GORGE MAKER CLUB CURRICULUM

Created by:
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SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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US 2020 STEM Coalition Challenge

Makers + Mentors NETWORK

Columbia Gorge EDUCATION SERVICE DISTRICT

Contents

About this Project

This curriculum was designed to introduce children grades 4-8 to the maker mindset, inspiring them to be makers from a young age. The goals of the activities are to promote creativity, boost problem-solving skills, and encourage perseverance. The activities are also planned in such a way to expose children to design thinking and give them a chance to try a variety of "making" activities.

Many of these activities come from publicly available resources and all original content is cited. However, the actual lesson plans and supplemental documents were created primarily by Jacob Field, Maker Work Study at the Columbia Gorge STEM Hub, with support from Christy Christopher (Hub Director) and Lisa Bren (Communications & Special Projects). The work is largely funded by the US 2020[1] grant from Citizen Schools. The Oregon Department of Education STEM Hub funds also support the work.

In 2018-19 the curriculum was tested at nine sites in the Columbia Gorge region of Oregon. These sites included a middle school, five elementary schools of varying demographics (mostly Title I schools), a public library, and a migrant summer school. The findings from those sites were incorporated into these lessons, and after the 2019-20 school year, the curriculum was revised slightly again to incorporate minor feedback from that year.

We anticipate the Gorge Maker Club Curriculum will be a living document, evolving over time. Any questions, comments, or suggestions can be directed to:

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Makers + Mentors NETWORK

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[1] Now known as Makers + Mentors Network.

Getting Started

This quick-start guide will help you get a Maker Club started at your location.

Overview:
A typical maker club involves around 20 makers, from grades 4 to 8. It works best if run by an experienced educator, mostly because they understand classroom management techniques. Having interest and experience in making is helpful but not necessary. We refer to the program as a "club" because they have been used as after-school programming at our sites. However, this curriculum could just as appropriately be used as part of a Maker class or to enrich a conventional elementary class.

The lesson plans are designed as complete one-hour sessions, including an icebreaker, time for snacks, and the activity. If you have the time, adding an extra 30 minutes can be helpful to feel less rushed or have more time for building, but that's not crucial. This curriculum is designed to last most of a school year, meeting once a week. As presented, the lessons progress somewhat from more guided to more open-ended.

How to start a maker club:

1. **Gather supplies:** See "Supplies" near the end of this curriculum, for a list of everything you'll need, and instructions on assembling the "Prototyping kit."
2. **Print guides:** We've arranged the guides into a "Maker Notebook" that each student will use throughout the year. You can find a copy at the end of this curriculum or at www.GorgeSTEM.org/makerclub
3. **Recruit a helper(s):** It's good to have at least one person who can help with classroom management, support makers, and be there in case you need to leave the room.
4. **Schedule a time:** You should schedule 1 to 1.5 hours/session, with 15 minutes for setup and cleanup.
5. **Recruit makers:** We recommend having about 20 makers per club. It works best when participants sign up for the club and agree to show up each session.

How to prepare for each lesson:
Once you have set up the club, here's what you should do to prep for individual sessions:

1. **Gather tools ahead of time.** If the lesson requires something you need to reserve or borrow, such as computers, ensure you will be able to use them by checking in advance.
2. **Review the lesson plan** and any guides, videos, or slideshows that accompany it, so you are familiar with the activities. For more complicated activities, test them out.

Tips and Tricks:

Refer to participants as makers: To help students begin to self-identify as "makers" and "engineers" we refer to them that way throughout this curriculum.

Encourage diverse partnerships: Many of the activities include the makers partnering into groups of two. Even when an activity does not call for this, we encourage partner work. That way, each partner will have someone to troubleshoot, brainstorm, and share problems or frustration with. Try to vary partners so that makers learn from different people each time.

Display timers on a large screen or projector: This will help the makers (and you!) keep track of time better, especially while building during the activity.

Download an ad blocker: Adblock for YouTube™ enables you to block ads in Google Chrome that would otherwise show up in the videos. Viewpure.com is also helpful; it filters out comments and videos that are not suitable for children.

Play music: Fun, upbeat music is a great way to get energy flowing during an activity. For more focused activities, play calmer instrumental music or none.

Provide snacks: Snacks are key to a successful afterschool club: makers need something to boost their energy and help them think. Some good snacks are: trail mix (beware of nut allergies, though), fruit leather, granola bars, easy-peel oranges, Goldfish, and graham and Ritz crackers. Each lesson plan includes a suggested time for snacks--**however**, after testing, we found that it's sometimes easier for teachers to do snacks at the end as a reward for cleanup.

Figure out where Maker Club Notebooks will be stored: Makers will use the same notebook throughout the whole year. Make sure you have a good place to store them. It's best that makers don't bring them home since they might leave them there. When the club concludes at the end of the year, makers can keep their notebook.

Do an icebreaker before some sessions: Icebreakers give the makers a chance to expend some energy and get in the right mindset to be creative and collaborative. They also improve the group moral and help break up the monotonous classroom feeling. It's really important that everyone participates—yourself and other adults/helpers included! (Note: An icebreaker has been included in many lessons already.)

Callback idea: Regrouping a class after they've been working independently can be a challenge. At the beginning of the year, establish a call-back routine to get the group's attention. For instance: Leader says: "Maker gonna make!" Makers say: "Make"
Introduce by saying: "When I say 'Makers gonna make' you say 'make'" and then practice. When you use this, say it a few times until the response is consistent across the room and you have everyone's attention.

Ask open-ended questions: While makers are building, walk around and ask them to tell you about their creation—how does it work, what features does it have? Ask open-ended questions about how they might improve it, fix issues, or make it look better.

Using all the time: When makers are done with the activity and others are still working, encourage those who are finished to add more to their project or make a new version. Makers who have finished can also help others, but the effectiveness of that approach will depend on the project and dynamic of the group.
Use any extra time to play a game. Extra icebreakers are located in the back of the curriculum.

Use "Rock, Paper, Scissors" to settle disputes: For example, if two makers work on one project, you can have them do best out of three to decide who takes the project home. Alternatively, makers can also disassemble items to recycle the supplies if there is a dispute about who takes it home.

Set expectations about cleaning up: Messes are inevitable after a good Maker Club lesson. Ensure your students know you expect them to clean up their mess and a little more. If possible, make them clean the room to your satisfaction before leaving. You should also set clear expectations about cleaning during the first several lessons. You might also hold snacks until the end, and then set a timer (5 minutes is usually enough). If makers are finished cleaning in time, they get snacks--otherwise, they will not. This seems to work well in practice.

Optional: disassemble and re-use: You will go through many supplies. When appropriate, you might want to have makers disassemble their prototypes and return the supplies to the bins. Keep in mind that cleanup will take longer if you are disassembling and it is nice for makers to take home or display things they're proud of.

A note on adapting lessons:

These lessons are geared toward makers in grades 4-8. However, many of the lessons may also be appropriate for younger audiences. Unit summary pages show ideal grade ranges for the lessons in that unit. Tips for adapting for younger ages, English Language Learners, and those needing an extra challenge are also included, when appropriate,— at the end of each lesson.

A note on lesson design and standards:

Each lesson has been designed with the National Education Association's "Four Cs" in mind: critical thinking and problem solving, communication, collaboration, and creativity and innovation. Additionally, several lessons are relevant to Next Generation Science Standards—particularly K-2-ETS1 Engineering Design and 3-5-ETS1 Engineering Design. Units containing NGSS aligned lessons are noted in the applicable unit summaries.

Safety Protocols

With any hands-on project, safety is a crucial concern. Maker clubs are no exception, and leaders should take precautions upfront and with each lesson. These projects also provide a good introduction to safety protocols for young makers: the risks are limited, but still exist.

Here are some tips to facilitate safe maker clubs:

Safety Onboarding:
During the second day of Maker Club (Backpack Challenge I), do a safety onboarding. This is included in the lesson plan. Discuss the three items from the Prototyping Kits that could be troublesome: glue guns, cardboard cutters, and scissors.

During this session, make a chart to summarize safety protocols for these items and any other safety protocols you may want to include. If possible, keep this chart up in the Maker Club classroom and definitely refer back to the safety practices often.

Zero Tolerance for Unsafe Behavior:
Upfront, communicate to the youth makers that there is **ZERO TOLERANCE** for unsafe behavior with the maker supplies. You should decide the appropriate approach for your site. One option: removal from the activity for the first infraction; removal from Maker Club for the 2nd infraction.

Glue Gun Station:
School sites that tested this maker curriculum suggested setting up a glue gun station. This would be one or two tables where all the glue guns are located. Makers only go there when they need to glue something. Ideally, one adult will monitor that station while another is leading/monitoring the class overall.

Safety Tests:
A common practice in more hazardous making environments, such as woodshops, is to do safety tests for dangerous items. You may want to consider this practice for glue guns and cardboard cutters. The student shows the instructor that they can safely use the item and then they are approved to use it.

Unit 1: Design Thinking

This unit introduces makers to the engineering and design thinking process, including key ideas such as:

- It's ok to fail!
- Prototyping and iteration
- Empathizing and feedback

This is also an important time to establish and regularly review the rules and expectations so that subsequent units run smoothly.

I. Spaghetti and Marshmallow Challenge[NGSS]	
Summary: Introduces makers to the idea that failing is important, ok, and valuable.	**Ideal Grades**: 2nd-8th
II. Introduction to Maker Club	
Summary: Covers Maker club goals and expectations, as well as crucial safety protocols.	**Ideal Grades**: 2nd-8th
III. Backpack Challenge 1[NGSS]	
Summary: One half of a full design thinking experience, going through empathizing, brainstorming, getting feedback, prototyping, and iteration.	**Ideal Grades**: 4th-8th
IV. Backpack Challenge 2[NGSS]	
Summary: A continuation of the Backpack Challenge with more time for prototyping.	**Ideal Grades**: 4th-8th
V. Blueprinting[NGSS]	
Summary: An introduction to what a blueprint is and how to make one. This lesson supports future activities that include blueprinting.	**Ideal Grades**: 2nd-8th

NGSS Alignment
K-2-ETS1 Engineering Design Performance Expectations: Asking Questions and Defining Problems (K-2-ETS1-1), Developing and Using Models (K-2-ETS1-2) Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (K-2-ETS1-1), ETS1.B: Developing Possible Solutions (K-2-ETS1-2)

Crosscutting Concepts: Structure and Function (K-2-ETS1-2)
3-5-ETS1 Engineering Design Performance Expectations: Asking Questions and Defining Problems (3-5-ETS1-1) Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (3-5-ETS1-1), ETS1.B: Developing Possible Solutions (3-5-ETS1-2; 3-5-ETS1-3) Crosscutting Concepts: Influence of Engineering, Technology, and Science on Society and the Natural World (3-5-ETS1-1; 3-5-ETS1-2)

I. Spaghetti and Marshmallow Challenge

Stuff:

- ☐ Spaghetti and marshmallows (in supplementary materials tub)
- ☐ **Video**: "Succeed by Failing: Crash Course Kids" on YouTube: https://youtu.be/TcUX6eNT2j4
- ☐ Computer and projector/large screen

Do it!

(15 minutes before) **Setup**: Set out the spaghetti and marshmallows in a place where you can monitor them. (Makers will probably try to eat the marshmallows.)

(10 minutes) **Opener**: Fail Test*

1. Partner up. First round: Each pair counts to 3 repeatedly, switching off saying each number. "1," 2"," 3," "1," … Go as fast as you can!
2. Whenever a group fails/messes up, they must celebrate by waving their arms in the air and cheering really loud. (Make sure they do this!)

Round 2: Same as before but replace the "1"s with claps.
Round 3: Same as before but replace 2s with snaps.
Round 4: Same as before but replace 3s with stomps.

Pass out snacks, and have Makers split into groups of 2, and have them sit down.

(5 minutes) **Ask makers**: "*Is failing bad? Raise your hand if you think so.*"
"*What if I told you that failure is really, really important, especially to engineers and designers? We're going to watch a video that shows us why…*"

Play the video linked above.
"*In the video, she used the bridge Galloping Gertie as an example. But failing isn't important just to bridge engineers—it's important for self-driving cars, rockets, airplanes, roads, phones, buildings, and anything that is engineered.*
But, ***why*** *is failing so important, again?*" **Get feedback.**
Answer: "*Failing—especially failing fast—is important to engineers, because it helps them find problems with their designs,* ***before*** *they build them and use them in cases when it would hurt people or destroy something. To do this, engineers build test versions of their designs, called prototypes. They test the prototypes to see how they fail, then change their design, building a new prototype.*"

(5 Minutes): **Introduce today's challenge**:
"*Today we're going to experience building prototypes and failing fast with an engineering challenge. Your challenge is to build the tallest freestanding tower possible in 10 minutes with (only) these materials: 20 pieces of spaghetti and 10 marshmallows. The highest piece of the tower must be a marshmallow, so there must be a marshmallow on top.*"

Note: Encourage thinking outside the box with the challenge. They have their restrictions and if they get more creative (breaking spaghetti, ripping marshmallows, that's fine). Be prepared with your answer for whether they can use other materials. If that's not allowed, make sure to say "only" in the instructions above.

(10 minutes): **Challenge time**: Set a timer for 10 minutes, tell makers to begin. Play music. Warn makers when there are 3 minutes left.

Note: if you have time, it can be great to do the activity a second time, either keeping or switching partners. This gives makers a chance to really learn from their "mistakes" and improve their designs. It will also lead to a more insightful debrief discussion.

(2 minutes): **Regroup**. Take a few minutes to have everyone walk around the room and look at all the tower designs.

(8 minutes) **Debrief the challenge**: Discuss these questions with Makers:

- What was the hardest part of this challenge?
- What was the easiest?
- What have you learned?
- Why is testing super important?
- What would you do differently if you had the chance to rebuild the tower?
- Rebuilding the tower is called iteration—that's when an engineer uses the information they got from testing a prototype, and makes a new prototype to solve the problems the old one has. Iteration is really important. Why?
- Sometimes engineers spend too much time planning, and not enough time prototyping—when that happens, sometimes things will fail catastrophically once they've been built, like Galloping Gertie.
- What do you think about failing now? Is it good to fail sometimes?

(10 minutes) If time allows, **second challenge round**: Have makers build a second tower.

(10 minutes): **Cleanup**: with music to taste.

Adaptations:

For Younger Makers: This activity is one where younger makers actually do better! But if needed, give them extra tips if younger makers are having a hard time making their structures stay together. For example: try sticking the spaghetti in the center of the marshmallow, etc. You may also want to give the tip that triangles are strong shapes.
For An Extra Challenge: Add more restraints. For example, more than one marshmallow on top, cannot have a square base, must use all materials, must be at least 1 foot tall, must have at least two stories, etc. Have makers measure their structures and/or make comparisons.

*From the Stoke Deck by the Stanford d.school

II. Introduction to Maker Club

Stuff:

- ☐ Cardboard, scissors, and glue guns from Prototyping Kit
- ☐ Optional: poster paper or flip chart paper
- ☐ Cardboard cutters (keep these with you, not out with makers today)
- ☐ **Maker Notebooks**: Cardboard Attachments

Do it!

(15 minutes before) **Setup**: If room allows for it, arrange desks in pods of 2 or 4. Set up a circle of chairs (you can move them back later).
Set out cardboard and scissors. Make a glue gun station (table with glue guns and cardboard underneath each). Have Maker Notebooks

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(5 minutes) **Opener**: Never Have I Ever

1. Arrange in a circle, either standing or sitting (works slightly better). One person is in the middle. If using chairs, use one fewer than the total number of people.
2. Person in the middle says "Never have I ever_____" ("used a hot glue gun" or "eaten Thai food" etc). It should be something they haven't actually done, but they think others have.
3. Everyone who has done that thing has to get up and find a new spot (including the person in the middle). The last person standing becomes the new announcer.
4. Repeat for as long as it is fun.

(10 minutes) **Snacks and Maker Club discussion**: Pass out snacks to all makers, have them sit in a circle with the leader as part of the circle. (Reason for this discussion: cover the goals and expectations of Maker Club).
"Last time you got your first glimpse of what Maker Club will be like. You'll get to do lots of designing, experimenting, and building. You'll make some things that don't work well the first time, but that's actually good because they'll help you learn how to make things better the next time. What do you think are some of the ***goals*** *of Maker Club?"*
→ Discuss as a group. Potentially write answers on board or a poster to keep in the room..

Potential answers:

- Become designers and engineers
- Work together
- Be creative
- Have fun
- Be better problem solvers
- (Add ones you think are crucial to call out.)

"We also need to talk about expectations so that everyone is safe and has a good time at Maker Club. That doesn't mean everything you do is going to be easy, but we want our whole group to feel like we're supporting each other. What are some ***expectations*** *we should always have at Maker Club?"*

→ Discuss as a group. Potentially write answers on board or a poster to keep in the room.

Potential answers:

- Always be safe
- Work together
- Be respectful of classmates and classroom
- Always clean up when we're done
- (Add ones you think are crucial to call out.)

(6 minutes) **Safety onboarding**:
"*In Maker Club, you will get to use some tools that could be a little bit dangerous. They're not used in every classroom and they're only for responsible students. I'm trusting you to use these tools safely to make really cool stuff.*
It's ***very important*** *that you are safe with the tools. This is so that you're safe, others are safe, and so we can keep having Maker Clubs.*"

[Make a chart on the board or large paper about "how to be safe with…" scissors, cardboard cutters, and glue guns].

"*How should you be safe with glue guns?*"

A: don't touch the metal tip or melted glue; make sure to use only a little glue; don't squirt onto your finger; only use glue gun at glue gun station; always have paper or cardboard under the glue gun.

"*How should you be safe with cardboard cutters?*"

A: put extra cardboard under whatever you're cutting so you don't cut the floor or table; don't cut toward yourself or others; only use it to cut cardboard; don't walk with the cutters pointing outwards; only walk with the cutters.

"*What are some ways to be safe with scissors?*"

A: use properly, not open like knives; hand the HANDLE to partners; only walk with scissors (don't run).

At the end of the discussion, call on random makers to summarize the safety protocols for each item. If possible, keep the chart in your room. Come back to these safety tips regularly.

"*We want everyone to be safe and be able to have fun. That means we'll have a zero tolerance approach to safety. Can anyone guess what that means?*"

A: After discussion with makers, confirm that zero tolerance means doing an unsafe activity will result in immediate removal from the activity that day. If the unsafe behavior happens again, that maker will no longer be part of Maker Club (or whatever your site's consequence is).

(30 minutes) **Tool practice, safety tests, and building**:
Have makers sit down at their desks. Give everyone a Maker Club Notebook and begin passing around a Sharpie. Have makers write their names on the Notebooks, and tell them

that will be their Notebook for many things they will do in Maker Club this year. Tell them that because the notebook is important for many of the activities, they need to take good care of it. No spilling water on it, cutting it up, throwing it across the room, etc.

"For the rest of today you will get a chance to practice using some of our tools and get approved to use them in the future. You will be building a house out of cardboard. Inside your notebook are some examples of ways to attach cardboard together. Try to practice using those ideas in your house. I will come around and test you for safety with the cardboard cutters. Once I've tested everyone, I will call on groups of two to come get tested at the glue gun station. You may now get cardboard supplies and scissors, and get started at your table."

If you have a document camera, show the picture on the next page for some inspiration.

(20 of the 30 minutes) As makers begin building, go around to pairs and test them on cutting with the cardboard cutters. Sign off on their safety approval on the table of contents page in their Maker Notebook. (Note: This approval can always be revoked if a Maker does not continue being safe with the item).
Important for safety:

- Keeping fingers completely away from the blade.
- Never grab the cutter by the blade.
- Have cardboard under where they're cutting so they don't scratch the table.
- As soon as done using, put the cutter back where it belongs.

(10 of the 30 minutes) Call on three makers at a time to come to the glue gun station and show that they can safely use the tool.

Important for safety:

- No touching the metal tip or fresh, wet glue.
- Always have paper or cardboard under the glue gun to catch dripping glue.
- Don't use excessive glue (more risk of accidentally touching it or spilling).

(7-9 minutes) **Cleanup**: Have makers ensure that all areas are spotless and also help with the supply cleanup. Stress that makers should keep cleaning until everything is clean--not just until their own area is cleaned up. Ensure they remember to clean up the supplies table, too!

Adaptations:

This lesson is crucial for all makers. Ensure that you adjust the safety onboarding and tests as appropriate for learners of different ages, language proficiencies, and skill levels.

*From the Stoke Deck by the Stanford d.school

III. Backpack Challenge 1

Stuff:

- ☐ Pencils
- ☐ **Maker Notebooks**: Backpack Challenge
- ☐ **Video**: "The Design Thinking Process by Sprouts" https://youtu.be/_r0VX-aU_T8

Do it!

(15 minutes before) **Setup**: Separate everything from Prototyping Kit into different piles to make access easier. Set up tables so interaction between makers will be easy. Set up a hot glue gun station and place a piece of paper or cardboard under each glue gun.

(3 minutes) **Snacks and Introduction**:
Have makers partner up and sit down. Give everyone pencils, snacks, and their Maker Club Notebooks.

(7 min) **Safety and expectations refresher**:
"*Last time we spent a lot of time talking about our Maker Club expectations and how to be safe while you're creating things. Since it's just our third day, let's do a quick refresher.*"
(If you made them, refer back to the posters from the last session.)

"*How should you be safe with glue guns?*"
A: don't touch the metal tip or melted glue; make sure to use only a little glue; don't squirt onto your finger; only use glue gun at glue gun station; always have paper or cardboard under the glue gun.

"*How should you be safe with cardboard cutters?*"
A: put extra cardboard under whatever you're cutting so you don't cut the floor or table; don't cut toward yourself or others; only use it to cut cardboard; don't walk with the cutters pointing outwards; only walk with the cutters.

"*What are some ways to be safe with scissors?*"
A: use properly, not open like knives; hand the HANDLE to partners; only walk with scissors (don't run).

(5 minutes) **Introduce the plan**: "*In this and the next session, we'll be going through the engineering and design thinking process to design and prototype a better backpack for our partner. This video will give us a quick introduction to the design thinking process.*"
Show video, linked above. (3:56 minutes.)

"*Let's review the design thinking steps:*
- *First, you need to get to know the person you're designing for. This is called* ***empathizing****.*

- *Second, you'll use what you learned about them to find a problem they experience. This is called* ***defining a problem****.*
- *Third, you'll think up a bunch of ways you might be able to solve that problem. This is called* ***brainstorming****, or* ***ideating****.*
- *Fourth, you'll make a test version, or a* ***prototype*** *of the best idea. This is called* ***prototyping****.*
- *Fifth, you'll test your prototype. This is called* ***testing*** *and* ***getting feedback****.*
- *Finally, you'll use what you've learned to make a better version of it. This is called* ***iteration****. Adult designers iterate their designs many times to make sure they're really good.*

In the real world, designers do these steps over and over—especially prototyping and testing—until they find the best way to solve the problem."

(5 minutes) **Mock Interview**:
Makers, having had little to no experience doing interviews, are likely to struggle some. Help them by demonstrating an interview between yourself and a maker.

"In just a moment you are going to interview a partner about what they might need in a backpack designed for them. To help you get the idea of that to do, I need a volunteer who I can interview."

Choose one maker to come be interviewed for a few minutes with open ended questions. Some sample questions are below.

"I'm going to ask my partner several open-ended questions that will help me understand what they might need or want in their perfect backpack design. Open-ended means they can't be answered with a yes or no response."

"What do you like to carry with you most days?"
"What do you like best about your current backpack"
"What problems have you had with your current backpack?"
"How do you feel when you put on your backpack?"
"How would you describe your style?"

"Your goal with interviewing your partner is to find a problem with their backpack that you can fix by building a new one--but it's important to remember that you need to know more than *just* the problem to make them a good backpack."

(9 minutes) **Interviews**:
1. Tell makers: "Now, you each need to pick one partner to start. That partner has 4 minutes to interview the other. When the time is up, you switch who is interviewing. Ask your partner about their backpack—what do they like, what don't they like, and so on. Draw or write what you learn in the first box."
2. Set a timer for 4 minutes. When it ends, tell them to switch, and reset the timer.

(3 minutes) **Defining the problem**:

1. Have Makers split from their partners and move away (so they can't see the ideas and problems that their partner is generating for them).
2. Tell the makers: "Now you need to use what you learned about your partner to find a problem they have with their backpack. What should their backpack do for them? How should they feel while wearing it? Write that in the second box. No talking! You have 3 minutes."
3. Set a timer for 3 minutes.

(5 minutes) **Brainstorming**:

1. Tell makers: "Now it's time to brainstorm—think of a bunch of ideas that might solve your partner's problem. NO worrying about how silly the idea is—just write or draw it! You can pick the best idea later. Draw or write the ideas in the 3rd box. You have 3 minutes!"
2. Set a timer for 3 minutes.

(5 minutes) **Feedback**:

1. Have maker partners get back together.
2. Tell makers: "Now, share your ideas back and forth with your partner. Figure out which ideas your partner likes best. You can even combine ideas together! Draw or write the best idea in the 4th box. You have 5 minutes total!"
3. Set a timer for 5 minutes.

(6 minutes) **Idea presentations**: Call on a few partners to stand in front of the group and present, introducing their partner, the problems their partner has with his/her current backpack, and some of the ideas they've come up with to solve the problem.
Example: "This is Marta. She doesn't like how her backpack is so heavy and ugly. My idea is to make a cute robot backpack with wheels that follows her around."

"Great job everyone! Next time you will actually start building your prototype. Now it's time to clean up and put your notebooks back where they belong."

(5 minutes) **Cleanup**: Have makers put notebooks and pencils away.

Adaptations:

For Younger Makers: We suggest only doing this activity with 4th graders & above. DO cover the safety protocols with all ages!
For English Language Learners: If possible, try to pair English language learners with bilingual students who are mature and engaged in the activities.
For An Extra Challenge: Give more constraints: limit supplies, tell makers their creations have to serve more than one purpose, etc.

*From the Stoke Deck by the Stanford d.school

IV. Backpack Challenge 2

Stuff:

- ☐ All of the Prototyping Kit (both tubs)
- ☐ Scissors & glue guns
- ☐ Pencils
- ☐ **Maker Notebooks**: Backpack Challenge
- ☐ Ball for opener activity (or something soft that can be tossed around)

Do it!

(15 minutes before) **Setup**: Separate everything from Prototyping Kit into different piles to make access easier. Set up tables so interaction between makers will be easy. Set up glue gun station/s.

(7 minutes) **Opener**: Nameball

1. Get a ball, or something soft that can be tossed around.
2. Everyone circles up.
3. You say your name, then the name of someone else in the circle, then toss the ball to them.
4. They say their name, then the name of someone else in the circle, and toss the ball to them.
5. This repeats, with the ball being thrown to someone who hasn't had the ball yet, until everyone has had the ball.
6. Now, challenge the group to do it again, in the same order, but faster. You may time it if you wish.

(3 minutes) **Snacks and Introduction**:
Have makers partner up with the **same partners as last time**, and have them sit down. Hand out snacks and the Maker Club Notebooks.

Introduce the plan: "*Today, we'll be building prototypes of the best ideas we came up with for our partner's feedback. Remember that a prototype isn't the final design! Your prototype doesn't have to be perfect, and it doesn't have to work exactly like the finished design would.*

You can use any of the materials in the Prototyping Kit, just remember to be nice and not take too much of one thing."

(35 minutes) **Prototyping**:

1. Tell makers: "*Now it's time to build your best idea for your partner. You have 20 minutes! Go!*"
2. Set a timer for 20 minutes. If possible, display timers on the large screen or projector.
3. Play loud, upbeat, energizing music. (This really does help!)
4. Warn when there are 10 and 5 minutes left.

While makers are prototyping, walk around and help them as needed. Remember to ask open-ended questions that help them think about a problem in a new way, think of a new way to use a material, or overcome an obstacle they're facing.

(5 minutes) **Share and Test**:

1. Tell makers: "Now it's time to test the prototypes. Share your prototype with your partner and tell them about it. See what they think! Ask them what they like, what they don't like—do they have any questions about it? Do they have suggestions to make it better? Write these down in the 6th box in your guide. You have 5 minutes!"
2. Set a timer for 5 minutes.

Tip: If you have a maker who is finished early with their design, task them with making a magazine advertisement for their product.

(10 minutes) **Cleanup**: Have makers put away all unused or reusable materials, pick stuff up off the floors, etc. Again, remember to stress that they are responsible for continuing to clean until **everything** is clean--not just until their own area is clean.
Makers may take the thing their partner made for them home.

Adaptations:

For An Extra Challenge: Throw in a twist: tell makers they have to incorporate a specific item into their design.

V. Blueprinting

Stuff:

- ☐ Pencils
- ☐ **Maker Notebooks**: Blueprinting
- ☐ 7 items to use for blueprint stations. (ex: milk jug, various toys, soup can, coffee mug, cereal box, thick book, etc.) These can be items you already have in the classroom. Try to have a range of difficulty for drawing. (Bring an extra item if you have >20 makers).
- ☐ 2 rulers per station (~12)
- ☐ **Video**: "Topic 12.2 Views of Solids" on YouTube: https://youtu.be/lfcXpWbHyYc

Do it!

(15 minutes before) **Setup**: If possible, arrange desks in pods of 4-5. Put one item at each station, 2 rulers, and a label #1-6). Ideally make #1 the easiest item to draw and #6 the hardest.

(5 minutes) **Snacks and Introduction video**:
Grab snacks and introduce the activity for today.
"*Today we're going to be practicing something that's really important for engineers and architects: making blueprints. Blueprints are detailed plans that show* **exactly** *how to make something, and all kinds of engineers and makers create blueprints. While you have your snack, we're going to watch a quick video about how to draw from a different perspective. Later, you will try doing it yourself.*" Play video, linked above. (4:14)

Optional: Look at some examples of blueprints or engineering designs.
Do a Google Image search for "blueprints" or "CAD drawing."

(10 minutes) **Drawing together**:
"For most of today you will do your own engineering designs or blueprints for some objects in the room. First, to help figure out what's important in a blueprint, I'm going to have you help me make one."

Demonstrate drawing a blueprint on a whiteboard, large piece of paper, or document camera. Pick an object in the room to blueprint, and draw one side of it. Then ask Makers questions to have them tell you what's missing in the blueprint. For example, "If I was building this, and I had never seen it before, how would I know how big to make it?" or "how would I know what kind of material it's made of?"

The three most important things to have them tell you to include are:

- Views from each unique side (labeled)
- Measurements to show how big the object and its features are
- Labels that tell what it and parts of it are/are made of

As you're doing this, explicitly show makers how you'd look at something from the top, side, and front. If it fits with the flow, have them practice looking at the different views along with you (perhaps looking at something on their own desk).

(25 minutes) **Blueprint practice**:
"Now is your chance to practice drawing blueprints or designs. There are six stations around the room, number is the easiest and six is the hardest. Your goal is to draw detailed designs of as many as possible."

Set a timer for 25 minutes. Give a 5 minute warning.

(15 minutes) **Engineer-builder game**:
"Now you get to be a little more creative. You have 10 minutes to draw a blueprint for one object in this room. After 10 minutes, you will find a partner and see if they can figure out which object you drew."

Set a timer for 10 minutes. After timer goes off:

"OK, find a partner! See if you can figure out which item your partner was designing without asking them for clues!"

(5 minutes) **Cleanup & debrief**: There shouldn't be much cleanup. Use this time to quickly debrief as a class or in small groups. Possible questions:

- "Describe a blueprint."
- "What's the purpose of a blueprint?"
- "What are some important details to include in a blueprint?"
- "What did you find difficult about drawing blueprints?"
- "What did you like best about this activity?"

Adaptations:

For Younger Makers: Make sure that all the items are simple, such as boxes, cups, and books. Also make sure it's pretty easy to determine what's the top, front, and side view (for instance, this would be difficult for a spoon). You could event label the top, front, and side with masking tape and a Sharpie.
For English Language Learners: This activity is mostly independent drawing time, so it's fairly well-suited as-is for EL makers.
For An Extra Challenge: Make the items more complex, such as a doll house or other complicated toy. Additionally, you may require that the items are drawn to scale and that the scale is noted on the drawing (for example, 1 inch on item = ¼ inch on drawing to practice fractions or 1cm = 1 mm to practice metric).

Unit 2: Electronics

This unit includes several simple electronics projects, to introduce makers to core concepts/components of electrical circuits, such as:

- Electricity flows in a loop
- Batteries
- Polarity
- Switches
- Lights/LEDs
- Diodes
- Motors
- Wires

I. LED Flashlights	
Summary: Introduces the basics of an electrical circuit through the process of building a simple flashlight.	**Ideal Grades**: 2nd-8th
II. Bristlebots	
Summary: Makers build little “robots” using toothbrush heads and pager motors.	**Ideal Grades**: 4th-8th
III. City of Bristlebots	
Summary: Makers build mazes, houses, etc. for their bristlebots.	**Ideal Grades**: 4th-8th
IV. Artbots	
Summary: Makers build “artbots” based on the same ideas as the bristlebots.	**Ideal Grades**: 4th-8th
V. Light-up Cards 1	
Summary: Makers build a variation on the LED circuit, this time with cards that light up.	**Ideal Grades**: 4th-8th
VI. Light-up Cards 2	
Summary: A continuation of the previous activity	**Ideal Grades**: 4th-8th

I. LED Flashlights

Stuff:

- ☐ LED Flashlight parts (coin cells, LEDs, popsicle sticks, copper tape, binder clips)
- ☐ Scotch tape
- ☐ **Maker Notebooks**: LED Flashlights
- ☐ **Video**: "The Power of Circuits" on YouTube: https://youtu.be/HOFp8bHTN30
- ☐ Computer and Projector/Screen

Do it!

(15 minutes before) **Setup**: Set the materials for the LED flashlights out on a few tables. This activity works best when makers can easily access the materials, but for larger groups, you can have them take just what they'll need, then move to their own workspace.

(7 minutes) **Introduction to electricity**: Pass out snacks, makers can eat while you discuss electricity.

"*Today, we're becoming electrical engineers. Electrical engineers design phones, flashlights, computers, robots, cars, Xboxes, Nintendo Switches, PS4s, and more. Today, we'll be building LED flashlights!*

First, we need to know how they work. Flashlights use electricity—but what is electricity?"
(Get a little feedback from makers.)
"*Let's watch a video to learn how flashlights use electricity…*" **Play the video** linked above.

(3 minutes) **Review**: Have makers raise their hands to answer these questions:

- What is electricity? (The flow of electrons, or a form of energy.)
- How does it move? (In a circuit or circle, flowing from its source and back to it.)
- How do we control it? (With a switch.)

(30 minutes) **Build flashlights**: "*Now, we're going to build our own flashlights. Because these are electronics, reading the instructions is* ***really important*** *to make sure it will work. If you can't figure something out, you have to read the instructions to try and figure it out. This is something adult electrical engineers have to do, too!*"

Makers begin building flashlights. Walk around to help, if needed, but encourage them to read the instructions and ask other makers before helping them. Makers may play with their flashlights when they are finished. Encourage those who are finished to help others who aren't.

(10 minutes) **Cleanup**: Have makers clean everything up. They make take their flashlights home.

(10 minutes) **Reflection**: *"Now, we're going to discuss what we just did. I'll ask you a question, and then you'll have a minute to discuss it with the people around you. When the time is up, I'll ask groups to share what their answer is. There aren't any wrong answers to these questions!"*

Have makers sit down. Ask a question, give them a minute to quietly talk among themselves about it, and then share answers with you. You may have to skip some questions based on time.

1. What was easy about this project?
   A: varies
2. What was kind of hard?
   A: vaires
3. What new ideas did you discover?
   A: vaires
4. Why do you think the LED only works one way?
   A: It's a type of diode, which means electricity can only flow through it in one direction.
5. Guess: Why is the battery marked with a "+" and "-"?
   A: The "+" and "-" on the battery mark which side electricity goes into or out of. The "+" side pushes electricity out, and the "-" side is where it goes back into the battery.
6. Do all flashlights work this way?
   A: Yes, all flashlights work on this same basic circuit

Another question you may get: "why is one leg of the LED longer than the other?"
A: The longer leg marks which side of the LED electricity goes into.

Adaptations:

For Younger Makers: The entire group could go through the instructions together and work on the flashlights at the same pace.
For English Language Learners: Partners can be assigned so that makers have someone to troubleshoot with.
For An Extra Challenge: Have makers use some materials from the Prototyping Kit to add on to their flashlights or make them more functional. Examples include: a handle, a shade, casing to cover the circuitry, etc.

II. Bristlebots

Stuff:

- ☐ Bristlebot parts: pager motors, CR2032 coin cells, foam tape, toothbrush heads
- ☐ Pipe cleaners, googly eyes, pompoms, scotch tape
- ☐ Scissors
- ☐ **Maker Notebooks**: Bristlebots

Do it!

(15 minutes before) **Setup**: Set parts and tools out on a table, easily accessible. You can use paper bowls from the paper supplies to organize the parts.

(5 minutes) **Opener**: "You as a robot"
Group disperses throughout the room. You tell them that they're all robots now. They must go in a straight line until they bump into something, and then they can pick a random new direction to go in. Because they're robots, they also have to make robot sounds while they move, like buzzing, making R2D2 noises when you bump into something, apologizing in a robotic voice to anything (not just people!) you bump into, etc.

> **If contact is an issue** for some makers, tell them they can't run into each other--if they're on a collision course, there is an invisible bubble 1 foot wide around each "robot" that you can't go through.

(1 minute) **Introduction**: Pass out snacks, Maker Notebooks, and introduce them to the activity. "*Today, you'll be building robots that do basically the same thing we did during our game. You'll be following a guide in the notebook like we did with LED flashlights. Once you finish building your bristlebot, you can decorate it.*"

Makers can eat while building.

(40 minutes) **Robot build time**: Makers self-guide through the instructions, building bristlebots. Set a timer for 44 minutes, and play music. Walk around and help, as needed. Again, encourage makers to read the instructions and problem-solve before helping them.

> **Note**: if makers finish early, they can decorate their robot or start blueprinting for the next activity.

(6 minutes) **Debrief**: Regroup the whole class. Arrange in a circle or have everyone sit at their seats to have a brief whole-class discussion. (Have them discuss answers with their partner first if time allows.)
"Like the flashlights, these robots have a circuit. Where is it?"
A: Battery → red wire → vibration motor → blue wire → battery.

"Which part functions as the switch"
A: Pressing the tape down to complete the circuit is like having a switch.

“These robots move around kind of randomly. Why might that be?”
A: They have a vibration motor rather than a motor that spins an axle or wheels. So that just shakes them around rather than moving them in one direction.

“How might we be able to get these robots to move straight?”
A: varies. Some ideas: make a track for the robots so they can’t go sideways; use a different motor and add wheels.

(8 minutes) **Cleanup**. Have makers clean everything up. Again, ensure all makers continue cleaning until everything is cleaned up. Also, make sure they know that it isn’t acceptable to throw usable supplies away.

Adaptations:

For Younger Makers: Younger makers may need more direction. You may want to work through the activity together as a class, step-by-step..
For English Language Learners: Assign groups or teams so that makers can work through the steps together and troubleshoot if necessary.

III. City of Bristlebots

Stuff:

- ☐ All of the Prototyping kit
- ☐ Scissors
- ☐ Bristlebots from last time
- ☐ **Maker Notebooks**: City of Bristlebots

Do it!

(15 minutes before) **Setup**: Set the prototyping materials out.
Set the bristlebots out so makers can get to them.

(1 minute) **Introduction**: Pass out snacks, and introduce them to the activity.

"Today, we're going to build cities or mazes for our Bristlebots! We'll follow the design process: You'll need to blueprint, build, test, and iterate. Does anyone remember what it means to iterate?"
Get a student response.
"Great! OK, first I want you to first decide on what you're building. You can make a house, or a maze, a small city, or something else good for your robot to navigate. Navigate means to move around in.

Once you have an idea, you need to blueprint your idea. Remember, blueprinting is when you draw a detailed plan of your idea. It must include sketches of how each side of the design will look, labels to point out what each part of the design is, and measurements to show how big the design is.

Once you've finished, bring the blueprint to me, explain it to me, and when I approve it, you can start building. You have 45 minutes total for blueprinting and building. Ok, Go!"

Makers can eat while blueprinting.

Note: The times for each section below are flexible and shown only as rough guidelines; makers will finish different parts at different times.
If a maker was gone last session, have them make a bristlebot instead.

(15 minutes) **Blueprinting time**: Set a timer for 45 minutes, and display it on a large screen or projector, if possible. When makers are finished with their blueprints, have them explain their design to you. Don't worry about potential issues with their design, unless it's related to safety or they will use too many materials—just ensure makers have a clear idea of their final goal in mind, and have put thought into how they will achieve it.

> **Tip**: After 15 minutes have passed, warn makers that they should finish their blueprints in five minutes so that they'll have time to build. Alternatively, you could split this lesson in two: one day for blueprinting and one day for building.

(30 minutes) **Building time**: Once makers have had their blueprint approved by you, they may begin building their design. Encourage them to test their design frequently with their bristlebots. Warn everyone when there are 10 and 5 minutes left.

Optional - Bristlebot tour & debrief: if time allows, give makers a chance to look at the designs from their fellow classmates. This is especially good to add if you split this day's lessons into two days.
Possible debrief questions:

"What did you like best about this project?"
"What was hard about using your blueprint to actually build something?"
"What surprised you about this project?"

(10 minutes) **Cleanup**: Have makers clean everything up. Makers may take their bristlebots home—the cities can be taken home, displayed at school, or salvaged for materials. If makers don't want to keep their project, have them deconstruct it and put usable supplies back in the supplies bins.

Adaptations:

For younger learners: This is one of the most challenging activities for younger Makers, because the small wires involved require fine motor skills to ensure the circuit is built properly. Expect to spend the most time helping makers get their 'bots working. For especially young makers, you might skip the circuit part and make just the bots, though you will miss a large part of the educational aspect that way.
For An Extra Challenge: Encourage makers to draw their blueprint to scale and include their scale on the drawing (for example, 1 inch on item = ¼ inch on drawing to practice fractions or 1cm = 1 mm to practice metric).

IV. Artbots

Stuff:

- ☐ Artbot parts: DC motors, battery holders, switches, AA batteries, foam tape, cork pieces, washable markers, and paper cups
- ☐ Hot glue guns
- ☐ Pipe cleaners, googly eyes, Sharpies, pom poms, from Prototyping Kit
- ☐ Scrap paper with one blank side
- ☐ **Maker Notebooks**: DIY Artbot

Do it!

(15 minutes before) **Setup**: Set all parts and tools (excluding the decoration supplies) out on a table, easily accessible. Set the decoration materials on another table. You may want to cover a third table with scrap paper, or at least have paper out, so makers can test their Artbots without getting marker on tables or the floor. Set up a hot glue gun station and place a piece of paper or cardboard under each glue gun.

(5 minutes) **Opener**: Crazy Creature
Group splits into teams of 2. They each get a marker and a piece of paper folded in half (hotdog or hamburger). Then, each person draws part of a "creature" on one half of the paper. They must draw lines onto a tiny bit of the other half so the next person can match their part up. The drawing is done without letting the partner see. Once both people are done drawing, they unfold the paper and try to come up with a name for their creature.

(5 minutes) **Introduction**: Pass out snacks, and instructions.
"*Today we'll be making Artbots that use a motor circuit like the Bristlebots to create art! There are four steps today: parts, building, decoration, and art. You'll start by gathering supplies, then head back to your places to build the robots, decorate them, and test them.*"
Makers can finish eating snacks while they build.

(30 minutes) **Build time**: Makers self-guide through steps, building Artbots. Partners can assist each other, but each person makes their own robot. Program leader/teacher walks around, assisting as needed.
If your prototyping kit has sharpies in it, **make sure none of the sharpies sneak onto the 'bots as legs!** Artbots should be built with washable markers only.

Note: The connections between the wires and the motors are brittle, and will break if they are wiggled too much. Before they do anything else, have makers put a blob of hot glue over where the wires are attached to the motor, and warn them to be careful with the wires.

(5 minutes) **Art time!** Allow makers to "create art" with their Artbots. Makers can move on to this when they're finished decorating the 'bots. Encourage them to experiment with the position of the cork and see how it changes the drawings/patterns the 'bots make.

(5 minutes) **Cleanup**: Challenge makers to finish cleaning up in five minutes. Ensure everything is properly cleaned up. Makers may take Artbots and art home (leg markers included).

(10 minutes) **Debrief**: If time allows, close with a few questions that helps makers reflect on what they just did. Possible questions:

"Just like other activities from the past few days, this project has a circuit. Where is it?"
A: battery box → motor → switch → battery box
"What observations did you make about how the artbot works?"
"What happens when you move how the cork is positioned?"
"What was most challenging?"
"How might you design the artbot differently?"

Adaptations:

For younger learners: This is a pretty difficult activity for makers under 4th grade. It requires well-developed fine motor skills, following detailed instructions, and a more complicated circuit. You could avoid the circuit altogether and just make a 3-color contraption, but that obviously misses some of the learning associated with this activity.
For English Language Learners: Have makers work in pairs to support each other. Encourage them to do each step together. Makers of all languages tend to rely mostly on the pictures, but having one strong English reader in the pair will likely help the project go more smoothly.
For an extra challenge: Encourage makers to predict how changing the cork's position in various ways will change how the artbot draws. Have them test their predictions and note how well their hypotheses matched reality.

V. Light-up Cards 1 - Designing

Stuff:

- ☐ Light-up card materials: CR2032 coin cells, smaller LED lights, and copper tape
- ☐ Card decoration materials: construction paper, markers, pompoms, fabric, googly eyes, wax paper, foil, etc.
- ☐ Scissors
- ☐ Pencils
- ☐ **Video**: "The Power of Circuits" on YouTube: https://youtu.be/HOFp8bHTN30
- ☐ **Maker Notebooks**: Design a Light-up Card!

Do it!

(15 minutes before) **Setup**: Set out all the electronics and decoration materials. You can use small paper bowls from the recyclable materials to organize the electronics.

(5 minutes) **Opener**: Yes, Let's!*

1. Someone makes an offer to the entire group, e.g. "Let's be baby birds!" or "Let's act like we don't understand gravity!"
2. Everyone replies with "yes, let's!", and then acts out the suggestion.
3. Anyone can yell out another offer at any point.
4. When you feel like the makers are sufficiently excited, then yell out "let's make light-up cards!" and move on to the introduction.

(3 minutes): **Introduction**: Pass out snacks while introducing today's activity.
"Today and next time, we're going to graduate to the next level of electrical engineering: we get to design our own circuits and make light-up cards!

To do this, we'll follow the design process. First, you'll design the outside of your card, then blueprint a circuit. In electrical engineering, the blueprint is called a ***schematic****. When you finish your schematic and card design, I'll approve it, and then you can make it."*

If you think your makers are confident enough with circuits, you may skip this review of how a circuit works. The guide explains circuits as well, but reviewing the video is best if your group had trouble with the previous lessons.

(5 minutes) **Review circuits**: *"Before we start designing, let's review how a circuit works. We're going to watch the video we watched when we made the LED flashlights, and I want you to pay really close attention, because—remember—you'll be designing your own circuits, so you need to know exactly how they work."*
Play video, linked above.
"Ok—that was a quick review on circuits. Now, let's discuss it a little bit."
Ask makers these questions, and have them raise their hand to answer.

- What is electricity? (The flow of electrons, or a form of energy.)
- How does it move? (In a circuit or circle, flowing from its source and back to it.)

- How do we control it? (With a switch.)
- What is a switch? (A space/break in the circuit that we can open or close.)

(40 minutes) Different makers will finish the steps at different times, so we won't allocate specific time to any one step here. Instead, set a timer for 40 minutes, and then help each maker as needed. Play music.

Blueprint/plan: "Now, it's time to design the artwork on your card, and then make a schematic for the circuit. Your Maker notebook has the steps you need to follow. When you've finished both your card design and schematic, you must bring it to me, explain how it works, and get my approval before you build it. When you get to the circuit design, it's really important to read the helpful info. Remember that you'll need to design your circuit in a loop."

Prototype, Test, Revise: Makers will now self-direct through the rest of the design process. As they do, walk around and ask them how it's going. Ask what step of the process they are in, and try to get them thinking about problems they experience without leading them in any direction.

Suggestion: Pair makers up so that they can support each other; they can make their own cards, but can help each other solve problems.

(10 minutes) **Cleanup**: Have makers mark their projects with names, then clean everything up, put extra supplies back, and throw away garbage. Put the projects in a safe place.

Adaptations:

For Younger makers: You may want to download a premade template. There are lots available, but make sure to choose one that is simple. Google "light up card template" or "paper circuit card."
For English Language Learners: This activity, especially the part about designing the circuit, requires quite a bit of reading. Make sure partners are heterogeneous in terms of English reading level so that a stronger reader can support a maker who may struggle with the text.
For An Extra Challenge: Challenge makers to add a pop-up feature to their card.

*From the Stoke Deck, by the Stanford d.school

VI. Light-up Cards 2 - Constructing

Stuff:

- ☐ Light-up card materials: CR2032 coin cells, smaller LED lights, and copper tape
- ☐ Card decoration materials: construction paper, markers, pompoms, fabric, googly eyes, wax paper, foil, etc.
- ☐ Scissors
- ☐ Pencils
- ☐ **Maker Notebooks**: Design a Light-up Card!

Do it!

(15 minutes before) **Setup**: Set out all the materials, and put makers' projects in a place where they can collect them.

(5 minutes): **Introduction**: Pass out snacks while introducing today.
"*Today, we're finishing the light-up cards we started last time. Remember the design process: You've all planned, now most of you are prototyping and revising. Today, you want to finish the cards, and make a final version.*

Some tips as you start building:
Tear the copper tape carefully or cut it with scissors.
Make sure copper touches copper so that you make a complete, unbroken circuit."
Makers can eat while building.

(30 minutes) **Building time**: Makers will finish and decorate their cards. Set a timer for 30 minutes, and play music. If you had makers pair up last time, have them pair up again the same way.

(10 minutes) **Cleanup**: Makers clean everything up, put extra supplies back, throw away garbage. Ensure usable supplies aren't thrown away, and remind makers that they must continue cleaning until **everything** is clean, not just their own area. Makers may take their cards home.

(15 minutes) **Reflection**: Have makers sit down. "*Now, we're going to discuss what we just did. First, go through the reflection sheet in your notebook, think about the questions, and write your own answers to the questions. There aren't any wrong answers to these questions! I'll give you 5 minutes. No talking!*"

Set a timer for 5 minutes.

"*Now, we'll discuss each question with the people around us. When we're done, I'll ask groups to share what they came up with.*"
Ask each question, give them a minute to quietly talk among themselves about it, and then share answers with you.

- What was easy?
- What wasn't as easy?
- Did you discover something new?
- What was it like designing your own circuits?

Adaptations:

See adaptations from the previous lesson.

Unit 3: Toy Making

This unit contains a series of fun activities that encourage makers to develop better hands-on building skills.

I. Ball Roller Coaster 1	
Summary: Makers create a marble run using recycled materials.	**Ideal Grades**: 2nd-8th
II. Ball Roller Coaster 2	
A continuation of the previous activity	**Ideal Grades**: 2nd-8th
III. Musical Instruments	
Summary: Make a variety of simple instruments, such as pan pipes and percussion items.	**Ideal Grades**: 2nd-8th
IV. Sew a Creature 1	
Summary: Makers learn the basics of sewing, and create their own stuffed creatures.	**Ideal Grades**: 4th-8th
IV. Sew a Creature 2	
Continuation of previous activity	**Ideal Grades**: 4th-8th
V. Balloon-Powered Vehicles 1	
Summary: Makers build balloon-powered vehicles using common materials.	**Ideal Grades**: 2nd-8th
VI. Balloon-Powered Vehicles 2	
Continuation of previous activity	**Ideal Grades**: 2nd-8th

I. Ball Roller Coaster 1

Stuff:

- ☐ All of the Prototyping kit (both tubs)
- ☐ Bouncy balls from Supplementary Materials
- ☐ Computer/projector (to show pictures of examples)
- ☐ **Maker Notebooks**: Ball Roller Coaster

Do it!

(15 minutes before) **Setup**: Begin by spreading out the materials from the Prototyping Kit on a table. Ensure the supplies from the paper materials tub are accessible as well. You'll want the supplies accessible to all makers easily without lots of pushing or waiting in line.

(5 minutes) **Opener**: Soundball*
Everyone circles up. Someone starts by making a funny sound ("Blerp!") and throwing an imaginary ball to someone not next to them in the circle. That person catches it and makes the same sound, then makes a new sound and throws it to someone else. Nobody can have the ball twice. This goes on until everyone has had the ball thrown to them.
Note: each thrower only needs to make two sounds (previous one and their own) unless you want to make it complicated and have them do all the sounds.

(3 minutes) **Explain activity**: Eat snacks while explaining.
"*Today and next time, you're becoming amusement park ride engineers. You each get one ball, and your goal is to design the coolest roller coaster/marble run for your ball that you can think of.*
With this activity, we're giving you a budget. The amusement parks you're designing for want the coasters to cost less than $500 imaginary MakerDollars. Different supplies are worth certain amounts, and your roller coaster can't cost more than $500. Your notebook has the costs for each kind of piece.
Because we're engineers, we're going to start with a blueprint before we build. Your blueprint must show your design from several sides, with labels showing what different parts are. It also needs measurements showing how big the design will be."

> **Tip**: you can do a Google image or Pinterest search for "cardboard marble run" to show students examples. If they've never played with a marble run, some may struggle to conceptualize the idea without seeing some examples.

Have makers partner up. They can each build their own, or work together on one.

(40 minutes) **Blueprinting and Building**: Because makers will finish blueprinting at different times, there is no set time for each step. Instead, set a timer for 40 minutes, and play music.
Note: Makers should at least finish their blueprinting today so they have enough time to build next time.

Blueprinting: Makers must blueprint their design from multiple angles/sides, label specific parts, and include measurements to show how large their design will be. When they finish, ensure their designs include the above, and aren't too large, and then approve them.

Building: Makers begin building once their blueprint is approved. Encourage them to test frequently, to ensure each piece works, and that they work together.

Note: If the $500 budget proves to be too little, you may tell the makers that the amusement park decided to give them a bigger budget, and increase it to $1000. Makers may also ask if they can "sell items back." This is fine, so long as the items are reusable and not modified.

Warn makers when there are 15, 10, and 5 minutes left.

(10 minutes) **Cleanup**: Have makers clean up. Again, stress that nobody is done cleaning until everything is clean. Put coaster projects and balls in a safe place for next time.

Adaptations:

For Younger makers: Do this activity in pairs. When blueprinting, focus just on the front view. Depending on multiplication skills, skip the budgeting part. (Of course they can also add up the item costs instead of multiplying by the quantity).
For An Extra Challenge: Have makers verify the cost of other maker's coasters.

*From the Stoke Deck

II. Ball Roller Coaster 2

Stuff:

- ☐ All of the Prototyping kit (both tubs)
- ☐ Bouncy balls or Marbles from Supplementary Materials
- ☐ Computer/projector (to show pictures of examples)
- ☐ **Maker Notebooks**: Ball Roller Coaster

Do it!

(15 minutes before) **Setup**: Begin by spreading out the materials from the Prototyping Kit on a table. Ensure the supplies from the Paper Materials tub are accessible as well. You'll want the supplies accessible to makers without pushing or waiting in line.

(1 minute) **Introduction**: "*Today, we'll be finishing the roller coasters we started building last time. Remember to look at your blueprint to see how you wanted to build your design, and keep track of how much you've spent on your coaster so you don't go over the budget. Today, we'll build for most of the time, then clean up, and talk about what we did.*"

(34 minutes) **Build time**: Set a timer for 34 minutes, and play music. Warn makers when there are 15, 10, and 5 minutes left. Walk around and ask makers to explain their prototypes to you, or demonstrate what they've built so far. Encourage them to test frequently.

Note: If the $500 budget proves to be too little, you may tell the makers that the amusement park decided to give them a bigger budget, and increase it to $1000.

(10 minutes) **Cleanup**: Ensure everyone continues cleaning until everything is cleaned up. Makers will take coasters and **one** ball home, or alternatively, they can be displayed at your location.

> **Note**: There are supposed to be some extra balls leftover—we will use them in another activity.

(15 minutes) **Reflection**: Have makers sit down. "*Now, we're going to discuss what we just did. First, go through the reflection sheet in your notebook, think about the questions, and write your own answers to the questions. There aren't any wrong answers to these questions! I'll give you 5 minutes. No talking!*" Set a timer for 5 minutes.

"*Now, we'll discuss each question with the people around us. When we're done, I'll ask groups to share what they came up with.*"
Ask each question, give them a minute to quietly talk among themselves about it. Then, ask for volunteers to demo their coaster for the class and share some of their answers to the discussion questions.

- What was easy?
- What wasn't as easy?
- Did you discover something you hadn't known before?
- What was it like building with a budget?

Optional - Conclusion: if time allows, conclude by giving a real-world example of working on a budget. Building a house is a good example that probably most makers will be able to understand and connect with a bit.

Adaptations:

For Younger makers: As before, have young makers work in pairs. Potentially allow more adaptations of their design as they go along. If you do that, do have them adjust their blueprint accordingly.

For An Extra Challenge: Calculate the speed of the ball. If makers need help with this, guide them by explaining that speed is measured by a ratio of distance/time.

1. Calculate the linear distance the ball travels by using a ruler (inches or centimeters).
2. Time test: time the ball's travel for 5 or 10 trials, then get the average time in seconds.
3. Divide the linear distance by time to get inches/second.
4. For especially advanced learners, they can work on converting this time to the standard measure used in the US: miles/hr.

Hint: They'll need to multiply their inches/second by:
1 mile/63,360 inches and 3600 seconds/hour. Example:

$$\frac{20\ inches}{2\ seconds} \times \frac{1\ mile}{63360\ inches} \times \frac{3600\ seconds}{1\ hr} = 0.6\ miles/hr$$

Alternatively, have makers time the ball, and try to improve the time by modifying their coaster.

III. Musical Instruments

Stuff:

- ☐ Prototyping kit
- ☐ Recyclable materials
- ☐ Speaker + Fun/upbeat music playlist
- ☐ Large screen/Projector + computer
- ☐ **Video**: "What is Sound?" by SciShow Kids on YouTube: https://youtu.be/3-xKZKxXuu0
- ☐ **Maker Notebooks**: Instrument examples

Do it!

(15 minutes before) **Setup**: Set everything from the Prototyping kit out. Open the Recycled materials and put them somewhere easy to get to.

(10 minutes) **Opener**: Shake Down *

1. Everyone stand up!
2. Shake out your right arm 5 times, counting down from 5. (encourage the makers to be loud while counting down)
3. Shake out your left arm 5 times, counting down from 5.
4. Shake out your right leg 5 times, counting down from 5.
5. Shake out your left leg 5 times, counting down from 5.
6. Repeat for 4, 3, 2, and 1.

(10 minutes) **Snacks and Introduction**: Pass out snacks, and discuss instruments:
"What's a musical instrument?" (get feedback)
"What are some kinds of instruments?" (get feedback)
"What do we use them for?" (make music)
"What is music?" (get feedback) "It's a collection of sounds—to understand how sound works, let's watch a video."
Play video till 2:29: https://youtu.be/3-xKZKxXuu0

"Today we're making instruments! The notebook guide has examples for instruments you can make, but you can also make your own if you have another idea. Once you've built both of the ones in the guide, try something new!"

(30 minutes) **Build time**: Set a timer for 30 minutes, and play music. Warn makers when there are 5 minutes left. As usual, encourage makers to test their designs: Ask them to show you which part makes the sound (and how), or to demonstrate to you how their instrument works.
(10 minutes) **Cleanup:** (music to taste, makers can help if time allows). Makers may take their instruments home.

Adaptations:

For Younger makers: A few options:

- Choose specific instruments to make together as a whole class.
- Set up stations for various instruments and have an example they can manipulate at each station.
- Pair up makers to support each other. Require that they each make their own instrument, but do so together.

* From the Stoke Deck

IV. Sew a Creature 1

Stuff:

- ☐ Sewing supplies: Fabric, scissors, spools of thread, needles, buttons, pompoms.
- ☐ Scrap paper with at least 1 side blank
- ☐ Markers
- ☐ **Maker Notebook**:
  - ☐ "Sew a stuffed animal"
  - ☐ "Stuffed animal templates"
  - ☐ "Basic Sewing Handbook"
- ☐ **Video**: "Sewing skills: running stitch and whip stitch" on YouTube: https://youtu.be/YwfukGGSe3c
- ☐ Speaker + Slower, focused/quiet music playlist
- ☐ Computer and Projector/Screen

Do it!

(15 minutes before) **Setup**: Set sewing-related materials out: fabric, sewing kits, and templates.
Read the **Basic Sewing Handbook** guide (in the Maker Notebook) to familiarize yourself with the sewing techniques makers will be using.

(5 minutes) **Opener**: Misnamer*

1. Have makers partner up.
2. Taking turns, makers will point at something and call it anything BUT what it actually is (e.g. point at an eraser and say "look, a pizza!").
3. The more imaginative, the better!
4. After a minute or two, have makers switch partners and repeat.

(10 minutes) **Snacks and Introduction**: Pass out snacks, Maker Notebooks, several pieces of scrap paper, and a writing utensil for each maker, then introduce the plan:

"Today we're starting another 2-session project—we're going to make stuffed animals!

The Maker Notebook has three different guides in it: The basic sewing guides, which show you how to do the actual sewing; the "Sew a stuffed animal" guide, which shows you how to make an animal; and the "Stuffed animal templates," which has templates you can use.

You don't have to use one of the templates. If you want to make your own animal, you can modify one of the templates. Don't make it too intricate though or it will be hard to cut and sew!"

Show makers where the materials are: the templates, scissors, and fabric.

Warn them to be careful with needles: *"Today and the next session, you'll be using needles—I'm trusting you with them, but you need to be safe. Make sure your finger or body*

is never right behind where the needle will poke through. (Show demo of safe vs unsafe stitching). If you're not being safe, I'll take the needle away from you, and then you can't make an animal—so be safe.
When you're ready for a needle, come see me and I will help you thread it."

Tip: help makers with the first threading of their needle, but also show them enough so that they can do it if their thread falls out.

(30 minutes) **Main activity**: Set a timer for 30 minutes. Put on some slow, focused music. makers will make their designs or choose one of the templates. If makers are using their own design, ensure they don't take longer than 10 minutes to make the template—otherwise, they might not have time to finish sewing.

While makers are sewing, helping them as needed. Ensure they stay on task, since sewing is somewhat time consuming and we plan to finish the majority of the sewing in this activity. Let them know when there are 10 minutes left to finish.

(10 minutes) **Cleanup**: Have all makers stop sewing and clean supplies up. Make sure they **don't throw away fabric scraps**; they can be used for stuffing next time.
Put all the projects in a safe place, label with names if necessary.

Adaptations:

For Younger makers: Skip custom templates and have them pick one of the premade templates. Then, walk everyone through the steps of threading the needle, making a knot, and starting the stitch, then let them go on their own once they get started. Finally, help makers individually if they need help finishing the stitch or with other steps.
Another approach is to make the "stuffed animals" out of paper, hole punching the edges and sewing with yarn. But in many cases that may be more effort than it's worth since it won't seem that close to a stuffed animal.
For English Language makers: This lesson went particularly well without any adaptations when tested at a migrant education summer school with 4th and 5th graders. For those makers, Spanish was their first language, though most spoke some English.
For An Extra Challenge: This activity naturally lends itself to modification by the makers themselves to make it more challenging. If needed, you could have them create a second item for a friend or family member.

*From the Stoke Deck

V. Sew a Creature 2

Stuff:

- ☐ Sewing supplies: Fabric, scissors, spools of thread, needles, pompoms, pipe cleaners, googly eyes, misc. Decoration materials.
- ☐ Creature projects from last session
- ☐ **Maker Notebook**: from last session
  - ☐ "Sew a stuffed animal"
  - ☐ "Stuffed animal templates"
  - ☐ "Basic Sewing Handbook"

Do it!

(15 minutes before) **Setup**: Set sewing-related materials out. Set up a hot glue gun station: place a piece of cardboard or paper under each glue gun.
Set out the projects from last time.

(5 minutes) **Opener**: Die, Category, Die!

1. Circle up.
2. You pick a category (IE, kinds of cereal)
3. Go around the circle with each person naming something from the category (IE, "Cheerios," or "Trix")
4. If someone takes too long, or says something that's already been said, everyone yells "Die, Category, Die!" and that person is out.
5. The "out" person now chooses the next category, and play continues with the person who was next to them.

(To indicate someone is taking too long, start slowly counting down from ten after a "grace period.")

(5 minutes) **Snacks and Introduction**: Pass out snacks, then introduce the plan: "*Today we're finishing our animals. We'll stuff them, then finish sewing them up and decorate them. You'll start on the step you were on in the guides last time.*

Remember to be safe with the needles!

For decoration, you can use whatever you want. You can sew things onto your animals, use glue, tape, whatever. We have pompoms, pipe cleaners, felt to cut up, string, googly eyes, construction paper. If there's anything else in the Prototyping Kit that you want to use, let me know."

(30 minutes) **Main activity**: Set a timer for 30 minutes. Put on some slow, focused music. makers will continue their animals. They may not be finished with sewing, in which case they will finish that first. When they are finished with the sewing, they'll stuff their creatures and then decorate them.
Make sure makers are being safe with the needles. Warn them when there are 10 minutes left on the timer.

Tip: Some makers may finish early. Here are some options for them:

- Make another animal if there's enough time.
- Make furniture or accessories for your animal.
- Write a poem or short story about your animal.
- Design packing or an advertisement for your animal (as if it's going to be sold in a store).

(10 minutes) **Cleanup:** Makers must clean everything up. You should collect needles and sewing supplies. Makers may take their animals home.

Adaptations:

See adaptations from the previous lesson.

* From the Stoke Deck

VI. Balloon-Powered Vehicles 1

Stuff:

- ☐ Prototyping kit: both bins, but especially these materials: Cardboard, straws, balloons, tape, skewers, scissors, rubber bands, markers
- ☐ **Maker Notebooks**: Balloon-powered vehicle

Do it!

(15 minutes before) **Setup**: Set everything out so it's easy to get to.

(5 minutes) **Opener**: The wind blows*

1. Circle up with one person in the middle.
2. The person in the middle says "The wind blows for everyone who…" and then states something that is also true about him/herself. (e.g. "for anyone wearing flip flops" or "for anyone who is an only child.")
3. Anyone who the statement is true for must leave their spot, and take an empty spot in the circle. (Including the person in the middle! Similar to musical chairs.)
4. Whoever is left out is in the middle and goes next.

(5 minutes) **Snack and Introduction**: Hand out snacks.
"Today and at our next session, we'll be making balloon-powered vehicles!
We'll start with a car, but you can modify your car, or build a different vehicle if you have an idea for one. First, what do you think a balloon-powered vehicle is?"
(allow for feedback)

(5 minutes) **Discuss**: Ask makers what they think they will need to focus on to make their balloon-powered vehicles work. The goal is to get them thinking about how they will ensure the wheels stay on and spin, and where the balloon will go to make the vehicle propel forward.

"First we need to come up with a plan for how we want to build our vehicles. Look at the materials you have available and then create a blueprint. Use lots of labels and try to draw your design from more than one angle. When you're finished, raise your hand so I can approve your design."

(10 minutes) **Blueprinting**: makers must blueprint their design from multiple angles/sides, label specific parts, and include measurements to show how large their design will be. When they finish, ensure their designs include the above, and aren't too large, and then approve them.
Optional but recommended: Require that makers include dimensions.

(30 minutes) **Building**: Have makers focus on building their wheels & axles first. Makers may begin building once their blueprint is approved. Encourage them to test frequently, to ensure each piece works, and that they work together.

Warn makers when there are 15, 10, and 5 minutes left.

(10 minutes) **Cleanup:** Have makers clean everything up. Ensure usable supplies are not thrown out. Makers should leave their vehicles with you for the next session.

Adaptations:

For Younger makers: This can be pretty tricky for younger makers, so we suggest skipping the blueprinting step, and just building the vehicle shown in the Maker Notebook. It uses straws with skewers inside the straws to make sure the cardboard wheels can spin freely.
For An Extra Challenge: Set a distance requirement, which will likely make it vital that makers go through a few iterations of their design.
Have makers calculate the speed their car travels (distance over time). Have them calculate how long it would take their vehicle to cover a certain distance (assuming their balloon could continue to be inflated) or have them convert the speed to miles/hour.
In addition, you could have makers build two different cars to race against each other.

*From the Stoke Deck

VII. Balloon-Powered Vehicles 2

Stuff:

- ☐ Prototyping kit: both bins, but especially these materials: Cardboard, straws, balloons, tape, skewers, scissors, rubber bands, markers
- ☐ **Maker Notebooks**: Balloon-powered vehicle

Do it!

(15 minutes before) **Setup**: Set everything out so it's easy to get to.

(5 minutes) **Snack and Introduction**: Hand out snacks.

Discuss: "Today we're going to work more on our balloon-powered vehicles.
How did your designs work last session? Did your vehicle move the way you expected it to?
What can you try differently this time to make it work better?"
(allow for feedback)

(40 minutes) **Building & Testing**: This session is an opportunity for makers to continue building and testing their balloon-powered vehicles. Encourage makers to test often and think of new ways to make their vehicles stronger and go farther. Play upbeat music, and warn makers when there are 10 minutes left.

> **Tip**: If makers have lots of extra time, they could make a wind-powered car. Do a similar base but put a sail on top instead. Or, they could design a balloon-powered boat. Alternatively, they could race their cars, which would make it so they have to make them go in a straight line, and faster/further.

Note: It's likely makers will finish early. If they aren't interested in building iterations or improving their vehicles, feel free to clean up early and play group games for the rest of the day.

(10 minutes) **Cleanup**: Ensure everything is cleaned up--do not allow makers to stop cleaning once their area is clean. Ensure everyone is cleaning until everything is cleaned up. Makers may take their vehicles home.

Adaptations:

See adaptations from previous lesson.

Unit 4: Engineering

This unit includes several lessons designed to introduce makers to structural and mechanical engineering.

I. Bridge Challenge 1[NGSS]	
Summary: Makers use household materials to build a bridge that can support weight over a specific gap.	**Ideal Grades**: 2nd-8th
II. Bridge Challenge 2[NGSS]	
Continuation of previous activity	
III. Tower Challenge 1[NGSS]	
Summary: Makers build towers that can withstand an "earthquake."	**Ideal Grades**: 2nd-8th
IV. Tower Challenge 2 - Using a Budget[NGSS]	
Continuation of previous activity	
V. Launcher Challenge 1	
Summary: Makers learn about potential and kinetic energy, and build their own pom-pom launcher.	**Ideal Grades**: 2nd-8th
VI. Launcher Challenge 2	
Continuation of previous activity	
VIII. Playground Machines 1	
Summary: Whole group discusses and explores various playground "machines" in preparation for building their own.	**Ideal Grades**: 3rd-8th
IX. Playground Machines 2	
Summary: Makers design and build their own mini playground machine(s).	**Ideal Grades**: 3rd-8th

NGSS Alignment

K-2-ETS1 Engineering Design
Performance Expectations: Asking Questions and Defining Problems (K-2-ETS1-1), Developing and Using Models (K-2-ETS1-2)
Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (K-2-ETS1-1), ETS1.B: Developing Possible Solutions (K-2-ETS1-2), ETS1.C: Optimizing the Design Solution (K-2-ETS1-3)
Crosscutting Concepts: Structure and Function (K-2-ETS1-2)

3-5-ETS1 Engineering Design
Performance Expectations: Constructing Explanations and Designing Solutions (3-5-ETS1-2)
Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (3-5-ETS1-1), ETS1.B: Developing Possible Solutions (3-5-ETS1-2; 3-5-ETS1-3), ETS1.C: Optimizing the Design Solution (3-5-ETS1-3)
Crosscutting Concepts: Influence of Engineering, Technology, and Science on Society and the Natural World (3-5-ETS1-1; 3-5-ETS1-2)

I. Bridge Challenge 1

Stuff:

- ☐ Straws, popsicle sticks, string, tape, and construction paper.
- ☐ Scissors
- ☐ Hot glue guns, hot glue sticks
- ☐ **Maker Notebooks**: Bridge Challenge
- ☐ 1 paper cup full of popsicle sticks (for weight testing bridges)
- ☐ Measuring tape, ruler, or yardstick to measure towers

Do it!

(15 minutes before) **Setup**: Set supplies on a table to be easily accessed by makers. Review the lesson plan, specifically the requirements for the bridges. Set up the hot glue gun station, and place a piece of cardboard under each glue gun.

(5 minutes) **Opener**: Misnamer*

1. Have makers partner up.
2. Taking turns, partners will point at something and call it anything BUT what it actually is, e.g. point to an eraser and say "Look, a pizza!" The sillier, the better!
3. After a minute or two, have makers switch partners and continue.

(5 minutes) **Introduction**: Pass out snacks.
"Today, we're going to become civil engineers! Civil engineers design things like bridges and skyscrapers, houses and parking garages, and roads.

We're going to start with a bridge challenge. Today and the next session, we'll blueprint, prototype, test, and revise our bridges, until we've finished the challenge.

When adult engineers design bridges, they have to follow a set of requirements—the bridge has to be a certain length, it has to support the weight of the things going over it, it can't cost billions of dollars, and it has to use materials that are easy to find.

We're going to follow a set of requirements too. Here they are:
[Write on whiteboard if one is available]

- *The bridge must cross a gap of 1 1/2 feet without touching in between.*
- *It must support the weight of a cup full of popsicle sticks.*
- *It may not cost more than $1000 to build.*
- *Finally, it has to use only these materials: straws, popsicle sticks, paper, tape, & string.*

Your notebooks have the budget and prices for items in the Prototyping Kit. You'll have to keep track of how much your bridge costs!

Your notebooks have examples of bridge design types in them—there are several kinds to choose from. First, I want you to look through the examples, and choose which type of design you want to make. Then, create a blueprint for it. Remember, the blueprint has to include

clear sketches of several sides of your design, labels for important pieces, and measurements."

(40 minutes) **Blueprinting, Prototyping, and Revising**: Set timer for 40 minutes, and display it on a large screen or projector. Play music to taste.

Blueprinting: Makers will look at their notebooks, choose a bridge type to build, and blueprint it. When they are finished, they must bring the blueprint to you, and explain it. Inspect it to ensure it clearly shows their design from several sides/angles, has labels where needed to explain the important parts, and has some measurements to give an idea of the size. When you're done, approve it.

Building and Revising: When makers get their blueprints approved, they may begin building. Walk around and ask makers to explain what they've built so far, how it works, and how it matches or deviates from the blueprint.

Encourage them to test whenever possible, even if they think it will fail—remind them that it's important to find the failure points. Remind them to make changes if they need to. Have makers ask you for the cup of popsicle sticks for testing, so it doesn't get lost or used.

Warn makers when there are 15, 10, and 5 minutes left.

(10 minutes) **Cleanup**: Have makers clean up all supplies, and throw away garbage. Have makers give you their bridges to keep safe for next time.

Adaptations:

For Younger makers: Shorten the bridge length to a foot, and remove the budget requirement. They may only use the materials listed, and a total of 30 popsicle sticks and straws combined. Skip the budgeting, or show makers how they can add instead of multiply.
For An Extra Challenge: Increase the bridge length to 2 feet, and/or add another weight of some kind.

*From the Stoke Deck, by the Stanford d.school.

II. Bridge Challenge 2

Stuff:

- ☐ Straws, popsicle stick, paper, string, and tape
- ☐ Scissors
- ☐ Hot glue guns and glue sticks
- ☐ **Maker Notebooks**: Bridge Challenge
- ☐ 1 paper cup full of popsicle sticks (for weight testing bridges)
- ☐ Measuring tape, ruler, or yardstick to measure towers
- ☐ Bridge prototypes from last time

Do it!

(15 minutes before) **Setup**: Get out the straws, tape, and string from the Prototyping Kit. Put all the supplies and tools on a table where they can be easily accessed by makers. Set up a hot glue gun station: place a piece of cardboard under each glue gun. Set bridge prototypes out so makers can retrieve them.

Write bridge requirements on a whiteboard, if available. Requirements are:

- The bridge must cross a gap of 1 1/2 feet without touching in between.
- It must support the weight of a cup full of popsicle sticks.
- It may not cost more than $1000 to build.
- It has to use only these materials: straws, popsicle sticks, paper, tape, and string.

(5 minutes) **Introduction**: Have makers partner up. If two makers worked on the same bridge last time, they should partner up again.

"*Today, we're finishing our bridges. We'll build for a while longer, clean up, do a bridge showcase, and then reflect on what we did. Make sure you look at your blueprint to remember how you plan to make your bridge! You have 25 minutes to finish the bridges.*"

(20 minutes) **Finishing bridges**: Set a timer for 25 minutes, and display it on a large screen or projector if possible. Play music.

Encourage makers to test their bridges frequently, and change things if needed. Again, gave them ask you for the cup of popsicle sticks when they need to test.

Warn makers when there are 15, 10, and 5 minutes left.

(10 minutes) **Cleanup**: Have makers put all supplies away, and throw unusable pieces away. Bridges should be left on desks.

(20 minutes) **Bridge show and Reflection**: "*Now, let's take some time to go around the room and look at each other's bridges. While you do, ask the makers who made them what was hard, what was easy, and what they discovered. Think about those questions yourself, too.*"

Set a timer for 5 minutes, and allow makers to wander around the room. When time is up, have them sit down or gather in a circle with their notebooks.

Reflection: "*Now, we're going to discuss what we just did. First, go through the reflection sheet in your notebook, think about the questions, and write your own answers to the questions. There aren't any wrong answers to these questions! I'll give you 5 minutes. No talking!*"

Give the makers a few minutes to write their answers.

When time is up, ask the group each question, and allow makers to answer.

- What was easy?
- What wasn't as easy?
- Did you discover something you hadn't known before?
- What was it like building with a budget?

Put notebooks away. Makers may take their bridges home, display them at school, or disassemble to reuse materials.

Adaptations:

For Younger makers: Shorten the bridge length to a foot, and remove the budget requirement. They may only use the materials listed, and a total of 30 popsicle sticks and straws combined.
For An Extra Challenge: Increase the bridge length to 2 feet, and/or add another weight of some kind.

III. Tower Challenge 1

Stuff:

- ☐ Tower materials: Straws, tape, hot glue, paper, string, cardboard (for base ONLY), pipe cleaners
- ☐ Pencils
- ☐ **Maker Notebooks**: Tower Challenge
- ☐ Rulers or yardsticks for measuring towers

Do it!

(15 minutes before) **Setup**: Set out the materials listed above from the Prototyping Kit. Ensure they are easily accessible to makers. Set up the hot glue gun station, and place a piece of cardboard under each glue gun.

(5 minutes) **Opener**: "I like..."

1. Have everyone gather in a group.
2. You make a statement about something you like, e.g. "I like cats better than dogs!" and go stand away from the group.
3. People who agree with you come and stand with you, while those who don't stand away.
4. Now, someone else makes a statement, and the process repeats, with different people making statements once the groups have formed.

(You may have to encourage makers to say statements, and do several yourself to get it going.)

(5 minutes) **Introduction**: Pass out snacks.
"*Today, we're going to be starting a tower challenge. It's a lot like the bridge challenge we finished last time. With towers, we're going to blueprint a design, budget it, build it, and test it. Of course, it has several rules:*"

List the rules:

- It must be at least 2 feet tall
- It must not use cardboard except for the "ground" to build it on
- It must be able to withstand an earthquake, which you (the leader) will simulate by shaking the cardboard base
- It must only use the materials listed in the maker notebooks
- It must not cost more than $500 imaginary MakerDollars to build

Makers will follow these steps:

1. Blueprint a design, and get it approved
2. Prototype their tower, and while they do, keep track of how much they spend with their budget.
3. Test their towers with you.

Note: The costs for items include some decimals so that makers practice the 5th grade standard of multiplying with decimals. If your group is not ready for that, you can change the costs to whole numbers. Write the new costs up on the board and have makers adjust the numbers in their budget sheet.

Once you've outlined the challenge, allow Makers to take a minute to **look** at the materials (no touching or taking back to desks!) before starting on their blueprints.

(45 minutes) **Build time**: After this point, makers are self-directed until their tower is ready to test.

When groups are ready, you will test their tower with an "earthquake." (You shake the cardboard at a level you deem appropriate. Try to make tests equal between groups.) Encourage the groups to write down anything that went wrong, or changes they could make to make the tower better. Additionally, measure the towers to ensure they meet the height requirement.

(10 minutes) **Cleanup**: Have makers clean up supplies, and throw away garbage. Put the tower prototypes in a safe place for next time.

Adaptations:

For Younger makers: Give tips about strong shapes (triangles) and effective ways to make strong connections at the corners.
Round prices in the notebooks to whole numbers instead of decimals.
For An Extra Challenge: Require that the tower hold a weight at the top and/or exclude some of the most helpful connector supplies (such as hot glue).

IV. Tower Challenge 2

Stuff:

- ☐ Tower materials: Straws, tape, paper, string, flat pieces of cardboard, pipe cleaners; scissors & glue guns
- ☐ Pencils
- ☐ **Maker Notebooks**: Tower Challenge
- ☐ Rulers or yardsticks to measure towers

Do it!

(15 minutes before) **Setup**: Set out the materials listed above from the Prototyping Kit. Ensure they are easily accessible to makers. Set out towers from last time.
Write tower requirements on a whiteboard, if available. Requirements are:

- The tower must be at least 2 ft. tall and survive an earthquake.
- It may not cost more than $60 to build.
- It has to use only these materials: Straws, popsicle sticks, paper, tape, and string.

(1 minute) **Introduction**: Pass out snacks.
"This time, we're going to finish the towers we started last time. Remember, you ***must*** *follow your budget!*
If you finished last time, I'm going to have you build a new tower. It has to meet all the requirements except for the earthquake one. Instead, it has to hold a weight at the top: a cup full of popsicle sticks."

(35 minutes) **Build time**: Set a timer for 40 minutes, and play music. Makers will finish their bridges, or build new ones if they are already finished.

(10 minutes) **Cleanup**: Have makers clean up supplies, and throw away garbage. They may take their towers home or disassemble to reuse/recycle supplies.

(10 minutes) **Debrief**: Regroup the class and talk through some of the following:

- "What are some things you discovered about building strong towers?"
- "What would you do differently if you designed a tower again?"
- "What was hardest about this challenge?"
- "What wasn't hard about this challenge?"

Adaptations:

For Younger makers: Simplify the costs to whole numbers or remove the budget all together. Remove the rental costs for scissors and glue guns. Make the height requirement lower, such as 1 foot.
For An Extra Challenge: Make the budget more challenging, such as using decimals that are not multiples of 0.05 or 0.1. Have the makers draw their designs from 3 perspectives.
Give makers an extra requirement: their towers must also hold a weight near the top of the tower.

V. Launcher Challenge 1

Stuff:

- ☐ Prototyping Kit
- ☐ Paper Materials
- ☐ **Maker Notebooks**: Launcher Challenge

Do it!

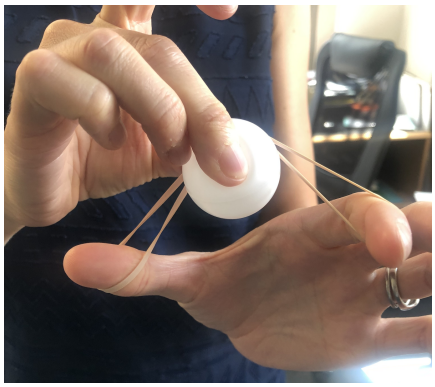
(15 minutes before) **Setup**: Put all the supplies and tools on a table where they can be easily accessed by makers. Set up a designated "launch zone" with a starting line and "goal" that's 5 feet away. These can be as simple as taped lines on the floor, or more complex.

(5 minutes) **Opener**: Lemonade*

1. Gather in a circle.
2. First person states a "lemon" - a bummer about their day or week (e.g. "I spilled coffee on my pants this morning").
3. The next person turns that into "lemonade" by looking on the bright side (e.g. "But now you have a great new pattern on your pants!").
4. The next person states a new "lemon," and the cycle continues around the circle.

Note: Tell Makers they can't say "At least ..." (eg "at least you didn't burn your leg!")

(6 minutes) **Introduction and Snacks**: Pass out snacks. Introduce the idea of a "launcher"—a machine that stores energy and can be used to launch an object. Demonstrate how your finger and a rubber band can be used as a launcher.



Explain the two types of energy here:

- The stretched rubber band is an example of potential energy (stored energy).
- When the rubber band is let go, the energy is released and becomes kinetic energy (energy of motion).

Optional discussion: "Can you think of other examples of potential and kinetic energy?"

- If you have classroom whiteboards, you could have makers sketch an example and label the PE or KE.
- Examples: roller coaster cresting a hill (PE at top, KE as moving down); bow pulled back in a bow and arrow (PE); a compressed spring (PE).

(4 minutes) Discuss launchers: Ask makers if they can think of other examples of launchers (e.g. baseball pitching machines, diving boards, trampolines, pop-up toasters, etc.) Explain that those are all machines that have been designed by mechanical engineers. Today, they'll get to be mechanical engineers—they'll be designing their own launchers.

→ Makers will decide on a type of launcher—either from the guide, or their own design—and build it.

Explain the plan: They'll blueprint their launchers, and then they'll have 15 minutes to build and test a launcher prototype. The final goal is to launch something into a container or over a line 5 ft from the launch point. The launchable can be pompoms or cotton balls.
Note: They will work as partners, but each Maker may make their own launcher.
Variation: You could also choose to have the makers create their own (safe) launchable. This presents the extra challenge of making something that flies well (has some mass and is perhaps aerodynamic).

(30 minutes) **Blueprinting and Prototyping**: Set a timer for 30 minutes. Warn Makers when there are 15, 10, and 5 minutes remaining.

Blueprinting: Have Makers follow the steps in the Launcher Challenge section of their Maker Notebook. They will blueprint a design, and then bring it to you for approval when finished. When their design is approved, they may begin building.

Prototyping and Testing: Remind Makers that this is not the final build, just a quick prototype to test with. They'll get to build a proper version next time.

(10 minutes) **Cleanup**: When the timer ends, call testing to a halt. Have makers clean everything up, and put launcher prototypes in a safe place for next time.

(5 minutes) **Discuss**: Allow partners time to discuss their launcher designs. Encourage them to discuss similarities, differences, and how these affect the way the pompoms are launched. Also encourage them to talk about how they could make their launcher work better. Teams can share their thoughts or ideas with the entire group if time allows.

Adaptations:

For Younger makers: Use only pom-poms for launchables, and remove the goal, so all they have to do is launch it 5 feet. You may also reduce the length, if you think it's necessary. Alternatively, you could all build together (same design), but that will limit individual creativity and problem solving.
For An Extra Challenge: Increase the distance and/or precision required to launch into the goal.

*From the Stoke Deck, by the Stanford d.school.

VI. Launcher Challenge 2

Stuff:

- ☐ Prototyping Kit
- ☐ Paper Materials
- ☐ **Maker Notebooks**: Launcher Challenge

Do it!

(15 minutes before) **Setup**: Set out materials from the Prototyping Kit. Put all the supplies and tools on a table where they can be easily accessed by makers.

(5 minutes) **Introduction and Snacks**: Pass out snacks.
"Today we're going to finish our launchers." If everyone met the target easily last time, change the goal. You can move the target 7ft from the launch zone, or make a more narrow target that will require teams to make their launcher (or launchable) launch more precisely.

(30 minutes) **Building Time**: Give makers some time to work on making improvements to their launchers. Encourage them to test their designs frequently. Feel free to adjust the goal if they need a more challenging target.

Walk around and encourage makers to test their designs frequently. Ask questions like "Can you show me how your design works?" and "How could you make it launch the pom-pom further?" Warn when there are 10 and 5 minutes left.

Note: Some makers may realize that the pompoms are not aerodynamic, and decide to modify them somehow, like wrapping them in tape—that's fine! Though aerodynamics aren't *really* related to mechanical engineering, it's very relevant in designing a launcher, and we want them thinking in multiple disciplines. Just ensure other makers realize it's OK to do if one group figures it out.

(10 minutes) **Cleanup**: Makers clean up areas, put unused/reusable supplies back. Make sure everyone keeps cleaning until everything has been cleaned up.

(10 minutes) **Final Launch/Test Time**: Have teams take a turn launching, while other teams watch.

(15 minutes) **Reflection**: Have makers sit down. "Now, we're going to discuss what we just did. First, go through the reflection sheet in your notebook, think about the questions, and write your own answers to the questions. There aren't any wrong answers to these questions! I'll give you 5 minutes. No talking!"

Set a timer for 5 minutes.

"Now, we'll discuss each question with the people around us. When we're done, I'll ask groups to share what they came up with."

Ask each question, give them a minute to quietly talk among themselves about it, and then share answers with you.

- What was easy?
- What wasn't as easy?
- Did you discover something you hadn't known before?

Adaptations:

For Younger makers: Make the target closer to the launch zone and/or larger. Give more guidance on what materials might be most useful. Use only pompoms as launchables.
For An Extra Challenge: Create a more difficult target. Have makers make their own launchables, instead of using pompoms.

VII. Playground Machines 1

Stuff:

- ☐ **Video**: Choose one:
  - ☐ **Six Simple Machines Rap** by Jack Hartmann Kids Music Channel (https://youtu.be/_NTCToqZ_3Q) - really cheesy, but actually a great quick intro
  - ☐ **Simple and Complex Machines** by Happy Learning English (https://youtu.be/8GHRZabpsQE) - short and not cheesy, but skips screw and wedge; narrator has an accent.
  - ☐ **Simple Machines for Kids** by Clarendon Learning (https://youtu.be/LSfNYpCprw4) - serious and many examples, but also a little boring and long.
- ☐ Laptop & Projector/Large screen
- ☐ **Maker Notebooks**: Playground Machines
- ☐ **If possible**: An available playground

Do it!

(15 minutes before) **Setup**: Set out all materials from the Prototyping Kit. Put all the supplies and tools on a table where they can be easily accessed by makers.

(5 minutes) **Opener**: Remember When?
Have makers partner up. Partner A begins with "Remember when..." and then states the beginning of a (fake) shared memory (e.g. "...we went to the zoo?"). Partner B builds on the memory with "Yeah, and then..." (e.g. "...the monkeys shared their bananas with us?"). Partners continue adding on to their "memory" until time is up.
Alternatively, you can also do this as a whole group, standing in a circle and telling the story around the circle.

Note: This is a good activity to show the value of building on one another's ideas.

(10 minutes) **Introduction and Snacks**: Pass out snacks. Have the partners from the game stay together, and sit down.
Ask makers: "What is a machine?"
Get feedback; the ideal answer is "something that makes work easier."

"Now, imagine we had to move an elephant between two zoos. We can't just lift the elephant and carry it to the other zoo, it's way too heavy! But, we have a truck and a ramp, so what would we do?" Get feedback. "We'd use the ramp to put the elephant into the back of the truck, then drive to the other zoo. The ramp, and the wheels on the truck are examples of simple machines: the basic pieces that make machines. They're what made us able to move the elephant—they made the work easier."

"To learn about the different types of simple machines, we're going to watch a video about them, and then we'll go to the playground so we can identify the simple machines used there."

Play the video you've chosen, linked above.

(25 minutes) **Playground machine identification**: Take the makers out to the playground. Before makers can play on anything, the group must identify at least 1 simple machine used in each piece of equipment. If necessary, have two makers demo the playground item.

Examples of simple machines in playgrounds:

- Wheel and Axle: Merry go round, swing, see-saw
- Inclined plane: Slide, ramp, stairs
- Lever: See-saw
- Screw: Bolts or screws used in playground, spiral corkscrew climber
- Wedge: We couldn't think of any, but makers may identify something.
- Pulley: As above.

Go through all aspects of the playground simple machines that you want to explore, then let makers play for 10-15 minutes. Then, return to the classroom.

(15 minutes) **Design**: "Now, here's the challenge you'll be working on this time and next time. Your challenge is to make a mini playground toy that uses a simple machine you learned about today. It can be one of the toys from this playground, or a different one—the only rules are that it has to use a simple machine, and it has to work.

Your Maker Notebook has a space for blueprinting a playground toy, and it also has examples of simple machines and how they work. Follow the instructions in your notebook to pick a simple machine and playground toy to use, and then blueprint it. We'll do that for 15 minutes—while we do, no talking is allowed. Next time, you'll get to make your designs!

You have 15 minutes—no talking, go!" Set a timer for 15 minutes.

(5 minutes) **Cleanup**: Have makers put any materials away. Gather the papers/drawings for next time.

Adaptations:

For Younger makers: Focus on the inclined plane (ramp), teeter totter, swing, and slide. Those will be easier to make than screw and wedge.
For An Extra Challenge: Design a playground toy that can be used by a child who uses a wheelchair, or by a child who can't see well.

VIII. Playground Machines 2

Stuff:

- ☐ Ball of yarn or twine (should be in Prototyping Kit, but double-check)
- ☐ Prototyping Kit
- ☐ Paper materials
- ☐ Scissors
- ☐ **Maker Notebooks**: Playground Machines

Do it!

(15 minutes before) **Setup**: Set out all materials from the Prototyping Kit. Put all the supplies and tools on a table where they can be easily accessed by makers.

(5 minutes) **Opener**: Human Spider Web

1. Have whole group circle up.
2. Explain: "We're going to make a human spider web together, and then see if we can disassemble it too! First we will toss the string to someone who doesn't have it, making sure to hold on to it so you can make a web. Say this person's name as you toss to them."
3. Leader begins by saying a maker's name, tossing the yarn ball to them, and showing the whole how to still hold on.
4. The maker who got the yarn ball continues the process. Keep going until everyone is holding the string and you have a web.
5. "OK, now we're going to see if we can undo the web, so we have to go backwards. The challenge now is that there's not talking. Let's see if we can do it!"

(5 minutes) **Introduction and Snacks**: Pass out snacks. Introduce today's plan: "Today, we're making the mini playground toys we designed last time. We'll prototype for 30 minutes, then clean up, and then you'll each present the playground toys you made."

(30 minutes) **Prototyping**: Set a timer for 30 minutes. If possible, display it on the projector or a large screen.

1. Have makers come and grab their designs from last time. Once they've reviewed it, they can gather materials and start prototyping.
2. While they're prototyping, play music. Walk around and help makers keep on track while building their designs. Help them overcome problems by asking open-ended questions that encourage thinking in the right direction.
3. Warn everyone when there are 10, 5, and 2 minutes left.

(10 minutes) **Cleanup**: Have makers clean their work areas and put away all unused supplies.

(10 minutes) **Present**: Have each group present their playground pieces to the group. Encourage makers to explain which simple machines were used and how, and demonstrate the toy working.

Playground pieces may be taken home or displayed somewhere. Or have makers disassemble them to reuse/recycle supplies.
Adaptations:
See adaptations from the previous lesson.

Unit 5: 3D Computer-Aided Design

This unit covers the basics of 3D CAD design, and how to use a free online 3D design program called TinkerCad. This unit was tested successfully in 4th - 5th grade classrooms. TinkerCAD is relatively user-friendly, but it is good for the instructor to practice a bit before leading the lessons.

I. Introduction to Tinkercad	
Summary: Makers learn how to use TinkerCad, a free online 3D design program.	**Ideal Grades:** 2nd-8th
II. Design & 3D Print a Name Tag!	
Summary: Makers use their new skills to design a personal name tag.	**Ideal Grades:** 2nd-8th
III. Model a Cool Thing	
Summary: Makers apply everything they've learned to design something of their own in TinkerCad.	**Ideal Grades:** 2nd-8th

I. Introduction to Tinkercad

Stuff:

- ☐ A computer of some kind for each maker (Chromebooks work great)
- ☐ Internet connection for all computers
- ☐ Computer/projector for instructor
- ☐ A tinkercad account for instructor

Do it!

(15 minutes before) **Setup**: Ensure all computers are charged and ready to go, and connected to the internet.

Create your tinkercad account: Go to www.tinkercad.com, click "Join now", and go through the process of creating an account. Once finished, click on "Teach". You should see several options for your account type. Select "Teacher", then click "Apply". You will now see a button to "Create an invite code". You may click this to create a code that will allow your makers to create accounts without using personal email addresses.

> **Tip**: Go through the Tinkercad lessons ahead of time so that you are familiar with the program. It is pretty intuitive, but trying it out before the makers is still a good idea.

(3 minutes) **Introduction**: Tell the makers what they'll be doing: Learning how to use a fun online 3D design program, so they can model their own 3D designs that can be 3D printed. While they are finishing their snacks, show them what tinkercad looks like on the projector or screen.

Once they finish, have them find partners (in pairs of 2), then have each partner get a computer.

(20 minutes) **Create student accounts**: Have your makers go to www.tinkercad.com, and click "Join now". Ensure they put their correct birth dates: users under 13 years old can then get an account without providing a personal email address.

Have everyone use these usernames and passwords:
Username: firstnamel(ast initial)school1819 - example: jacobfdryhollow1920
Password: maker1920 (all makers will use the same password)
Parent email: Have makers enter **your** school email address.

Note: The "parent email" is just an alternative verification method. You'll probably get an email for each maker asking you to verify their account—but don't worry about it, the classroom code takes care of that. **You can delete the emails.**

Once they are finished, there will be a large notification that says their accounts need to be approved. Sign into your teacher tinkercad account, create a code, and display it on the projector. (The makers will all use the same code to verify their accounts) Have the makers

copy the code into the box, then click “Get approved”. They should each have an account that is ready to use now.

(20 minutes) **Starter lessons**: From their tinkercad home page, have makers click on “Learn”. Walk them through the first lesson on the projector. The instructions will be on the left side of the screen. Once they’re finished with the lesson, have them click continue (on the left side of the screen) to go on to the next lesson. Let them work through the lessons at their own pace, but ensure they know to ask you questions if they get stuck. You can walk around to supervise and help as needed. Have them do all the lessons.

Encourage makers to finish all the lessons (they aren’t that long and will really help the makers make cooler stuff.) Once makers finish, they can free-design on TinkerCad.

If makers are getting restless, feel free to call a break and play a game, such as: Yes, Let’s!

1. Someone makes an offer to the entire group, e.g. “Let’s be baby birds!”
2. Everyone replies with “yes, let’s!”, and then acts out the suggestion.
3. Anyone can yell out another offer at any point.
4. Finish off with suggesting we go back to learning how to do 3D designs.

(5 minutes) **Cleanup**: If the computers need to be put away, you can allow makers to do that.
Note: You can access moderator settings for the makers’ accounts by clicking on your account picture at the top left of the tinkercad page, then clicking on “Moderate makers.”

Adaptations:

For Younger makers: Unless you have a particularly tech-savvy group, we don’t suggest this lesson for younger than 3rd grade.
For English Language makers: If it helps, makers can change the language of the TinkerCAD web page in the lower right-hand side of the homepage.

II. Design and 3D Print a Name Tag!

Stuff:

- ☐ A computer of some kind for each maker (Chromebooks work great)
- ☐ Internet connection for all computers
- ☐ Computer/Projector for yourself
- ☐ Flash drive to collect project files on & a way to 3D print (if possible)

Do it!

(15 minutes before) **Setup**: Ensure all computers are ready to go, and connected to the internet.

(5 minutes) **Snacks and Opener**: Remember When?
Pass out snacks, have makers partner up.

1. Pick one person to be Partner A. The other is Partner B.
2. Partner A begins with "Remember when..." and then states the beginning of a (fake and silly) shared memory (e.g. "...we drove to Mount Hood?").
3. Partner B builds on the memory with "Yeah, and then..." (e.g. "those penguins went snowboarding with us?").
4. Partners continue adding on to their "memory" until they're satisfied!

(2 minutes) **Introduction**: "Today, we'll be designing personal name tags with Tinkercad. If your nametag is finished today, I'll 3D print it for you and you'll get it soon!"
Split the makers up into groups of two, have each person get a computer.

(35 minutes) **Design a name tag**: Have makers sign into their tinkercad accounts; remind them of their login info. (You may want to display it on-screen.)
Example:
Username: jacobfdryhollow1920
Password: maker1920
On the projector, walk them through starting their own name tag project. Have them click on the search button (Magnifying glass in the upper right), then type "cgstemhub". The first result should be called "Name Tag #CGSTEMHUB". Have them click on that and click "Copy and Tinker." They now have their own copy of it, and can modify it as they want.
Instruct them to create a personal name tag using the template. Play music to taste.

When makers are finished with the name tag, allow them to do free design.

(15 minutes) **Gather designs**: Once the time is up, instruct makers on how to download their name tag designs:

1. Have them rename the design by double clicking the name at the top left, and naming it after themselves.
2. Have them select the actual name tag shape (or delete the extra letters).
3. Have them click on the "Export" button in the upper left toolbar.
4. Have them select the ".stl" option, and the file should download.

Once this is finished, collect all the files on the flash drive.

Tip: You can have makers play some simple game while waiting after you've retrieved the file from their computer.

(10 minutes) **Cleanup**:
If you are working with a partner to print the 3D designs, email the files or upload them to Google Drive to share with the printing entity.
Have makers put away all computers, if necessary.

Adaptations:

For Younger makers: Unless you're working with a particularly tech-savvy group, this lesson is not well suited for makers younger than 3rd grade.
For English Language makers: If it's helpful, change the website language by changing the settings in the lower right-hand side of the homepage.
For An Extra Challenge: Challenge makers to create cutouts in their keychain (rather than just adding shapes) or to change the keychain's overall dimensions.

IV. Model a Cool Thing

Stuff:

- ☐ A computer of some kind for each maker (Chromebooks work great)
- ☐ Internet connection for all computers
- ☐ Computer/projector for yourself

Do it!

(15 minutes before) **Setup**: Ensure all computers are ready to go and connected to the internet. If you were able to print them, set the Makers' 3D printed name tags out.

(10 minutes) **Opener**: Name Tag*

1. Circle up shoulder to shoulder.
2. One person volunteers to be "it" and steps into the middle of the circle.
3. Someone calls out the name of someone else in the circle.
4. The person whose name was called must call someone else's name before the person in the middle tags them!
5. If the person in the middle tags them before they can call another name, they switch places, and the person in the middle calls a new name.

(5 minutes) **Introduction**: "Today, you get to model your own thing on Tinkercad!" Split groups into pairs. Makers grab computers. They will sit with partners, but each maker does their own model. This will basically be a nice long modeling session.
Tip: if you think your makers will need more direction, have them design something for a friend or family member, thinking about what that person likes. Have them sketch the item in the back of their notebook before they begin.

(30 minutes) **Model**: Makers will model whatever they want in Tinkercad. Set a timer for 30 minutes, and play light music to taste. As makers finish, gather their designs on a flash drive. Afterwards, they may continue with free-design until time is up. When time is up, everyone cleans up.

(5 min): **Cleanup**: save files to a flash drive or the cloud if you are planning to print them.
Note: Many maker's models won't print successfully, since 3D printers have limitations that makers won't be aware of. It may be best not to print these ones.
Logout and return computers to their storage location, if necessary.

(10 min) **Discussion/reflection**: "Today was your last day working with TinkerCAD here. But, you have an account now so you can do it at home or at the library.

- What surprised you about 3D Computer-Aided Design?
- How was the process on the computer similar to blueprinting on paper?
- How was it different?
- Why do you think people moved from creating designs on paper in the past to computer aided designs now?

Adaptations:
See adaptations notes from the previous lesson.

*From the Stoke Deck, by the Stanford d.school.

Unit 6: Aeronautics

This short unit consists of two aeronautics-related lesson plans to help makers learn about the science of flight.

I. Paper Airplanes[NGSS]	
Summary: Makers build and fly paper airplanes, to experience how things move through the air.	**Ideal Grades**: 2nd-8th
II. Parachutes[NGSS]	
Summary: Makers design and build parachutes for plastic animals, and learn about air resistance.	**Ideal Grades**: 2nd-8th

NGSS Alignment
K-2-ETS1 Engineering Design Performance Expectations: Asking Questions and Defining Problems (K-2-ETS1-1; 3-5-ETS1-1), Developing and Using Models (K-2-ETS1-2) Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (K-2-ETS1-1), ETS1.B: Developing Possible Solutions (K-2-ETS1-2), ETS1.C: Optimizing the Design Solution (K-2-ETS1-3) Crosscutting Concepts: Structure and Function (K-2-ETS1-2)
3-5-ETS1 Engineering Design Performance Expectations: Asking Questions and Defining Problems (3-5-ETS1-1) Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (3-5-ETS1-1), ETS1.B: Developing Possible Solutions (3-5-ETS1-2; 3-5-ETS1-3), ETS1.C: Optimizing the Design Solution (3-5-ETS1-3) Crosscutting Concepts: Influence of Engineering, Technology, and Science on Society and the Natural World (3-5-ETS1-1; 3-5-ETS1-2)

I. Paper Airplanes

Stuff:

- ☐ Prototyping kit: Paper, Scissors, Pencils, Paperclips, Tape
- ☐ A Tape measure (ideally more than 10 feet)
- ☐ Masking/Painter's tape
- ☐ **Video**: How to make Paper Airplanes that fly far and straight - Easy, Simple, Basic Plane by TOYS FUN and GAMES https://youtu.be/zwiZX5EYI7g
- ☐ Projector or large screen and computer (**NOT optional** for this lesson)
- ☐ Speaker + Fun/upbeat music playlist

Do it!

(15 minutes before) **Setup**: Set out the prototyping materials listed above, in an accessible place where makers will be able to reach them.

Set up a testing area: In a hallway, use masking tape to mark a testing area with a starting line, and marks in a line every 5ft up to 45 ft. If a hallway is not available, use whatever open area may work, and adapt the distances as needed.

(10 minutes) **Opener**: I'm a plane!

1. One person begins by saying "I'm a _____!" and picking something to fill the blank, e.g. "I'm a plane!" then begins acting it out.
2. Everyone else chooses to either say "Me too!" and act it out, or say "But I'm a _____ with a _____!" (eg "But I'm a plane with a rocket engine!")
3. Everyone continues to either say "Me too!" to new ideas, or add on to them ("But I'm a plane with a rocket engine and a bubble blower!")
4. Anyone can decide to start a new "thread" by going back to "I'm a ____!" with a different object, and everyone else can choose to follow them or continue adding to an old idea.

(10 minutes) **Introduction and Snacks**: Have makers each get a piece of paper, then partner up and sit down.
Pass out snacks, and introduce the plan: "*Today we'll be making paper airplanes! First, let's learn how to build the classic "Dart" paper airplane. We'll watch a video, and as we do, you can follow along and make the plane in the video.*

This is important! *When you make a fold, fold slowly, and carefully—make all the folds as lined up as possible. This will make your plane fly much better.*"

Play video, linked above. Tell makers to raise their hand during the video if they need it paused or have a question.

Explain the Distance Challenge: "*Once you're done testing your first plane, I'm going to give you a challenge: You must make another plane that reaches at least 30 feet.*

How might you make a plane that flies more than 30 feet?" (Get feedback, discuss briefly.)

(25 minutes) **Build/Test/Modify**: "*Your goal is to make a plane that flies at least 30 feet. You can make as many as you want to try.*" Allow makers to build their planes and test inside the classroom.

(5 minutes) **Cleanup**: Have makers keep their planes, but clean everything else up. Don't remove the distance markings in the testing area, though!

(5 minutes) **Final testing**: Have everyone go out into the hall, and test their planes. It works well to have two lines. Make sure everyone gets to go at least once.

(5 minutes) **Debrief/Closing**: "Modifying things is important. When you make something, you often don't get the best version you could have on the first try. As we saw today, even something as simple as a classic paper airplane can be modified, or changed. To make it better. This is something that is done all the time. For example, the first cars went only 20 miles per hour. But, through many different modifications, cars can now go 120 miles per hour or even more." Possible discussion questions:

- Can you think of some things you have modified to make them better? (projects for maker club, stories they wrote for class, etc.)
- Besides cars, can you think of some things that have probably gone through lots of rounds of improvement to get to where they are today?

→ This can lead to discussions about how a specific item was improved over time. Think about: phones, boats, clothing (materials), etc.

II. Parachutes

Stuff:

- ☐ Prototyping kit
- ☐ Recycled materials
- ☐ Plastic animals from supplemental tub
- ☐ Large screen or Projector + computer with internet
- ☐ **Video**: Playtime with Parachutes | Physics for Kids by SciShow Kids https://youtu.be/Ab_g5sLoXoY
- ☐ (Optional) Stepladder or small ladder

Do it!

(15 minutes before) **Setup**: Set everything from the Prototyping kit out so it's accessible. Open the recycled materials tub and place it somewhere nearby. Put the plastic animals nearby as well, so makers can grab them.

Set aside a plastic cow for yourself.

(10 minutes) **Opener**: Three-Headed expert*

1. Have 3 people volunteer to be the "Three-headed expert."
2. Pick two random things in the room (e.g. Skateboard and iPad).
3. The Three-Headed expert now shares their expertise on "Skateboard-iPads," with each "head" saying one word at a time.

Play a few rounds.

(10 minutes) **Snack and Introduction**: Pass out snacks, then as makers are eating, explain the activity.

"Today we're making parachutes! We've got some plastic animals that have decided they want to try skydiving, which is silly - but we'll pretend they've decided to hire us to design parachutes for them.

First, what is a parachute? (Get feedback from makers).
It's a thing designed to help slow something down—but it's often used by skydivers jumping out of airplanes. We're going to watch a video about how they work, so you can be better parachute designers.
→ Watch the video, linked above.

(Hold up the plastic cow) Now, imagine Bonnie the cow dropped a little too fast, and she broke her leg. Now a paramedic cow named Buttercup needs to come help her, but there's no way she can get there fast enough unless... (See if the makers will guess) she parachutes!

She can't help Bonnie if she breaks her leg, too—so your challenge today is to design a safe, slow parachute so Buttercup can get to Bonnie. We'll know it's a successful parachute if it

noticeably improves how slowly the animal falls. Before you design, you'll need to test dropping your animal without a parachute."
→ Show a demo of dropping an animal without a parachute.

Set Bonnie aside in a safe place; we'll use her in later lessons.

Have the makers partner up into groups of 2. Ensure they understand they are building parachutes for the plastic animals, and they can take 1 animal each.

(20 minutes) **Parachute Challenge**: Set a timer for 15 minutes, and play upbeat music. While makers are building their parachutes, encourage them to test frequently. During this time, you may want to do an image search for "Parachute" and display it on the screen/projector. While makers are testing, ask open-ended questions about how they might improve their parachute's performance or get it to behave differently.
At 12 minutes, warn everyone that they have 3 minutes left to finish their parachutes.

Once the timer is up, call a halt to building. Everyone gets to test their parachutes. If you have a stepladder or ladder, set it up, have makers line up behind it, and allow makers to take turns dropping their parachutes from it (or, if makers climbing on a ladder will be an issue, you could drop them instead). Allow them to evaluate how well theirs did, and encourage them to compare designs and think of ways they could improve theirs.

(10 minutes) **Cleanup**: makers may take their parachutes and animals home. Or, have makers disassemble parachutes so materials can be reused.

Optional debrief (if time allows):

- What are some design aspects that seemed to work well?
- Why do you think those worked well?
- What were some design choices that didn't work as well?
- What design criteria do you think real parachute designers have to consider besides making a parachute that works? Ex: make it sturdy but lightweight; can still work when wet; can fit on someone's back when packed; easy to operate.

Adaptations:

For An Extra Challenge: Restrict the supplies, for instance no plastic or no string. Have Makers try to design a parachute that takes as long as possible to fall.

Unit 7: Nautical

This short unit consists of two nautical-themed lessons.

I. Rafts and Houseboats[NGSS]	
Summary: Makers learn about buoyancy, then build rafts, and then build houses for the rafts.	**Ideal Grades**: 2nd-8th
II. Sailboats[NGSS]	
Summary: Makers build boats, then sails for the boats.	**Ideal Grades**: 2nd-8th

NGSS Alignment
K-2-ETS1 Engineering Design Performance Expectations: Asking Questions and Defining Problems (K-2-ETS1-1), Developing and Using Models (K-2-ETS1-2), , Analyzing and Interpreting Data (K-2-ETS1-3) Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (K-2-ETS1-1; 3-5-ETS1-1), ETS1.B: Developing Possible Solutions (K-2-ETS1-2), ETS1.C: Optimizing the Design Solution (K-2-ETS1-3) Crosscutting Concepts: Structure and Function (K-2-ETS1-2)
3-5-ETS1 Engineering Design Performance Expectations: Asking Questions and Defining Problems (3-5-ETS1-1) Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems (3-5-ETS1-1), ETS1.B: Developing Possible Solutions (3-5-ETS1-2; 3-5-ETS1-3), ETS1.C: Optimizing the Design Solution (3-5-ETS1-3) Crosscutting Concepts: Influence of Engineering, Technology, and Science on Society and the Natural World (3-5-ETS1-1; 3-5-ETS1-2)

I. Rafts and Houseboats

Stuff:

- ☐ Prototyping kit
- ☐ Recyclables
- ☐ Shallow plastic tub for testing rafts
- ☐ Old towels or rags to place under bin of water
- ☐ Plastic animals
- ☐ **Video**: Buoyancy: What Makes Something Float or Sink? by Kids Want to Know https://youtu.be/nMlXU97E-uQ
- ☐ **Maker Notebooks**: Raft types
- ☐ **Maker Notebooks**: Houseboat Examples
- ☐ Speaker + Fun/upbeat music playlist
- ☐ Computer and Projector/Screen

Do it!

(15 minutes before) **Setup**: Set all materials out so they are easy to get to.

Fill the plastic bin with a layer of shallow water, and set it on top of a towel somewhere the makers will be able to reach it easily. Set a few rags/towels nearby to dry rafts with.

Get Bonnie the plastic cow out from wherever she is stored.

(5 minutes) **Opener**: Fail Test*

1. Partner up.
2. First round: Each pair counts to 3 repeatedly, switching off saying each number. “1,” 2,” ”3,” “1,” … Go as fast as you can!
3. Whenever a group fails/messes up, they must celebrate by waving their arms in the air and cheering really loud.
4. Round 2: Same as before but replace the “1”s with claps.
5. Round 3: Same as before but replace 2s with snaps.
6. Round 4: Same as before but replace 3s with stomps.

Note: Demo the game with an assistant or willing maker while explaining the rules.

(5 minutes) **Introduction**: Pass out plastic animals, 1 per maker. “Remember Bonnie the cow? She and her friends are tired of the farm, and they want to live on a houseboat—so they hired you to design them! There are lots of variations on boat designs, but the simplest is a raft. Can anyone describe a raft for me? (Get feedback).
It’s just a flat, squarish boat that floats on top of the water—that’s the kind of boat we’ll make. We’ll build the rafts first, and then add the houses on top of them.
“Before we make our rafts, we need to learn how things float. Can you tell me what might be the reason something floats or not?”

(Answer will likely have to do with the object being light)

"What about a giant cruise ship? That's really heavy, but it still floats. Let's watch a video to find out why..." **Show video** linked above.
"So, why do things really float?" (Get feedback.)

Explain, if needed: "*Density is the amount of mass, or stuff in an object. Things that are denser feel heavier than something the same size that is less dense. For instance, a regular egg is more dense than a plastic Easter egg. A sandwich is more dense than a sponge. When the density of an object is less than the density of the water it displaces—the object floats. When the object has more density than the water it displaces, the object sinks.*"
(Could explain "displaces" as the water that's pushed out of the way.)
Note: If possible, draw a sketch on the board to help illustrate a boat displacing the water.

Now we're ready to make our rafts. You have 20 minutes, and you can use anything in the Prototyping Kit, with one rule - you can't use a paper cup or bowl for your boat. If you use paper or cardboard, remember to make it waterproof somehow!

Once you finish the raft, build a house or shelter on top for your plastic animal. You get one each."

Point out the tub full of water so makers know where to test. "Ok, Go!"

When finished, do an image search for "river raft -game -whitewater" and display images for inspiration.

(30 minutes) **Main activity**: Set a timer for 20 minutes, and play music. Encourage makers to test often, and ask open-ended questions to encourage thought in new directions. Warn them when there are 10 minutes left.

(10 minutes) **Cleanup**: Makers can take their animals and houseboats home. Dry the water tub, and put it back for use next time.

Adaptations:

For Younger makers: Before building, have a discussion about what could be used to make a raft that floats. If time allows, have stations where makers can test out different materials.

*From the Stoke Deck

II. Sailboats

Stuff:

- ☐ Prototyping kit
- ☐ Recyclables
- ☐ Pan/Tub for water container
- ☐ A few Towels and/or rags to dry off boats and dry up water
- ☐ Plastic animals from last session
- ☐ Speaker + Fun/upbeat music playlist
- ☐ **Maker Notebooks**: Boat examples
- ☐ **Maker Notebooks**: Sail examples
- ☐ (Optional) Large screen/Projector + Computer with internet

Do it!

(15 minutes before) **Setup**: Set all materials out so they are easy to get to.

Fill the water tub, and set it on top of a towel somewhere the makers will be able to reach it easily.

Get out Bonnie, the plastic cow from wherever she was stored.

(5 minutes) **Opener**: Yes, Let's!*

1. Someone yells out an offer to the group (e.g. "Let's be baby birds!" or "Let's act like we don't understand gravity!").
2. Everyone replies with a shout of "Yes, let's!" and then acts out the suggestion.
3. Anyone yells out the next offer at any time!

(10 minutes) **Snack and Introduction**: Pass out snacks and Maker Notebooks. "*This time, Bonnie wants to try sailing a boat. So we're making boats, and then sails for the boats. This time, you don't have to make a raft! Your Maker Notebooks have several different types of boat you can try.*"

Have makers look at "Boat examples" in their Maker Notebooks. Have them identify the **hull**, **stern**, and **bow** on each picture. Help as needed. Discuss some of the questions at the bottom of the guide.

"*To make the boats move, we'll need sails. What is a sail?*"
(Get feedback. It's just something designed to catch the wind and move something - usually on a mast or pole, and often made out of fabric or similar material)

"*You might want to just put a huge sail to catch all the wind - but remember—it can't be so heavy it tips the boat over! Remember also that you need to make both the boats and the sails waterproof!*"

Have makers look at “Sail examples.” Have them guess which way the wind is blowing in each picture.
Discuss some of the questions at the bottom of the guide.

“Now we’re ready to make sailboats. You each get a plastic animal to make the boat for, and you have 30 minutes. Go!”

(30 minutes) **Main activity**: Set a timer for 30 minutes, and play music. Encourage makers to test often, and ask open-ended questions to encourage thought in new directions. Warn them when there are 10 minutes left.

(10 minutes) **Cleanup**: Have makers clean up, and throw garbage (but not usable supplies!) away.
Dry the water container, and put it away. Makers can take their sailboats home.

Adaptations:

For Younger Makers: Make the activity more guided, building the boat together and adding sails together. Or, prepare components ahead of time and let makers use them to build independently.

*From the Stoke Deck

Unit 8: Cardboard Arcade

A final 4-day project that can incorporate everything they've learned to this point.

I. Cardboard Arcade 1	
Summary: Introduction to the arcade project. Makers learn about arcade games, brainstorm, and blueprint.	**Ideal Grades**: 2nd-8th
II. Cardboard Arcade 2	
Summary: Makers begin building their arcade game.	**Ideal Grades**: 2nd-8th
III. Cardboard Arcade 3	
Summary: Day 2 of building. (Note: may need a 3rd day).	**Ideal Grades**: 2nd-8th
IV. Cardboard Arcade 4	
Summary: Game day (showing off!) the arcade games and debriefing the project.	**Ideal Grades**: 2nd-8th

I. Cardboard Arcade 1

Stuff:

- ☐ Prototyping kit (both bins) - maybe, depending on timing
- ☐ Supplementary Supplies
- ☐ Hot glue guns, glue sticks
- ☐ Scissors and Cardboard Cutters
- ☐ **Maker Notebooks**: Cardboard Arcade
- ☐ **Video**: Caine's Arcade (YouTube)
  https://youtu.be/faIFNkdq96U

Do it!

Prepare for the final session: If possible, plan to invite families of makers to come on the final day (15-20 minutes after the session starts) to play the arcade games. If it's not against your school policies, you may invite them to bring snacks to create an "end-of-year party" atmosphere.

(15 minutes before) **Setup**: Set all materials out so they are easy to get to. Set the Supplemental supplies bin out, but don't open it.

Set the hot glue station up, with a piece of cardboard beneath each glue gun.

(15 minutes) **Introduction**: Have makers sit down, facing your large screen or projector.

"For the last 4 sessions, we're going to do a really fun, big project. But first, we should watch a video..." Play video, linked above.

"What did you think of that?" Get feedback from makers. *"Guess what we're going to do?"* (Make our own cardboard arcade.)

"Here's the plan. On the last day, we're going to have a game day, where everyone gets to play the arcade games. But before that, we need to make them. So, listen closely to the plan."

(If you'll be able to invite families, tell the makers that their families will come to play the games, too. This will give them extra motivation to finish and make a nice game.)

"We'll have about two full days for building. It will be hard to make your arcade in two days, but you all can do it. Since this is a big project, I'm going to have you split into groups of three to four people. You'll need to decide on the game you're making, blueprint it, prototype it, test it, and do those again and again till it works.

Today, we'll decide what games we're making, and create blueprints for them.

There are a few guidelines I'm going to set in place to make it work better:

- *No prizes or tickets for your game. The game needs to be fun without them.*

- *Your game needs to be tested a bunch. It has to work when people play it!*
- *You need to have a good blueprint to make your game. Otherwise, it will be hard to make it properly.*
- *Finally, you may not look up ideas on Google. This is your chance to make something you thought of!*

Ok! Go ahead and form groups of 3-4 people. If anyone is left out, I'll volunteer a group for them to join. Once you've formed your groups, you can start brainstorming ideas for your arcade game. When that's done, you should start blueprinting.

One more thing—You are allowed to use materials from the supplemental supplies, like LEDs, Motors, and anything that's left—BUT you must include a clear plan in your blueprint of how you will use it in your arcade."

(40 minutes) **Brainstorming and Blueprinting**: *"Now, begin brainstorming. You might start by writing down as many arcade games as you can think of."*
Set a timer for 40 minutes, and display it on a large screen or projector. Play quieter background music.

Warn makers at 15, 10, and 5 minutes.

Help groups to brainstorm fairly; ensure all makers get to share their ideas. Encourage them to decide quickly, so they can begin brainstorming.

Blueprinting: When a group finishes their blueprint, have them bring it to you for approval. Make sure it shows a clear idea of a game, and that you can understand it without much explanation from the group. If not, send them back until it's clear and understandable. Ensure it also contains specific measurements to show how big it will be, the size of holes, lengths of sides, and so on. It should be possible for someone to build their game without having to guess anything.

(You can give makers some leeway on this—the intent is to make sure they have their arcade planned out well, and will be able to split the work between individuals in the group.)

Building: Once groups' blueprints have been approved, they may begin building, if there are more than 10 minutes left. Help them work together smoothly, and remind them not to take a bunch of materials they don't need yet.

(5 minutes) **Cleanup**: Have makers clean things up, put all supplies away, and store anything they've built in a safe place. Especially for these activities, remind makers that they are not finished cleaning up until **everything** is clean.

Adaptations:

For Younger learners: You may want to have a menu of game ideas available, such as: foosball/soccer; claw machine, ball throw, etc.

For An Extra Challenge: This project lends itself well to self-differentiation. If a group does seem to be designing something too simple (or too complex) for their capacity, make sure to redirect as needed.

II. Cardboard Arcade 2

Stuff:

- ☐ Prototyping kit (both bins)
- ☐ Supplementary Supplies
- ☐ Hot glue guns, glue sticks
- ☐ Scissors and Cardboard Cutters
- ☐ **Maker Notebooks**: Cardboard Arcade

Do it!

(15 minutes before) **Setup**: Set all materials out so they are easy to get to, including the supplemental supplies.

Set the hot glue station up, with a piece of cardboard beneath each glue gun.

(5 minutes) **Introduction**: "*This is the first build day for our cardboard arcades. Today, you'll start (or continue) the arcade you blueprinted last time. Remember that we only have one more build day after this—so you want to be more than half done today.*

Remember to look at the cardboard attachment sheets on the back of your Notebook!

You get 45 minutes of building today and tomorrow. To make that work, I need you to promise me that you'll drop everything when time is up, and clean up as fast and as well as possible. Can you do that?" Get verbal confirmation from makers. "*Great. Let's start, then!*"

(45 minutes) **Prototyping**: Set a timer for 45 minutes, and display it on the large screen or projector. Play upbeat music.

As makers build, remind them to test parts of their game to ensure it's playable. Remind them that it has to be easy for the player, e.g. a ball that's tossed must return to the player.

Warn at 20 minutes, 15, 10, and 5.

(10 minutes) **Cleanup**: When time is up, call everything to a halt. Makers must put their arcades in a safe place, put supplies back away, and throw away what can't be reused. Remind them to keep cleaning until **everything** has been cleaned up.

III. Cardboard Arcade 3

Stuff:

- ☐ Prototyping kit (both bins)
- ☐ Supplementary Supplies
- ☐ Hot glue guns, glue sticks
- ☐ Scissors and Cardboard Cutters
- ☐ **Maker Notebooks**: Cardboard Arcade

Do it!

Note: to have enough time to complete games, you may need to do two days of work time (i.e. two days with this lesson plan). But, a drawback of spending more time is that makers may lose interest after spending a month on the project.

(15 minutes before) **Setup**: Set all materials out so they are easy to get to, including the supplemental supplies.

Set the hot glue station up, with a piece of cardboard beneath each glue gun.

(1 minute) **Introduction**:
On building days: "*Today you're going to continue to build your arcade game. Make sure to use your tools safely and ask for help if you need anything.*"

On your last building day: "*This is the last build day for our cardboard arcades. Today, you'll finish your arcade. Remember that you need to have a finished arcade by the end of today! Ready? Go!*"

(49 minutes) **Prototyping**: Set a timer for 49 minutes, and display it on the large screen or projector. Play upbeat music.

Heavily encourage makers to test frequently to ensure their game is playable and easy for players who don't know how the game works. You may ask them if you can play it, and then comment on ways you think it could be easier to play. Warn at 20 minutes, 15, 10, and 5.

(10 minutes) **Cleanup**: When time is up, call everything to a halt. Makers must put their arcades in a safe place, put supplies back away, and throw away what can't be reused. Ensure everyone keeps cleaning until everything is cleaned up!

IV. Cardboard Arcade 4 & Maker Club Celebration

Stuff:

- ☐ **Maker Notebooks**: Cardboard Arcade
- ☐ (If possible) other kids or families of Maker Club students to play the games.
- ☐ Sticky notes, pencils

Do it!

(A week before) **Invite families, other students at school**: If possible, invite families of Makers to come and play their arcade games. Have them arrive 15 minutes after the session starts, so makers have time to set up. If possible with your school's policies, invite families to bring food and snacks to create an "end-of-year party" atmosphere. Have them expect a 30-minute event, and an additional 15 minutes where makers will reflect and parents can watch (but be quiet). Consider also showing off projects from the whole year of Maker Club.

(15 minutes before) **Setup**: Set up your room so the arcades can be set up and easily accessed.

(1 minute) **Introduction**: "*Today, we're having an arcade day—we'll get to play each other's arcades, and then we'll reflect on what we did.*" If you've invited parents or families over, remind makers that they will be showing up in 15 minutes.

(10 minutes) **Set up game day**: Have makers set up their arcades, and create "stations" for people to play at. Ensure everything is ready to go. At this point, parents and families should be arriving.

(20-30 minutes) **Game day**: Play upbeat music. Everyone can wander around the room, eating and playing games. Makers will run their own stations, helping families play the games and fixing them if things break.

(15 minutes) **Final reflection**: Have families sit down to the side. Have makers gather in a circle, and give them all sticky notes and pencils.

"*Now, we're going to reflect quickly on the Arcades, and then about Maker Club.*" Ask them these questions, and have them discuss for a minute, then answer as groups.

- What was easy about the arcades?
- What was hard about the arcades?
- What did you discover that you didn't know before?
- What was it like working with a team? What was hard and what was easy about working with a team?

When you finish with those questions, move on to Maker Club as a whole. "*Now, let's talk about Maker Club in general.*"

Hand out sticky notes. Ask them these questions, and have them write answers on sticky notes. After each question, have makers share out their answers.

- What did you like best about Maker Club?
- What didn't you like about Maker Club?
- What was the coolest thing you discovered in Maker Club?
- Do you feel like you're able to make things on your own?

(4 minutes) **Cleanup**: Have everyone clean up food, arcades, and so on. Arcades can be displayed at school, recycled, or given to a group member. (Have groups agree to do rock-paper-scissors to decide who gets the arcade, if you don't want to display them.)

Adaptations:

For English Language makers: Offer a chance to see reflection questions written down and to discuss in a group before asking for whole-group responses.

Extra Activities

Here are some additional activities, which can be used if you need to replace one of the planned activities, or fill up extra time in the school year.

DIY Operation Game 1	
Summary: Makers create their own version of the classic "Operation" game, while learning about circuits and continuity.	**Ideal Grades**: 4th-8th
DIY Operation Game 2	
Summary: Continuation of previous lesson.	**Ideal Grades**: 4th-8th
Introduction to 3D modeling	
Summary: Makers gain experience with the concepts of 3D modeling by creating something out of clay.	**Ideal Grades**: 3rd-8th

Special Supplies for Extra Activities:

DIY Operation game	☐ Alligator leads, 90 ☐ Metal Tweezers, 30 ☐ Active buzzers, 30 (Make sure the listing says they are active) ☐ AA battery, 30 ☐ AA battery holders, 30 ☐ File folders, 30	$100-$130
Introduction to 3D modeling	☐ Air dry clay, 5-10lbs	$15

Note: If you are receiving supplies from the Columbia Gorge STEM Hub and would like to do one of these activities, contact us about supplies—we may have some left over from last year.

Introduction to 3D Modeling

Stuff:

- ☐ Decoration materials for clay: Googly eyes, pompoms, foam pieces, pipe cleaners, skewers, toothpicks, paper clips, pipe cleaners, buttons, etc.
- ☐ Air dry clay
- ☐ Scrap paper (at least 1 side blank) and pencils
- ☐ Building from Blueprints sets (1 per maker), from Supplemental Materials
- ☐ Wipes to clean clay residue off desks

Do it!

(15 minutes before) **Setup**: Set all materials out on a table.

Get the bag of clay, but don't open it yet because it will start to dry. (You will split it into small portions for each Maker later on.)

(10 minutes) **Opener**: Make a Shape
Cut and tie some string into a ring large enough for everyone to hold a section of the string with both hands. (String is located in the General Prototyping Kit.) Everyone stands in a circle facing each other and holds a section of the ring string with both hands. Give the group a shape they must make (circle, triangle, etc.) The group attempts to coordinate their movements and then lay the string down on the floor with the shape as instructed. Repeat as desired. Encourage the group to discuss how they should move to make the shape, as they are coordinating movements.
Note: Split large groups (more than 10 makers) into two groups.
Adapted from http://www.leadershipgeeks.com/leadership-games/

(5 minutes) **Introduction and Snacks**:
Pass out snacks. (Makers can eat while doing the following activity, too.)
Explain the plan: Makers will think of a simple thing they want to make (small animal, Pokemon, flower, etc.), and draw it. Then, they model it in 3D with air-dry clay.

(15 minutes) **Draw a thing**: Makers get pencils/Sharpies and scrap paper, then pick a simple object/creature/thing they want to make. They must blueprint it from at least 2 sides, with measurements. Remind them that they can't make it very big, because they only get about a fist-sized portion of clay. They must bring their blueprint to you for approval before they can get clay.

(8 minutes) **Model a thing**: Makers can now use the clay to model the thing they blueprinted. They may also use other things from the Prototyping kit to decorate or work the clay. Markers don't work very well on wet clay, so discourage that. Play music to taste.

(12 minutes, if time allows) **Designer-builder challenge**: Pair up makers. Have them hide their clay creation and give their blueprints to their partner. Each maker tries to create the thing their partner designed. Set a timer for 10 minutes; warn when they have 2 minutes left. After 10 minutes, have makers get out their original creation and compare it with their partner's creation. If time allows, have a discussion about how well their blueprints guided the builders and how they could improve next time.

(10 minutes) **Cleanup**: Have makers clean up. You may want wipes to clean off the desks. Put all the models in a safe place to dry. (Air-dry clay will take up to 2 days to fully cure. Makers can take creations home once they are dried.)

Adaptations:

For Younger learners: Limit materials to keep the design simpler. Or, reverse the order of the activity and make the item first, then draw it from various perspectives (blueprint it).
For An Extra Challenge: For partner building, the makers could sit back to back and take turns describing in words how to build their thing. It will be much harder to guide each other to a matching design in words than with the blueprints.

DIY Operation Game 1

Stuff:

- ☐ Prototyping kit: Folders, markers, scissors, scotch tape, aluminum foil.
- ☐ Scrap paper (with at least one side blank)
- ☐ **Maker Notebooks**: DIY Operation Game
- ☐ **Game**: Operation (the actual game, if possible)
- ☐ **Video**: Hasbro Games - Operation Game - Electronic (If you don't have the actual game to show).
  https://youtu.be/mKUQEn35IdE

Do it!

(15 minutes before) **Setup**: Set all the materials, and the Maker Notebooks out on a table.

(5 minutes) **Opener**: Soundball*

1. Circle up.
2. Start by making a sound and throwing the ball to someone who is not next to you.
3. That person catches it and makes the same sound, then makes a new sound and throws it to someone else.
4. This goes on until everyone has had the ball thrown to them.

(Nobody can have the ball twice.)

(5 minutes) **Introduction and Snacks**: Pass out snacks. "*How many of you have played the game Operation?*"

If you have the actual game, demonstrate it.
If you don't have the actual game, show the video linked above.

"*Guess what we're making today? Our own Operation Games!*

Today we're going to make the actual box and the drawing on top. You can draw something other than a person, if you want—as long as it's appropriate: an animal, Pokemon, plant, some creature, or whatever else. You'll follow the guides up to the point where you start making the circuit. We have lots of time, so make your box look cool!
Finally, here's a tip for making the game: The larger the drawing, the more holes you can put in it! Also, the smaller the holes, the harder the game is. Don't make them too small!"

(40 minutes) **Box building**: Set a timer for 40 minutes, and play music. Help makers (as needed) to follow the instructions. Ensure makers are creating appropriate drawings, and help them think of ideas if they are stuck. Warn them when there are 5 minutes left.

(10 minutes) **Cleanup**. Ensure makers put all unused materials away. Gather the boxes for use next time.

Adaptations:
For Younger learners: Make the activity more guided, or at least partner makers to support each other. Note that fine motor skills need to be pretty strong for this activity. **For English Language makers:** The guide is somewhat text heavy. Most makers (including native English speakers) will likely rely more on the photos than the text. Do partner makers up so they can support each other and troubleshoot together. **For An Extra Challenge:** Most makers will naturally create their game to be as complicated as they like. Thus, this adapts well to those who need an extra challenge.

DIY Operation Game 2

Stuff:

- ☐ Operation game parts: Alligator leads, AA batteries, AA battery holders, buzzers, tweezers.
- ☐ Scotch tape
- ☐ Scrap paper (with at least one side blank)
- ☐ **Maker Notebooks**: DIY Operation Game (reuse from last time)

Do it!

(15 minutes before) **Setup**: Set all the materials, and the Maker Notebooks, out on a table.

(5 minutes) **Introduction and Snacks**: Pass out snacks. "*Today, we're going to be making the electrical buzzer circuit for the operation game! Do you remember one of the most important things about electricity in a circuit?*"
Get feedback: Answer is "It goes in a loop." (Or something like that.)

"*Remember, for an electrical circuit to work, the electricity needs to be able to go all the way around the loop. In the Operation game, what do you think is happening when you touch the side of a hole?*" Get feedback: Answer is "the circuit is being completed."
"*That's what happens when you touch the side of the holes—the circuit, or loop, gets completed, and electricity flows around and through the buzzer.*"

"*As with all electrical circuits, this one has to be put together in just the right way, so make sure to read all the instructions carefully! If it's not working, reread the instructions to figure it out.*"

(40 minutes) **Circuit building**: Set a timer for 40 minutes, and play music. Help makers (as needed) to follow the instructions. Warn them when 5 minutes remain.

(10 minutes) **Cleanup**. Ensure makers put all unused materials away. makers take Operation Games home.

Adaptations:

See adaptations from the previous day.

Extra Icebreakers

These are a great way to break up ice and get makers excited, as well as bring them together so you can introduce the day's activity. In addition, they are good for extra time or breaks.

Fail Test*

1. Partner up.
2. First round: Each pair counts to 3 repeatedly, switching off saying each number. Person 1: "1!" Person 2: "2!" Person 1: "3!" Person 2: "1!" Go as fast as you can!
3. Whenever a group fails/messes up, they must celebrate by waving their arms in the air and cheering excitedly. (Encourage this!)
4. Round 2: Same as before but replace the 1s with claps.
5. Round 3: Same as before but replace 2s with snaps.
6. Round 4: Same as before but replace 3s with stomps.

I'm a plane!

1. One person begins by saying "I'm a _____!" and picking something to fill the blank, e.g. "I'm a plane!" then begins acting it out.
2. Everyone else can either choose to say "Me too!" and act it out, or say "But I'm a _____ with a _____!" (e.g. "But I'm a plane with a rocket engine!")
3. Everyone continues to either say "Me too!" to new ideas, or add on to them ("But I'm a plane with a rocket engine and a bubble blower!")
4. Anyone can decide to start a new "thread" by going back to "I'm a ____!" with a different object, and everyone else can choose to follow them or continue adding to an old idea.

Encourage people to start with something simple and recognizable, so it will be easy to build onto.

Misnamer*

1. Have makers partner up.
2. Taking turns, makers will point at something and call it anything BUT what it actually is (e.g. point at an eraser and say "look, a pizza!").
3. The more imaginative, the better!
4. After a minute or two, have makers switch partners and repeat.

Common Categories

1. Pick a category: Eye color, type of shoe they're wearing, favorite season, favorite sport, etc.
2. You announce the category, and everyone must get into groups based on the category. Talking is fine, but no yelling. Or, make it harder and require NO talking.
3. Once groups are formed, have each group announce what they are (e.g. Shoe type: flip flops)

(Can add or skip rounds, depending on group dynamic).

Rock Paper Scissors war*

1. Partner up.
2. Play rock-paper-scissors.
3. Winner moves on to challenge another winner; loser becomes the winner's biggest fan. They go with the winner and must cheer as loudly as they can for them in subsequent rounds.
4. Continue until you have half the group on each side for the final match!

Tip: agree on rules of rock-paper-scissors before you start! For instance, shoot or no shoot?

Animal Sounds

1. Tell everyone to choose an animal that they're going to pretend to be.
2. Without talking, the whole group will start making their animal sounds.
3. Everyone must get together with the other animals of the same species.
4. Time it, and if you have time, challenge the makers to do it again with different animals, and faster.

Remember, no talking is allowed while the makers are grouping together!

Lemonade*

1. Gather in a circle.
2. First person states a "lemon" - a bummer about their day or week (e.g. "I spilled coffee on my pants this morning").
3. The next person turns that into a "lemonade" by looking on the bright side (e.g. "But now you have a great new pattern on your pants!").
4. The next person states a new "lemon," and the cycle continues around the circle.

Encourage people not to start with "at least..."
You'll need to keep this fast-paced to fit within 5-10 minutes.

Soundball*

1. Everyone circles up.
2. Someone starts by making a sound and throwing an imaginary ball to someone not next to them in the circle.
3. That person catches it and makes the same sound, then makes a new sound and throws it to someone else.
4. This goes on until everyone has had the ball thrown to them.

(It doesn't have to go around in order - just make sure nobody gets the ball thrown to them twice)

Crazy Creature*

1. Group splits into teams of 2.
2. They each get a marker and a piece of paper folded in half (hotdog or hamburger).
3. Then, each person draws part of a "creature" on one half of the paper.
4. They must draw lines onto a tiny bit of the other half so the next person can match their part up. The drawing is done without letting the partner see.

5. Once both people are done drawing, they unfold the paper and try to come up with a name for their creature.

One-Word Stories*

[You may want to give a short example before beginning]...

1. Everyone gathers in a circle.
2. Someone begins a story by saying one word.
3. The person next to them continues the story with another word.
4. Keep moving around the circle until the story feels complete, at which point everyone taps their fingers together and says, "yesyesyesyesyesyesyesyes...".

Explain that anyone can initiate the tapping if they feel the story is complete. If enough people agree, then it will restart. Play a few rounds until everyone is relaxed and giggly.

Gesture Name Game*

1. Circle up.
2. Each person says their name and does a motion or gesture of their choice.
3. The whole group repeats that one person's name and gesture/motion.
4. It continues with the next person around the circle until everyone has had a turn.

Die, category, die!*

1. Circle up.
2. Facilitator chooses a category (e.g. types of tree or cereal brands).
3. Go around the circle with each person naming something from the category (e.g. Maple or Trix).
4. When someone can't think of one or repeats one that's been said, everyone yells "Die, category, die!" and that person is out.
5. The "out" person chooses the next category, and play continues with the person next to them.

I bet you can't smile!

1. Circle up.
2. Choose one person to be it. They go to the center of the circle.
3. They must try to get someone to smile. They can make faces, sounds, and motions to try to get a smile, but not touch.
4. If any player smiles, they also become "it." The game continues until everyone has smiled, or you want to stop.

Yes! And...*

1. Partner up.
2. Introduce a theme (e.g. party or vacation planning).
3. Partner A suggests an idea within the theme.
4. Partner B builds on that idea, starting their sentence with "Yes! And..."
5. Partners continue to build off each other until time is up!

→ This can also be done in a circle, with 2-4 people in the middle doing the game OR everyone in the circle contributing to the story.

Alphabet*

1. Someone shouts out the letter “A.”
2. The group attempts to progress through the alphabet at random, one letter at a time, without the same letter being shouted at once.
3. If the same letter is shouted at once by multiple people, you start over at “A”!
4. See if you can get the whole alphabet! If that’s too easy, see how high you can get using numbers!

Tip: remind makers for the alphabet game not to look at each other for planning who will go next. And, they cannot simply go around the circle saying the next letter.

Accelerating Introductions*

1. Partner up.
2. Partners introduce themselves to each other in 2 minutes.
3. Pair up with another pair.
4. In 1 minute total, everyone introduces their partner to the group of 4.
5. Pair up with another quad.
6. In 30 seconds total, everyone introduces their partner to the group of 8.
7. Continue doubling the group size and halving the time until you have one big group and not enough time!

Story Swap*

1. Partner up.
2. Partner A tells Partner B a 30 second story about a recent experience of theirs.
3. Partner B retells Partner A’s story in first person back to Partner A in 30 seconds.
4. Partner B tells partner A a 30 second story about a recent experience of theirs.
5. Partner A retells Partner B’s story in first person but has 60 seconds - so they must embellish!

Three-headed Expert*

1. Identify three people to be your “three-headed expert.”
2. Identify two things in the room (e.g. skateboard and iPad).
3. The three-headed expert now shares their expertise on “skateboard-iPads” one word at a time!

Remember When?*

1. Partner up.
2. Partner A begins with “Remember when…” and then states the beginning of a (fake) shared memory (e.g. “…we drove to Mount Hood?”).
3. Partner B builds on the memory with “Yeah, and then…” (e.g. “…we rented snowboards?”). Partners continue adding on to their “memory” until they’re satisfied!

Awkward Silence*

1. Partner up.
2. Each pair stares into each other's eyes for 15 seconds.
3. Pairs now begin conversations (facilitator can choose topic), except they must wait 15 seconds before every response, during which they don't lose eye contact!

Drawing Director

1. Partner up. Each person grabs a piece of scratch paper and a writing implement.
2. Partners sit back to back.
3. One person (designer) takes 30 seconds to draw a simple picture.
4. Designer then describes to their partner (builder) how to draw the same thing, but without getting any hints about what it is! (Tip: you can tell the builder that it's OK to ask questions. Or, you can leave that tip out).
5. When the designer feels they are done explaining, partners compare drawings.
6. If time allows, switch roles.

Variation: This idea could also be used to mold with playdough, build with pipe cleaners, etc.

Robot Airplanes

1. This is similar to the drawing director. Make sure "robots" understand that they should take their programmer's instructions very literally.
2. Partner up. Each person grabs a piece of scratch paper.
3. One person is chosen as the robot and one as the programmer. Sit or stand back to back.
4. Programmer explains step by step how to make a paper airplane. Programmer may be making an airplane at the same time, but may NOT show the robot anything.
5. When the programmer thinks the task is complete, robot and programmer turn to face each other and compare their planes.

Optional: Discuss as a group what was hard about this task. Ask what was especially helpful.

Yes, Let's!*

1. Someone yells out an offer to the group (e.g. "Let's be baby birds!" or "Let's act like we don't understand gravity!").
2. Everyone replies with a shout of "Yes, let's!" and then acts out the suggestion.
3. Anyone yells out the next offer at any time!

Origin Story*

1. Partner up.
2. Each partner tells the (fake, silly) story of how they got their name.
3. Pairs can share stories with the group when time is up.

Detective

1. Circle up and choose a “detective” to stand in the middle of the circle. Explain the rest of the instructions:
2. Choose instigator: detective closes eyes; facilitator chooses one person from circle to be instigator.
3. With the detective's eyes still closed, the instigator begins a motion (snapping, touching nose, etc.). Everyone else in circle copies.
4. Detective opens their eyes. Their goal is to identify the instigator.
5. When the instigator doesn’t think the detective is looking, they change to a different motion. Everyone in circle copies. Repeat this until the instigator is discovered.

Tip: if it’s taking awhile to identify the instigator, the facilitator can start giving tips (“they have brown hair”).

Telephone

1. Arrange in a circle. One person is chosen as the caller.
2. The caller whispers a sentence in the ear of the person on their left and right.

Tip: depending on your group dynamic, you may need to give them a theme so that they don’t get tempted to say something inappropriate or mean. Example: “Tell us about your favorite Halloween Costume” or “What’s your favorite food and why?”

3. The person on the left passes the message to the left; the person on the right passes it to the right (all with whispers).
4. Once the message gets to the last two people, they say what they heard. It should be fun to see how much the message changed.
5. Repeat with a new caller and continue for as long as desired.

Rapid Fire Teams*

Everyone mingles and creates shared experiences with multiple partners in multiple rounds:

1. Make a secret handshake with your partner.
2. Make up a nickname for a new partner.
3. Make up a life motto together with a new partner (perhaps speaking one word at a time each?). Make up your own!
4. Optional: Everyone mingles afterward, until the facilitator says “Go find your nickname partner!” or “Go find your handshake partner!” and pairs share out their creations.

The Wind Blows*

1. Circle up with one person in the middle.
2. The person in the middle says “The wind blows for everyone who…” and then states something that is also true about him/herself (e.g. “for anyone wearing flip flops” or “for anyone who is an only child”).
3. Anyone to whom that statement pertains must find a new spot in the circle.
4. Whoever is left out is in the middle and goes next!

Convergence*

The goal of this activity is to converge on the same word after starting with two random, unrelated words.

1. Two people volunteer to start. They count down from 3 and then say one random word each.
2. The first two people who think of a word related to both previous words say “Got it!” and say their words simultaneously after counting down from 3.
3. Eventually, two people will say the same word, and the group has converged!

Note: this may be too tricky for some elementary-aged groups.

For sale!

1. Arrange in a circle with 3 people in the middle, or get into groups of 2-3.
2. One person starts out “Look at this great new invention, a_____” (“Light up dog collar” or “collapsable straw”.... (This starting point could be an actual or imaginary product).
3. Someone else shouts “yes, and _____” (EX: “it has built in doggie bags”)
4. Another adds on another great addition.
5. This continues until the invention is complete. Then one of the improvisers shouts “buy it today” and everyone applauds.
6. Begin again with new partners and a new product.

Never have I ever

5. Arrange in a circle, either standing or sitting (works slightly better). One person is in the middle. If using chairs, use one fewer than the total number of people.
6. Person in the middle says “Never have I ever_____” (“been to Mount Adams” or “eaten Thai food” etc). It should be something they haven’t actually done, but they think others have.
7. Everyone who has done that thing has to get up and find a new spot (including the person in the middle). The last person standing becomes the new announcer.
8. Repeat for as long as it is fun.

Have you...?

A slight twist on the previous game. Instead of saying things the person hasn’t done, they can say any idea regardless of if they’ve done it. Again, everyone who has done the thing would get up.

1. Example: “I have been to Dufur.”
2. Everyone who has been to Dufur would have to get up and find a new spot.
3. Last one standing would be the new announcer.

Shake Down*

Facilitator says:

1. Everyone stand up!
2. Shake out your right arm 8 times, counting down from 8.
3. Shake out your left arm 8 times, counting down from 8.
4. Shake out your right leg 8 times, counting down from 8.
5. Shake out your left leg 8 times, counting down from 8.
6. Repeat the progression for 7, then 6, then 5, 4, 3, 2, 1! (Or start at a lower number).

Yee-Haw!*

This is an elimination game built on the passing of motions and phrases around a circle. Introduce the motions/phrases one at a time, with a brief practice round after each.

1. Say “Yee-haw!” and swing your arm to point in the direction you’re passing.
2. Say “Reee-verse!” and pump your fist to send it back in the other direction.
3. Say “Hay barn!” and clap your hands over your head to skip the next person in the circle.
4. Say “Get down, little doggy!” and point to anyone in the circle to dance with them in the center while everyone claps a beat, then switch spots with them in the circle. The sender then continues with a “Yee-haw!”

If anyone messes up in any way, they’re out! They sit down on the floor and the circle does not compress. The last two people can have a “veggie-off” - the group identifies a vegetable and the final two compete to impersonate that vegetable best!

Note: might be a bit tricky for makers under 6th grade or with English-Language makers.

Blind Disco*

1. Everyone closes their eyes.
2. Facilitator plays a funky jam.
3. Everyone dances like nobody is watching - because no one is!

Name Tag*

1. Circle up (shoulder to shoulder!).
2. One person volunteers to be “it” and steps to the middle of the circle.
3. Someone calls out the name of someone else in the circle.
4. Person in the middle must tag the person whose name was called before that person says someone else’s name.
5. This continues until the “it” person tags someone before they can name someone else. When they do, they switch places.

* From the Stoke Deck, by Stanford d.school

Supplies

These instructions will help you gather and assemble all the supplies and tools you will need for a year of Maker Club.

The supplies for Maker Clubs are broken into two main parts: The Prototyping Kit and Supplementary Materials.

- The Prototyping Kit consists mostly of common craft/household items and recyclable materials.
- Supplementary Materials include specific materials needed for certain activities (such as batteries for LED flashlights).

To organize our kits, we use large (26 gallon) tubs. The prototyping materials are separated into smaller tubs and labeled; recyclable materials are loose in the other large tub. We use a smaller tub for the supplementary supplies, with containers to organize parts by activity or type. If you don't need the materials to be portable, you could also organize them on a shelf or cart, into drawers or smaller tubs.

Clockwise from top left: Recyclable materials for prototyping kit, prototyping materials, Supplementary Materials. The first two bins represent the "Prototyping Kit."

Prototyping kit:

Bin 1: Prototyping materials

- ☐ Popsicle sticks, 800-1000
- ☐ Straws, 500-800
- ☐ Twine/string, one large roll
- ☐ Construction paper, 1 pack
- ☐ Felt sheets, 1 pack of ~48
- ☐ Pipe cleaners/chenille stems, ~100-250
- ☐ Foil, one roll/pre-cut box
- ☐ Balloons, ~250
- ☐ Scotch tape, 10+ rolls w/dispensers
- ☐ Duct tape of assorted colors, 8-10 rolls, or 6-8 rolls of plain
- ☐ Washable markers, ~24
- ☐ Gluesticks, 6-10
- ☐ Pompoms, 500
- ☐ Rubber bands, 250-500
- ☐ Googly eyes, 50-100
- ☐ Buttons, ~100
- ☐ Hot glue sticks, 60-100
- ☐ Scrap fabric, if possible

Bin 2: Recyclable materials:

- ☐ Plastic bags, ~20-50
- ☐ Paper plates, ~20-50
- ☐ Paper bowls, ~20-50
- ☐ Paper cups, ~20-50
- ☐ Misc paper containers
- ☐ Plain cardboard sheets (As many as can be fit into the box)
- ☐ Cardboard tubes (toilet paper, paper towel rolls, etc.)
- ☐ Wax or parchment paper, one roll or box.
- ☐ Egg cartons
- ☐ Other fun recycled materials

Tools:

You may already have some of these tools in your classroom or space, in which case you don't need to get more. If you need to borrow/reserve some of the tools, try to do so a week in advance.

- ☐ Hot glue guns, 6-12
- ☐ Scissors, 10-20
- ☐ Two pairs of utility scissors
- ☐ Cardboard Cutters, 10-20

Tip: Cutting the cardboard can be a challenge and it happens often. At least some of the scissors should be on the more heavy-duty side; dollar store ones will not all last throughout the year. Cardboard cutters are not absolutely necessary, but are helpful; they're also much safer than box cutters and utility knives.

Supplementary supplies:

Activity	Supplies	Est. Cost
Spaghetti towers	☐ 1 bag each of spaghetti & standard marshmallows	$10
LED Flashlights	☐ 10MM LEDs, 30 ☐ CR2032 coin cell battery, 30 ☐ Copper tape, 4 rolls (5mm width, can reuse from Holiday Cards) ☐ Small Binder clips, 30 ☐ Colored Jumbo popsicle sticks, 30	$45
Bristlebots	☐ Mini vibration motors, 30 ☐ CR2032 coin cell batteries, 30 ☐ Double sided foam tape, 1 roll ☐ Toothbrush heads, 30	$45
Artbots	☐ Hobby motor, 30 ☐ AA battery, 30 ☐ AA battery holder, 30 ☐ Rocker switch (2 pin SPST), 30 (Aliexpress) ☐ Cork pieces, 30 ☐ Double sided foam tape, 1 roll ☐ Sturdy medium white paper cups, 30 ☐ Washable markers, 90	$58-78
Light up cards	☐ Copper tape, 4 rolls (5mm width) ☐ 3MM LEDs, 30 ☐ CR2032 coin cell batteries, 30	$35
Recycled marble run	☐ Marbles or bouncy balls, 30-60	$15
Sew a Creature (all)	☐ Sewing “sharps” needles, 30 ☐ Upholstery thread, 6-10 spools of different color ☐ 1+ pack of ~48 felt sheets (additional to P. kit)	$35
Parachutes, Houseboats, and Sailboats	☐ Plastic animals, 30-90	$15

Tips:

- Electronic parts are often much cheaper when ordered from a Chinese supplier, such as Aliexpress. If you order from China, order 2-3 months in advance; shipping takes a long time.
- The numbers listed are enough for exactly 30 makers—but we recommend no more than 20-25, so that you will have extra parts in case any parts break.

NGSS Alignment

The Design Thinking, Engineering, Nautical, and Aeronautical units include lessons that relate to Next Generation Science Standards. Specifically, performance expectations, science and engineering practices, disciplinary core ideas, and crosscutting concepts for K-2-ETS1 Engineering Design and 3-5-ETS1 Engineering Design are most relevant. The standards in grey are not addressed in any of these lessons.

K-2-ETS1 Engineering Design

Performance Expectations:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1)
- Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1)

Developing and Using Models

- Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2)

Analyzing and Interpreting Data

- Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)

Disciplinary Core Ideas:

ETS1.A: Defining and Delimiting Engineering Problems

- A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1)
- Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1
- Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)

ETS1.B: Developing Possible Solutions

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)

ETS1.C: Optimizing the Design Solution

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)

Crosscutting Concepts:

Structure and Function

- The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

3-5-ETS1 Engineering Design

Performance Expectations:

3-5-ETS1-1. Define a simple design problem reflecting on a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.*

Science and Engineering Practices:

Asking Questions and Defining Problems

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Planning and Carrying Out Investigations

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-EST1-3)

Constructing Explanations and Designing Solutions

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem (3-5-ETS1-2)*

Disciplinary Core Ideas:

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)*

ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)*

ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)*

Crosscutting Concepts:

Influence of Engineering, Technology, and Science on Society and the Natural World

- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

*These standards could be met (or better met) by having makers complete multiple designs or iterations and recording/reporting on observations.

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Jacob Field, Columbia Gorge STEM Hub Maker Work Study
Christy Christopher, Columbia Gorge STEM Hub Director
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