft, so we don't need a lot of force. We can just tap the nail."

Demonstrate hammering a hole into the spine of the journal.

### FACILITATION

#### Lead

Explain the agenda of today's activity: To make our own bound journals

Write out the day's plan on the board.

Ask, "What do you think *personalize* means?"

#### Support

Make sure the materials for the demo are ready.

Leave the sample journals out as guides and inspiration.

For students who may have difficulty hammering holes through paper, have prehammered stacks of paper ready for them to use, or encourage them to use Method 2.

Place a foam block under the folded part of the paper. This will be the binding. Hammer approximately 5–8 holes in the spine. If they ask, and there is time, students can make more holes in the binding. You can then explain that the more holes you have, the stronger the binding will be, but it will also take you longer to sew. Providing a benefit and challenge to questions students ask throughout the program allows them to make their own decisions and be aware of the possible outcomes.

Demonstrate cutting the thread and weaving it into the journal.

Now demonstrate Method 2, which is a binding technique that requires no sewing.

Explain to students that once they are done making their journals they will have some time to personalize them. If they need inspiration, you can prompt them to look at all the journal examples on the tables.

## Activity (1 hour)

Ask the students to get their materials for Phase 1, one table at a time. Each student should have 10 sheets of paper, 1 colored cardstock sheet, 2 binder clips, 1 hammer, and 1 nail.

Students will likely finish this phase at different times, so allow them to get the materials for Phase 2 and then for the personalization phase as they finish. They don't have to wait for the other students to finish.

### FACILITATION

| Lead | Support |
|---|---|
| Remind students not to rush, this step needs to be done slowly. | . |
| Provide needle threaders for students who struggle with getting the thread through the needle. Or suggest that students use Method 2: No-Sew Binding. | |

## Reflection (10 min)

Get students' attention and guide the class through a reflection. You can write the questions on the board:

- What did you make today?
- What tools did you use?
- Did you find any part of this challenging?
- Was it easy?
- Did something not work?

Ask students to write their first reflection in their journals. These reflection questions can be used for the reflection section for every activity, and please feel free to come up with your own.

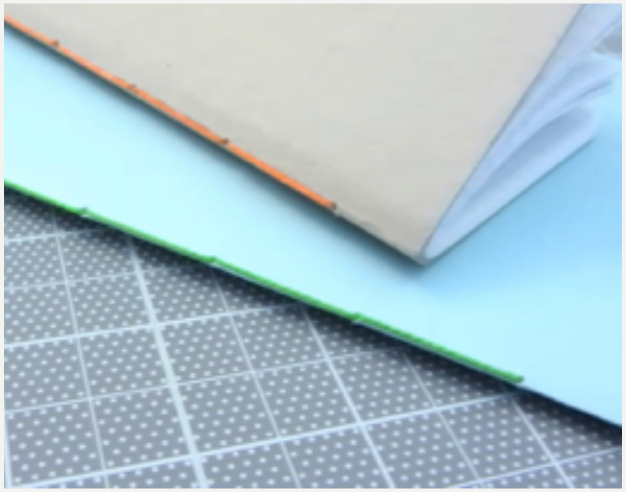
## FACILITATION

| Lead | Support |
| --- | --- |
| "What did you make today? What materials did you use? Write it in your journals." | Hand out pencils/pens so students can write in their journals.<br><br>Collect students' journals and projects. Put them in a labeled box or their individual bins. |

## Method 1: Sewn Binding

1. Take 10 sheets of printer paper and one sheet of cardstock.
2. Fold the 10 sheets and the cardstock paper in half. After you've folded them, open them up and lay the paper flat on top of the opened up cardstock.
3. Clip 1 binder clip on the top side and 1 binder clip on the bottom side of the stack to keep the pages in place while you hammer the holes and sew the binding.
4. Lay your booklet open (paper side up) on the foam block, lining up the crease from the fold with the foam. Be sure the binder clips are holding all of the pages.
5. Start your first hole at the top of the binding in the crease. Hammer the nail all the way down, through all of the pages and the backing. It's alright if it goes into the foam. That's what the foam is there for. You just want to make sure you don't hammer it in so far that you can't pull it out of the foam.
6. Pull out the nail and move down the seam about a half an inch (use a ruler and mark with a pencil if you want to be precise) and add another hole. Continue in this manner until you've reached the bottom of the page. You're now ready to sew your binding. Make sure you keep the binder clips on.
7. Measure and cut the thread. The appropriate length of thread should be about the length of your outstretched arms. Hold the end of the thread with the fingers of one hand, and slowly unroll the thread with your other hand until your arms are stretched wide. Snip it off.

   Thread your needle. Embroidery needles have a slightly larger eye and are therefore a bit easier to thread; however, a needle threader is always helpful. No matter how you do it, once you get the thread through the eye, pull it until it's doubled. Then knot the two ends together (an overhand knot will do).
8. Sew the binding. keeping the binder clips in place until you're done. Insert the needle into the first hole on the outside of the journal (i.e., the cardstock side) and go up



*Sewn Binding Example*

through to the paper. Make sure you go through all of the layers, from the cardstock through all 10 sheets. Pull the thread until the knot reaches the cardstock. Then go back down through the next hole in the paper, and pull the thread until it is taut again.

9. Continue in this fashion until you've reached the opposite end of the book, then go back in the other direction to where you started. This time, sew in and out of every opposite hole to close up the gaps between the stitches from the first pass.

10. Tie off. When you get back to the top where you started, tie off your thread. Cut the remaining thread at whatever length you like. (Sometimes leaving a longer thread is nice for a bookmark.)

## Method 2: No-Sew Binding

1. Prepare the paper in the same way you prepared it for Method 1: Take 10 sheets of printer paper and 1 sheet of cardstock and fold them all in half. Clip 1 binder clip to the top side and one binder clip to the bottom side.
2. Take the sheet of cardstock that is now folded in half, and cut two triangles—one at the top of the page and one at the bottom of the page—1 inch from the spine, as in the photo:
3. Insert 5 of the folded sheets of printer paper into the folded cardstock paper. Use the triangles you cut out of the cardstock sheet to cut similar triangles out of the printer sheets. Repeat this step with the other 5 sheets.
4. Combine all 10 sheets and insert them in the cardstock sheet. Make sure the triangles you cut out are all aligned.
5. Take an arm's length of the string and wrap it around your sheets by inserting it in the triangles you cut out.
6. Wrap the string around the journal 5–8 times then cut off the remaining string.
7. Tape or hot glue the tail of the string to the back of the book. You can also hot glue the spine to make your journal extra sturdy.

*No-Sew Binding Example*


*No-Sew Binding: Step 2*

# Activity 3: Intro to 3D Printing

**Complexity Level:** ●●○○○

**Pre-activity Preparation:** ★★☆☆☆

**Duration:** 1.5 hours

**Key Vocabulary:**

- Layering
- Thermal plastics
- 3D printing
- Extruder
- Change of state
- Overhangs
- Engineering
- Design
- Process
- Prototype
- Iteration
- Brainstorming
- Testing

## Objective

Create a solid 3D design out of different materials to simulate 3D printing

## Learning Objectives

**Students will:**

- Learn what 3D printers are and how they work
- Understand how 3D printers print in layers, and how layering happens in complex 3D shapes
- Understand glue guns as tools and learn how to safely use them
- Learn the properties of different materials
- Learn to be conscious of their design choices
- Learn the Engineering Design Process (EDP)

## Materials Needed

**Materials (Per Student):**

- Paper
- 1 glue stick
- 1 container of Play-Doh
- 1 piece of parchment paper
- Foam sheets
- Paper clips
- EDP diagram printed

**Tools:**

- Hot glue gun
- Scissors

## Pre-Activity

**Prep: (1 hour)**

1. 3D print a few objects so that students can see that the 3D printer prints in layers. Make sure to print simple, solid objects with no holes, such as a pyramid, a cube, or a star. You can make them yourself on TinkerCAD by clicking and dragging basic shapes onto the platform and sending them to the printer. This is great practice for your TinkerCAD lesson! You can also find 3D print files here at https://www.thingiverse.com/. Search the site for files labeled as "test prints."
2. Copy two EDP diagrams (see below) and cut paper in half; distribute one diagram to each student.
3. Familiarize yourself with the EDP diagram.
4. If you are running the program during shorter sessions, you can do one of the stacking activities and a glue gun activity over different sessions. Figure out a good place for you to stop and then continue next time.

## Setup

Have all the materials organized by type (foam sheets, paper clips, Play-Doh, etc.) on a separate table. Before the students come in, set up and plug in glue guns in a location out of the way of the students. When you are ready to do that part of the activity, students can go to those tables. There should be one glue gun per 1–2 students.

### FACILITATION

| Lead | Support |
| --- | --- |
| Project: EDP diagram<br><br>Set up an area to demo the Play-Doh, foam stacking, and glue gun activity. | Organize materials by type.<br><br>Cut the parchment paper the size of an index card, one per student. |

### 3D Printer Kinesthetic Activity – General Information

The first part of this activity is short and is meant to provide a general understanding of the design parameters specific to 3D printing models. There are certain aspects of a design in CAD that help to ensure a successful 3D print:

**Orientation** and **Surface Area**: It is important to print objects with as much surface area on the build plate as possible. Even if the object normally stands vertically it is best to lay it down for the printing process. Doing this will limit overhang.

**Overhang**: The overhang is part of the design that does not have contact with the build plate during printing and has empty space below it. This is a problem because the printer would start printing that part of the design in midair, and it would fall.

This activity is a full-body kinesthetic activity and needs some space for the entire class to stand up. If you do not have room for the entire class to participate, then you can choose a few volunteers and have the rest of the group observe and discuss solutions.

### Introduction (5 min)

Begin by reviewing the activity from the last session. (You can use these review questions at the beginning of every activity.) "What did we do the last time we met?" Be open to all responses even if they are unrelated to the activity. Allow for students to authentically represent their own memory in their own voice.

- What tools and materials did we use?
- Did we make anything?
- What did we make?

**FACILITATION**

| Lead | Support |
|---|---|
| "Can anyone tell me what we did last time?"<br><br>"What tools or materials did we use?" | |

Once you have reviewed the previous activity, introduce what you all will be doing today. Some introduction questions:

- What is a 3D printer?
- Has anyone ever seen or used a 3D printer?
- What did you use it for?
- How does a 3D printer work?

Write students' answers on the board. Or if appropriate, allow those who gave the answers write them on the board.

**Important info to know**: A 3D printer is a computer-aided manufacturing (CAM) machine that creates 3D objects. Similar to regular printers, it uses a digital file, but instead of printing ink on paper, it builds a 3D dimensional model one layer at a time using a thermoplastic.

Imagine you are icing a cake. You make one circle with the icing, and then put another circle on top of the first circle. You continue stacking circles until you have a cylinder. Instead of icing, a 3D printer pulls plastic filament through a heating element, similar to how a glue gun melts the glue stick, and builds individual layers according to the CAD file.

## FACILITATION

| Lead | Support |
|---|---|
| What is a 3D printer?<br><br>Has anyone used a 3D printer before?<br><br>How does a 3D printer work? | |

## Step 1 (10 min)

Ask students to stand up and get into a circle. Have them get into different positions, with some standing, sitting, and lying down. Make sure at least 2 or 3 of them are in difficult-to-hold positions (standing on one foot, leaning over, or with arms fully out), and some are in comfortable positions (lying down, standing in a regular position). Have them hold the positions for 20–30 seconds and then release them.

Afterward ask them if there were any positions that were difficult to hold or were uncomfortable. Why were they difficult? Typically the more difficult positions are harder because they are in an awkward **orientation**, have very little **surface area** on the ground, or have parts **overhanging**, such as arms out or legs lifted.

Now relate this experience to a CAD design for 3D printing. Explain that the forces that made their positions difficult to hold will make it difficult for the 3D printer to print those positions. Discuss ways they can maximize the potential for a successful print:

- Can you think of a way to change your position to make it a more successful print?
- Is there a better orientation for printing your object?
- Will that orientation help with the overhang?
- How can you maximize your surface area for a better print?"

If students are unable to figure it out, then they can choose a different position. Explain that when they are designing on TinkerCAD, if they have the same issues, they may have to redesign or rethink their design.

### FACILITATION

| Lead | Support |
| --- | --- |
| Take students outside of the classroom to the hallway or move tables so that there is a lot of room in the classroom. | Help direct students out of the classroom or help move chairs and tables out of the way. |
| You can do this demonstration with 2–3 students if there isn't enough space or if there are students who wouldn't want to get up. | Make sure at least 1–2 students are in positions that will make it difficult to stand for 30 seconds. |
| | Bring students back into the classroom |

## Demonstration (5 min)

Students will replicate how a 3D printer prints in layers by using a few different materials: first Play-Doh, then foam, and then glue guns. Feel free to use one of these materials depending on how much time you have, or you can split the group into stations and then have each station share what they make.

**Demonstrate**: How would you build an object layer by layer?

1. Lay a piece of parchment paper on the table. Emphasize with students that they must build within the boundaries of the paper. You can cut the parchment paper to the same dimensions as the 3D printer build platform to provide a direct connection to the size students will have to design in when using TinkerCAD.
2. Use the Play-Doh to create a simple shape, such as a circle. Then create another circle and put it on top of the first circle. Repeat this a few times until you can distinctly see a cylinder taking shape. Make sure the shape is not too tall since you will need to recreate it with hot glue.
3. Repeat this with the other materials or, depending on time, have the students get right to work. You know your students.

## FACILITATION

### Lead

"We're going to simulate how a 3D printer works using a few materials. We are going to use these materials to build up an object layer by layer, exactly how the 3D printer does."

Go to the demo table and demo the Play-Doh activity.

To save time, provide a limit to the amount of layers students should build, such as 5 or 10. This will also make the glue gun activity easier as well.

### Support

Make sure the demo table is ready.

Set up the glue guns at each table during the demo.

## Step 2: Play-Doh and Foam (30 min)

Have the students gather their materials one table at a time: a piece of parchment paper and Play-Doh. The students should build an object out of the Play-Doh first and then move onto the foam.

The second facilitator can move the glue guns to each table during the demo.

***Offer the 3D printed objects you prepared as inspiration.***

### FACILITATION

| Lead | Support |
|---|---|
| | |

## Step 3: Hot Glue Layering (30 min)

After 30 minutes, prompt students to take their hands off the table and to look at you. Ask a few students to share what they made. Go through some reflection questions: "How did you make it? Did you find it easy or difficult? Why was it easy/difficult?"

The students will now build an object using a hot glue gun. Explain that hot glue guns work in a similar way to 3D printers. They heat up thermoplastic into a liquid, and once it cools, it is solid again. The hot glue is a *thermoplastic*, because it changes state with temperature, exactly like the material being used in the 3D printers.

**Start making:** Students use the hot glue gun to create a simple shape. They can even use the same shape they made with the Play-Doh. Hot glue takes some time to cool down, so after putting down the first layer of the shape, students must wait for it to solidify.

They can blow on it to cool it. Ask them: "Did you see the color changed from clear to white?"

After the first layer cools, students can add a second layer, then continue on until they have a few layers. Keep in mind that they technically have a 3D object after one layer, so this can be a shorter experience if necessary.

If you want to do all three activities simultaneously, have students work on the other projects as the glue cools. This will occupy the down time while they are waiting for the glue to solidify.

## FACILITATION

### Lead

Prompt students to stop the first activity. Do a full-class short reflection.

Take students to the demo table again and demonstrate the hot glue gun activity.

"By layering hot glue, we are simulating how a 3D printer works!"

Students may want to touch the hot glue to fix something. **Remind students not to touch the glue gun tips or the hot glue to prevent burns!**

### Support

Use language such as "good enough" and celebrate students' being "flexible" to help manage student anxiety or frustration that the things they are creating may not look "exactly right."

Some students may get upset if they do not achieve what they want. The big concepts you want to highlight in all of the engineering design activities are (1) being flexible, (2) trying things out, and (3) learning from iterative testing.

Make sure none of the designs have overhangs.

## Reflection (10 min)

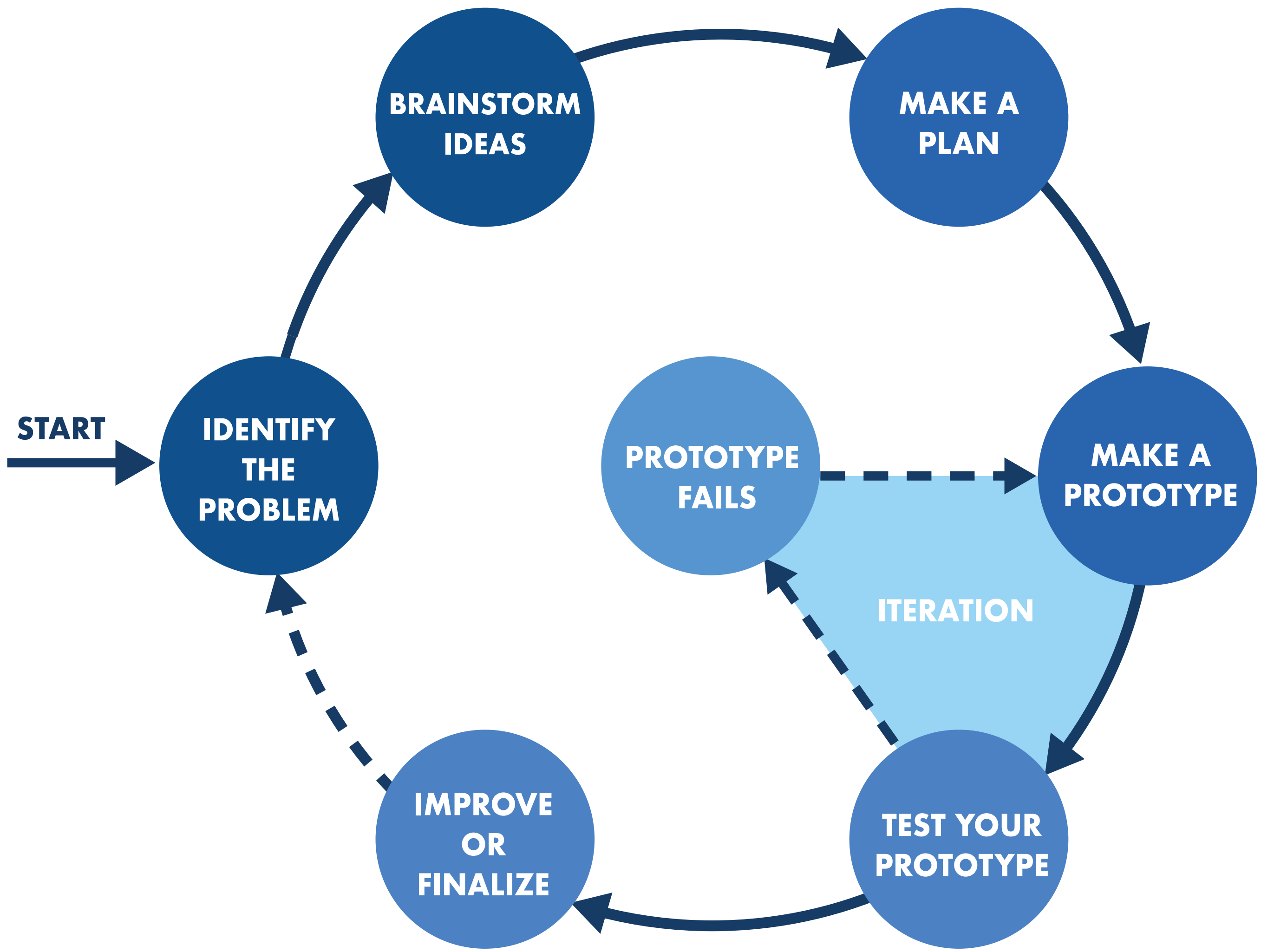
For reflection, ask students:

- What did we do today?
- What tools did we use?
- Can anyone explain to me how a 3D printer works?
- Does anyone remember the aspects of a CAD design that will make a successful 3D print?

Have a discussion and write the answers on the board. Follow up with a journal reflection and have students describe what they did. If students need prompts to reflect on you can provide a framework for them to answer specific questions. This helps when you first start to build a reflective practice, but it should be phased out as students start developing their reflections.

Hand out the EDP diagram to all students and go over the different steps listed in the diagram, noting which ones they did that day. Have students tape or staple the diagram to the back inside cover of their design journals.

*Engineering Design Process Diagram*



# **Activity 4:** Wooden Blocks

**Complexity Level:** ● ○ ○ ○ ○

**Pre-activity Preparation:** ★ ☆ ☆ ☆ ☆

**Duration:** 1 hour

**Key Vocabulary:**
- Structure
- Iteration
- Design

## Objective

Use wooden blocks to create 3D shapes

Design the letters of their name with wooden blocks

## Learning Objectives

**Students will:**
- Learn how to combine a variety of shapes together to create 3D objects
- Learn how to prototype and iterate their design using wooden blocks

## Materials Needed

**Materials (Per Student):**
- 1 sheet of cardstock paper
- Wooden blocks

**Tools:**
- Ruler

## Setup

Set out blocks on each table, with approximately 10–15 blocks per student depending on the size of the blocks. The students should have enough room to build flat on the table. If need be, spread them out with 2 or 3 students at each table.

## Introduction (5 min)

Begin by reviewing the activity from the last session. These review questions can be used at the beginning of every lesson. "What did we do the last time we met?" Be open to all responses even if they are unrelated to the activity. Allow students to authentically express their own memories in their own voices. "What tools and materials did we use? Did we make anything? What did we make?"

Discuss how they started the program by learning the basics of 3D design (the One Sheet of Paper activity) and how 3D printers work (the previous activity). Then tell them that today they will design their first 3D object using wooden blocks.

## Activity (45 min)

Provide 10 minutes for the students to play with the blocks. They will naturally start designing projects and discussing their process. Have a limit of 10–15 blocks per student to give them a constraint for their design. This also helps to keep the structures small. Facilitators should also sit at a table and design something alongside the students.

Once 10 minutes have passed, prompt students to look up at you. Ask 2–3 students to share what they made.

Now, hand out a piece of cardstock paper and ask students to design their initials or their names with the blocks. They should use the piece of cardstock as a guide for the size of their creation. You can cut the cardstock to the size of the 3D printer build plate if you want. Once students have designed their initials or name have them diagram it in their journals: (1) First draw the blocks and shape of each letter then (2) measure each one of the blocks and write down the measurements in the diagram. Documenting this in their journals is important for the TinkerCAD activity later.

### FACILITATION

| Lead | Support |
| --- | --- |
| Set up your computer so that it's ready to be projected for the TinkerCAD demo later in the lesson (if doing TinkerCAD on same day). | Prepare 1 sheet of cardstock paper per student.<br><br>Put the wooden blocks in the middle of each student table. |
| "What did we do last time? What did we learn?"<br><br>"Today we will be designing our own 3D objects with wooden blocks." | |
| "Play with the blocks for the next 10 minutes. You can build whatever you want. Use a maximum of 10–15 blocks!" | Facilitate any trading of shapes between students. "I noticed that__________ actually had a shape that is similar to the one you described, maybe you could see if you have a shape that she needs." |
| Hand out 1 sheet of cardstock paper per student | Help students record measurements with the rulers or tape measurers if available. |

## Reflection (10 min)

When most of the class is done, ask them to look up at you. Ask 2–3 students to share with you what they made and if they used *sketching* to help them document what they made. Double check to make sure they wrote the measurements on their diagram.

The next step is to transfer students' designs into TinkerCad. This step is why it is important to have the diagram so students can reference it when building their model in TinkerCAD. Depending on how much time you have, you could do this on another day.

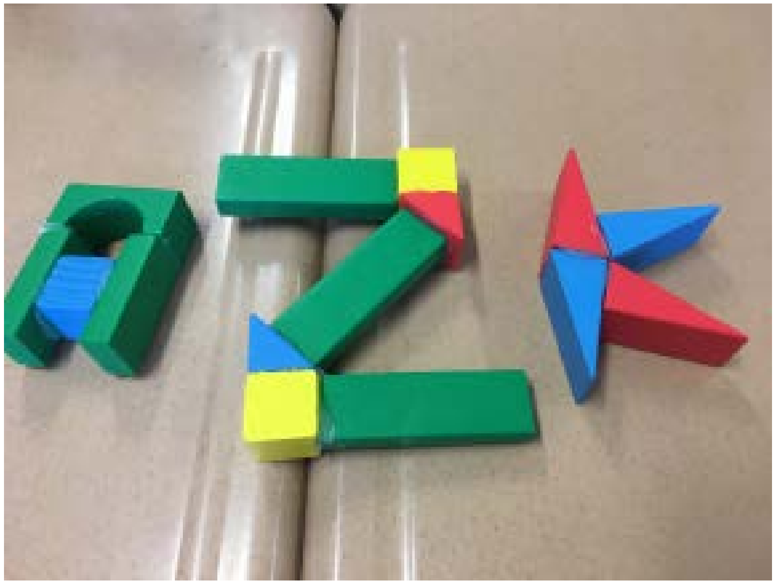
***Helpful tip:** You can take a photo of each student's design in case the diagrams are challenging. They can use the photo to rebuild the block name as well.

Review the parts of the EDP that students did during the activity.

### FACILITATION

| Lead | Support |
|---|---|
| "Remember to record *height*, *width*, and *depth* of your designs in your journals!" | If you are going right into the TinkerCAD lesson, prepare the laptops. Get ready to run the TinkerCAD demo.<br><br>Hand out 1 laptop per student and prepare to give them their login. |

## Examples of letters using blocks



# Activity 5: TinkerCAD

**Complexity Level:** ●●●○○

**Pre-activity Preparation:** ★★★★★

**Duration:** 1.5 hours

**Key Vocabulary:**

- 3D modeling
- Prototyping Iteration
- CAD basics
- TinkerCAD
- Workplane
- Brainstorming

## Objective

Build a 3D Model in TinkerCAD

## Learning Objectives

**Students will:**

- Understand what 3D CAD software is and how it works
- Revisit prototyping and learn about the iteration process
- Understand how to transition from physical to digital design
- Transfer physical measurements to digital measurements

## Materials Needed

**Materials (Per Student):**

- Wooden block model from Activity 4
- Wooden blocks
- Piece of cardboard/ cardstock (from previous activity)

**Tools:**

- Laptop
- Projector
- Mouse
- Journal

## Pre-Activity

**Prep: (1 hour)**

1. Book a laptop cart and have laptops charged by the Maker Club start time. Make sure you have one computer per student.
2. Create an educator TinkerCAD account and create accounts for each student. To do this, go to https://www.tinkercad.com/teach. Note down the account name and password for each student so you can provide them with both during the activity.
3. Bring mice for all students, if possible. Some people find it is easier to control the tools with a mouse.
4. Make copies of the 3D design checklist so that there is one per student.
5. Print the TinkerCAD cheat sheet as an additional support for students.
6. Practice building a house in TinkerCAD as a demonstration for the class.
7. Practice TinkerCAD as much as possible.
8. Build your own name tag to show the students or project it on the screen.
9. There are many tutorials on TinkerCAD, so if you have time explore them as well. It will help you troubleshoot, answer unanticipated questions, and provide skill challenges for the students who have worked with TinkerCAD before or who learn it easily.
10. Be ready to provide one-on-one attention to those who need it.

## Setup

Students will need their own laptop. Laptops should only be opened when prompted, usually after the facilitator demonstration.

Project TinkerCAD on an interactive whiteboard or screen so that the entire class can see. Set this up and sign into your TinkerCAD account before the session starts.

## Introduction (15 min)

"Today we will learn how to create a 3D model using TinkerCAD. We are going to transfer our block initials or names that we made in the previous activity and prepare them to be 3D printed."

Direct the students' attention to the interactive whiteboard or projected screen. Explain that you will be showing them how to use a software called TinkerCAD: "We will be using a variety of tools within the program to build our projects. We suggest building a house or any object that will showcase the following functions:"

- Pick a solid shape from the TinkerCAD library and place it on the platform.
- Change height, width, and length.
- Move the object up/down, left/right, forward/backward.
- Make a hole in a solid object.
- Put 2 objects together.
- Move the view of TinkerCAD and reset it.
- Change the workplane.
- Align things.
- Manually input height and width.

### FACILITATION

| Lead | Support |
|---|---|
| Set up the computer to be projected on the board for the demo. You will need a projector for this activity.<br><br>Log in to the TinkerCAD account for demo. | Distribute one laptop per student.<br><br>Give out mice for students who prefer it or to students who may be struggling. |
| "Today we are going to learn how to make a 3D model. Has anyone used TinkerCAD to make a 3D model before? What did you make? Do you remember how to use TinkerCAD?"<br><br>Demonstrate the basic tools in TinkerCAD by building a house or your building a house or your provide a visual for each tool. | Make sure students are paying attention to the demo and not playing on their laptops. |

- Change measurements from inches to centimeters.
- Use a ruler.
- Group/ungroup objects.
- Undo/redo.
- Duplicate.

Once you're done with the introduction, provide students with the *cheat sheet* for reference to the different tools and commands. Show them the 3D model of your name tag that you designed as a reference and point out the base you added to the bottom to keep all the letters together for a cohesive print. The base should be at least ¼ inch thick. Make sure you emphasize that each letter needs to be designed by combining multiple shapes together rather than using the TinkerCAD pre-fab letters.

## Activity (15 min)

Have students open their laptops, go to tinkercad.com (write the URL on board), and sign in using the credentials you provided. Allow 10–15 minutes to play around in TinkerCAD. Then prompt students to transfer their wooden block design into TinkerCAD using only shapes. Remind them they will need to add a base to their name tag. The base will keep the letters together as one cohesive object to print. When helping students individually, resist the urge to do it for them. If you have tried several times to help, and it doesn't seem to be working, you can show them how to do it on their computer and then let them try.

### FACILITATION

| Lead | Support |
|---|---|
| Provide students with their login credentials. Let students play around in TinkerCAD for a few minutes.<br><br>Check in with students throughout the activity to make sure they understand. | |

### Additional Challenge or Alternative

If students are done early, or if they want to make something other than a name tag, challenge them to turn their name design into something else. For example, a necklace, a bracelet, or a keyring.

After the students are done, hand out the 3D design checklist form and tell them to check each requirement. After that's been checked off by a facilitator, tell them to rename their final design "Final Name Tag *student name.*" You will check them and 3D print them from your educator account after the class is done.

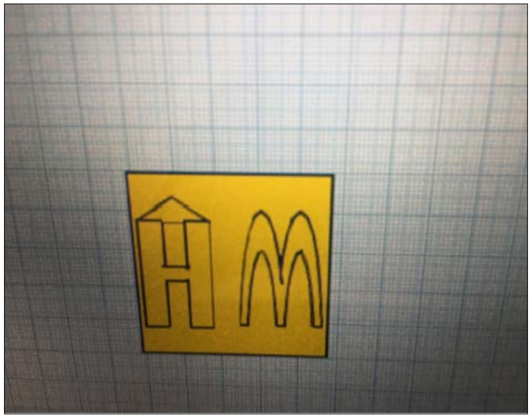
## Reflection (15 min)

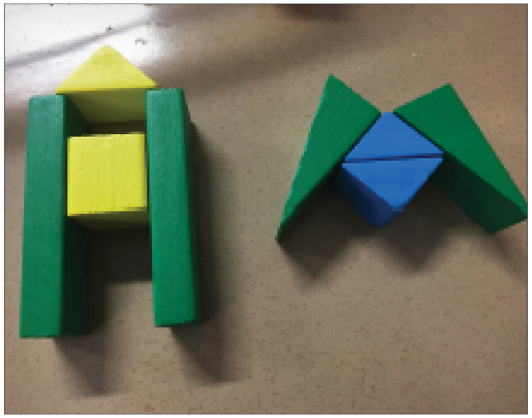
Have students take out their journals. Ask the students to look at the EDP diagram and identify which steps they did today. Go around to tables and chat with the smaller groups of students and ask: "Which steps did you do? What actions did you take?" Some students may not recognize the steps they took. If you know they achieved certain steps, lead the reflection so that they can arrive at the answer on their own.

### FACILITATION

| Lead | Support |
|---|---|
| Provide students with the alternative challenge if they finish early. | |
| Hand out copies of the 3D design checklist to each student. | Check that each student's design fulfills the 3D design checklist. |
| Tell students to name their files "Final Name Tag *student name*" | |
| Hand out journals. | |

## Examples of transferring wooden block designs into TinkerCAD





# Activity 6: Paper Circuits

**Complexity Level:** ●●●●●

**Pre-activity Preparation:** ★★★☆☆

**Duration:** 1.5 hours

**Key Vocabulary:**

- Circuit
- Polarity
- Electricity
- LED
- Switch

## Objective

Design a paper circuit that will turn an LED on and off

## Learning Objectives

**Students will:**

- Learn the basics of how a circuit works
- Understand the basics of what electricity is
- Learn what a light-emitting diode (LED) is
- Learn what a basic switch is and how it operates

## Materials Needed

**Materials (Per Student):**

- 1 strip of conductive copper tape
- 1 coin cell battery
- 1 index card or small cardstock sheet cut into smaller pieces
- 2 binder clips
- 2 LEDs

**Tools:**

- Scissors
- Tape

**Optional:**

- Pre-pasted circuits
- Decoration materials
- Markers/Color pencils
- Additional LEDs

## Pre-Activity

**Prep: (30 min)**

1. Make 2 pre-pasted circuits without an LED and a battery for students who have fine motor skill difficulties.
2. Make a fully functional circuit demo for the demonstration.
3. Cut conductive tape strips the length of the entire circuit, one per student.
4. Print the circuit steps handout and put one on each table.
5. Print the circuit diagram handout and provide one per student.

## Setup

1. Set up the classroom so that all materials are ready to use.
2. Before the students come in, cut the conductive tape in strips the length of the entire circuit. Make one strip per student, but don't give them out yet.
3. Put all the materials in separate trays for each table but keep all trays on the facilitator's table until ready to start making. Materials should be sorted: All LEDs in one box, all the batteries in another, etc.
4. Take out the fully built circuit to be ready to explain a switch mechanism and to do a demonstration.

## Introduction (10 min)

**Ask students:**

- "What did we do last week? What did you make? What tools did you use? What skills did we learn?" This will help students who were absent hear about what the other students did in the last session.
- "Does anyone know what a circuit is? Does anyone know what materials we would need to make a circuit?" List the materials on the board: battery, wire, light. Then diagram a simple circuit on the whiteboard. Have the students try to label the parts.
- "Where does the battery go? Where does the LED go? What material connects them?"

### FACILITATION

| Lead | Support |
|---|---|
| Prepare at least 1 demo for each table.<br><br>Prepare a table for a demo. There should be enough materials to build 1 circuit, and there should be enough space around the table for students to gather and watch. | Cut strips of conductive tape: 1 per student.<br><br>Organize and sort all materials on a table.<br><br>Test the batteries and LEDs to identify which ones don't work! |
| "What did we do last week? What tools did we use?"<br><br>"Can anyone tell me what a circuit is?"<br><br>"If I wanted to light this LED, what would I have to do?"<br><br>Draw the diagram with the LED, disconnected wires, and battery. | Help maintain students focus on the introduction.<br><br>Make sure students are seated in a place with enough room to work. |

Have students come up to the board and draw aspects of the circuit diagram, such as drawing the wire and connecting it to the battery and light.

When the diagram is complete, let them know this is a basic circuit diagram, and that they will be making their own circuit. Make sure to discuss the plus (positive) and the minus (negative) signs on the battery and how they line up with the LED and wire. When students begin exploring the materials, you can introduce polarity with the LED and battery.

Hand a battery and an LED to each student. Ask them to see if they can get the LED to light up. "What did you notice?"

Reinforce the + and – signs on the battery. "Do you notice anything about the LED? Are the legs the same size? How are they different?" You can explain that the longer leg on the LED is the + side and the shorter leg is the – side. The negative leg of the LED will only work on the negative side of the battery and the positive leg on the positive side of the battery.

Have students experiment with putting the LED on the battery both ways and see the difference for themselves. The polarity only allows the electrons to flow when connected to the same + or – symbol.

Write all of this information on the board for students to reference throughout the activity.

## Demonstration (10 min)

Now go to the demo table you set up earlier and walk through a demonstration of how to build the circuit in front of the class. After the demonstration, give out pre-made circuit demos to each table of students so they have an example.

### FACILITATION

| Lead | Support |
|---|---|
| "How would you light this LED?" Allow students to come up to the board and draw the circuit.<br><br>"Batteries have polarity because electricity flows from negative to positive. What is electricity?"<br><br>"What is an LED?"<br><br>"LEDs have polarity. They have 1 positive side and 1 negative side. The long leg is positive, and the short leg is negative."<br><br>"When you connect the LED to your battery, make sure you connect positive to positive and negative to negative." | Guide students to gather around the demo table and make sure all students can see and are paying attention. |

## Activity (1 hour)

Give each student the conductive tape strips you prepared, the Circuit Steps handout, the Circuit Printout, a binder clip, and scissors. Instruct them to follow the steps on the Circuit Steps handout and to build the circuit directly on top of the circuit printout.

Distribute the remaining materials in the following order:

1. Battery – After students finish pasting the tape
2. LEDs (let them pick a color) – After students tape the battery
3. Optional decoration materials – After students insert the LEDs, and they've shown you that it works

**Extra challenge:** Students can try to add more LEDs to the circuit or decorate their circuit with markers or color pencils.

## Reflection (10 min)

Ask students to demonstrate what they have made and to explain how their circuit works.

Hand out the student journals and have students answer the prompts in their journals. Ask, "What steps of the EDP did you do today?"

**Follow up with:** "Some of the prototypes didn't work. But that's why the EDP has a prototype failed step! It happens all the time to engineers."

Collect students' projects before they leave and put them in a labeled box.

## FACILITATION

### Lead

A lot of LEDs will not light up right away. Check:

1. LEDs are properly oriented (flip them)
2. The conductive tape is flattened all around
3. The circuit is not open
4. The batteries are working

When things don't work, emphasize that failure is an important part of the engineering design process, and it challenges students to solve problems.

"You guys built circuits like an engineer! You followed the EDP."

[Project the EDP diagram on the board.]

### Support

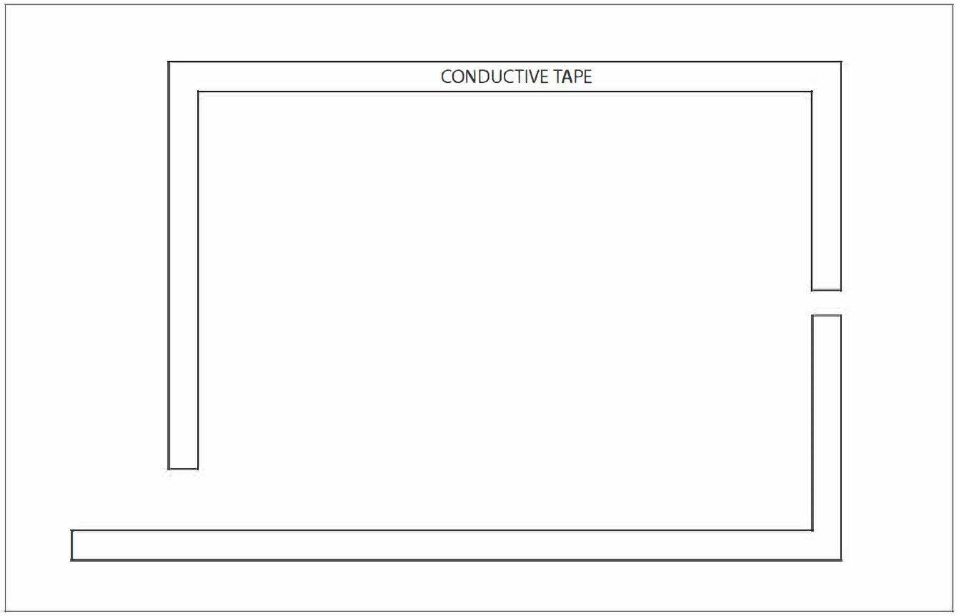
Hand out:

- Conductive tape strips
- Index card
- Circuit Steps handout, 1 per table
- Circuit Printout handout, 1 per student

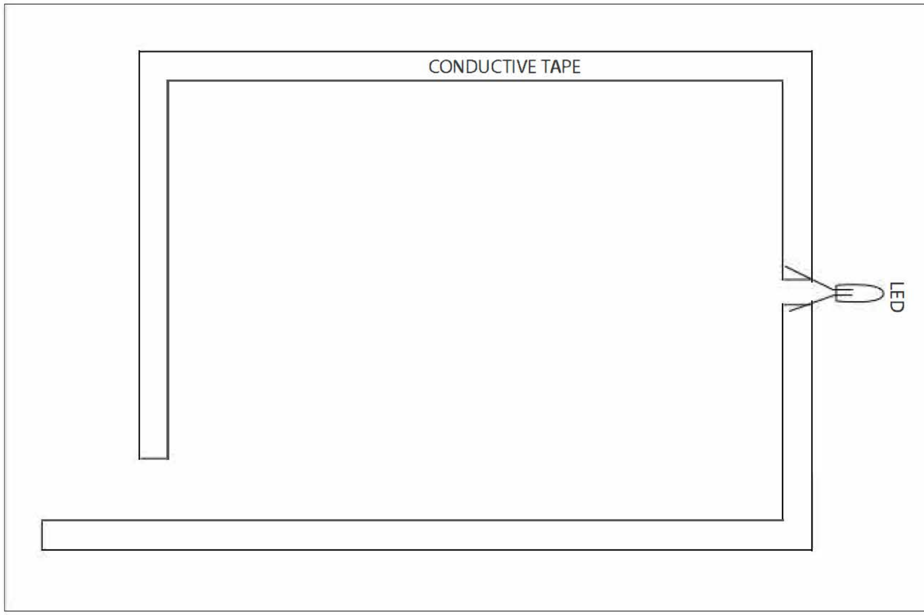
Hand out pre-made circuits to students who have trouble pasting the circuits.

Assist individual students as needed.

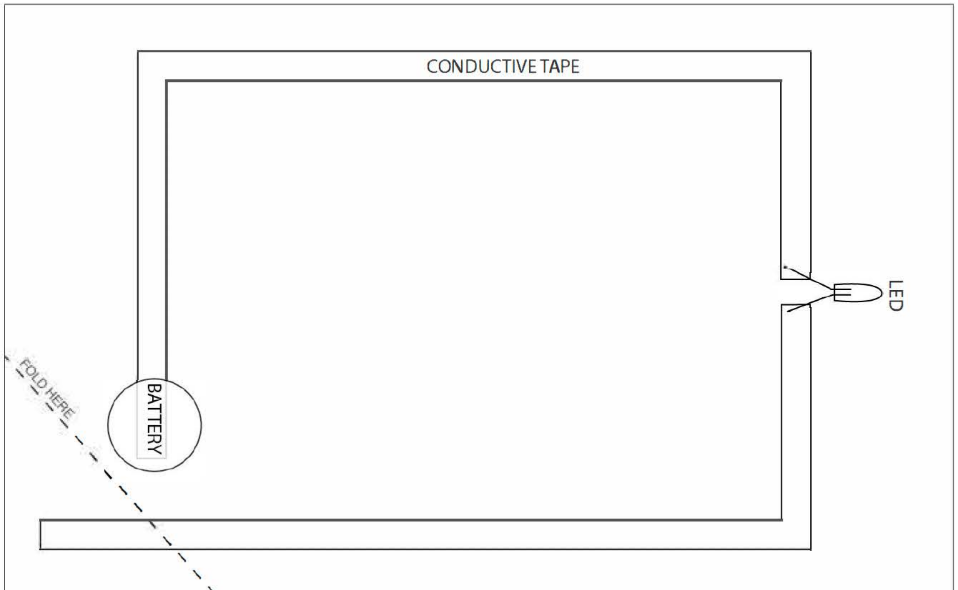
① Paste conductive tape



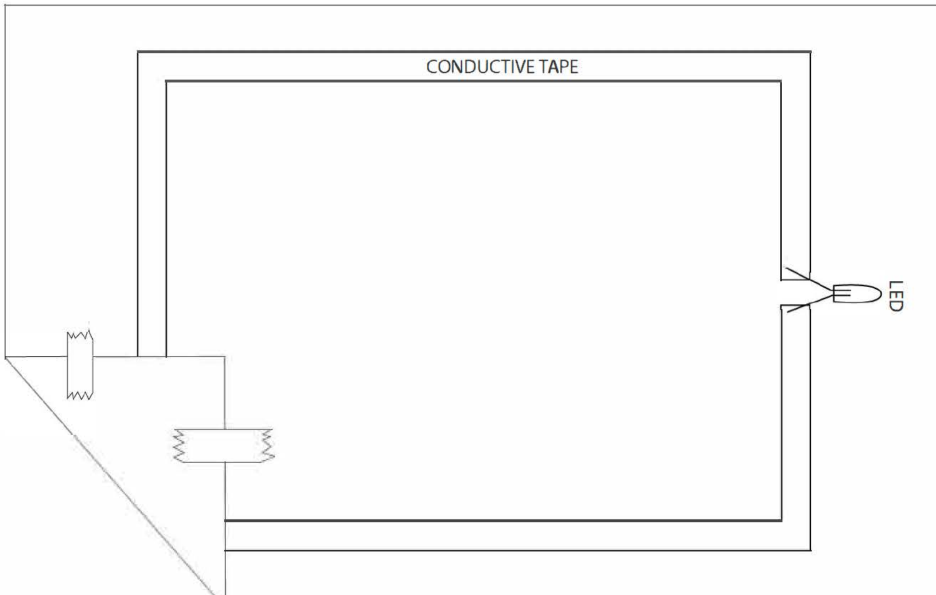

② Choose LED, tape it down

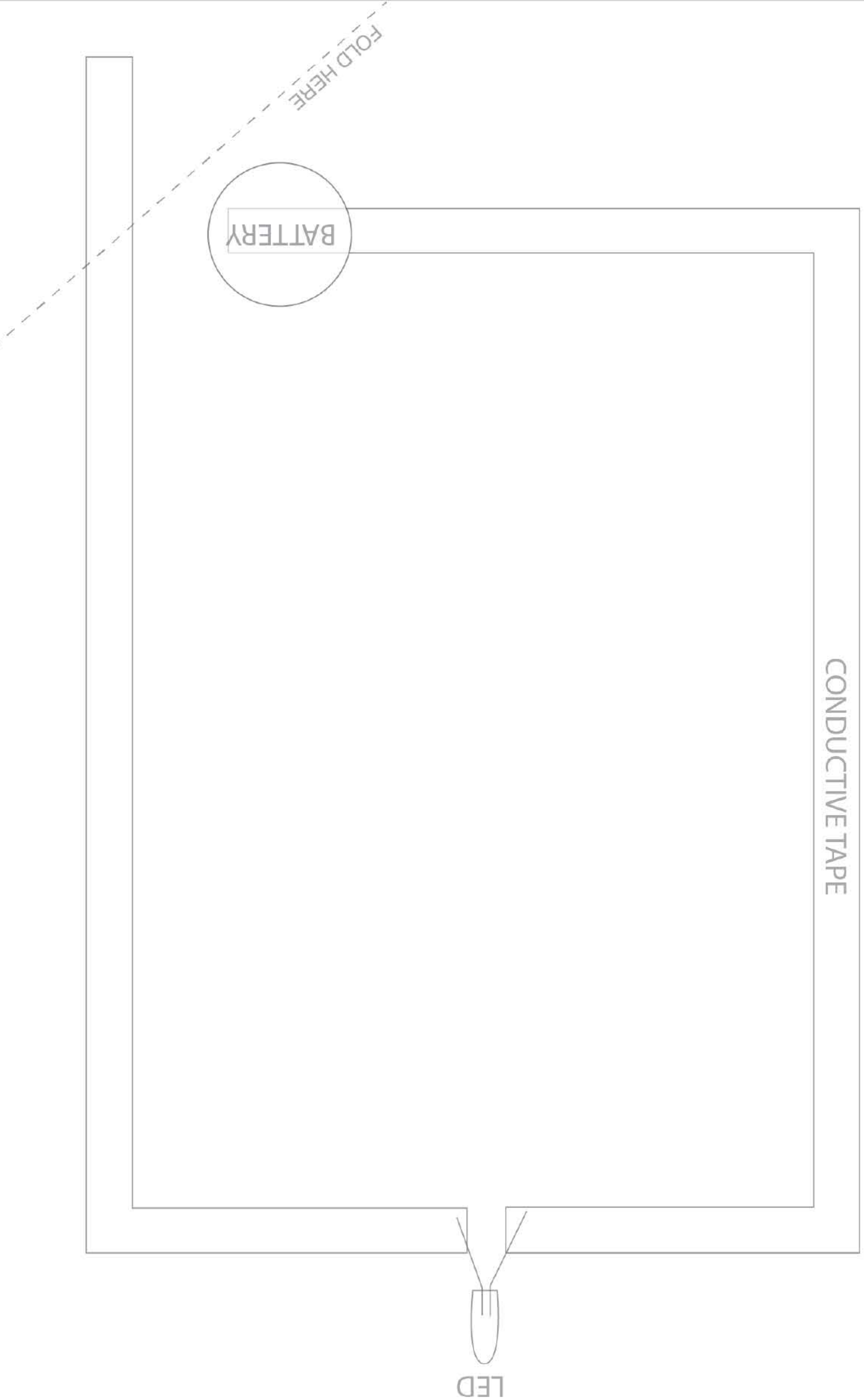


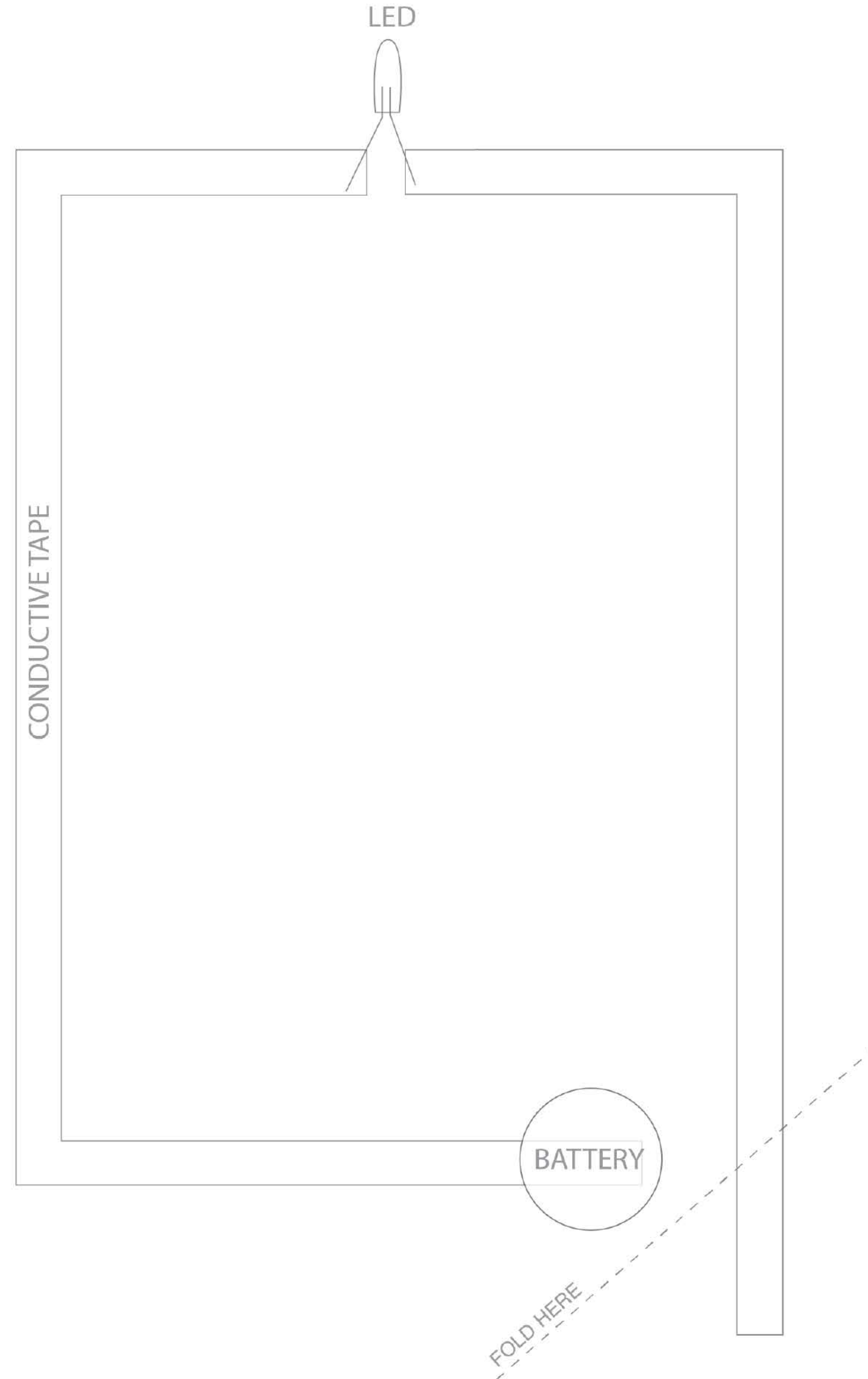

③ Place battery, and fold to test circuit




④ Tape battery under the fold




FOLD HERE
BATTERY
CONDUCTIVE TAPE
LED


LED
CONDUCTIVE TAPE
BATTERY
FOLD HERE

# Activity 7: LED Greeting Cards

**Complexity Level:** ●●●○○

**Pre-activity Preparation:** ★★★☆☆

**Duration:** 70 minutes

**Key Vocabulary:**

- LED
- Circuits
- Battery
- Card

## Objective

Use circuits and LED lights to create an LED Greeting card

## Learning Objectives

**Students will:**

- Learn how to create multiple circuits in a single project
- Gain hands-on experience with simple electrical circuits

## Materials Needed

**Materials (Per Student):**

- 1–2 LEDs
- 1 coin cell or AA battery
- 1 strip of conductive tape (10–15 in)
- 1 roll of washi tape
- 2–3 coloring pens
- 1/2 sheet of cardstock paper

**Tools:**

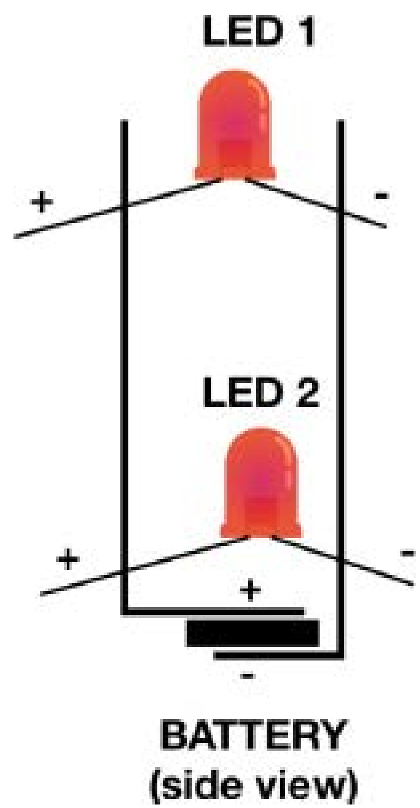
- Scissors
- Glue

## Pre-Activity

**Prep: (30-45 min)**

Before this activity you should:

1. **Create** at least one sample greeting card for each table that students can use as reference.
2. **Test** the batteries and LEDs to make sure they are functional (if they were used for another activity).
3. **Practice** how to connect 2 LEDs. The following diagram illustrates how to do it. If students get to this point, **draw** this on the board:



## Setup

Start the exercise with students seated in groups of 2 or 3, ensuring that every student has enough space to work on their cards. All of the materials should be organized and ready to be distributed after the students enter the room.

## Introduction (10 min)

**Review:** "What did we do the last time we met? What did we make? What tools did we use? What materials did we use? What is a circuit? What is polarity?"

Continue the discussion by asking students "What is your favorite day of the year?" Students can share which day they like the most and why. "What is a common thing that people give to each other on special occasions?" If students say "presents," ask them what accompanies a present. Once someone points out "a greeting card," say to the class, "We are going to make a greeting card with a simple circuit added to it to make it light up. They will be similar to the paper circuits we made last time, but now we can design and make something for a special occasion."

Have students look at the sample LED greeting card on their table. Ask them, "What do you notice? Does this look familiar? How are the LEDs working?"

### FACILITATION

| Lead | Support |
|---|---|
| Make sure students are seated in groups of 2–3. | Organize all the materials neatly into categories and set them on a materials table. |
| Review what LEDs are and the concept of polarity. | The whole club share-out/ intro may be overwhelming for some students. Offer the chance to go out for a walk or to take a break in a dedicated corner of the class (if the class size allows). |
| "What is your favorite day of the year? What is one common thing that people give to each other on special occasion?" | |
| Facilitate a discussion about the sample cards being passed around. | Pass around sample LED cards. |

1. Fold a piece of cardboard paper in half.
2. Decorate the card with the design you want.
3. On the inside or other side of the card, draw the circuit in pencil and plan where the LEDs are going to be.
4. Emphasize how important it is to sketch out the circuit and to label and draw ALL elements. For example, they should draw the battery and LED in the proper place and use + and – signs to indicate the polarity on the battery, LED and copper tape.
5. Decorate the card before making the circuit with the copper tape, batteries and LEDs. It is generally good to plan for the battery to be near a corner since folding the corner will complete the circuit.
6. Poke 2 holes in the card where the LED legs will slide through.
7. Put the LED in and bend the legs 90 degrees so that they fix the LED on the paper.
8. Lay the copper tape down. Add the battery and tape it down.
9. Be sure you emphasize the importance of matching the polarity of the battery and LEDs.
10. If the LED doesn't light up, have students troubleshoot to ensure everything is connected properly.

## Activity (45 min)

1. Tell students that they will now create their own greeting cards.
2. Hand out the materials for the activity, as listed in the "Materials" section.
3. Remind students to make holes in the cards so they can push the legs of the LED through the paper.
4. Let them know that this card can be for anyone and for any occasion. It will be a very special card because it will be one-of-a-kind.

The students are free to design anything with the materials. You can limit the amount of LEDs and batteries depending on your supply.

### FACILITATION

| Lead | Support |
|---|---|
| Go to the demo table and demonstrate how to make a card. Emphasize the importance of drawing the circuit and decorating the card *first*. | Test all batteries to make sure they work. |
| Expect a lot of LEDs to not light right away. Check the following:<br>• LEDs are properly oriented (flip them)<br>• Conductive tape is flattened all around<br>• Circuit is not open<br>• Batteries are working | Hand out materials to students. |
| The shorter the circuit, the more likely it will work.<br><br>Students may have issues hiding the battery. Guide them through ideas of how to do that with the given materials or materials around the class. | |

After 45 minutes, prompt students to take their hands off the table and to look at you. Ask them to demonstrate what they made and to report on the kind of challenges they faced in the activity.

## Reflection (10 min)

**Ask the students to reflect upon these questions:**

- What did you make?
- How did you make it?
- What tools did you use? How did you use them?
- How might you use them in the future?
- What was challenging? What was easy?
- Did anything surprise you?
- Can you think of anything else you can create with LEDs?

Remind students that they are working toward their final projects. Tell them that they will use everything they have learned to build their final projects, including circuits and LEDs.

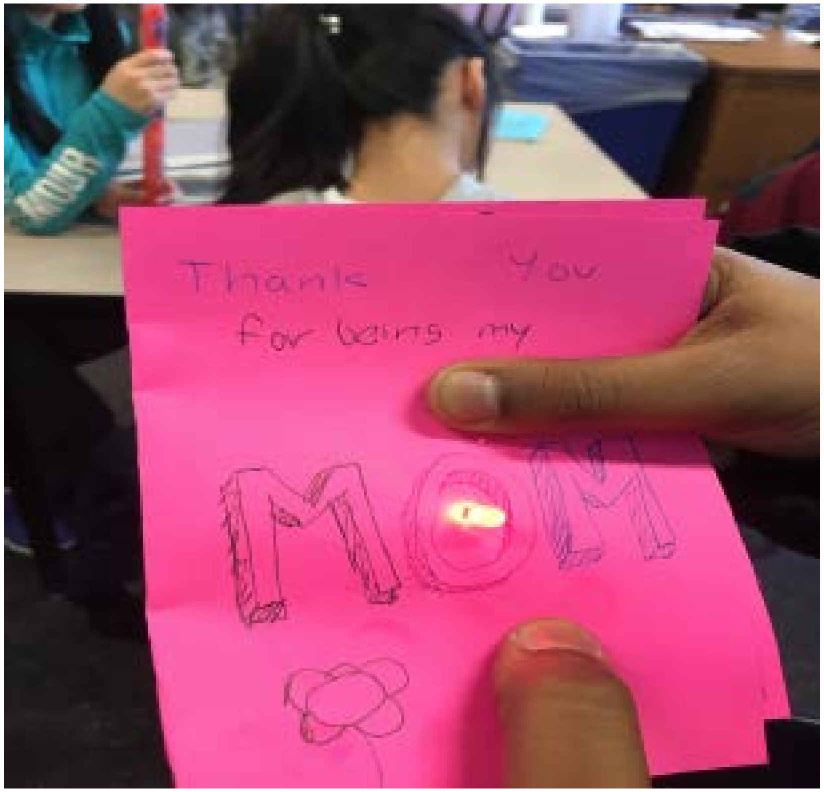
Hand out the students' journals. Ask: "What steps of the EDP did you do today?"

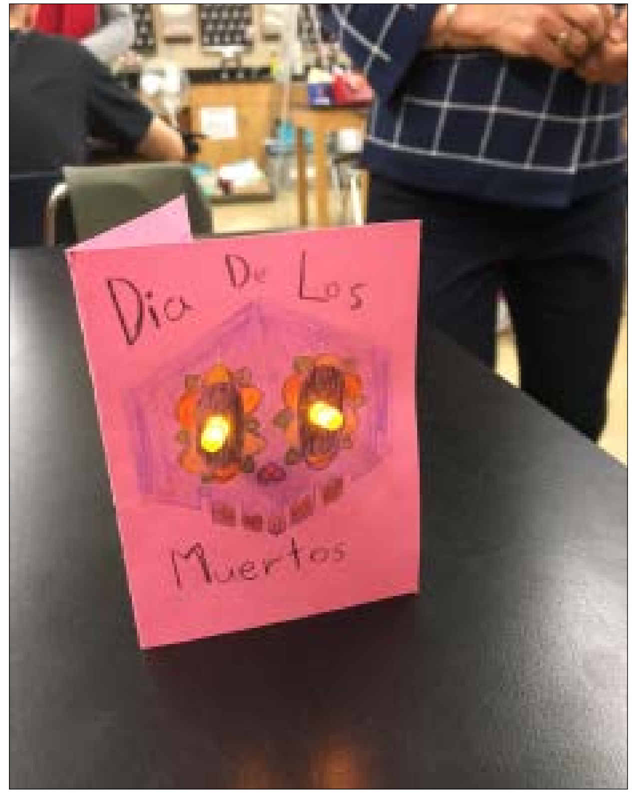
Collect students' journals and projects before they leave, and put them in a labeled box.

### FACILITATION

| Lead | Support |
|---|---|
| "What did you make? Who wants to share? What were some of the challenges? How did you fix them?" | Prompt students to look up at the main facilitator. |
| Do a class-wide reflection. | |
| "You can use what you learned in these activities in your final projects." | Hand out students' journals.<br><br>Collect students' journals and projects, or have students put them in their individual bins. |

## Examples of the LED GREETING CARD



# Activity 8: Motors

**Complexity Level:** ●●○○○

**Pre-activity Preparation:** ★★☆☆☆

**Duration:** 1.5 hours

**Key Vocabulary:**

- Motors
- Engines
- Power
- Energy
- Electricity
- Vibrations
- Motion
- Robot

## Objective

Use vibrating motors to create a vibrating object.

## Learning Objectives

**Students will:**

- Learn to use vibrating motors
- Learn to create an object from given materials
- Review the concept of circuits

## Materials Needed

**Materials (Per Student):**

- 1 motor with insulated conducting wires
- 1 AA battery
- 1 paper plate
- 1–2 paper cup
- Wooden clips or craft sticks
- Rubber band
- 1 roll of washi tape
- 1–2 paper sheets

**Tools:**

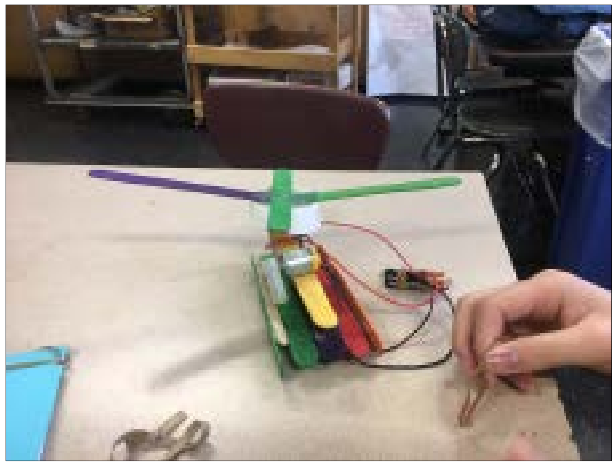
- 1 pair of scissors
- Glue stick

## Pre-Activity

**Prep: (20 min)**

Before this activity you should:

1. Start collecting cardboard for prototyping the final project. Students should bring some from home, and teachers should collect it from their own school.
2. Create a couple of examples of vibrating objects with the motors. These can be passed around to inspire the students. These are some examples:



## Setup

Start the exercise with students divided into groups of 2 or 3. Ensure every student has enough space to work on their prototypes. All of the materials should be organized and ready to be distributed after the students enter the room.

## Introduction (15 min)

Review the program so far. Start by explaining to the students that they are already half-way through the program. "We have all learned so much, and we should be thinking about what we want to make for our final project. If you have ideas already you can discuss them with me or write them in your journal."

"Let's review what we have done so far. What has been your favorite part of the program? What has been the most challenging for you?"

Chances are the least favorite aspect of the program has been an activity in which they didn't get the results they wanted and weren't sure what to do about it. Reinforce that making mistakes is part of learning, and the most important thing about a mistake is how you handle it. "What did you do to try to fix it? Has anyone made a mistake that they had to fix or figure out a different way to do it?"

Empathize with the students by sharing instances in which something went wrong when you were making samples for the activities for this program. Describe what did not work the way you wanted and how you dealt with it.

### FACILITATION

| Lead | Support |
|---|---|
| Prepare a demo table. | Prepare a table with all the sorted materials. |
| | Cut glue sticks into pieces 4–5 inches long. |
| "What has been your favorite part of the program so far?" | |

"Can anyone tell me what we did last time? What tools did you use? What materials did you use? What did we learn?"

"Today we will be making another circuit. Although it will be different, it will have some similarities. Can anyone tell me what we used to make our last circuit? When we make our circuit today, we will be using a variety of materials. Some will be similar to the last time, and some will be different."

"We are going to make a circuit that moves. How might we do that? What could we use that would move when we connect it to electricity?"

"Today we will be using a motor, and we will be adding something to our motor to make it vibrate." Show them an example of a vibrating motor. Pass it around for them to play with, or have one motor on each table so they can see it up close. "Now I will show you an example of what we will be making today."

**Go to the demo table and have students gather around:**

1. Take a piece of a hot glue stick and attach it to the stem of the motor. Attach it off center so it wobbles as it spins, which will cause it to vibrate.
2. Build a creature out of everyday materials and attach the battery and motor to it.
3. Ask students: "What do you think would happen if I centered my hot glue gun stick on the motor? Would it move faster or slower?What if I made it more off center?"

**FACILITATION**

| Lead | Support |
|---|---|
| Show students what a motor looks like and discuss their definition of *motor*. Write their answers on the board. Pass around a few finished examples of the vibrating motors. | |
| Make sure you put the glue stick off-center on the motor. This will allow the bots to move a lot. But if it is too off-center, then it may move too much. Experiment with it. | |

## Activity (1 hour)

Pass out all materials and have them build their own.

Once they have built their vibrabots, encourage students to move the motor around to different spots on their creation. What happens?

Discuss *iteration*: Once the bots are moving, encourage students to experiment with materials of different sizes and weights. What happens if you add more weight?

Emphasize the importance of *iteration*. Students can document the changes and iterations in their journals. They can use the same motor with different creations for quick experiments.

**Additional Challenge:** Try to combine multiple bots together into a megabot!

OR

Battle bots against one another! This challenge can be prompted and guided using the question, "How can you make your bot stronger to fight?"

## Reflection (15 min)

Hand out journals and have the students to reflect upon these questions:

- What did you make?
- How did you make it?
- What tools did you use? How did you use them?
- How might you use them in for other projects?
- What was challenging? What was easy?
- Did anything surprise you?
- Can you think of anything else you can create with circuits?

## FACILITATION

### Lead

Encourage students to move their motor around. A rubber band can be used to attach the motor wires to the battery.

Provide the additional challenge to students who finish early or who find the activity easy.

### Support

Distribute 1 motor, 1 battery, and 1 piece of glue stick to each student.

Provide students with their journals in case they want to sketch their bots first.

Expect students to have trouble:

1. Connecting the wires to the battery
2. Keeping the battery connected
3. Hiding the battery

Assist them by suggesting ideas, not by doing anything for them. You can show them one of the finished demos for troubleshooting.

# Activity 9: Project Planning

**Complexity Level:** ●●○○○

**Pre-activity Preparation:** ★★☆☆☆

**Duration:** 1 hour

**Key Vocabulary:**

- Sketching
- Prototype
- Iteration
- Solution
- Real-world problem

## Objective

Come up with an idea for the final project and sketch it out

## Learning Objectives

**Students will:**

- Learn how to turn their ideas into a visual plan
- Decide what their final project is going to be
- Create sketches of their final project

## Materials Needed

**Materials (Per Student):**

- Journals
- A3 sheets of paper
- Pencils
- Rulers

## Setup

This exercise is to generate ideas and plans before students start prototyping their final project. Ensure students are seated in such a way that they have space to work in their journals or on an A3 piece of paper.

## Activity (45 min)

All students should meet with a facilitator to come up with a final project idea (see *Final Projects Facilitator Guide*). This can be one-on-one or in small groups. While some students meet with facilitators, others can start sketching or listing ideas they have for final projects. These can be used for discussion when it is their turn to meet with the facilitator. Once everyone has an idea for a final project, they can start planning.

Give a quick review to the whole class about how a 3D printer works before they start sketching.

Ask them to sketch their final project, illustrating as many details as possible in the sketch. The sketch does not need to be a neat diagram. It can simply serve as a brain-storming idea for the students to better visualize their final product before they start with the first prototype.

**Typically, a student's sketch should include:**

- Name of their final project
- One or more rough diagrams of their final project
- Details about the materials they are going to need

### FACILITATION

| Lead | Support |
|---|---|
| "If you met one-on-one with a facilitator, you can take out your journals and wait for instructions." | Hand out paper and pencils to students. |
| "Does everybody remember how 3D printing works?" | For students who don't want to draw their final projects, offer other options. The key objective of the activity is to help students visualize their final project. |
| "Draw or sketch your final projects so you can start prototyping." | |
| "The designs need to have at least one flat base." | If there are hanging parts, consult with the students and assist them on how these can be printed separately and then joined together later. |
| "There needs to be minimal hanging parts" | If students have trouble starting, provide ideas about a part they can start with. Do not draw for them. |

## Reflection (15 min)

Once all of the students are done sketching ask them what their project is and whether it is solving a problem. The students need to have a basic level of clarity about their project. If they seem confused, ask or write on the board the following questions to help them gain clarity:

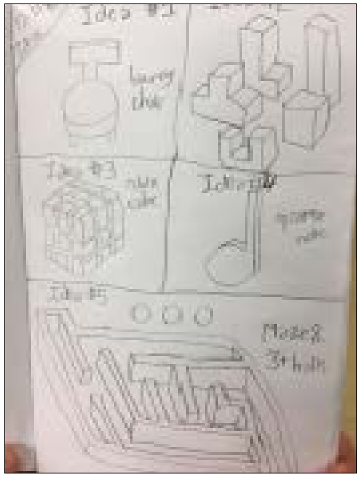
- What is the problem you are trying to solve?
- How are you solving the problem?
- What is your final project?
- How does it solve the problem?
- What tools/materials will you be using?
- What steps of the EDP did you do today?

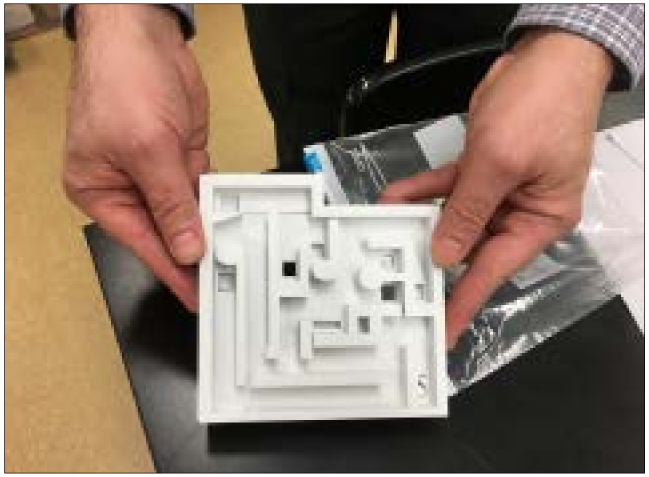
Ask the students to write these answers in their journals. If students did not sketch in their journals but on a piece of paper, make sure to collect their sketches and save them in a labeled box.

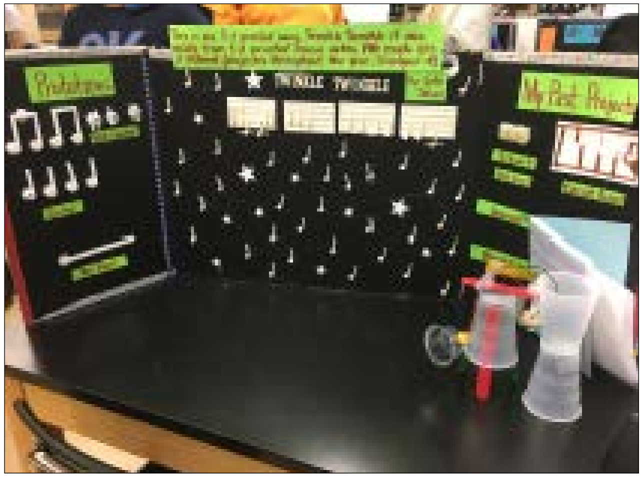
### FACILITATION

| Lead | Support |
|---|---|
| Ask students to explain their ideas to you.<br><br>"What is the project you're making?"<br><br>"Does it solve a problem for you or others? What is the problem?"<br><br>"What materials and tools are you going to be using in making your project?" | If a student is uncomfortable writing in their journal, they can tell you their answers. That will be enough. |
| "What steps of the EDP did you do today? Why?" | Hand out journals and collect students' sketches. |

## Examples of the prototypes, final products, and poster







# Activity 10: Prototype 1

**Complexity Level:** ●●●●●

**Pre-activity Preparation:** ★★☆☆☆

**Duration:** 1.5 hours

**Key Vocabulary:**

- Thermoplastics
- Material
- Properties
- Change of state

## Objective

Create the first prototype of their projects out of different materials

## Learning Objectives

**Students will:**

- Learn the properties of different materials
- Learn to be conscious of their design choices and the outcome of those choices
- Understand what prototyping means

## Materials Needed

**Materials (Per Student):**

- Cardboard
- Wooden blocks
- Glue sticks
- Play-Doh
- Foam

**Tools:**

- Glue gun
- Scissors
- Cardboard cutters
- TinkerCAD

## Pre-Activity

**Prep: (30 min)**

Set up all materials and tool stations. Plug in the hot glue guns, and organize the materials at different stations. This will help to spread students out as they are gathering materials and working on their prototypes.

## Setup

Have all the materials organized by type (foam, wires, cardboard, Play-Doh, etc.) on a separate table. Have a station with connectors (hot glue guns, glue sticks, tape, and anything else you have). This prototype is a great opportunity to get creative with reinterpreting materials. Feel free to provide any materials you think will help the students build their prototypes.

## Introduction (15 min)

"Today we are going to work on making the first prototype for our final project. Can anyone share what they think a prototype is? Why do we make prototypes?" Introduce the materials and stations available to build prototypes: "Today we will be using these tools and materials." Have them listed on the board and say them out loud.

**Materials (Per Student):**

- Hot glue
- Cardboard
- Foam
- Play-Doh
- Wooden blocks
- Any other materials you feel will help

**Tools:**

- Hot glue gun
- Cardboard cutters
- Tape

### FACILITATION

| Lead | Support |
|---|---|
| "Sit so that you have plenty of space around you." | Sit students down to minimize distraction by other students.<br><br>Plug in glue guns. |
| "Today you'll build the first prototype for your project. Does anyone remember what a prototype is?" | |

## Materials Review

**Review the properties of the materials and tools and discuss the benefits and challenges of these materials:**

- What is the material?
- What are the benefits of using it? What can it do?
- What are the challenges or constraints?

This could be an open discussion in the class, or if students prefer to write in their journals, you can let them answer the questions there. It is preferable to encourage the students to comment and discuss as much as possible, so you can assess their understanding of the materials and how they might use them.

**Here is some information to help guide the conversation:**

- Hot glue is good for connecting things. The hot glue gun heats up the glue (thermoplastic) to a liquid. Once applied to a project, the glue takes a few minutes to cool and dry. The glue gun gets hot, so students need to be careful when using it.
- Cardboard is a versatile material and great for prototyping ideas quickly. It is corrugated, which makes it strong and easy to score and cut. It is also easy to draw on.
- Foam is soft. It can be used at the bottom of an object to soften it, or it can be cut and stacked to make a larger object.
- Play-Doh is a soft clay-like material. It can be pulled apart and put back together. It is versatile and comes in a variety of colors.
- Wire is stiff, but it can be bent easily. It can be used for structural components of a project, and you can add other materials, like Play-Doh, to give it more form.

### FACILITATION

| Lead | Support |
|---|---|
| | |

## Activity (1 hour)

Provide some time for the students to explore the materials if they want to. This will let them see how each material may benefit the prototype they are about to build. Encourage them to cut the cardboard and foam, draw a straight or crooked line or shape, and cut it out. Doing this without a specific goal will help build confidence and improve skills. It will also help them experience the challenges of the materials before having to be precise.

Each student will want to start on their prototype at different times, so let them begin when they feel they are ready, while allowing the others to continue exploring material properties.

## Reflection (15 min)

This process may take more time, so at the end of the session, ask students where they are in the process. "Is anyone finished with their first prototype? Does anyone need more time? Would anyone like to share what they made? Remember you don't have to be finished to share your project. Sometimes, it's beneficial to share your project before it is finished. Getting feedback from others may provide you with an idea that you didn't think of."

**Write these questions on the board for students to use as reference, and ask them out loud as they are sharing:**

- What did you make today?
- What material(s) did you choose?
- Why did you choose that material?
- What do you like about your design?
- What else do you have to do? Or if they are done, What would you change in the second prototype

## FACILITATION

### Lead

Give students time to experiment.

"Ok, if you are ready to start building your prototype, feel free to gather your materials and start. If you would like to continue exploring, you can do that as well."

Tell students to look at what they made or check out a classmate's creation that is made out of a different material.

"Let's talk about what you made. What was hard? What part of your final project is it?"

### Support

Students may struggle with turning a concept into a 3D object. Help them by drawing on the board or referring them back to their own journals and sketches.

# **Activity 11:** Prototype 2

**Complexity Level:** ●●●●●

**Pre-activity Preparation:** ★★☆☆☆

**Duration:** 1.5 hours

**Key Vocabulary:**

- TinkerCAD
- 3D design
- Prototyping
- 3D print

## Objective

Continue building the final project or transfer the prototype to TinkerCAD

## Learning Objectives

**Students will:**

- Learn to iterate their prototype
- Learn to build their project in TinkerCAD

## Materials Needed

**Materials (Per Student):**

- Laptops
- Mice
- All materials from Prototype 1

**Tools:**

- TinkerCAD cheat sheet
- All tools from Prototype 1

## Setup

Set up the room, tools, and materials the same way you did for Prototype 1. Also set up computers and chargers for students to use TinkerCAD. Students should be seated in such a way that they have space to work on their laptops independently. This activity is open-ended and requires each student to work at their own pace. This format can be distracting, so try to set up the room in a way that helps students focus.

## Introduction (5 min)

Review what you did last time.

- What did you make last time we met?
- Did you finish your prototype?
- What do you have left to do?

If students didn't finish their prototype then they should continue. Keep in mind that some students will be building their final project with everyday materials, like the materials from Prototype 1, some will transfer their first prototype designs to TinkerCAD and 3D print them.

Explain that in any EDP it is totally normal to make mistakes and have challenges and it takes time to get the right solution. We want to create our prototypes so we can iterate and improve on our design. Use the engineering design chart to explain the process, and remind them the importance of *iteration*.

### FACILITATION

#### Lead

It might be difficult for some students to translate their designs into TinkerCAD. Work one on one with the students to ensure that they understand how they can proceed.

Help students by asking them questions so they can solve their problems on their own.

#### Support

"Why is it important to have multiple prototypes? Why can't we create our final design directly?"

"The more prototypes, the better your final product. Iterating will allow you to improve your solution."

## Activity (1 hour, 15 min)

Students should pick up where they left off, keeping in mind that they all may be at different points in the project. It is important to provide them with the opportunity to work at their own pace and do it themselves. During the program, facilitators should be walking around to assist students as needed.

If students are using TinkerCAD for their final prototype, make sure the model is set up to be successful. Ask them, "Do you remember what the parameters for a successful print are? Maximize surface area, orientation, and overhang." If the model looks good after your review and discussion with the student, have them export it as an .svg file. Provide them with a thumb drive, and ask them to name the file (Your Name_final project), put it on the drive, and give the drive back to you. If you have time, you can start the print with the student there.

## Introduction (10 min)

Write these questions on the board for them to use as reference and ask them out loud as they are sharing:

- What did you make today?
- What material(s) did you choose?
- Why did you choose that material?
- What do you like about your design?
- What else do you have to do?

Hand out journals, and have all the students respond to these prompts. When done collect the journals and all of the prototypes.

### FACILITATION

| Lead | Support |
|---|---|
| | "Why did your design fail? How can you fix it?"<br><br>"Do you remember what we need to avoid when designing for a 3D printer?" (Answer: holes and overhangs) |

# Activity 12: Final Poster

**Complexity Level:** ●●●○○

**Pre-activity Preparation:** ★★★★★

**Duration:** 1.5 hours

**Key Vocabulary:**

- Prototypes
- 3D design
- Circuits
- Iteration
- Process

## Objective

Create a poster that demonstrates what a student has done in the club

## Learning Objectives

**Students will:**

- Learn to talk about their design process
- Learn to discuss progression through prototypes and iteration
- Learn to talk about 3D design and the vocabulary they learned in the program

## Materials Needed

**Materials (Per Student):**

- Poster board
- All projects made in the Maker Club
- Tape
- Markers

**Tools:**

- Glue gun

**Optional:**

- Batteries (for motors)
- Mixed decoration materials

## Pre-Activity

**Prep: (30 min)**

1. Gather as many decoration materials as possible.
2. Collect and prepare all the projects the students have made so far in the program. They will be presenting them.
3. Photocopy the Certificate of Completion in the appendix. Make one certificate for each student, and fill it out.
4. (Optional) Create a slideshow of photos of students in the Maker Club to play in the background.

## Setup

Prepare all the materials on a table. Separate each student's projects, so that when they come in, they can just grab them and get started on their project board.

## Introduction (10 min)

Tell students that today is the day! They will be showing off their amazing projects to their families. Brainstorm together what they are supposed to do for the day (finalize their projects). Then tell them that they will also be making project boards to show off everything they made in the club. Ask the students to help you remember all the activities they did, listing them one by one. Write them on a whiteboard. You can draw a diagram of the project board, with "Name," "Maker Club," "Activity," and "Materials/ Tools" so that they remember what to write on their boards. Tell them they will put each of their projects next to where they wrote about it.

## Activity (1 hour, 15 min)

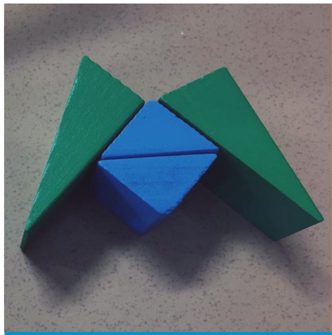
Students make their posters.

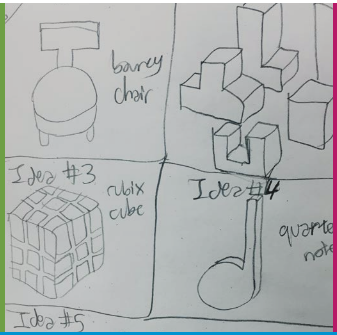
## Reflection (5 min)

You can conclude the program by running a PowerPoint presentation with photos of the students throughout the Maker Club sessions. Congratulate the students and hand out their Certificates of Completion.

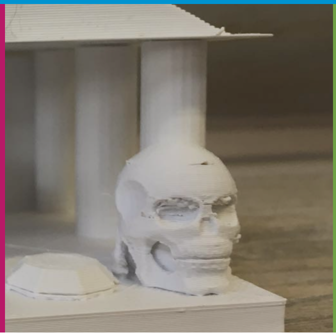
### FACILITATION

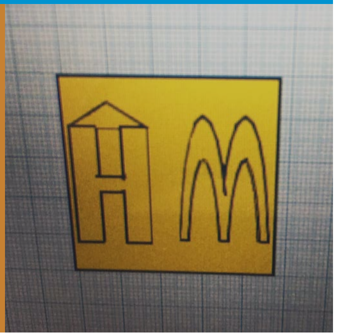
| Lead | Support |
|---|---|
| Write on the board suggestions for what the students can write on the project boards. | |
| | Distribute materials to each student. |






# RESOURCES



**Do you want to be an inventor? How about an engineer? Or a designer?**

**→ JOIN THE MAKER CLUB! ←**

**You can participate in a program that will spark your imagination!**

In the Maker Club, you will learn how to design your own objects and print them using a 3D printer. We hope you are as excited to show off your creativity as we are to work with you.

WHEN: ______________________________

WHERE: ______________________________

## PLEASE JOIN US FOR THE MAKER CLUB SHOWCASE!

Students in the Maker Club and their families are invited to the Maker Club Showcase! Share your own project and see what you fellow makers have created!

WHEN: ______________________________

WHERE: ______________________________

# CERTIFICATE OF COMPLETION

This acknowledges that

successfully completed the

**MAKER PROGRAM**

# **Journal Making Checklist—**Method 1: Sewn Binding

- ☐ **Collect** the materials.
- ☐ Make a **plan** for the design.
- ☐ Fold the **10 sheets of paper** and the cardstock sheet in half, then open them back up.
- ☐ Use **2 binder clips** to hold the paper in place.
- ☐ **Make** holes in the binding by hammering a nail through the paper.
- ☐ **Sew** the binding of the journal using needle and thread.
- ☐ **Decorate** your journal.
- ☐ Write your **first entry** in the journal.

# **Journal Making Checklist—**Method 2: No-Sew Binding

- [ ] **Collect** the materials.
- [ ] Make a **plan** for the design.
- [ ] Fold the **10 sheets of paper** and the cardstock sheet in half, then open them back up.
- [ ] Use **2 binder clips** to hold the paper in place.
- [ ] **Make** triangle cuts at the top of the fold.
- [ ] **Wrap** a thread around the binding of the journal.
- [ ] **Decorate** your journal.
- [ ] Write your **first entry** in the journal.

# Intro to 3D Printing Checklist

## PART I:

- [ ] Think of something simple you want to build out of foam. It could be a building, an animal, or an object around you.
- [ ] Pick a color of foam you want to use.
- [ ] Cut the foam into the first layer of your object. This is going to be the bottom layer, your base.
- [ ] Then cut the rest of the layers and layer them on top of each other.
- [ ] When you're done with your object, make a hole in the middle of your foam layer object and stick the wire through it.
- [ ] Wait for instructions from the facilitator.

## Part II:

- [ ] Make sure you have a glue gun for yourself.
- [ ] Pick 1 Play-Doh container and bring it to your desk.
- [ ] Think of something you want to create: a building, an animal, an object around you. You're going to build one thing with glue and one thing with Play-Doh.
- [ ] Start with the glue gun: Lay down the first layer of your object.
- [ ] Put the glue gun in the yellow tray while the layer dries.
- [ ] Take out a piece of Play-Doh and roll it on the table to create a thin snake. Now shape it into the first layer of your object.
- [ ] When the first layer of glue is dry, take the glue gun and lay the second layer on top of the first layer.
- [ ] Put the glue gun in the yellow tray and let your glue object dry.
- [ ] Go back to the Play-Doh, and build the object layer by layer while the glue layers dry.
- [ ] Go back and forth between the Play-Doh and the glue gun until your two objects are complete.

# Wooden Blocks Checklist

- ☐ Take the wooden blocks and **play** with them. Make a few different objects.
- ☐ **Show your design** to the faciliator.
- ☐ Now, use the blocks to **create** your initials.
- ☐ Once the design is finalized, **log in to TinkerCAD** and **recreate** your wooden blocks design on the computer.
- ☐ Once you're done, **add** a base to your design so it can print as a name tag.

## Additional Challenges

- ☐ **Design** your entire name.
- ☐ **Turn** your name into a keychain, bracelet, or something else.

# TinkerCAD Checklist

- ☐ Log into your computer.
- ☐ Ask for your TinkerCAD account login and password.
- ☐ Go to TinkerCAD.com and log in.
- ☐ Explore TinkerCAD on your own for 10 minutes and try to build something.
- ☐ Now use your wooden block name and reproduce it using shapes in TinkerCAD.
- ☐ Turn your name into a name tag by adding a flat base layer for the letters to lie on.
- ☐ If you mess up, it's OK! Press the home button or look at the TinkerCAD cheat sheet.

# 3D Printing Checklist

- ☐ All the shapes making the letters are touching a base so that it prints as one object.
- ☐ The design has no overhanging elements.
- ☐ The design fits on the 3D printer bed.
- ☐ The TinkerCAD project has been properly named (example: “Name tag - student name”).

# Paper Circuits Checklist

- ☐ **Get** an index card or a piece of cardstock paper.
- ☐ **Stick** the conductive tape onto the instructions sheet as shown.
- ☐ **Add** an LED to your circuit. Notice the long leg and the short leg.
- ☐ **Add** a battery to your circuit. Make sure the + and – sides go to the correct LED legs.
- ☐ **Test** your circuit.

## Additional Challenge

- ☐ **Add** another LED.

# LED Greeting Card Checklist

- ☐ **Sketch** your design on the card and **decorate** it.
- ☐ On the back or inside of the card, **sketch** your circuit. Include where the battery, LED, and tape will go.
- ☐ **Show your design** to the instructor.
- ☐ **Take** the LED and poke the legs through the holes you made in the paper (as your faciliator showed you).
- ☐ **Build** the circuit, making sure to match the LED legs to the right charge of the battery.
- ☐ **Write** a message!

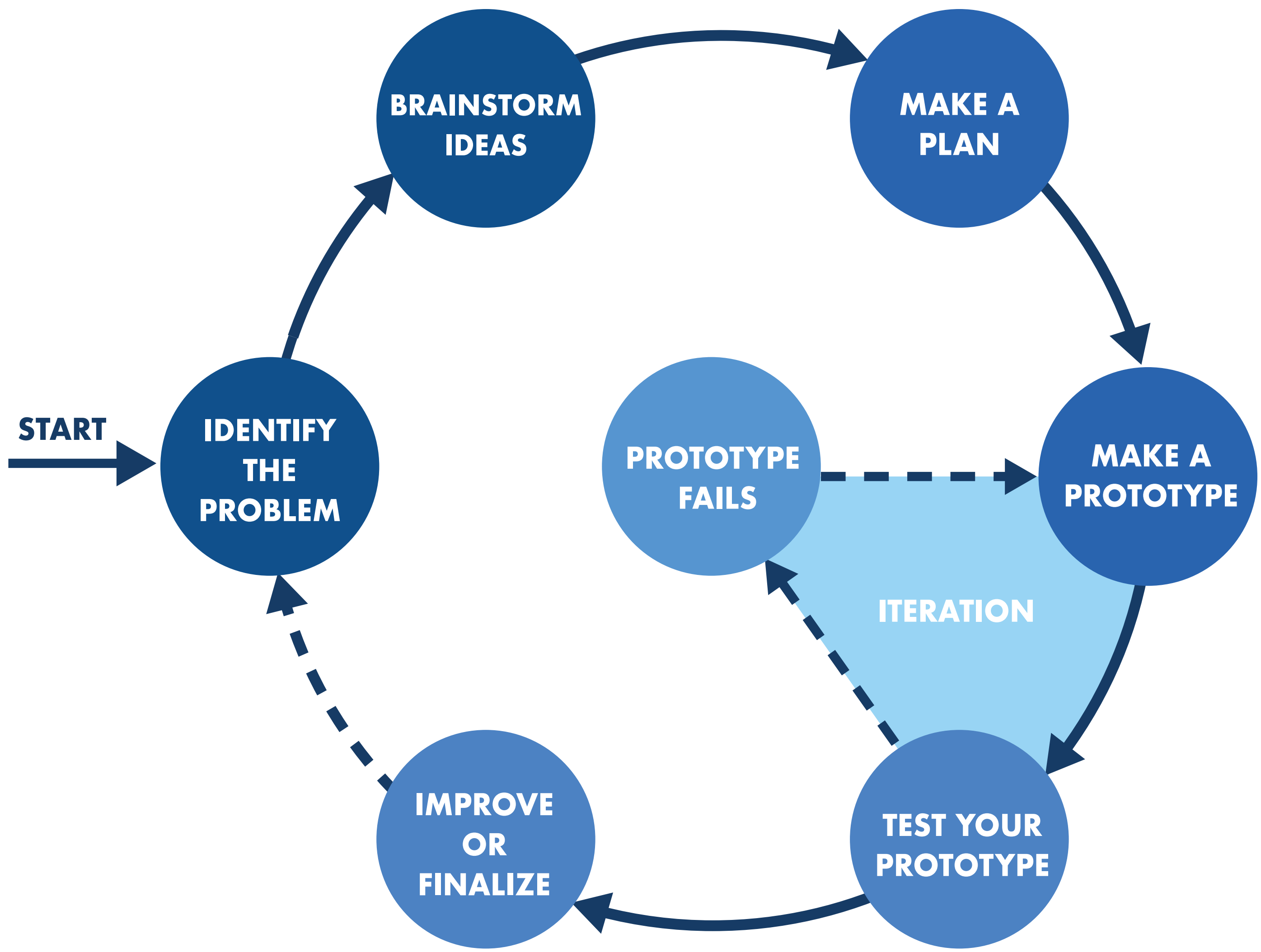
## Additional Challenge

- ☐ **Add** 1 or 2 more LEDs.

# Prototype 2 Checklist

- ☐ **Iterate your first prototype**.
- ☐ **Create** your second prototype in **TinkerCAD**.
- ☐ After finishing, **rename** your file as “Second Prototype - Your Name.” **Let** your facilitator know you’re ready to print it.
- ☐ If you haven’t finished by the end of day, it’s ok! You can **continue** in the next session.

## Engineering Design Process Diagram



# Materials Master List

| Material | Quantity needed | Current Quantity | Need to purchase (Y/N) |
|---|---|---|---|
| A4 Sheet Bundle | 1 pack | | |
| Glue gun | 14 units | | |
| Glue sticks | 6 lbs per school | | |
| Hot glue gun holders | 14 units | | |
| Pencil | 20 units | | |
| Rulers | 10 units | | |
| Basic first-aid kit | 1 kit | | |
| Power Strips | 3 strips | | |
| Extension cord | 2 cords | | |
| Materials Bin | 8 bins | | |
| Tray | 5 trays | | |
| Sharpies | 2 packs | | |
| Play Doh | 15-20 units | | |
| Scissors | 10 units | | |
| Parchment paper | 2 rolls | | |
| Cardboard | 1 per student | | |
| 7 oz Hammer | 7 units | | |
| 2 inch Nail | 20 units | | |
| Binder Clips | 20 units | | |
| Embroidery Needle | 20 units | | |
| Needle Threader | 5 units | | |
| Magnetic Tray | 5 units | | |
| Embrodery Floss | 20-30 units | | |
| Cardstock Paper | 40 sheets | | |
| Foam Tiles | 9 tiles | | |
| Washi Tapes | 1 pack | | |
| Conductive Copper Tape | 2-3 rolls | | |

| Material | Quantity needed | Current Quantity | Need to purchase (Y/N) |
|---|---|---|---|
| LEDs | 1 box | | |
| Index Card | 20-30 cards | | |
| Vibrating Motors | 15 units | | |
| Coin cell Batteries | 20-30 units | | |
| Paper Cups | 50 units | | |
| Wooden Clips | 30 units | | |
| Paper plates | 50 units | | |
| AA Batteries | 20 units | | |
| Tongue depressors/craft sticks | 30-50 units | | |
| Mice | 1 per student or per 2 students | | |
| 3D Printing Filament | 1-2 rolls | | |
| Cardboard cutters | 1 10-pack | | |
| Foam sheets | 1 pack | | |
| Sandpaper | 1 pack | | |
| Project board cardboard | 50 pack | | |
| Paintbrushes | 1 set | | |
| Acrylic paint | 1 set | | |
| Regular tape | 1 set of 6 | | |
| Custom Stickers | 1 per student | | |
| Circle colored stickers (optional) | ~1000 (1/3 of the pack) | | |

# TinkerCAD Cheat Sheet

Here are some keyboard shortcuts that you can use in TinkerCAD!

| | |
|---|---|
| ctrl + C | **Copy:** ctrl/cmd + C<br>Press ctrl/cmd + C to copy selected object/objects |
| ctrl + V | **Paste:** ctrl/cmd + V<br>Press ctrl/cmd + V to paste object/objects |
| ctrl + Z | **Undo:** ctrl/cmd + Z<br>Press ctrl/cmd + Z to undo |
| ctrl + ⇧ + Z | **Redo:** ctrl/cmd + shift + Z<br>Press ctrl/cmd + shift + Z to redo |
| ctrl + G | **Group:** ctrl/cmd + G<br>Press ctrl/cmd + G to group objects |
| ctrl + ⇧ + G | **Ungroup:** ctrl/cmd + shift + G<br>Press ctrl/cmd + shift + G to ungroup objects |
| ctrl + D | **Duplicate in place:** ctrl/cmd + D<br>Press ctrl/cmd + D to duplicate selection in the same place |
| ctrl + L | **Lock:** ctrl/cmd + L<br>Press ctrl/cmd + L to lock selection |
| ctrl + A | **Select all:** ctrl/cmd + A<br>Press ctrl/cmd + A to select all objects |
| ⇦ | **Delete:** backspace<br>Press backspace to delete object |
| W | **Workplane:** W<br>Press W to place workplane |
| R | **Ruler:** R<br>Press R to place ruler |
| F | **Fit view to selection:** F<br>Press F to fit the view on selected object |
| ▲ ◄ ▼ ► | **Move on workplane:** all arrows<br>Nudge selection on workplane, x&y-axis |
| ctrl + ▲ ▼ | **Move up & down:** ctrl/cmd + up&down arrows<br>Nudge selection up & down, z-axis |

# Keyboard Shortcuts with Mouse

**Duplicate:** Hold '**alt**' while starting to move to duplicate selection

**Select multiple objects:** Hold '**shift**' + '**left mouse button**' to select multiple objects

**45°-step rotation:** Hold '**shift**' while rotating to constrain rotation to 45 degree steps

**1D scale (center of the object):** Hold '**alt**' while scaling object from side handle to scale proportionally on one direction

**2D scale (center of the object):** Hold '**alt**' while scaling object from corner handle to scale proportionally on two direction

**3D scale (opposite corner):** Hold '**shift**' while scaling object from corner handle to scale proportionally on all directions

**3D scale (bottom center of the object):** Hold '**shift**' + '**alt**' while scaling object from corner handle to scale proportionally on all directions

**3D scale (center of the object):** Hold '**shift**' + '**alt**' while scaling object from top handle to scale proportionally on all directions

**Pan view:** Hold '**shift**' + '**right mouse button**' to view panoramic

# IDEAS

(INVENTING, DESIGNING, AND ENGINEERING FOR ALL STUDENTS) MAKER PROGRAM

Education Development Center

New York Hall of Science

NYU Tandon School of Engineering

NYU Steinhardt

ASD Nest Program

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