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Families Engineering Together in Communities and At Home: Facilitation Guide

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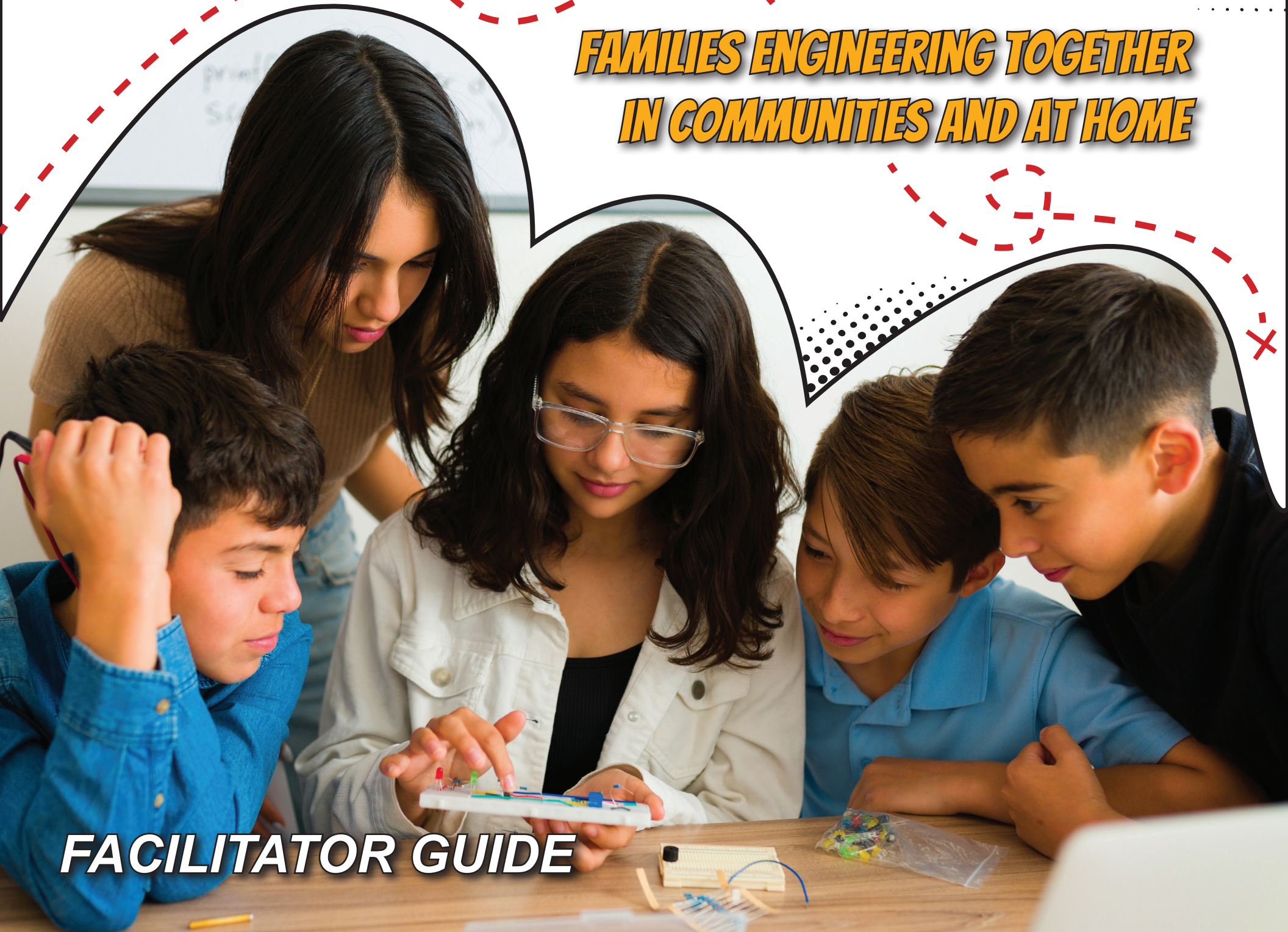
FAMILIES ENGINEERING TOGETHER IN COMMUNITIES AND AT HOME



FACILITATOR GUIDE

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PHILOSOPHY

VISION

This program serves as a bridge between families and learning environments of all kinds, and provides a pathway for engineering design to be incorporated into the everyday lives of families and kids. Supporting families in their home environment, the program offers a fun and approachable introduction to thinking about engineering and bringing these concepts to life. Conversation and engagement between children and caregivers is so important during elementary school years - this program encourages families to think about, discuss, and experience engineering in a fun and accessible way in their home and community environments.

Caregivers don't need any prior knowledge about engineering to support their children. Our vision is to have children and families understand that engineering is something everyone can do. Through learning about the various stages of engineering design, our aim is to demonstrate how families can use these practices and skills in all aspects of their lives.

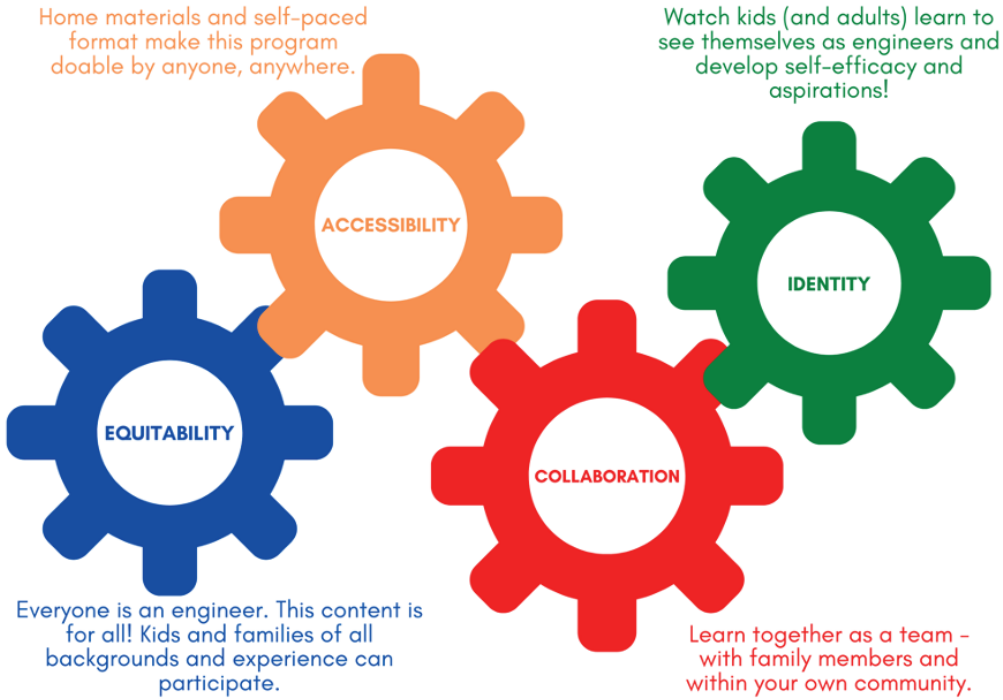
We believe that everyone does engineering - by creating solutions to problems in their environment. We also believe families can engage in the engineering design cycle together. This program is an opportunity to 'learn by doing' in an accessible, hands-on, and creative way while developing awareness of engineering practices and an identity as an engineer.

Many families already conduct a lot of engineering practices in their everyday life. Through this program, families will begin to see and know the engineering design cycle is everywhere they look. They will learn how to bring each part of the design cycle to life in everything they do!

Be sure to check out the ***SHARE*** page at the end of this facilitation guide. This page provides an opportunity for you to share how you've used this program. This may give other educators, caregivers, and community organizations ideas for how they might implement this work!

This vision is guided by four "gears" or concepts:

(A) EQUITABILITY
(B) ACCESSIBILITY
(C) COLLABORATION
(D) IDENTITY



MAKE IT YOUR OWN

We acknowledge that every community and organization is different and has unique needs. We encourage you to adapt the program to fit the unique elements of your community, as well as the cultural and environmental aspects that make your home, neighborhood, school, and/or community special. Co-creating a culturally-responsive program for families means actively listening to families and working with them to ensure the program builds on their prior knowledge, experiences, and culture.

One way we engaged in this was to ask families to focus on their home and/or community environment, encouraging questions such as ***'What needs to be fixed?'*** or ***'What could be changed to help a family member?'*** Framing kits and independent work in this way can help maintain focus and make the identification of a project or approach to building a kit project less intimidating.

You might also consider evaluating the economic and cultural landscape of your community and using the various cultures, industries, spaces and natural resources as inspiration for engineering challenges or tasks that families might engage in.

As an example, when implementing the program in Upstate New York, large organizations with engineering components and local industry ties (e.g., Chobani, Raymond Corp.) were solicited for partnership and inclusion in both mentorship/community engagement opportunities and as examples of ways that engineering is an integral part of the everyday lives of their neighbors and community members. Noting the engineering or STEM experiences that caregivers and children may have already been exposed to can also help guide how your version of the program evolves.

APPROACH

WHAT WERE THE PRINCIPLES THAT INFORMED OUR PROGRAM?

We present **EIGHT APPROACHES** that guided the development of our program. These approaches are based on our experiences, our cultural and historical biases and understandings of the field, research-based effective instructional approaches, and knowledge of the scholarship regarding family engagement.

1. CAREGIVERS AS PARTNERS AND CO-LEARNERS

Caregivers are critical partners in a child's education. We argue that caregivers are uniquely positioned to educate since they know their child(ren) - attitudes, interests, strengths and weaknesses, frustration points, personality, etc. - better than any other educator.

Our program invites caregivers and their children in grades 2-6 to engage in meaningful and fun engineering challenges. The program supports caregivers as co-learners and guides during the process such as including questions to be asked throughout the engineering design cycle. We encourage you to capitalize on the relationships and bonds that caregivers have with their child(ren) as learning does not happen in isolation. Creating a safe space for families to come together, make connections and have quality time is one of the most important aspects of engaging in these engineering activities.

CAREGIVER QUOTE

"The program afforded "a lot more collaborative learning, a lot more interactive learning, that took place on Saturday, and that also took place at home. And it changed our interactions, not only with the projects, but how we interact as a family, really intentionally spending time together and working on different tasks together."

FAMILY SPOTLIGHT

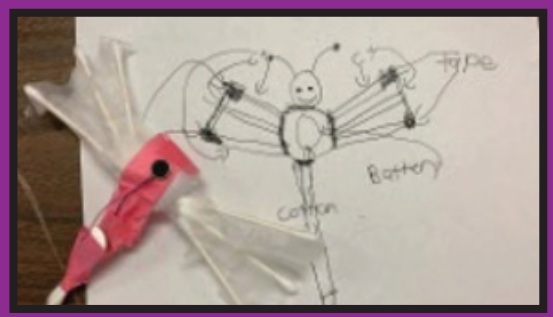
Kim (caregiver) and Mary (child) are from New York. This grandmother and granddaughter team worked together on numerous engineering challenges, including a family-oriented engineering problem. They brainstormed several ideas, finally landing on a mailbox messaging system for Mary's grandfather, who always enjoys collecting the mail. Through discussion, Kim and Mary planned an electronic signal system that would send a sound or light signal to a receiver inside their home when mail was delivered to their mailbox. Together, they began prototyping and testing receiver distances and mailbox sizes. They used the skills and processes learned through various engineering challenges of the program to inform their independent building process.

Kim reflected on her time with Mary in the program and said, "Well, she really impressed me with how quickly she learned and her quick thinking. I think I gained another insight into my granddaughter, who I always thought of as very bright and creative, but just to work together and problem solving, looking at our goal and then planning how we were going to attempt to achieve it, and the trial and error and modifications that we did together. Of course, she is so much quicker than I with computers, in general, just for the generational difference, but how quickly she picked up some of that programming that was relatively new to her. So I saw her grow in that area."

COMMUNITY SPOTLIGHT: THE RISE

The RISE is a residential community for families who are recovering from toxic relationships and environments. Caregivers and children have been exposed to mental health and financial issues, and expressed higher anxiety to external programs. Rather than inviting them out to a public place, we visited their building and contacted each family through the social worker who was directly working with them. One family moved from a shelter in a rural area to this center in a university town. Homeschooling and the center education programs were the only qualified programs they were able to attend.

For the first family STEM challenge, they designed a butterfly shaped watercolor bot. Children played with butterflies in a local shelter that inspired them to make a movable object. After the workshop, another engineering kit was provided for their home activity. Their dinner table changed into a making space. With the research staff's help, they registered for a LEGO program and summer STEM reading challenge in a local library.



2. DIMINISH BARRIERS TO ACCESS

Families Engineering meets families where they are - at home, in schools, and in the community. When working with school and community partners, we learned the benefits of working with a trusted individual, someone families can depend on and relate to. These components - location and trusted individuals - help diminish barriers of access such as transportation, fear of the unknown, and lack of trust. We encourage you to go where families are, build and maintain relationships with trusted individuals in your local schools and communities, and use schools and community organizations as a hub.

SCHOOL SOCIAL WORKER QUOTE:

"I also think that the fact that we already established a program that served the population that you were looking for, and having a link. I think that we already had something established, and then linking it together with the program was helpful for recruitment, because we were able to break a lot of barriers down."

3. CHILD-CENTERED APPROACH

The program models and promotes a child-centered approach that fosters interest-driven learning and agency. One way this is fostered is through engineering challenges and tasks that require hands-on, minds-open learning as families are afforded opportunities to take any number of approaches toward a functional prototype.

For example, in designing a prototype that will deliver an object at least 6 feet, we provided some general suggestions – a zipline, a wind-powered car, an airplane, a trebuchet, and a bird. But even in choosing one of these suggestions, families were not provided any guidance on the specifics of how the prototype should look or function.

This child-centered approach is exemplified in our **MAKEngineering Kits.**

Each kit has an engineering challenge and supports that are open-ended and allow for ideation, creativity, problem-solving, and collaboration among family members.

You can find information about these kits in the section **ENGINEERING KITS AND SELF-IDENTIFIED PROBLEM.**

TRENDY TENNIES KIT:

4. BLENDED LEARNING APPROACH

Engagement with families does not have to happen only in-person, but can include virtual meet-ups, posting photos in a shared online board (e.g., prototypes), and self-paced slide-decks or virtual guides for developing individual engineering projects.

For example, virtual meetings may provide families that live across a region with the opportunity to be part of an engineering family community, illustrate how their prototypes function, and get input from others in the group. A blended approach afforded our program a way to interact with families in their home environments.

This became part of our approach to meet the changing and evolving educational landscape many participating families experienced due to pandemic-related school closures, as well as family work schedule and issues accessing technology and learning resources As online and blended learning becomes more widely used, the flexibility that both in-person and virtual program implementation affords can ensure that a wide range of families and familial circumstances can be accommodated and included.

We acknowledge that this approach may not work well for all families as additional resources may be needed by families, such as tablets and hotspots, to have the best chances to participate. We encourage you to consider ways to engage and interact with families in-person, but also through synchronous and asynchronous online platforms.

As a resource for families, we created interactive slideshows to engage families during monthly virtual meet-ups, which we called:

SHOW-AND-TELLS

We utilized game formats such as **Bingo, Jeopardy, and Word Association**.

You can access and download a copy of the interactive slides at this below:

LINK TO SLIDES

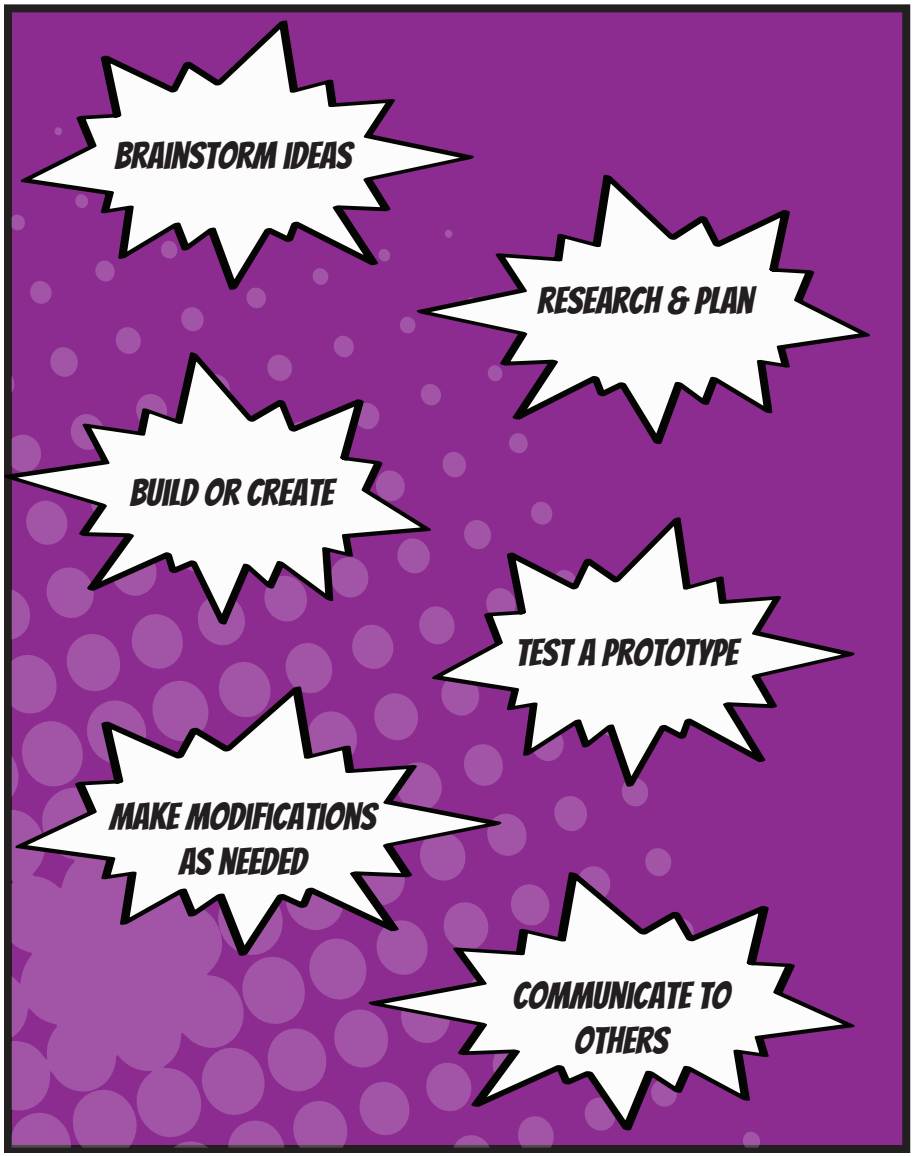
PARENT QUOTE ABOUT SHOW-AND-TELLS:

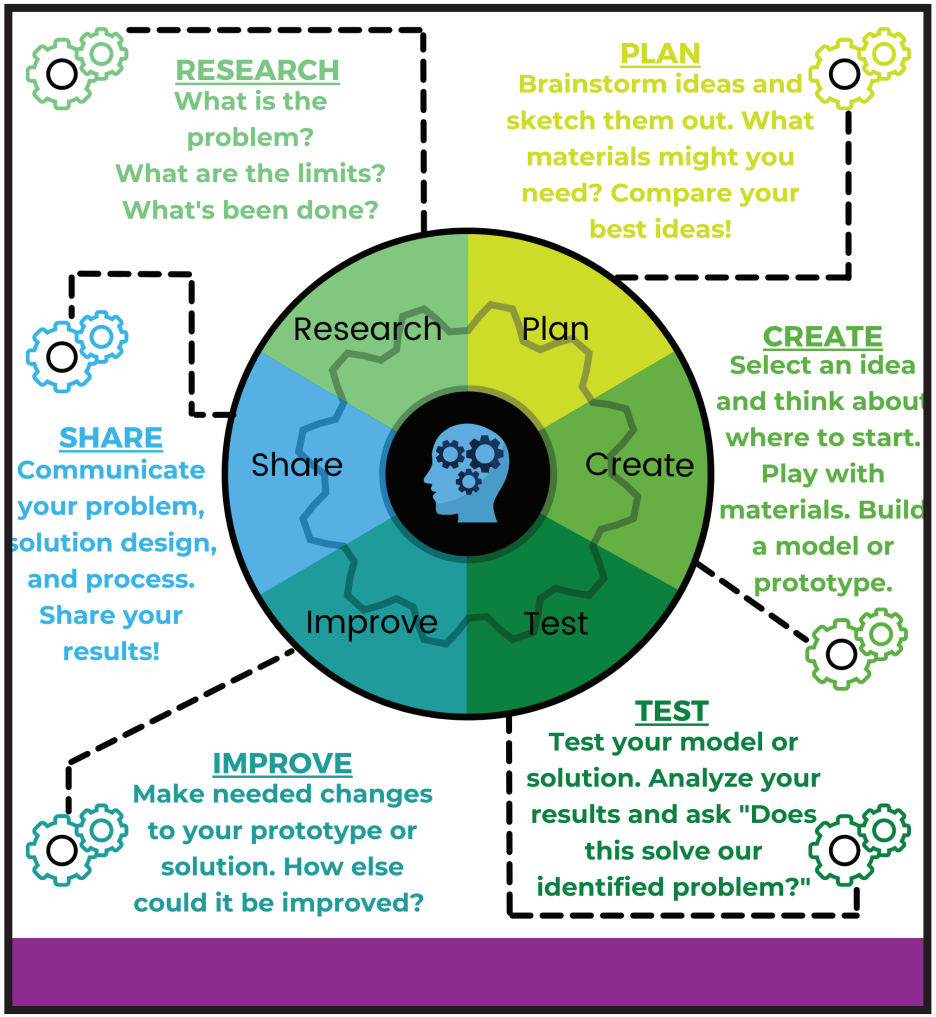
"And it was cool to see other families . . . everyone had a different approach to the same thing, which was cool. We didn't finish the roller coaster, so it was cool to see how everyone's looked completely different and they had a different idea. So that was really cool too."

5. ENGINEERING DESIGN / DESIGN THINKING

Our program was guided by and grounded in the engineering design cycle.

FAMILIES WORK TOGETHER TO:





The focus is on the collaborative process rather than the prototype or end product.

6. FOSTERING AN ENGINEERING MINDSET

Engineering is not only a set of skills, it's a mindset to approach life. This program gives children and caregivers an opportunity to think and act like an engineer. These are often embedded within the engineering design cycle. We provide a few engineering mindsets that guide our approach.

A. MAKING MISTAKES (AND EPIC FAILS) AND LEARNING FROM MISTAKES AND FAILURES TO SUPPORT PRODUCTIVE STRUGGLE.

B. THINKING OUTSIDE THE BOX (I.E., CREATIVITY AND INNOVATION) AND VISUALIZING MULTIPLE SOLUTIONS TO AN ENGINEERING TASK OR PROBLEM.

C. CONSIDERING THE NEEDS OF OTHERS - PEOPLE, ANIMALS, OR FICTIONAL CHARACTERS - WITHIN THE DESIGN.

D. INVESTIGATING, UNDERSTANDING, AND UTILIZING COMMON (E.G., TAPE, PIPE CLEANERS, COTTON BALLS) AND RECYCLABLE MATERIALS (E.G., CARDBOARD, PLASTIC BOTTLES) BASED ON THEIR PROPERTIES AND WHAT THEY CAN AFFORD WITHIN A PROTOTYPE.

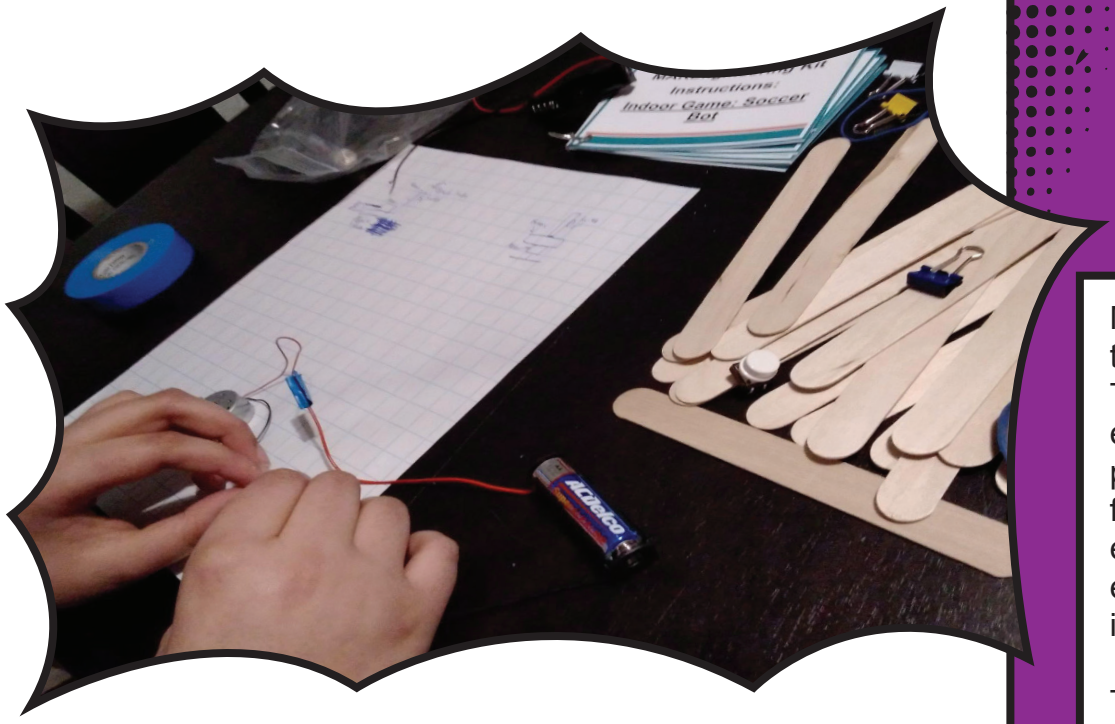
E. APPLYING MATHEMATICS AND SCIENCE CONCEPTS AND PRACTICES THROUGHOUT THE ENGINEERING DESIGN PROCESS.

CAREGIVER QUOTE

"I guess from my perspective...I feel like everything is an engineering idea now. I feel like it opened up her ways of thinking. Like she'll be clicking a pen and then five seconds later I look over and the pen will be apart and she'll be like, "Mom, look at this cool mechanism" or "what do you think of this?" And I think it helped her think of the world differently, so yeah, I could totally see her being an engineer now. I think veterinarian is out, engineer is in."

CAREGIVER QUOTE

"She started not just seeing the materials for what they were and what their practical uses were, but what they could become."



FAMILY SPOTLIGHT

Mother and daughter Angela (caregiver) and Annie (child) came to the program with no background in STEM or engineering. Together they enjoyed working on several of our at-home engineering challenges (the Soccer Bot kit and the Grabber kit pictured to the left) and through that process, Annie came to find out she had an aptitude and great interest in circuitry and electrical engineering. Angela and Annie also went through the entire engineering design cycle while working on their own self-identified engineering project.

Together they identified an engineering challenge in their home - a new and improved garden plot and box - and worked through brainstorming materials and concepts, building a prototype, and testing out their work. Annie enjoyed this process and said, “A good idea would be something that worked effectively and looked decent, in my opinion… I do like building a little bit more than designing, because designing is a little trap. But building stuff and putting it together is really satisfying for me. Our recent project with the garden, I had an idea to make a box for the garden and then notch it. So when we tried notching it, it kinda fell apart. So then I had to think about how we could change the design to make it actually work so that it was sturdy.” Angela felt that through their conversations and working together, the whole family learned a lot. She noted,

"WHAT I DIDN'T REALIZE IT WOULD DO IS IT REALLY IS A PROBLEM SOLVING MODEL, AND I THINK THE ONE THING IT TAUGHT US, ESPECIALLY IN OUR HOUSE, IS IT'S OKAY TO TRY SOMETHING AND MESS UP, WHICH I THINK IS A HARD LESSON TO LEARN."

7. CAREER AWARENESS: WHAT DO ENGINEERS DO?

Much of the public has a limited understanding of what engineers do, as well as the many different types of engineering fields that are available as a career. This is captured well in the following statement by Cunningham et al, (2005). “Children are more likely to think that engineers clean teeth than design ways to clean water!” (p. 6).

One way we addressed this was through embedding career information into the design of engineering kits (see Engineering Kits section). For example, one kit asked families to design a prototype of a handheld tool that can pick up three different objects from at least two feet away without damaging or dropping them. We connected this to the work of several engineers.

DID YOU KNOW?

Different types of engineers are needed to plan, create, test, and improve robots including robotic arms—mechanical engineers work on the body, electrical engineers work on the nervous system or the electrical components (e.g., circuits), and computer science engineers work on the brain or the computer program that tells the robot what to do. If you are interested in learning more, check out this video.

YOUTUBE LINK

Lastly, we actively engaged undergraduate and graduate students from the local university engineering programs to serve as mentors for families, as well as discuss elements of their own work and learning. Engineers from local companies and firms were also asked to volunteer time to present their work and talk about what they do on a daily basis. Through this, families were able to see and hear about various types of engineering, as well as see what “real life” engineers look like.

We also developed **ENGINEERING PASSPORTS** for families to not only learn about different engineering fields, but to also foster the development of an engineering identity in that children are able to learn about and “try on” engineering careers.

We provided children with stickers to place on the engineering page that they talked and/or acted like the most in completing an engineering task or problem.

For example, children may identify as a civil engineer through engagement with **THE ANIMAL HOUSE KIT (SEE ENGINEERING KITS SECTION).**

We encourage you to use and adapt our engineering passport for your own program.

LINK TO ENGINEERING PASSPORT

CAREGIVER QUOTE

“I guess I didn’t realize there were so many types of engineering. And then it made me think about, like in real life, like I started thinking who engineered this or created a building to make it look like that. And how many times did it take. . . . I guess I didn’t realize this broad expansion of engineering, like how many types there are of civil engineering, you know, things like that.”

8. RETHINKING WHO CAN BE ENGINEERS

Historically, there has not been a lot of diversity in the backgrounds and demographics of individuals who work in engineering.

For example, did you know that more MALES than FEMALES are engineers and that individuals with a learning disability are less likely to pursue a career as an engineer than a non-STEM career?

As a result, families often have a limited perspective regarding who can be an engineer. As part of our program, we created different opportunities for families to meet and engage with engineers that ranged in:

GENDER IDENTITY, ***ETHNIC IDENTITY***, ***AGE***, and ***ENGINEERING FIELD***.

During in-person workshops, local engineers volunteered to work closely with families on developing a solution to self-identified problems.

We also created a mentorship program where each family was matched with an undergraduate or graduate engineering student.

We encourage you to brainstorm ways to tap into engineering firms and post-secondary engineering departments in your community. From our experience, engineers are eager to work alongside the public.

Additionally, engineers are often eager to know how to better communicate with novices about the work they do.

As a resource, we developed ***ENGINEERING ENCOUNTERS*** to offer an opportunity for families to meet engineers and/or engineering students who provide interesting insight into their work.

These encounters are quite engaging for the children, especially when the engineer they meet is relatable and talks about real life experiences. When children can see aspects of themselves in the engineers they meet, they feel empowered.

When considering this for your own program, we encourage you to invite a diverse group of engineers, as well as consider how to support them in presenting their career and projects in a way that is understandable to families that are not familiar with engineering.

PARENT QUOTE:

"I think having the BU engineer to reach out to, that whole interaction that we had with that individual was... I think as a female, very inspiring to Annie,... I was very thankful for that because I don't feel like we necessarily get a lot of those kind of role models or that exposure, especially at this age. I saw that that kind of made her think like I am woman, hear me roar, I can do anything anybody else can do, and I was very thankful for that, for that exposure."

Our team helped to emcee the sessions but tried to set them up where the interactions were really between the engineers and the families.

WE INCLUDED AN INITIAL SEGMENT WHERE THE GUEST ENGINEERS WERE ASKED:

HOW DID YOU FIRST GET INTERESTED IN ENGINEERING?

WHAT CHALLENGES DID YOU FACE ALONG THE WAY TO BECOMING AN ENGINEER?

IF YOU COULD CREATE OR ENGINEER ANYTHING IN THE WORLD, WHAT WOULD IT BE?

OTHER THAN "KNOWING STUFF" WHAT DO YOU THINK IS THE MOST USEFUL SKILL YOU USE AS AN ENGINEER?

There were also questions asked by the children and caregivers.

In addition, we wanted them to share a bit about the work they engage in daily. We asked the engineers to share a brief description of this and to have a few pictures or diagrams ready that they could share with families.

Another component we included was a design challenge where everyone had to go and find some materials they could use around their home and then we asked them to "build something useful" and then had them share.

Finally, we prepared some playful questions if there was still time remaining at the end of the hour - we called these:

GAMESHOW SEGMENTS

which included Superpowers (ask participants how they might build a contraption that would mimic a superpower they want), Biggest failure in engineering, and Engineering Charades (participants act out machines like washing machine, toaster, cell phone...etc).

References

Cunningham, C., Lachapelle, C. P., & Lindgren-Streicher, A. (2005). Assessing elementary school students' conceptions of engineering and technology. Paper presented at the 2005 ASEE (American Society for Engineering Education) Annual Conference, Portland, OR. Retrieved from https://peer.asee.org/14836

LOGISTICS

WHAT MIGHT YOU NEED TO CONSIDER AS YOU ARE PREPARING FOR A FAMILY ENGINEERING PROGRAM?

We provide various suggestions that we considered and implemented based on our community partners and families. The intent is to find and utilize approaches that will work for your team.

RECRUITMENT

We advise recruiting families in partnership with local schools, libraries, community centers, and non-profit organizations. These institutions are able to promote the program in collaboration with your team through events, hands-on experiences, social media outlets, and personal invites.

For example, set-up a hands-on experience at back-to-school nights at local schools. Talk to families about your program and have a flier about your program, but have a flier or a brochure for them to take home.

Also, be sure to get family's preferred contact information so you can follow up with them.

OUR PREVIOUS RECRUITMENT STRATEGIES INCLUDED:

- ATTEND AND/OR CO-PLAN EVENTS HELD BY LOCAL INSTITUTIONS AND PARTNERS.
- PARTICIPATE IN STEM-RELATED COMMUNITY EVENTS.
- CREATE VIDEOS ABOUT THE PROGRAM, WITH BLOOPER CLIPS, TO POST ON ORGANIZATION'S AND SCHOOL'S SOCIAL MEDIA OUTLETS. WE HAVE INCLUDED ACCESS TO ONE OF OUR RECRUITMENT VIDEOS FOR VIEWING AND A BIT OF LAUGHTER.
- ASK LOCAL EDUCATORS AND TEACHERS TO PROMOTE THE PROGRAM.
- INCLUDE PROGRAM INFORMATION IN LIBRARY AND NON-PROFIT ORGANIZATION NEWSLETTERS.
- WORD OF MOUTH FROM LOCAL PARTNERS AND ALUMNI FAMILIES. FOR EXAMPLE, ONE ALUMNI FAMILY CREATED A STORYTELLING VIDEO TO PROMOTE THE PROGRAM.

THINGS YOU SHOULD CONSIDER WHEN RECRUITING

DO NOT USE TOO MUCH STEM-RELATED LANGUAGE INITIALLY AS THESE ARE OFTEN WORDS THAT MIGHT SCARE OFF SOME FAMILIES.

CONSIDER YOUR AUDIENCE, PARTICULARLY THEIR NATIVE SPEAKING LANGUAGE AND READING LEVEL.

PROVIDE TIME FOR FAMILIES TO ASK QUESTIONS BEFORE MAKING A COMMITMENT.

MAKE THEM AWARE THAT FAILURE AND FRUSTRATION WILL HAPPEN.

HIGHLIGHT THE PROGRAM IS FOR THE FAMILY AS A UNIT AND NOT A PROGRAM ONLY FOR CHILDREN.

CREATE A STAFF-ORIENTED SESSION TO PROVIDE INFORMATION ABOUT THE PROGRAM TO THOSE WHO ARE IN DIRECT CONTACT WITH FAMILIES.

BE CLEAR ABOUT THE TIME AND PROGRAM COMMITMENTS (E.G., ATTEND FOUR SESSIONS, ONE A MONTH FROM MARCH TO JUNE). ALSO, MANY FAMILIES THINK OF SCHEDULES IN ALIGNMENT WITH SPORTS SEASONS, SO IT SEEMS BEST TO SCHEDULE EVENTS WITHIN A SEASON RATHER THAN ACROSS SEASONS.

PROMOTE THE HOME AS THE LEARNING ENVIRONMENT.

SHARE IMAGES AND/OR STORIES FROM/ABOUT ALUMNI FAMILIES. SEE EXAMPLES BY CLICKING ON THE FOLLOWING LINK.

If you choose to utilize our kits, described in the next section, as a recruitment tool or to engage several families in an engineering challenge within a school or organizational environment, we provide (in the table to the right) one example of how we allocated our time.

Program Elements	Length (min)
Introduce educator(s) and goals of the program	5
Introduce the engineering task, materials in the kit, and expected roles of caregivers	5-10
Plan, design, and share design progress	15
Make and share progress	40
Share prototype and plans to improve	5-10
Discuss how to conduct an at-home engineering activity	5-10
Total time	75-90

SPACE

At the inception of the program, the set-up was in-person, where the families came together to work on engineering projects, as well as socialize with other families.

THINGS YOU SHOULD CONSIDER WHEN FINDING A SPACE INCLUDE:

- A CENTRALIZED COMMUNITY-BASED LOCATION WHERE THERE ARE MINIMAL ISSUES RELATED TO GETTING THERE (E.G., WALK OR EASILY ACCESSIBLE BY PUBLIC TRANSPORTATION) AND PARKING IS AVAILABLE.
- A SITE IN WHICH THE MAJORITY OF FAMILIES ARE COMFORTABLE ENTERING.
- ACCESSIBLE TO INDIVIDUALS WITH PHYSICAL DISABILITIES AND IMPAIRMENTS.
- ENOUGH TABLES AND CHAIRS TO ACCOMMODATE ALL FAMILIES.
- A PLACE TO STORE MATERIALS AND RESOURCES, AS WELL AS INDIVIDUAL FAMILY'S ONGOING PROJECTS.
- ABILITY TO COOK AND/OR SERVE FOOD.

COMMUNITY SPOTLIGHT

We worked with several organizations and institutions that provided us with a space to engage with families. In this spotlight, we highlight (and thank) a Boys & Girls Club in Indiana and a Methodist Church in New York. The two branches of the Boys and Girls Club were located in residential districts, which allowed families easy access to attend programs. We used these clubs for a series of family STEM workshops and theme-based family events such as the Earth day challenge.

The Methodist Church in New York was located in a neighborhood that was easily accessible to many families in the local area. We utilized the church for monthly sessions. The space included access to a kitchen in which we served families with food prior to diving into engineering challenges. We were also given access to their cafe and various classrooms as needed. We are thankful to members of the church for their kindness.

ONLINE PROGRAM

In the event that you offer an online program, you will need to plan out how you will deliver materials and resources to participants.

Our primary approach has been to deliver items to our partnering sites (e.g., schools, libraries). When needed, we delivered items to families' homes and caregivers' workplaces.

For partnering site deliveries, we suggest having one point of contact to ensure that the items go home.

For home drop-offs, you will need to establish where to leave the items in the event that no one is home. We often had requests to leave items on the front porch, but also received requests such as the "barrel at the end of the driveway: or "in the cab of a truck."

SCHEDULING

You should consider the best time and day of the week that families are able to join virtually or in-person, as well as how often they are able to meet (e.g., once a week). We suggest you ask families this information as an initial step but do not expect to easily find consensus.

For each online session, you should offer two time slots to better meet the various family schedules. For example, for show-and-tell sessions, we offered Thursday night at 7:00 pm to avoid dinner and sporting events, as well as Saturday mornings at 10:00 am to avoid errands, birthday events, and piano practice.

We suggest gathering this information at the onset of the program. See figure on the right for an example that we used.

BE PART OF A FUN PROGRAM FOR YOU AND YOUR STUDENT!

We have a fun and engaging program designed to help kids (age 7-12) grow a love of learning through making and building things with everyday items for self, others, and/or the community!

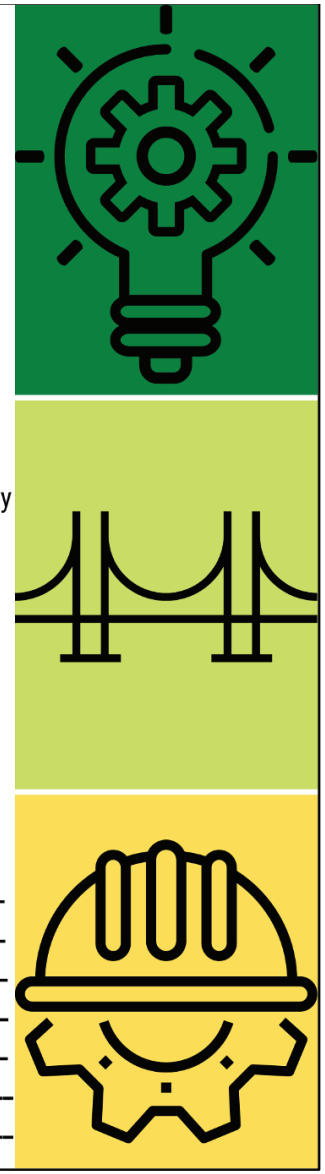
INTERESTED?! PLEASE FILL OUT THE FOLLOWING INFO TO HELP US PLAN...

BEST DAY(S) OF THE WEEK FOR YOUR FAMILY?
Monday / Tuesday / Wednesday / Thursday / Friday
Saturday / Sunday

BEST TIME(S) OF DAY FOR YOUR FAMILY?
Morning / Afternoon / Evening

WOULD YOU PREFER:
5 Sessions - 1 day a month for 5 months
5 Sessions - 1 day every other week, for 10 weeks

Parent Name: _____
Contact (Phone or Email): _____
Number of children: _____
Age of children: _____
Names of children: _____
_____
_____

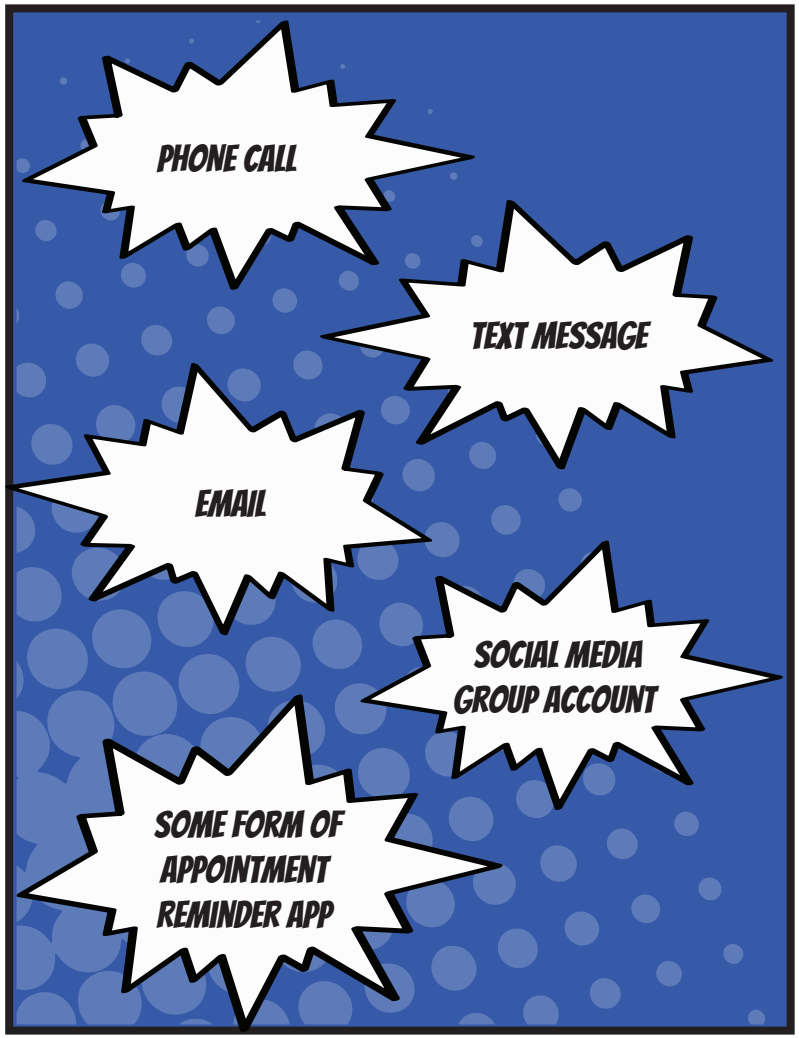


Family Sign Up Sheet

COMMUNICATION WITH FAMILIES

As a team, you need to plan in advance for how you will communicate with families, how often, and what information will be shared throughout the program.

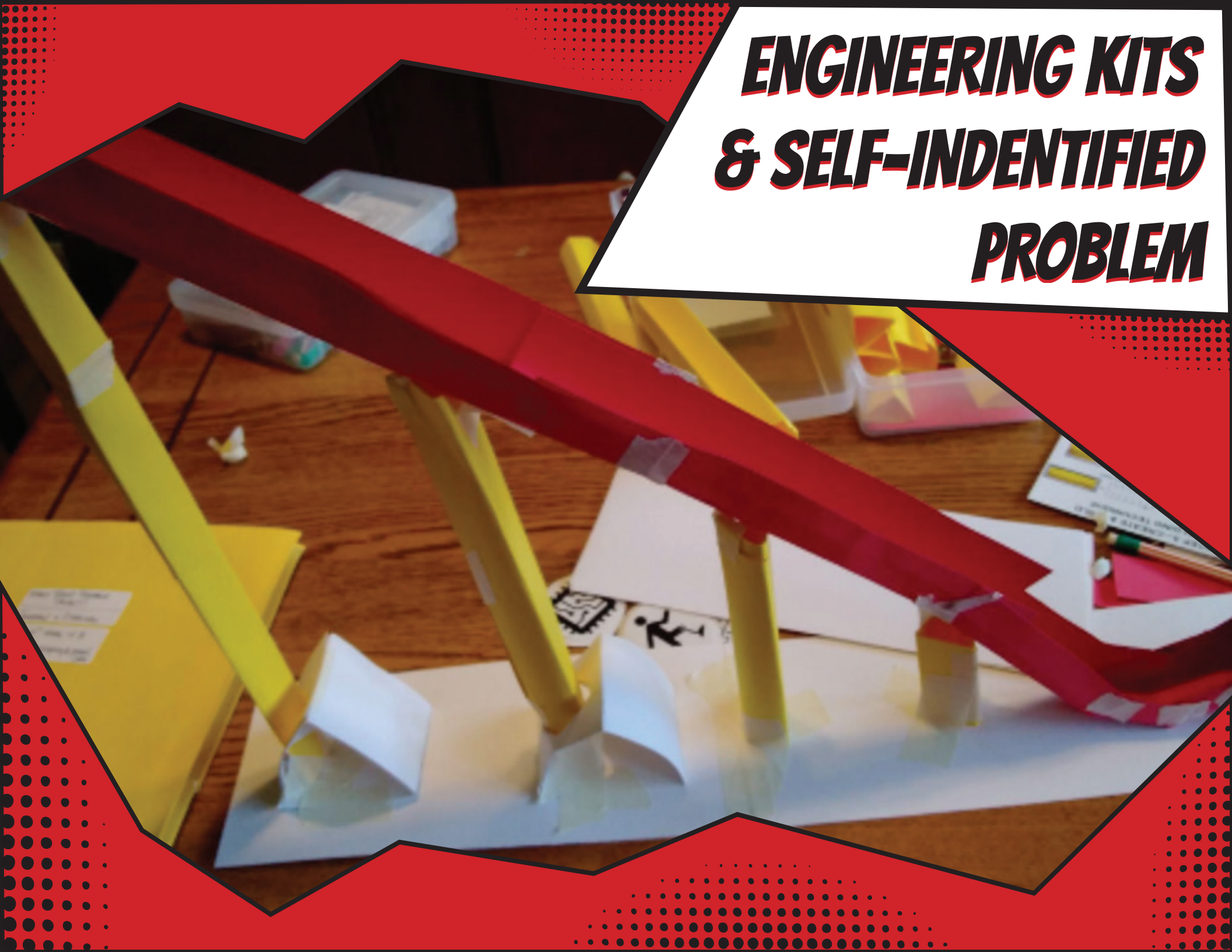
Consider the following forms of communication, but you may want to ask participating families for their preference.



From our experience, it will be important that you communicate the following:

- POINT OF CONTACT INFORMATION (FOR DELIVERY, IF APPLICABLE).
- THE COMMITMENT NEEDED IN TERMS OF TIME AND EFFORT.
- MORE INFORMATION ABOUT THE PROGRAM (IF DIFFERENT FROM THE PROMOTIONAL MATERIAL).
- LIST MATERIALS YOU WILL USE IN THE EVENT THAT SOMEONE HAS INTOLERANCE FOR SPECIFIC MATERIALS SUCH AS GLUTEN FOR MAKING A PLAYDOH.
- REMINDERS REGARDING TIMES, DATES, AND LOCATION OF IN-PERSON AND/OR VIRTUAL SESSIONS.
- POSITIVE HIGHLIGHTS YOU NOTICED WHILE FAMILIES WERE ENGAGED WITHIN THE ENGINEERING DESIGN PROCESS (E.G., ELEMENTS THAT EXCITED OR ENERGIZED THEM, CONNECTIONS TO OTHER STEM AREAS, WAYS ENGINEERING ALIGNED WITH THEIR OWN PERSONAL INTERESTS).
- PHOTOGRAPHS AND/OR VIDEOS FROM IN-PERSON SESSIONS.
- ANY SOCIALIZING ACTIVITIES THAT CREATE A SENSE OF COMMUNITY FOR THE PARTICIPATING FAMILIES.

ENGINEERING KITS & SELF-INDENTIFIED PROBLEM



INTRODUCTION

MAKEngineering kits are a set of learning experiences for children in grades 2-6 to engage in engineering design processes and practices with their families/caregivers. Each kit is themed with an engineering challenge relevant to our daily lives and allows for exploration, risk-taking, and agency in designing, creating, testing, and refining a shared prototype.

The MAKEngineering kits include all the materials needed to complete the engineering challenge, and also encourage families to personalize their design using home materials. Solving problems with everyday and familiar materials fully leverages the potential of family activities for STEM learning.

We have shown these kits also foster learning opportunities in which children and their caregivers engage with and/or explore science and math ideas and concepts (Kim & Simpson, 2021; Simpson et al., 2022).

Our MAKEngineering kits provide caregivers with multiple ways to support their child(ren) through the engineering design process. This was enabled by the two versions of instructions provided in each kit- one for children and one for caregivers.

FAMILY SPOTLIGHT

Amethyst (child) and Ethan (caregiver) participated in our program and engaged with six of the kits. As part of the Toy Hack kit, Amethyst and Ethan transformed a ladybug pullback car into a delivery device using the materials provided in the kit, as well as material from their home environment (e.g., a plastic plate, paint). Amethyst's original plan was to hot glue a plastic plate to a ladybug pullback car, so it could deliver things. When Ethan asked "Is there another thing you would do instead?" Amethyst suggested another car with a flat surface. After discussing the advantages, Amethyst decided to use the ladybug car. When Ethan asked "what do you think our first step should be?" They discussed whether to paint the plate first or glue it first. In addition, Ethan encouraged Amethyst to explore electronic parts. Amethyst decided to add a sound effect to the car with a buzzer. The images on this page illustrates Amethyst passing or delivering a pepper shaker, as well as toothpicks. As she stated, "Pretend we're eating a meal and we're going to need toothpicks to eat it. I'm going to put toothpicks in here and then we can roll it around to each other and everyone can take a toothpick. Everyone can take as many toothpicks as they need."

MAKENGINEERING KITS

We provide an overview of the engineering tasks below. You can access more information about the kits, as well as instructions for each kit, at **https://athomeengineers.com/**.

ANIMAL HOUSE

It is challenging for stray animals to survive extreme weather conditions.

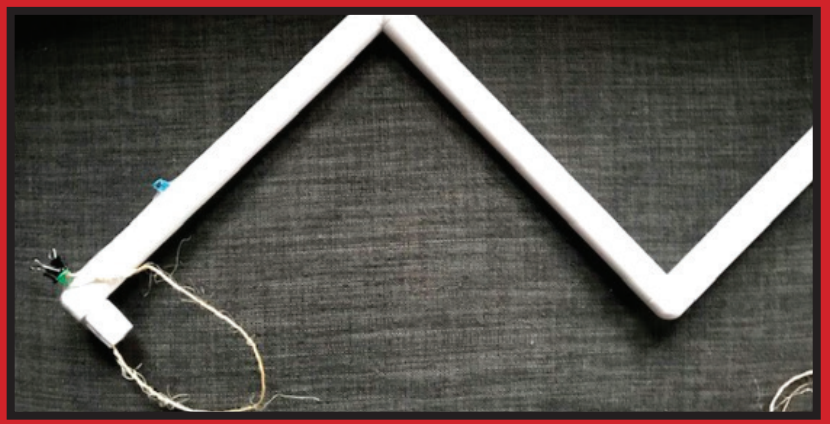
Your task is to design a prototype of an animal house that will help stray animals survive extreme weather conditions common to where you live—rain storms, really hot and really cold temperatures, earthquakes, or tornados.

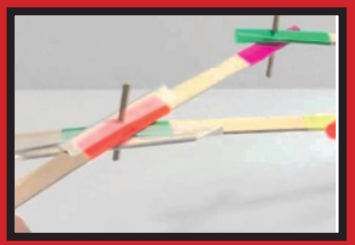
DELIVERY PACKAGE

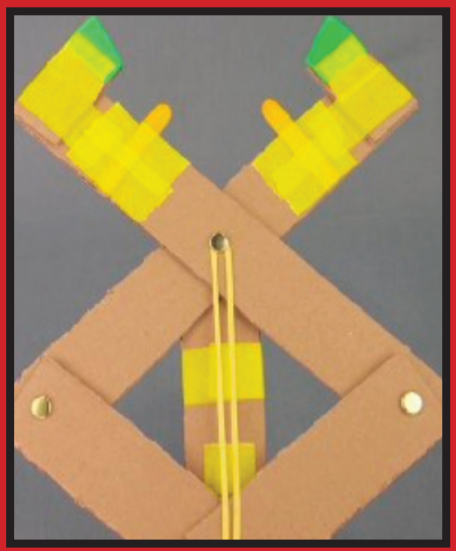
You want a way to secretly and safely share objects with your friend who lives next door. You choose to design a prototype that will deliver an object at least 6 feet.

GRABBER

Grabbers are handheld tools that can be used to retrieve items from a distance. Design a prototype of a grabber that can pick up three different objects from at least two feet away without damaging or dropping them.

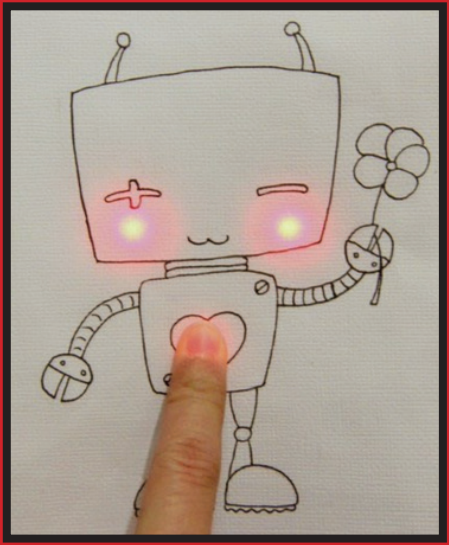






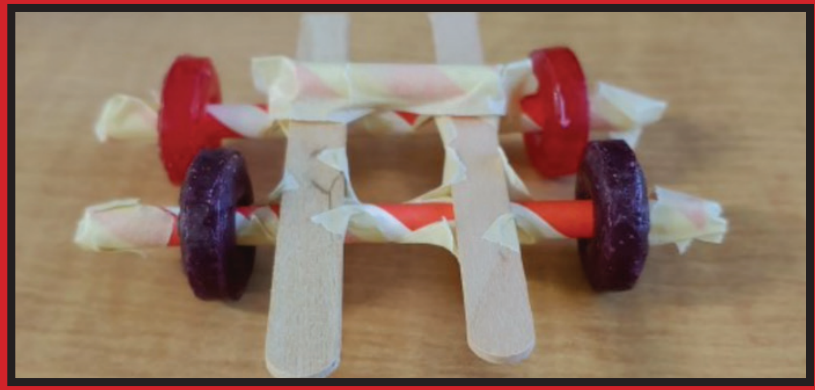
GIVE A GIFT

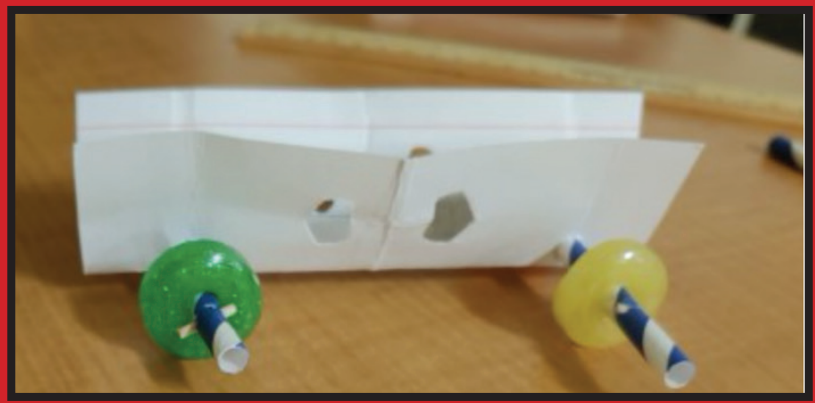
After you learn about how to create a simple and parallel circuit, create a paper-based gift that lights up. This could be a greeting card, a bookmark, a name tent, a door sign, an origami figure, etc.



MINT MOBILE

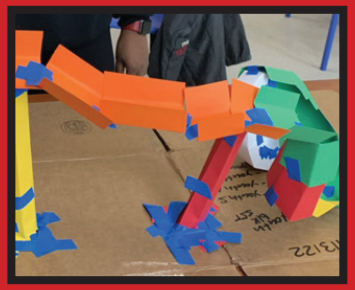
The automobile company, Rolls-Royce, has produced many cars that are considered of poor fuel efficiency by the United States Department of Energy. Similar to automotive engineers, your task is to build a prototype to test the effect of different variables to report recommendations to the company. The prototype should travel along a straight path down a ramp and travel as far as possible with a minimum of 8 feet.





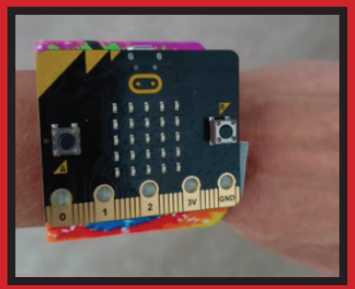
PAPER ROLLER COASTER

A local amusement park asked you to design their next roller coaster. You decide to design a prototype suitable for a marble to travel from the start to the finish. You will use the prototype during your presentation to the local amusement park.



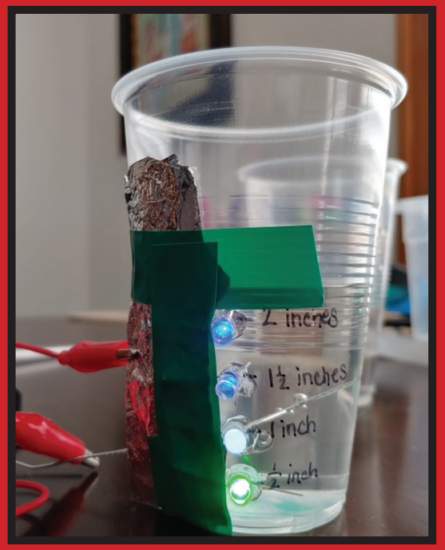
PEDOMETER

For improved health, it is recommended that all children between the ages of 5 and 19 should take around 12,000 steps a day. Your task is to design a wearable pedometer prototype that will track a child's number of steps.



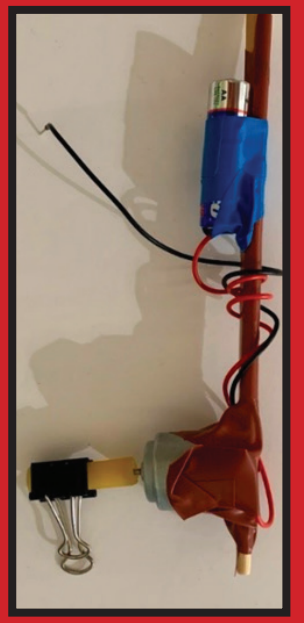
RAIN GAUGE

Several cities across the U.S. are experiencing their wettest year-to-date. The National Weather Service is asking for your help in measuring and reporting the amount of rainfall in your hometown. Using the provided material, build a rain gauge to measure the amount of liquid precipitation over a set period of time.



SOCCER BOT

You have been asked by a popular game company to develop handheld soccer bots for a new indoor game for two players. A soccer bot is a robot that plays soccer. For this game, players score goals by hitting a small ball into the opposing “net”.



TOY HACK

You have been asked by a toy refurbish shop to brainstorm ways to give old toys a second life using electronic parts. Make a prototype that renovates, redesigns, and/or remixes an old toy. The prototype should change the look and feel of the toy, or the toy’s role in our life, using new materials.

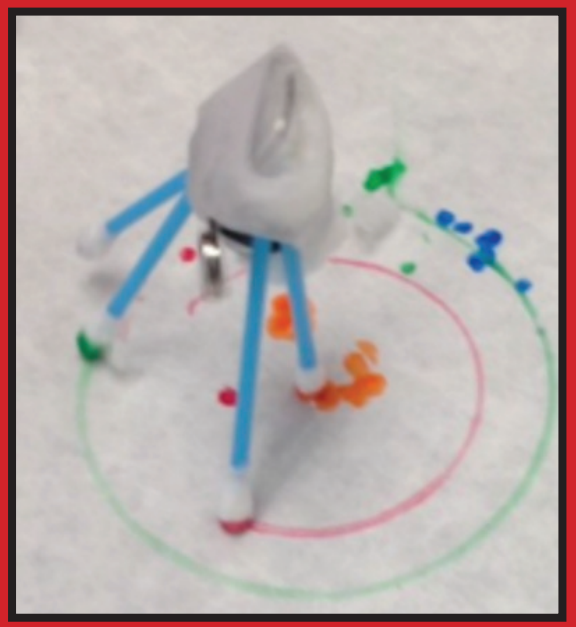
K-KIT SPOTLIGHT

TRENDY TENNIES

You have been asked by a popular shoe company to design a new trendy tennis shoe for the unique needs of their four customers. Pick one of the customers and design a tennis shoe to meet their needs. You decide to use everyday products to construct the tennis shoe prototype.

WATER COLOR BOT

Design a motorized bot that “paints.”



We also have five kits appropriate for children ages 5-7. You can check these out at the following website.

As an example, in Make Your Idea Fly, families would read the book - ***What do you do with an Idea*** by Kobi Yamada. After reading the story, children are tasked with building something that will make an idea fly.

CREATING YOUR OWN KITS

1. Modify and create engineering challenges that are open-ended and approachable to youth and families in your community.

WHAT ARE YOUTH INTERESTED IN?

WHAT IS SOMETHING UNIQUE TO YOUR COMMUNITY?

For example, one of our community sites is known as the Carousel Capital of the World as it is home to six antique hand carved carousels. An engineering task could engage families in developing a smaller scale version of a jumping horse using recyclable materials for a local museum to display. We have used curiositymaching.org and teachengineering.org as resources to guide our thinking.

You should also ask yourself if the engineering challenge affords opportunities for families to design and create different types of prototypes.

You may ask yourself questions like:

WILL MY ENGINEERING CHALLENGE RESULT IN ONE-SIZE-FITS-ALL DESIGN OR DIFFERENT DESIGNS?

WHAT SUBSTITUTE MATERIALS CAN FAMILIES FIND AT HOME TO CREATE DIFFERENT PROTOTYPES?

For example, the engineering task for the grabber afforded families an opportunity to create different prototypes grounded in the material they had access to in their home environments.

2. Use low-cost and everyday materials for children and families to transform in the creation of their prototype.

For example, in designing something to hold a tablet, the Ying family used a baby hanger, a box, and a water bottle.

We recommend creating a supply list for each kit and thinking about what materials and tools are available in families' homes such as plastic food containers, cardboard, art supplies, and natural resources.

One approach we have taken is to create a scavenger hunt for families to find material around their homes that would be useful in developing a prototype.

MATERIALS IN YOUR HOME—SCAVENGER HUNT

Now you need materials for the "body" of the grabber. As a family, find items around your house that start with the letters below. Only one object per letter, but you can have more than one of that object. For example, for the letter P, you can use 5 plastic bottles. Be strategic. We suggest recyclable materials.

B D E H L N P S T W

6

Paper-based item	Something that is round or a cylinder but as many of this item as you want.	Something that is flat and sturdy
Random items from a "junk" drawer or recycle bin	FREE SPACE (anything that will help you innovate)	Food container of any kind
Something that will help keep things together	Something that clips	Something that adds personality

8

Another approach is to promote family exploration around ways to transform everyday materials. For example, in the Toy Hack kit, families are encouraged to use their five senses to think about how particular objects might be used in their prototype.

STEP 2—PLAN

Let's start with one toy. This can be the toy we provided or an old toy you no longer play with.

Explore the toy using your four senses (vision, smell, touch, hearing). What can you do to change the look, feel, smell, or sound of the toy?

We have questions on the next page for you to discuss and brainstorm together as a family. Keep taking notes!!!! And feel free to ask someone else to take notes for you.

6

DID YOU KNOW…?

People who design products explore many materials to get insights into its possible use— its properties, how it can be manipulated (e.g., twisted), and how it feels.

Karana, Giaccardi, Stamhuis, & Goossensen (2016)

10

3. Engage in the task yourself. This will support the development of the instructional guides as you engage in the engineering design cycle - research, plan, create, test, improve, and share. As you are engaging in the challenge, create questions based on your experience, take photographs, and/or make videos as you see fit. For the Toy Hack kit, a member of our team transformed a baby toy into a lantern and took pictures to use an illustration. Questions were also formulated through engaging in the planning process. Ask colleagues, friends and family to test out the ideas too.

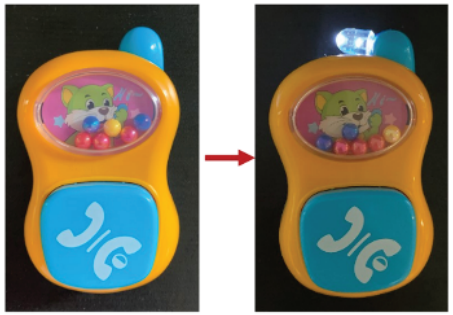
STEP 2—PLAN

1. What does the toy do? What role does it play in your life? What can you do to give it a new role?
2. Who is this toy designed for? What can you do to make it useful for other people?
3. What context does the toy belong? What can you do to make the toy appropriate for another context? For example, think about a setting for a dinosaur. How might your hack the dinosaur to be something used in the bathroom? (Psst. A toothbrush holder.)
4. Can you take apart or disassemble the toy (with the permission of your caregiver)? How might this be done?

7

STEP 3—CREATE

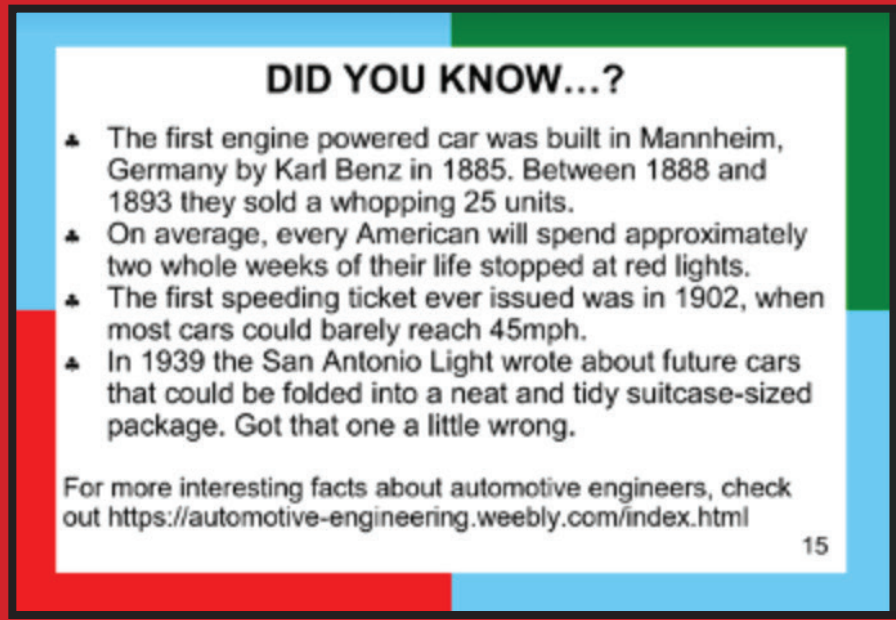
It is time to refurbish the toy—give it a new and different use for others to enjoy.

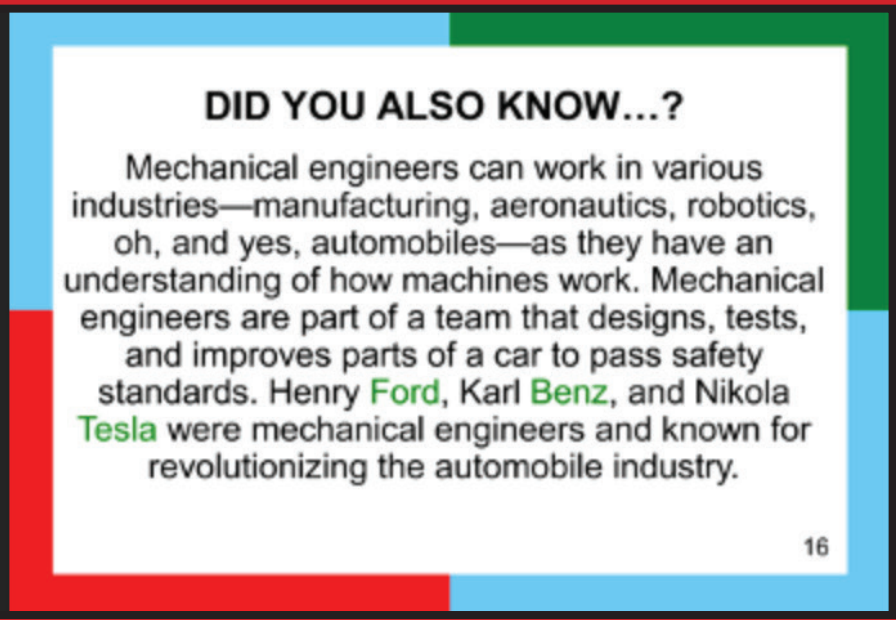


The transformation of a baby toy to a lantern.

11

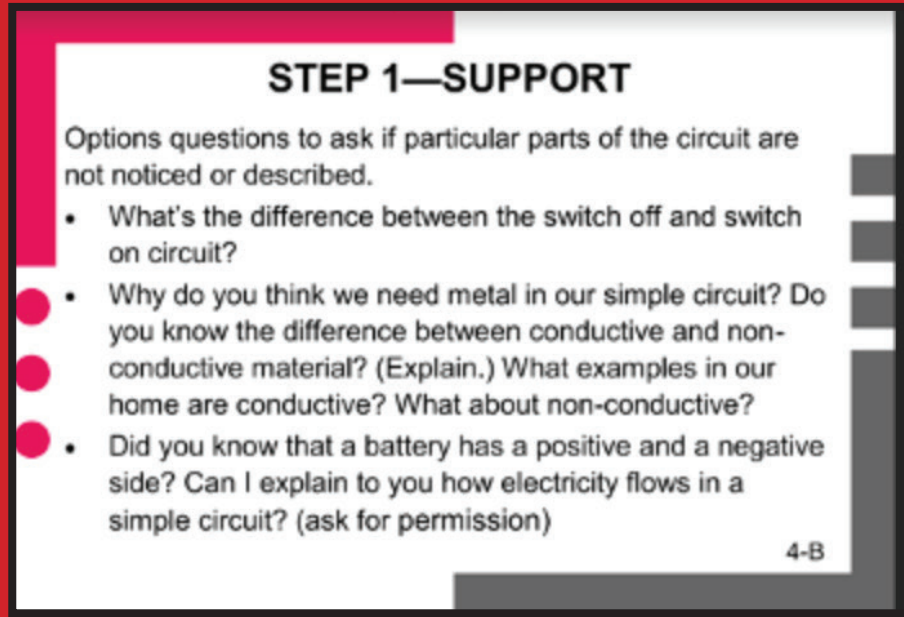
4. Find ways to embed connections to the engineering field and/or quirky facts about the field. This supports youth and families in broadening their views of engineering. We often framed these as “Did you know…”? We provide two examples from the Mint Mobile kit below.





5. Develop a caregiver facilitation guide to accompany the child instructional guide. We advise this for two reasons. One, when we had only one instructional guide, it was typical for the caregiver to maintain control. Two, many caregivers do not have an understanding of engineering and may shy away from providing guidance and support to their child(ren). Therefore, we suggest you provide extra support in the facilitation guide such as optional questions to pose or troubleshooting tips for kits with electronic components. We provide examples for the Rain Gauge kit.

The first image is a page that follows an image of a simple circuit. You will notice this is page 4-B. This is an indication to the caregiver that this is a page unique to their guide. The second image includes troubleshooting questions that support families to think about how to improve the rain gauge if their prototype is not functioning appropriately. Notice that we framed these as questions as opposed to a list of things to troubleshoot.

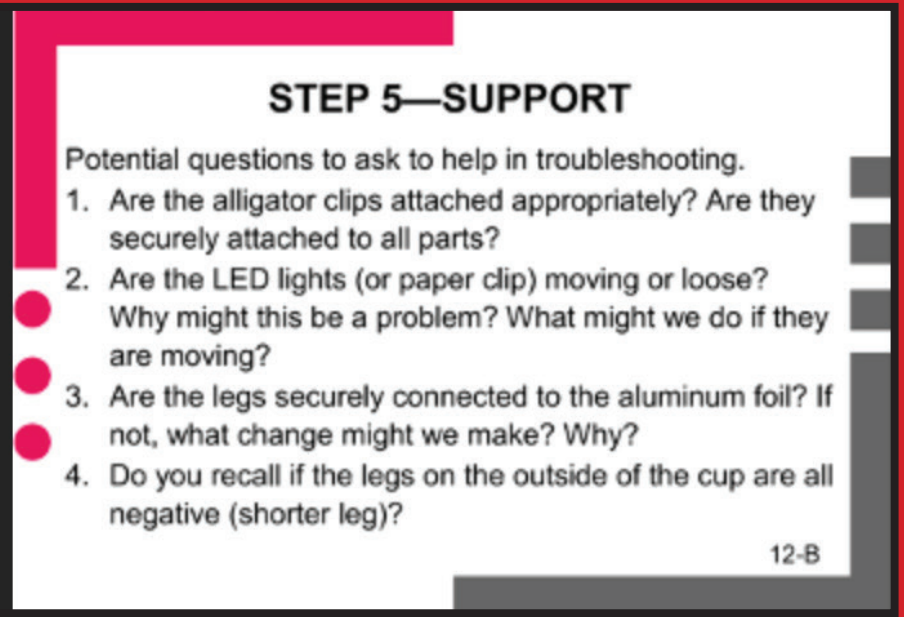


STEP 1—SUPPORT

Options questions to ask if particular parts of the circuit are not noticed or described.

- What's the difference between the switch off and switch on circuit?
- Why do you think we need metal in our simple circuit? Do you know the difference between conductive and non-conductive material? (Explain.) What examples in our home are conductive? What about non-conductive?
- Did you know that a battery has a positive and a negative side? Can I explain to you how electricity flows in a simple circuit? (ask for permission)

4-B



STEP 5—SUPPORT

Potential questions to ask to help in troubleshooting.

1. Are the alligator clips attached appropriately? Are they securely attached to all parts?
2. Are the LED lights (or paper clip) moving or loose? Why might this be a problem? What might we do if they are moving?
3. Are the legs securely connected to the aluminum foil? If not, what change might we make? Why?
4. Do you recall if the legs on the outside of the cup are all negative (shorter leg)?

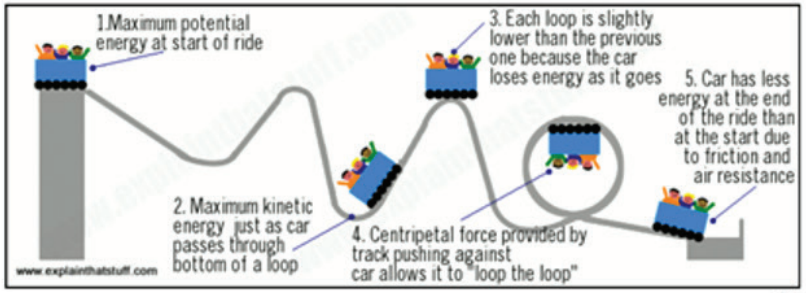
12-B

6. Embed math and science connections throughout the instructional guides. This will begin to develop youths' and families' engagement in STEM as interdisciplinary and authentic. For example, in the Paper Roller Coaster instructions, we included a graphic that describes the science principles that keep cars from flying off the tracks. We recommend keeping these explanations simple.

STEP 4—EXTENSION

How might the failures during testing be based on physics?

https://youtu.be/BunU6CTmhFw



18-A

STEP 4—EXTENSION SUPPORT

Optional questions to ask throughout this step:

- It seems the marble does not have enough energy to pass the loop. What can we do?
- What if we increase or decrease the curvature (or angle) of a hill or valley? What type of energy would we be changing? Explain.
- What can we do to prevent the marble from flying off of the track? Or getting stuck on the tracks?
- Should this (e.g., loop, hill) be higher or lower than the previous one? Why? Explain using the diagram.

18-B

SELF-IDENTIFIED ENGINEERING PROBLEM

Having explored several kits, caregivers and children will gain an understanding of the skills, processes, and practices that engineers utilize within their work. According to our prior study (Knox et al., 2021), caregivers and children began to understand engineering as things they already do, as well as a process that they will continue in the future as problems arise in the home.

A natural extension from the kits was for families to identify a problem or issue in their home, school, community or for someone they know, and then engineer a solution for the problem or issue using an engineering design cycle. The model for engineering a solution for a self-identified problem can be implemented in various forms and duration.

Here, we will share an online slideshow that guides families through the engineering design cycle, from developing a problem to communicating their product as a Shark Tank pitch. We detail this information below. Families were also able to engage in the process over a three month period and as it fit within their weekly schedule.

We started with making connections between families' experiences with kits and possible home projects with the prompt:

"WE WANT YOU TO THINK ABOUT THE ENGINEERING DESIGN CYCLE AND STEPS THAT YOU USED IN THE TAKE-HOME KITS. USE THOSE STEPS TO COMPLETE YOUR VERY OWN HOME ENGINEERING PROJECT!"

The process of implementing self-identified home engineering projects is no different from the MAKEngineering kits, except families are asked to come up with their own problems instead of being provided with an ill-defined problem.

Supporting families in defining a reasonable engineering problem is really important to a family's success.

For example, it is not likely that families will be able to cure cancer, solve world hunger, or open a new company. While it is always beautiful to dream about big problems, it's important to break those problems into more achievable elements and work on those.

Depending on your program goals, families should work on a problem that they can complete within your targeted time (a few days, weeks, or months) and with locally available resources. The problem should not rely on resources that are not accessible to families, or skills that may take a long time to develop.

You may find some families struggling to come up with a single problem. Here are a few supporting questions you may ask to help them identify problems:

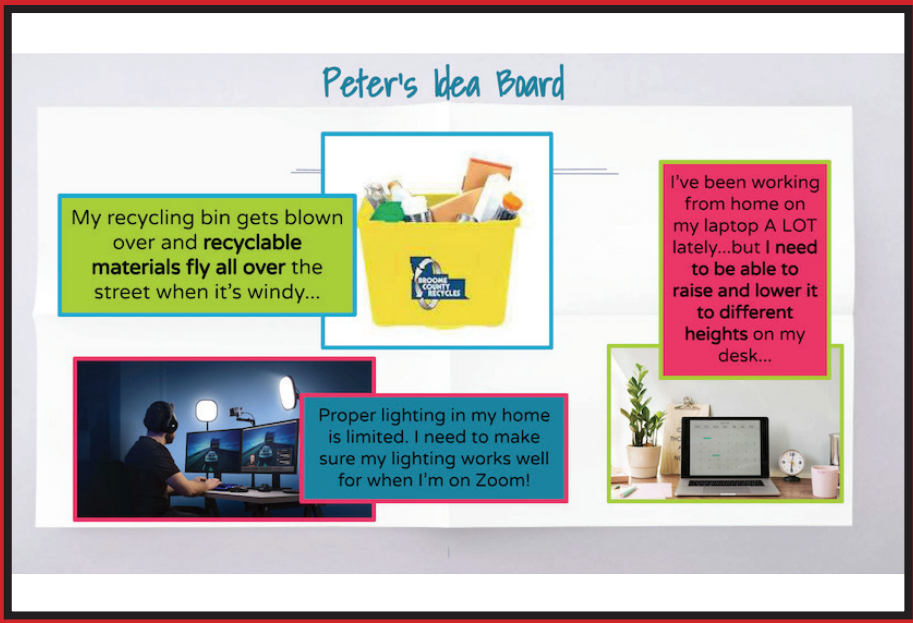
WHO MIGHT YOU WANT TO HELP?

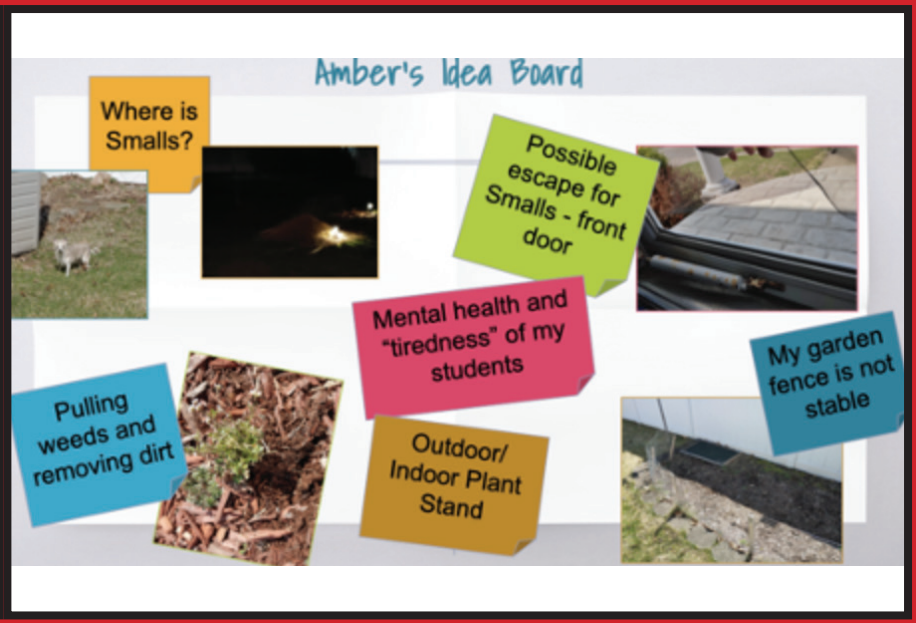
WHAT ARE THINGS THEY DO IN THEIR DAILY LIVES?

WHERE DO THEY DO THESE ACTIVITIES?

WHEN MIGHT THEY DO THESE ACTIVITIES?

You may also find some families coming up with too many problems at various challenge levels. An idea board could help families to identify a reasonable problem to work on. Below are two examples of our idea board.





FAMILY SPOTLIGHT

Cindy (child) and Tanya (caregiver) were introduced to the engineering design process during our first program session in which they designed and built a prototype of a comb to clean trash from the ocean.

As they progressed, Cindy identified her self-identified engineering problem as not wanting to get out of bed in the morning but still wanting to have breakfast. Together with a volunteer engineer, Cindy and Tanya brainstormed two possible solutions to solve the problem. One of them was to use the zipline idea from the Delivery Package kit; the other is to build a delivery robot (see Figure on the left). The following conversation with the volunteer engineer played a key role in shaping Cindy's idea.

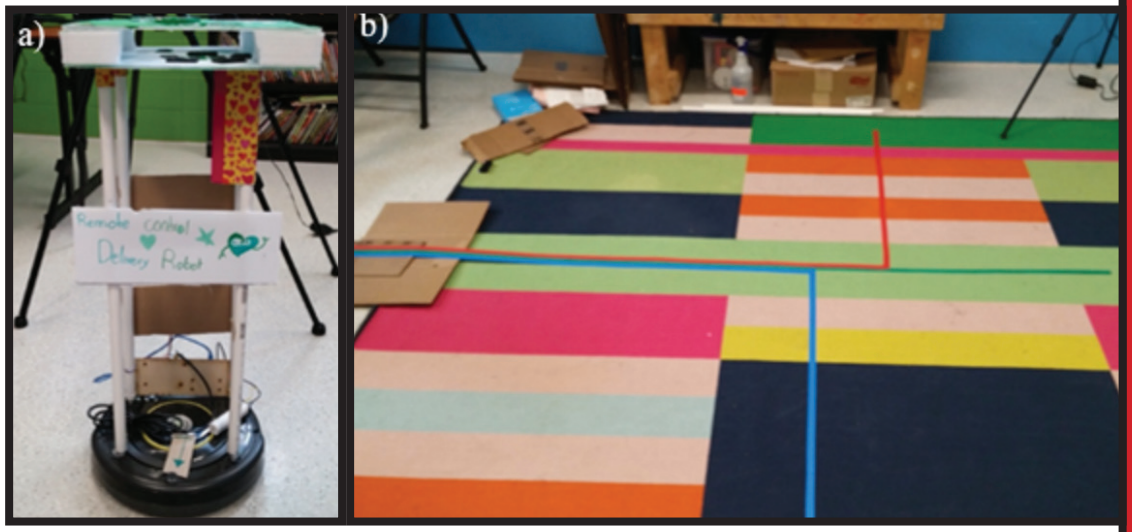
Engineer: So, someone still has to get out of the bed and put that on the chain?
Cindy: There could be a robot….
Engineer: Why doesn't the robot bring you the drink?
Cindy: We could do a robot.

After Cindy decided to pursue the idea of a food-delivery robot, we invited a robot expert, Matthew, who suggested the Roomba for Cindy. The Roomba is not only a vacuum cleaner, but an educational coding robot platform developed by the company iRobot. In the third session, Matthew taught Cindy to modify code so she could control the Roomba. Matthew also simplified the remote-control mechanism so it was accessible for Cindy.

At the same time, Tanya and another family member helped Cindy to build a tray. Cindy hopped between building the tray and learning to control the Roomba like a project manager. In the fourth session, as well as two home visits, Cindy mastered basic coding to control the Roomba. She worked on mounting the food tray on top of the Roomba. Cindy considered a scissor lift mechanism but it was challenging to collect materials for this idea. Instead, Cindy adopted a stationary tray idea as an alternative.

Throughout the process, Tanya supported Cindy with help building and pushed her by asking questions about design choices. They mapped out the paths the robot would travel in their home and controlled the food-delivery robot along the paths. In the final session, Cindy and Tanya presented their project to the whole group by re-creating a scaled version that the robot would travel in the home (see Figure on the right).

In the end, Cindy generalized the use of the "remote-controlled delivery robot to help people who can't get out of bed or are sick…I was thinking about someone in a nursing home or something like that."



It is important to explicitly remind families that you want them to think about the engineering design cycle and use the steps in the cycle to complete their own home engineering projects.

"BRAINSTORM SOLUTIONS" is a combination of ***"RESEARCH"*** and ***"PLAN"***.

"CREATE" and ***"TEST"*** a prototype are the same process as in the home kits.

It should be pointed out that we mark “Communicate” as Step 5, but we actually created opportunities for families to share ideas throughout the process.

Sharing ideas offers opportunities for families to receive feedback, adjust their plans, and gain deeper understandings of their projects. Sharing may emphasize different stages of the engineering process.

For example, the video recording moment to the left focuses on brainstorming solutions.

It’s also critical to emphasize that the process can be nonlinear and many steps may be repeated - as with many things -

there’s no single “right” way to work through these problems - so don’t force it!

The Shark Tank-style pitch we used in our online sessions is an example of summative sharing.

Shark Tank is a television show in which inventors and entrepreneurs pitch a “cool” product to a panel of investors. Children present their ideas through a Shark Tank Pitch to attract investors to put money into their product.

Below is our Shark Tank Pitch guideline. You can find an example pitch here.

Finally, it is important to discuss with families how they will define success. Engineering a prototype that solves a problem may be families’ primary goal, but whether they can produce a “working” prototype should not be the only criteria to define success.

There exists no standard criteria to define the success of a project. Encourage families to think beyond the prototype itself and come up with their own metrics for defining success and celebrating their achievements.

For example, what failures they have overcome, what skills they developed, what new concepts they learned, and/or what additional problems they identified.

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Kim, J., & Simpson, A. (2021). STEM moments in the family context throughout engineering design challenge activities. Proceedings of the 128th meeting of the American Society for Engineering Education, Virtual Conference. https://peer.asee.org/37726

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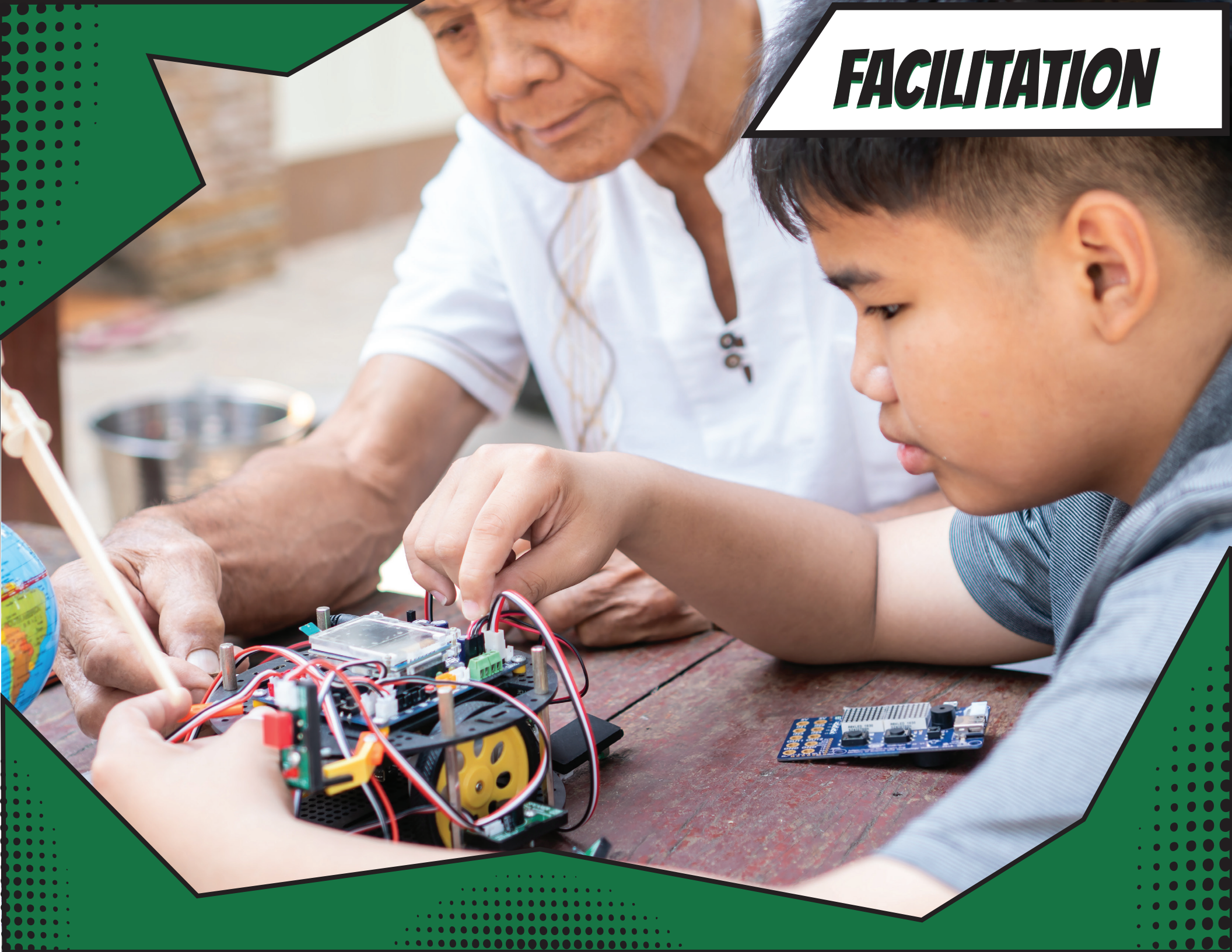
Simpson, A., Sun, J., & Yang, J. (2022). Caregiver-child communication of STEM concepts with engineering design tasks. Proceedings of the 129th meeting of the American Society for Engineering Education, Minneapolis, MN. https://peer.asee.org/40648

FACILITATION



USE YOUR WORDS AND THE POWER OF QUESTIONING

THREE TIPS:

A. USE YOUR EVERYDAY WORDS AND LANGUAGE AND LIMIT TECHNICAL JARGON.

B. ASK QUESTIONS THAT MAKE CHILDRENS' AND CAREGIVERS' THINKING PROCESS VISIBLE (E.G., "HOW DID YOU COME UP WITH THAT IDEA?" "EXPLAIN YOUR PROCESS TO ME!").

C. ASK QUESTIONS THAT POSITION THEM AS THE DECISION MAKER. ANSWER A QUESTION WITH A QUESTION!

EXAMPLE FROM PROGRAM

The Murphey family identified their home-based engineering problem as the dirty dog paw cleaner. When brainstorming possible solutions, Karen (caregiver) posed questions that encouraged everyone to support and/or contribute their thinking.

For example, Gabe (child) questioned if Hank's paws would continue to grow and if using a cup with water would hurt him.

Instead of responding to Gabe's concern directly, Karen asked, ***"ANYONE WANT TO ADD TO THAT IDEA, LIKE BUILD ON IT?"***

As another example later on the brainstorming process, Karen asked Gabe to share his thinking around two solutions.

"GABE, CAN YOU TALK ABOUT YOUR THOUGHTS OF THE CLEANING MITT WHERE THERE'S A CLEANING SOLUTION INSIDE THE MITT VERSUS THE INDOOR CARWASH FOR A DOG? WHAT ARE YOUR THOUGHTS ABOUT THE GOOD AND BAD OF THOSE THINGS?"

Karen also posed questions that made her family think about alternative solutions.

As expressed by Norah (child), ***"WE COULD USE A BLOW DRYER TO DRY HIM OFF!"***

Karen responded, ***"YEAH, A BLOW DRYER. WHAT'S ANOTHER WAY TO DRY SOMETHING?"***

LIMIT TAKING OWNERSHIP OF THE PROTOTYPE OR TOOL

While there are exceptions to every "rule," do not take ownership of the prototype or tool as it diminishes the child, and caregiver, agency. If you have to take ownership of the prototype or tool, show them and guide them along, then let them try again.

EXAMPLE FROM PROGRAM

In constructing a prototype to secretly and safely deliver objects with a friend that lives next door, Tammy (caregiver) demonstrated to Gemma (child) how to loop a pipe cleaner through a noodle and secure it. Their goal was to build a box with a lid.

Tammy provided language for her technique here. "Take it [pipe cleaner]. Put it in [the noodle]. Wrap it around. Pull it out." Tammy handed the in-process prototype to Gemma to replicate her approach.

EXPECT, AND SUPPORT, FAILURES AND FRUSTRATIONS

Failure and/or frustration moments will happen. As you support caregivers and children through such moments, highlight what they are learning or gaining through the process.

EXAMPLE FROM PROGRAM

Walt (child) and Mac (parent) had two cats, Sam and Figaro, one of which bullied the other. This caused problems when they were not home. Their project was to develop collars for the two cats. The collars would be programmed to set off an alarm (e.g., noise) so when the two cats were close to each other, they would move away.

Near the end of their project, they continuously tested their prototype. Mac framed these as experiments. **"I have an experiment I need your help with."** They went into the hallway to test the range between the two micro:bits as the range indicated how close the two cats should be when the micro:bits activate. As they returned from the hallway, Mac stated, **"We just about have it. We're running into one problem, which is that when they [two cats] argue…I'll show you."**

Mac continued by walking through the code with Walt; in particular, Mac shared his reasoning of the problem and the potential fix by talking aloud. In other words, Mac engaged in the troubleshooting process with Walt.

ENCOURAGE EXPLORATION AND EXPERIMENTATION

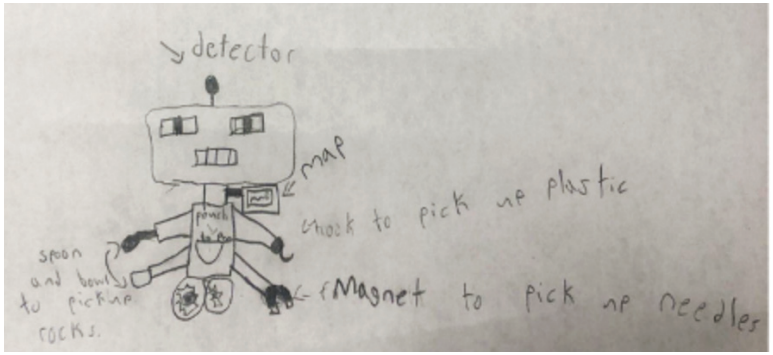
Invite children and caregivers to take risks and try something new, novel, or scary even though the outcome is unknown. They may need verbal assurance that this is okay. Provide an example of a time that you took a risk and it turned out okay. For some learners, you may need to initially explore and experiment with them before walking away.

EXAMPLE FROM PROGRAM

Lilly (child), Zelda (child), and Harold (caregiver) embarked on developing a robot that would pick up small harmful items from the floor (see Figure XX). Through conversation, the family decided to focus on picking up small metal items that would hurt if stepped on or could be swallowed by a child such as stick pins, thumb tacks, and paper clips. They were encouraged to test out different magnets for their strength with the following prompt:

Which magnet would be best to attach to the bottom of a robot and pick up metal items from the floor?

This family was also encouraged to consider how to remove the metal items from the magnets.



Exploration and experimentation can also be encouraged with materials and concepts.

EXAMPLE FROM PROGRAM

Eliot (child) and James (caregiver) were creating a rain gauge to measure the amount of rainfall over a period of time. In discussing the concept of simple circuits, James read that one leg of the LED leg is the positive one and the other leg is negative.

James stated, **"We may have to do some research. Because you are right, it [LED light] does not say negative or positive on there. But what do you notice is different about the legs?"**

Eliot responded, **"Oh, I think the positive is the long one."**

Together, James and Eliot tested Eliot's hypothesis. And guess what? Yes, the positive LED leg is the positive. James extended this exploration by encouraging Eliot to grab objects in their home to test if they were conductive and non-conductive.

As a team, they tested a paper clip, a paper, a glue stick, and coins.

NAME AND ADDRESS CHILDREN AS ENGINEERS

Recognize and connect a child's process(es) and practice(s) as a particular kind of engineer. Make this explicit.

EXAMPLE FROM PROGRAM

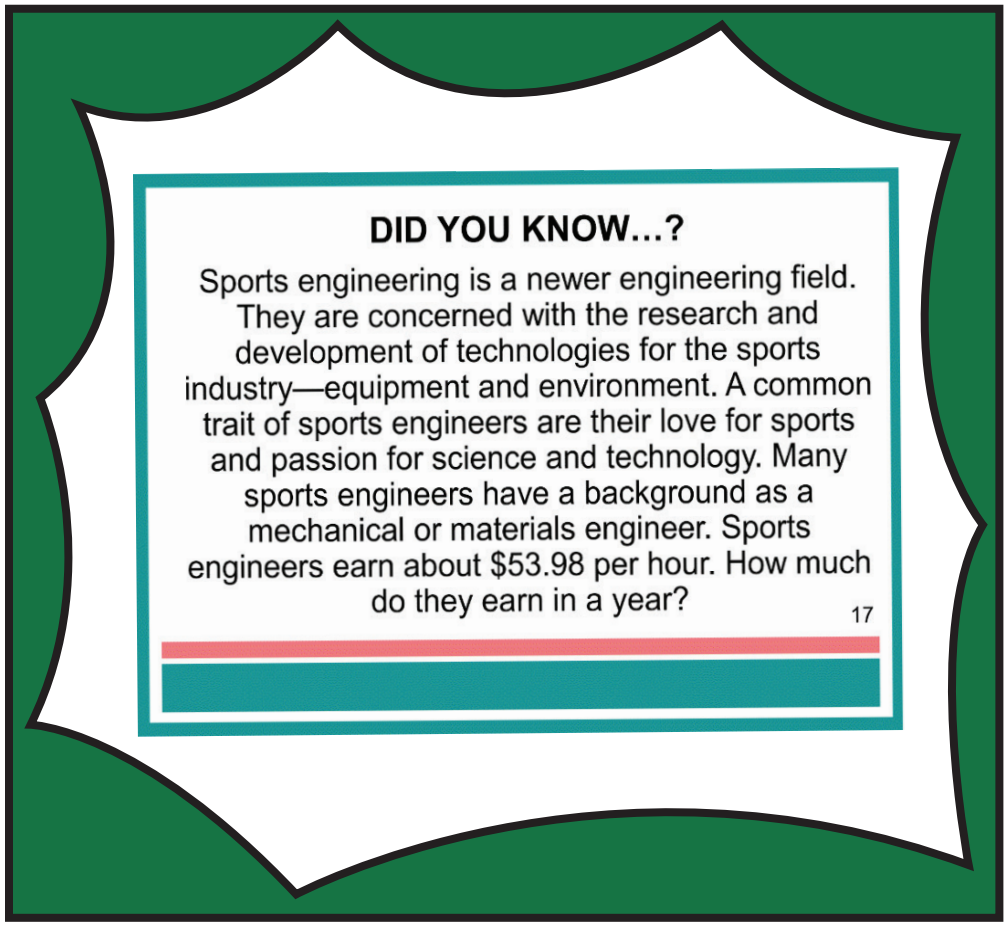
During show-and-tell sessions, children were encouraged to show their prototype and describe their engineering design process.

Atalia shared how they created their friendly delivery package. **"I put the post between two popsicle sticks, so when you pulled on one side, it circled to pull it to the other side."**

A facilitator followed up by making a connection to science concepts and the child's actions as a mechanical engineer.

"So you were using the force of motion and were using weights to make the machine move, to make your mechanism move, the mechanics of it like a mechanical engineer."

Another way to facilitate this is through the engineering kit guides. For example, in the soccer bot kit, childrens' engagement was connected to a sports engineer.



RECOGNIZE CHILD AND CAREGIVER PROCESSES AND ACTIONS AS ENGINEERING

Be observant and acknowledge moments in which children, and caregivers, enact the actions, behaviors, and/or talk common to the field of engineering.

You may reference components of an engineering design cycle that grounds your program (see Approaches section for an example).

EXAMPLE FROM PROGRAM

During a show-and-tell, siblings Cassie and Gabe described how their grabber did not work well with their first prototype and they had to redo it.

As described by Cassie, “We drew the pictures and then we designed and it made a mistake. So we picked a new one. But we also combined it with one of my brother’s pictures. And then we made it and it still fell apart. But we put it back together.”

A facilitator followed up by highlighting their collaboration as siblings, as well as how their actions mirrored an interactive process. “I like the idea of combining ideas as that shows collaboration and that you can actually get along with your brother or sister. I also heard you say that you both sketched out designs, created a prototype, but had to redesign the prototype because it didn’t work, which is an iterative design process.”

TAKE UP IDEAS AS POSSIBILITIES

Consider every idea as a possibility as opposed to squashing a learner's idea as not doable or feasible. The latter has the potential to diminish a learner's creativity and sense of self as an engineer. Engage in a conversation that makes any "out-of-this-world" idea doable.

EXAMPLE FROM PROGRAM

Aiden wanted to **"prevent bullying or stuff at school."** While this problem is one worth engineering a solution to address, the question is how do you build a prototype to stop bullying.

Below is how Anna, a volunteer engineer, was able to transform and narrow this idea.

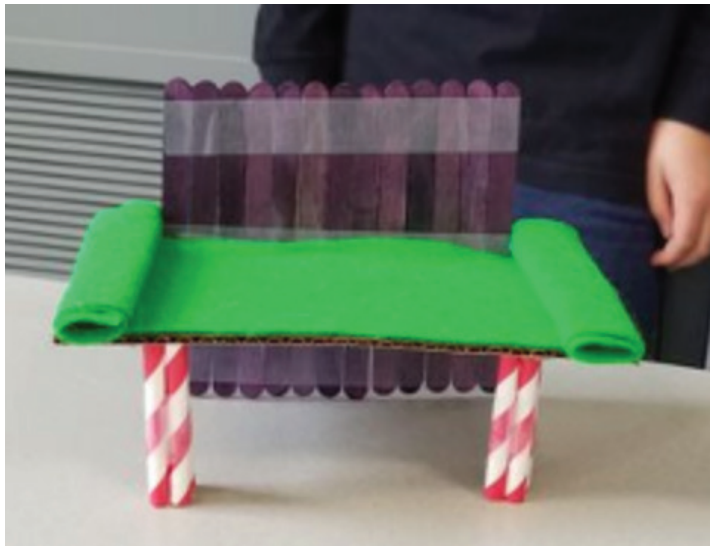
I LIKE YOUR PROBLEM A LOT AS IT SHOWS YOU HAVE COMPASSION, WHICH IS A GREAT TRAIT TO HAVE.

DO YOU THINK THERE IS A WAY TO BUILD SOMETHING TO HELP A BULLYING PROBLEM?

. . . SO BULLYING IS ABOUT HOW PEOPLE DON'T GET ALONG.

SO I KNOW SOMETIMES PEOPLE GET CLOSER WHEN THEY DO AN ACTIVITY TOGETHER.

COULD YOU MAKE SOMETHING THAT IS SOMETHING THAT PEOPLE THAT DON'T GET ALONG CAN DO TOGETHER THAT WOULD BE FUN FOR BOTH OF THEM?



What did Aiden create as a solution? ***A buddy chair.***

INSPIRE USE OF RECYCLABLE AND EVERYDAY MATERIALS

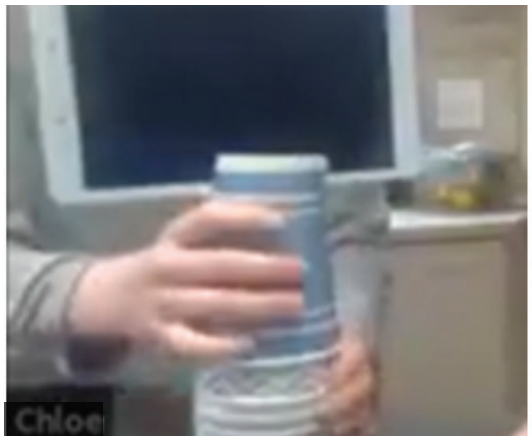
Promote a sense of resourcefulness. Encourage children and caregivers to envision how to transform materials and tools that are common (e.g., cardboard, yogurt containers, pipe cleaners) within the creation of their prototype(s).

EXAMPLE FROM PROGRAM

During a show-and-tell session, families were challenged to use recyclable and/or everyday materials from around their home to design and prototype a holding mechanism or stand for a tablet. We share two examples that we believe also highlight a creative use of materials.

Audrey and Daniel created slits into a folded box and used a baby hanger to adjust the position of the tablet. Courtney and Gabe used a stack of cups with a slit cut in the top cup to hold the tablet in place.

The stack of cups allowed the tablet to swivel, while adding or removing cups would alter the height.



PROMOTE THE CREATION OF MULTIPLE AND/OR ALTERNATIVE SOLUTIONS

Encourage learners to draw and/or write down more than one solution to a problem. This supports iteration and fosters creativity.

EXAMPLE FROM PROGRAM

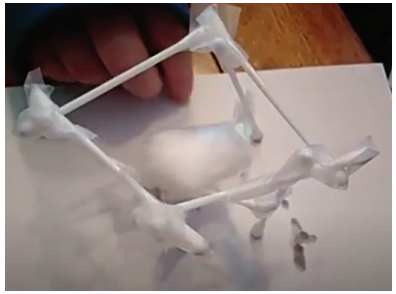
Eleanor designed/sketched three water color bots with a list of materials -

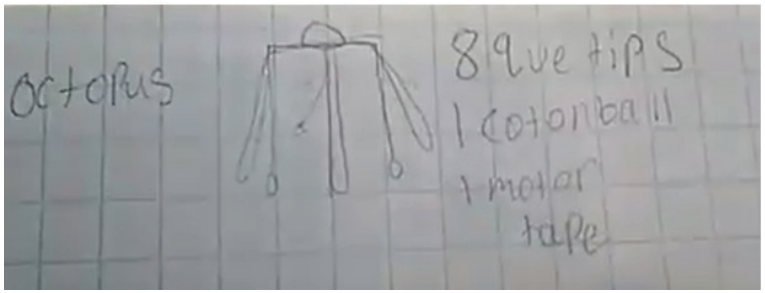
(1) THE OCTOPUS

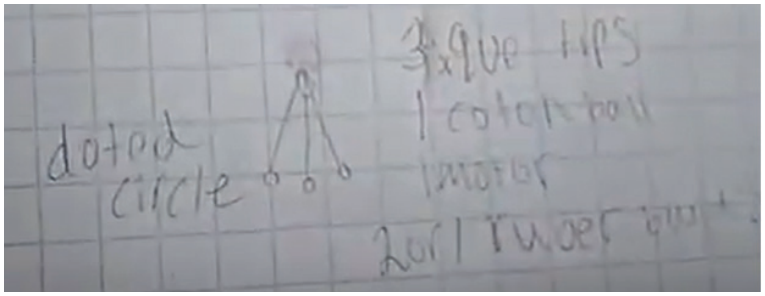
(2) THE DOTTED CIRCLE

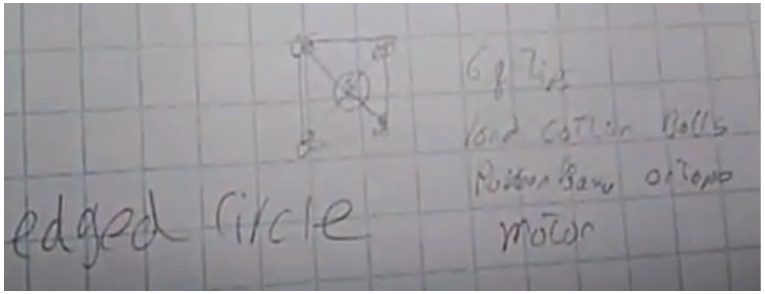
(3) THE EDGED CIRCLE

Eleanor relied on her three designs in the Test and Change stages.









ACKNOWLEDGE THE FACILITATION MOVES OF FAMILY MEMBERS

When working alongside families, verbally highlight their various ways of supporting their child(ren) throughout the process. In our experience, this has afforded us an opportunity to build a relationship and a level of trust with different family members.

EXAMPLE FROM PROGRAM

Cindy's (child) self-identified problem was to build a remote-controlled robot that would deliver things (e.g., food) to individuals who cannot get out of bed. Tanya (caregiver) often expressed that she wanted to support Cindy but did not want to overstep her boundaries. Researchers' acknowledgement encouraged Tanya to work closely with Cindy.

For example, **"I LIKE THE QUESTIONS YOU ASKED CINDY. THEY HELPED CINDY TO FINALIZE HER DESIGN."**

"I LIKE THE WAY TASKS WERE DISTRIBUTED BETWEEN YOU AND CINDY."

"IT WAS VERY HELPFUL THAT YOU REMINDED CINDY TO TAKE NOTES ON THE DIMENSIONS OF YOUR HOUSE."

Acknowledgement can be framed into a question.

For example, Amanda (caregiver) was excited to share her story, when a researcher asked

"DO YOU HAVE ANY PRIOR EXPERIENCE WORKING WITH KIDS? I NOTICED YOU OFTEN ASK GOOD QUESTIONS TO THEM."

ADVISE FAMILY MEMBERS TO UTILIZE THEIR SHARED EXPERIENCES

Families should be able to make connections between what they are doing within the various engineering design steps and their shared experiences as a family.

EXAMPLE FROM PROGRAM

MEET THE WILLIAMS FAMILY

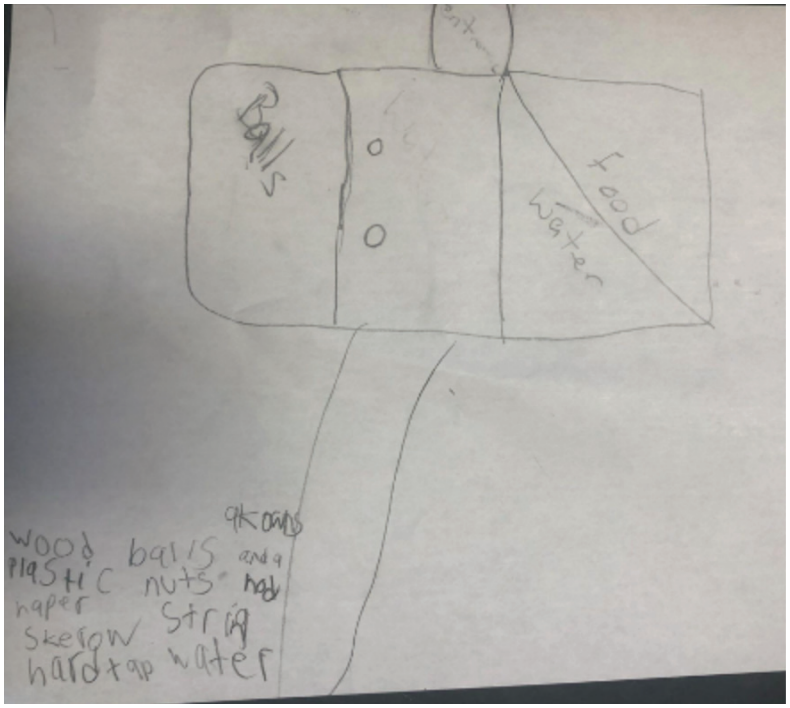
Bob (caregiver) and Jackson (child).

In identifying a potential problem, Bob used a familiar place and context in the local community to frame their conversation and engagement.

"HOW ABOUT WE BUILD...BECAUSE WE GO TO THE PARK A LOT... HOW ABOUT WE BUILD SOMETHING THAT THE SQUIRRELS CAN PLAY IN, OR THE LITTLE CHIPMUNKS AND STUFF CAN PLAY IN? . . . DON'T YOU SEE THEM RUNNING AROUND. OR WE CAN BUILD SOMETHING AND WE CAN PUT INSIDE OF A TREE, OR HANG IT ON A TREE, SO A SQUIRREL CAN...YOU KNOW YOU SEE 'EM RUN AROUND ALL THE TIME."

Jackson liked the idea so much that he jumped right into the planning stage.

"OH, I'M GOING TO DRAW A PICTURE."



ENCOURAGE FAMILIES TO CREATE/ADD THEIR OWN NARRATIVE AND MAKE IT RELEVANT TO THEIR LIFE

Encourage families to tell stories through their projects that reflect their interests and make the project meaningful and relevant to them. As they design and build a prototype, invite them to add personality.

EXAMPLE FROM PROGRAM

In the creation of a paper roller coaster, Eve and Ashley made it uniquely theirs by creating a theme park.

Beyond the creation of six roller coasters - **THE SNAKE, THE KID COASTER, THE DROP, THE TURNER, ZERO GRAVITY, AND THE TWISTER** - Eve and Ashley added elements that highlight their knowledge of theme parks.

"SO WE'RE GOING, WE HAVE SOME STOP SIGNS AND THIS IS THE ENTRANCE. AS YOU CAN SEE, IT SAYS CAUTION BECAUSE YOU'RE ENTERING THE THEME PARK AT YOUR OWN RISK. WE HAVE SOME STOP SIGNS WHERE YOU NEED TO BE CAUTIOUS BECAUSE OF THE COASTER RIDES. AND THEN YOU HAVE A BENCH JUST IN CASE PEOPLE GET TIRED AND THEY NEED SIT DOWN"

EVALUATION

Once you have planned and facilitated your own making/engineering design program, how can you know whether it is working or having an impact on families?

In this section, we highlight the value of evaluating your program and what you can gain from doing so. We provide suggestions that your team can use to evaluate and gain valuable information about the programs you offer.

IMPORTANCE OF EVALUATION

Providing and supporting programs for families to engage with one another involves a large amount of time, energy and planning. Given this investment, it is important to know whether the program is running as you intended and having the desired impact on families.

There are ***TWO PRIMARY*** ways you can learn how things are going in your program. You can take a step back and evaluate how things are going during the programming (implementation) as well as at the end of the program (reflection).

During

- Serves to gauge how things are going in the moment.
- Allows you to make changes as needed as you move forward.

After

- Provides a holistic view of the program and whether you succeeded in meeting your goals.
- Did the program impact families in the way you intended?

During the program, the primary focus is to gauge how the program is being implemented in order to determine whether any changes are needed as the program progresses.

This will serve as a quick self-check and can lead to minor adjustments/improvements as you go.

After the program has ended, the primary focus is to reflect on how the program went overall and the impact the program had on participants.

This information can be used to improve future events and activities to best meet program goals and the needs of the families who participate.

METHODS OF EVALUATION

To understand how families are doing and progressing during workshops and challenges, you can focus on three primary things: interactions, projects, and reflections.

Interactions

- Are family members interacting with one another?
- How are families working together? Is one person taking the lead or are they working collaboratively?
- Who is holding the materials and tools? Who is doing the "work"?
- Are families having fun together?

Projects

- What emotions do they exhibit? Do they appear excited or frustrated about their projects?
- How much effort do they put into their project? Do they extend it beyond the basic activity?
- How do they talk about their projects? How do their projects change over time? (if applicable)

Reflections

- What do families say about themselves, each other, and about the activities?
- How do these perspectives change over time or apply to other contexts?
- How are families continuing to use the information or skills they've learned and developed?

Observations can be conducted informally by facilitators as they watch and observe families during workshops or events. It is helpful to document these observations with photos or videos. You can set up video recorders around the room or at individual tables to capture videos of wide or narrow angle views during events.

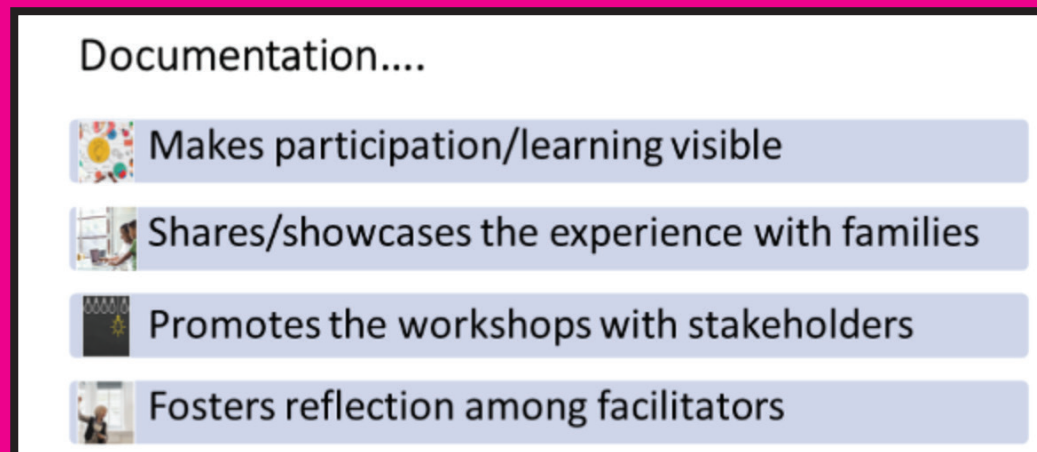
CHECK OUT THE PHOTOS THROUGHOUT THIS GUIDE TO VIEW EXAMPLES OF THE TYPES OF PHOTOS WE HAVE TAKEN OR SNIPPED FROM VIDEOS.

Experiment and see what works for your group!

DOCUMENTATION IS IMPORTANT!

Photos can **MAKE PARTICIPATION VISIBLE** by showing how family members work together, what tools and materials they use, what families create, and the emotions they exhibit as they work.

Photos are also a great way to **SHARE THE EXPERIENCE WITH FAMILIES**, as most families will enjoy seeing themselves in action and excited to share these pictures with other family members and friends.



Photos are a great way to **PROMOTE YOUR PROGRAM** with stakeholders, funders, volunteers, colleagues, and families.

Finally, photos can be used to **PROMPT REFLECTION** with your facilitators about the process, what went well, and what could be improved.

PICTURES ARE A GREAT WAY TO SEE HOW WORKSHOPS/IN-PERSON EVENTS ARE GOING. HERE ARE A FEW SUGGESTIONS TO GET THE MOST OUT OF PHOTOS:

- TAKE SOME IMAGES FROM ABOVE AND OTHERS AT HAND-LEVEL. (E.G., FROM CHILDREN, CAREGIVERS, AND FACILITATORS; OVERALL ROOM VIEW; ETC.)

- FOCUS PHOTOS SO THAT THEY SHOW CLOSE-UP VIEWS (E.G., SHOW HANDS) OF FAMILIES ACTIVELY ENGAGED IN WORK.

- GET PERMISSION IF YOU PLAN TO POST/SHARE, ESPECIALLY IF CHILDRENS' AND CAREGIVER'S FACES ARE IN THE PHOTO.

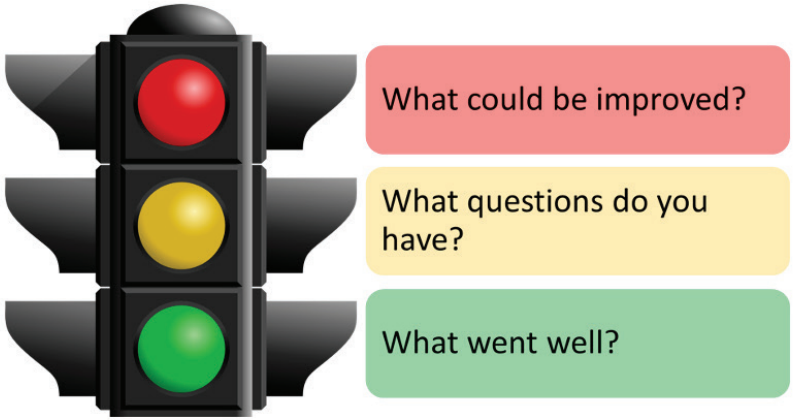
PHOTOS CAN PROVIDE INSIGHT INTO THE INTERACTIONS BETWEEN FAMILY MEMBERS (E.G., WHO IS PARTICIPATING, WHO IS HANDS-ON, ETC.) AND THE PROJECTS THAT ARE CREATED.

ADDITIONALLY, ENCOURAGE FAMILIES TO TAKE THEIR OWN PICTURES TO DOCUMENT THE EXPERIENCE. SUGGEST THEY TAKE PICTURES AT MULTIPLE TIME POINTS IN THE DESIGN PROCESS: EARLY PROTOTYPES, TESTING, WHEN THEY HAVE A FAILURE WITH THEIR DESIGN, A REVISED DESIGN, ETC. THESE PICTURES WILL GIVE YOU A PEEK AT THE PROJECT FROM THE FAMILY'S PERSPECTIVE! GIVE THEM A #HASHTAG TO POST TO SOCIAL MEDIA IF YOU SHARE INFORMATION VIA THOSE PLATFORMS.

IF YOU HAVE ACCESS, A SIMPLE PHOTO PRINTER PROVIDES A GREAT WAY TO BE ABLE TO GIVE FAMILIES A MEMENTO OF THE EXPERIENCE BEFORE THEY LEAVE.

TEAM REFLECTIONS

Reflections provide a quick check on how programs and workshops went. Reflections are based on observations and experiences during the workshop sessions and typically take the form of running notes or focused debrief sessions with facilitators at the end of each workshop. We recommend a quick debrief as your team is cleaning up AND a check in a few days later to see if any more thoughts or reflections are surfaced.



DEBRIEFING AS A TEAM PROVIDES MANY BENEFITS

- A STRUCTURED APPROACH HELPS FOCUS REFLECTIONS
  - A RED/YELLOW/GREEN LIGHT APPROACH IS ONE OF MANY OPTIONS. CHOOSE WHAT BEST FITS YOUR CONTEXT
- DEBRIEFING AS A TEAM HELPS ILLUMINATE MULTIPLE PERSPECTIVES SINCE ONE PERSON CANNOT OBSERVE EVERYTHING ALL AT ONCE
  - REFLECTIONS ALLOW YOUR TEAM TO LEARN NOT ONLY ABOUT ASPECTS OF LOGISTICS BUT ALSO ABOUT THE ACTIVITY AND EXPERIENCE OF PARTICIPANTS
- DEBRIEFING TOGETHER ALLOWS YOUR TEAM TO LEARN FROM ONE ANOTHER AND WORK TO MAKE IMPROVEMENTS TOGETHER. EVERYONE IS ON THE SAME PAGE
- IF YOU OFFER MULTIPLE PROGRAMS, SUBSEQUENT DEBRIEF SESSIONS CAN COMPARE SUCCESSES AND CHALLENGES BETWEEN THE PROGRAMS
  - DO FAMILIES ENJOY AND ENGAGE IN CERTAIN ACTIVITIES MORE THAN OTHERS?
  - HOW DID ATTENDANCE AND PARTICIPATION DIFFER BETWEEN PROGRAMS? WHAT FACTORS MAY HAVE LED TO THESE DIFFERENCES (E.G., ACTIVITY, TIME/DAY OF WEEK, SETTING, ETC.)

SURVEYS AND INTERVIEWS

Talking to families directly is one of the best ways to see the impacts of the program on participating families.

Interviews can be conducted at the end of the program to get a better understanding of the experience of families as well as how participation impacted them.

- **EXAMPLE CHILD INTERVIEW QUESTIONS INCLUDE:**
  - **WHAT ABOUT YOUR KITS OR PROJECTS MADE THEM YOURS?**
  - **WHAT IDEAS OR PIECES DID YOU ADD?**
  - **HOW DID YOU BUILD THEM SO THAT THEY WERE SPECIAL TO YOU?**
  - **NOW THAT YOU HAVE EXPERIENCE MAKING THINGS, IF YOU WERE TO DESCRIBE THREE TRAITS AN ENGINEER NEEDS, WHAT WOULD THOSE BE?**

- **EXAMPLE CAREGIVER INTERVIEW QUESTIONS INCLUDE**
  - **WHAT ASPECTS OF YOUR PERSONAL RELATIONSHIP AND/OR PRIOR EXPERIENCES WITH YOUR CHILD(REN) WERE HELPFUL FOR YOU AS YOU WORKED TOGETHER ON THE PROJECTS?**
  - **HOW DO YOU THINK YOU MIGHT CONTINUE TO USE WHAT YOU LEARNED IN THIS PROGRAM?**

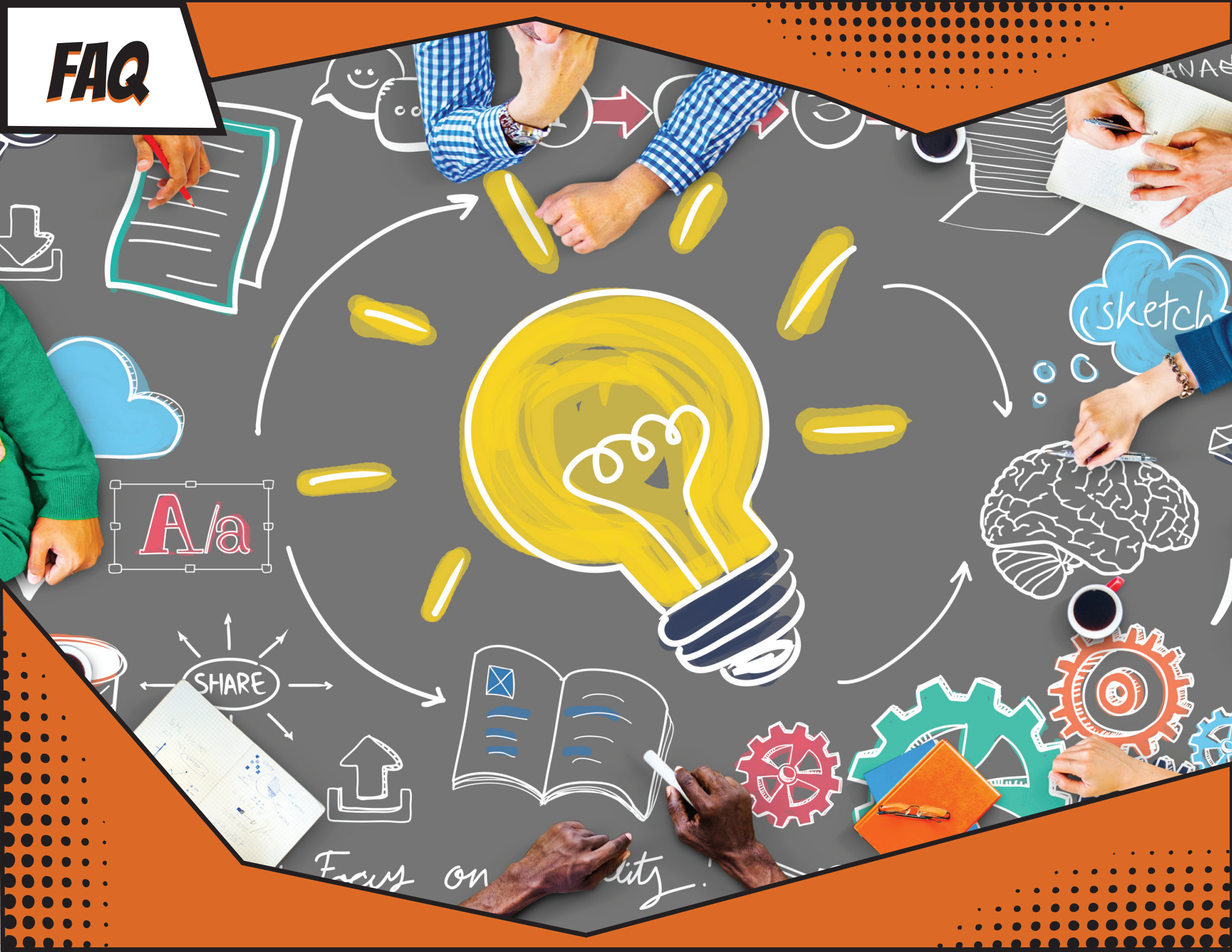
If you don't have time to conduct interviews, surveys can also be a quick way to collect information from families. These surveys can be paper surveys distributed at the end of an in-person event or distributed via email after the event for families to complete. Surveys often ask families to rate different aspects of the program and how much they learned or gained from participating.

If you are interested in more formal tools or assessments to evaluate program impacts, we suggest the following **WEBSITE** to get started or reach out to us for a conversation.

WHAT ARE YOU LEARNING FROM THE IMPLEMENTATION OF THE PROGRAM?

On our **WEBSITE**, we include an overview of the insights we have gained from our research with families.

FAQ



This section exists to provide answers to common questions, problems and sticky points not addressed in other areas of the facilitation guide.

1. WHAT IS THE AVERAGE COST OF ONE KIT?

The average cost of our kits is $6.98 including basic materials (e.g. scissors or pencils) and $5.71 excluding basic materials. However, we encourage you not to assume that everyone has access to basic materials. The least expensive kit is the Make your Idea Fly kit $1.17 and Paper Roller Coaster at $1.38. The highest cost is $42.96 for the Pedometer: Increasing Steps. We advise you to purchase items in bulk to reduce costs.

2. HOW ARE THE CONSUMABLES IN THE KITS REPLENISHED?

One tip is to create a material bin of consumable materials. You can place the material bin at a convenient spot in your center so that anyone has access (i.e. open access) and/or can donate materials. On the other hand, you can create a schedule for donating a material bin around the reception desk so that your staff can manage it (i.e. manageable access). Another tip is to reach out to local industries for donations.

3. WHAT IS THE AVERAGE TIME SPENT ON COMPLETING ONE KIT?

The average time for families to complete a kit is between 45 to 60 minutes. Families may feel stressed to finish the project once they open the kit. You should remind them that they can revisit the making process another day. This is a common practice of engineers.

4. HOW MUCH TIME DOES IT TAKE TO PUT THE KITS TOGETHER?

Time will vary, but from our experience, it will take longer than expected. There are several factors to consider when planning the time it will take to put one set of kits together such as number of people, amount of material, number of kits (e.g., 10 paper roller coaster kits) and additional prep work (e.g., cutting paper for roller coaster strips). If you choose to make index-card sized instructions, it will take additional time to put these together. Adding labels to the kits is another factor to consider.

5. WHAT IF OLDER OR YOUNGER SIBLINGS ARE INTERESTED IN THE PROGRAM?

Our kits are designed to be family oriented so older and younger siblings are welcome. We encourage a shared space where siblings work together. In creating a shared space, you may consider adding constraints and/or requirements to support the engagement of both siblings. For example, the paper roller coaster kit can be modified to include the requirement of a loop for older siblings.

6. WHAT IS A PROPER WAY TO DESIGN CULTURALLY RESPONSIVE FAMILY STEM PROGRAMS?

One, identify culturally relevant components for the basis of the engineering task. This may include specific ethnic cultures, geographic features, local industries, local events (e.g., apple festival), and interests of children (e.g., competitive cheerleading, skateboarding, bugs) in your community.

Two, focus on empowering youth living in your communities to use inexpensive materials (e.g., making a shoe box maker space).

Three, be critically conscious of how negative stereotypes and bias impacts the education of children within your program. Work to recognize ways in which children and their families are competent STEM learners (e.g., “The way you used straws in your prototype is unique. I appreciate how you transformed the straw into a gutter to collect rainwater for animals.”)

7. WHAT IF FAMILIES WANT TO STOP THE PROGRAM?

It is likely that families will choose to stop the program. Before the start of the program, you should make families aware that being a part of the program is voluntary and they can stop at any time. Maybe give an example when you had to stop a program or an experience, as well as why you made this decision. This will help set up an environment of trust.

8. How might we recruit volunteer engineers or engineering students?

For communities that have postsecondary education organizations with engineering or STEM programs, consider reaching out to those departments and learning about what community engagement requirements they have for students or mentoring programs they may administer. Both undergraduate and graduate programs often require some form of volunteering or community involvement and this program can be a great way for university students to gain experience working with the public while meeting their program requirements.

Recruiting professional engineers from the community can often be done through the marketing/communications office or official within an engineering firm. They are often knowledgeable about community outreach programs and professional development requirements that engineers, architects, and other STEM professionals may have. They can also be a great resource for spreading the word about the program and opportunities to volunteer or get involved through mentorship, show-and-tells, etc.

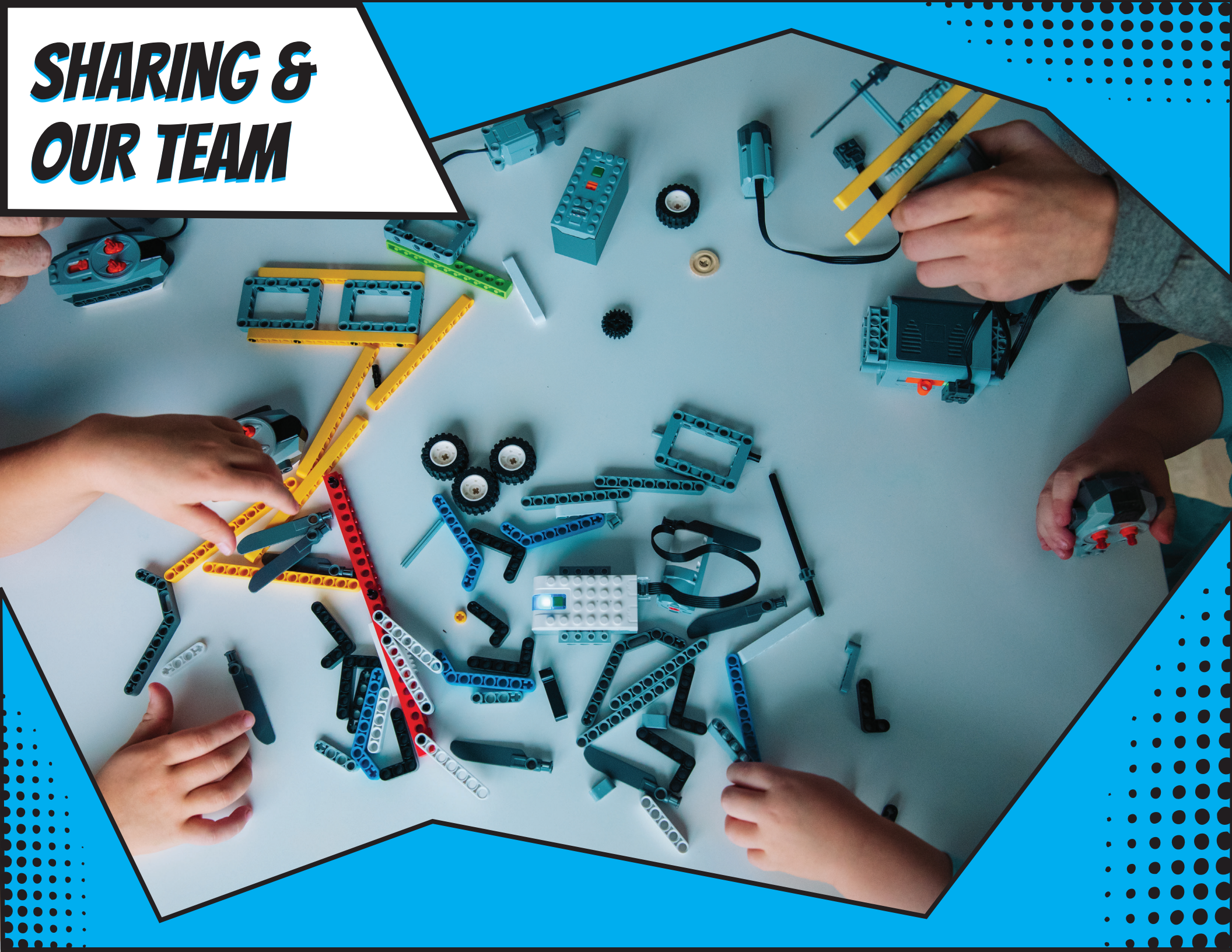
9. What are things we should budget for when conducting an in-person program for families?

You should consider the cost of food, materials and tools, transportation, and printing.

10. Where might we look for external funding and/or donations?

- Ask local STEM companies
- Find a collaborative partner organization which has the capacity to support your program. Discuss what parts of your program need support from your partner organizations. For example, Boys and Girls Club in Bloomington, Indiana provided pizzas and beverages for the family creative challenges. The 4-H club in Leavenworth, Indiana prepared basic craft materials for the family program.
- Research diverse resources about school fundraising ideas and select appropriate ideas based on your program's needs.
- Google "Community STEM grant", "STEM educator grant", "STEM grant for nonprofits", or use your own search terms based on your needs. There are various grants in the wide spectrum of funding limits with various levels from small foundations to the National Science Foundation. One example site to find funding resources is www.stemgrants.com.

SHARING & OUR TEAM



SHARE!

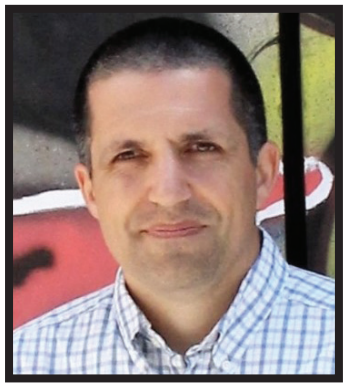
We would love for you to share how you utilized information in this facilitation guide with others, through emailing FAMILYMAKINGDESIGNNY@GMAIL.COM

We'd love to connect with you on ***Instagram*** too - @IUBSTEMED

ABOUT OUR TEAM

We are a collaborative team of educators, researchers, learners, and evaluators. Together, we brainstormed, struggled, laughed, and learned from one another through the multiple highs and lows of this project. Each member of our team contributed to the project in numerous ways - small and large: recruiting families, engaging with organizations and school districts, developing MAKEengineering kits, collecting and analyzing data, and writing this guide. Without these contributions the project would not have been so fruitful.

AMBER SIMPSON



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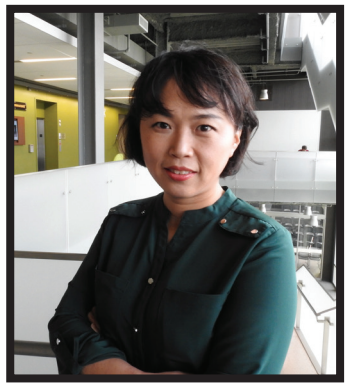

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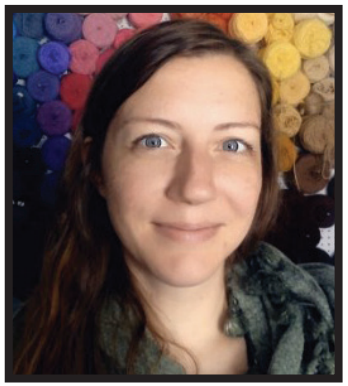
KELLI PAUL



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ACKNOWLEDGEMENTS

This project started before COVID-19 and ended after the main part of the pandemic passed. The project was strongly influenced by the pandemic, which caused our work to shift in unanticipated directions. At times, this strengthened our project and relationships with families. Through it all, we tried our best to engage families in making, creating and engineering at home.

We would like to give a special acknowledgement and thank you to the many families in New York and Indiana, community organizations and school districts, and the individuals within the community organizations and school districts who helped us in refining our program. We learned a lot from this experience and you were a part of our growth. We also thank the engineering firms and engineers that provided guidance and mentorship to families and to our team. Lastly, we would like to send a special thank you to Jubie Tan, Ala Marciuc, and Zachary Schinasi for their interest and support as student researchers.

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