CLOSET CRITTERS

A PAPER CIRCUIT SAMPLE PROJECT

Genesis Learning

Empower your students to imagine something into existence.

ABOUT THIS PROJECT

The maker movement represents student-centered learning at its best. It embraces self-directed research, rapid prototyping and acknowledges prototype failure as an essential part of the learning process.

While makerspaces provide excellent resources for kids who are personally driven to build something meaningful to them, I have watched some ambitious students struggle and spin their wheels when they try to tackle larger, complex projects but lack the foundational knowledge to give their ideas traction.

Thus, there has always been a tension in my classroom between student passion and interest and a teacher's goal of giving students the information and skills they need to follow their passion - kind of a chicken and egg scenario.

The instructional model used in this project combines key elements of project-based learning with some foundational principles of the maker movement and design thinking.

Educational research junkies will see that the design draws a lot of influence from the Buck Institute, Wiggins and McTighe, Lucy Calkins, Chip and Dan Heath, Daniel Pink, Alfie Kohn, Carole Dweck and others.

My greatest influence, however, has been my own classroom and students. Often something sounds great in a book, but it's not until you actually put it into practice that you uncover the nuances and details that make it work. I have refined this model over two years of using it with my 8th Grade Physical Computing class.

I hope that you find it useful.

Trevor Shaw--Teacher

Contents

What Good Problem Solvers Do

TAKE TIME TO CAREFULLY DEFINE A PROBLEM…

Ineffective problem solvers are are sometimes led astray because they make incorrect assumptions about what a problem requires. An effective problem solver will take the time to ensure that she understands the problem and what it is requiring her to do. She will be able to clearly state the problem in terms of what is known and what is unknown. She will be able to articulate the relationship of resources involved in a problem.

KNOW WHAT THEY KNOW…

Good problem solvers perform an inventory of what they already know and incorporate that knowledge into their understanding of the current problem. This is done both in terms of understanding the shortcomings of an existing system as well as designing a solution or improvement to that system. Effective problem solvers engage existing knowledge across disciplines and in novel situations.

CAN FIGURE OUT WHAT THEY NEED TO KNOW…

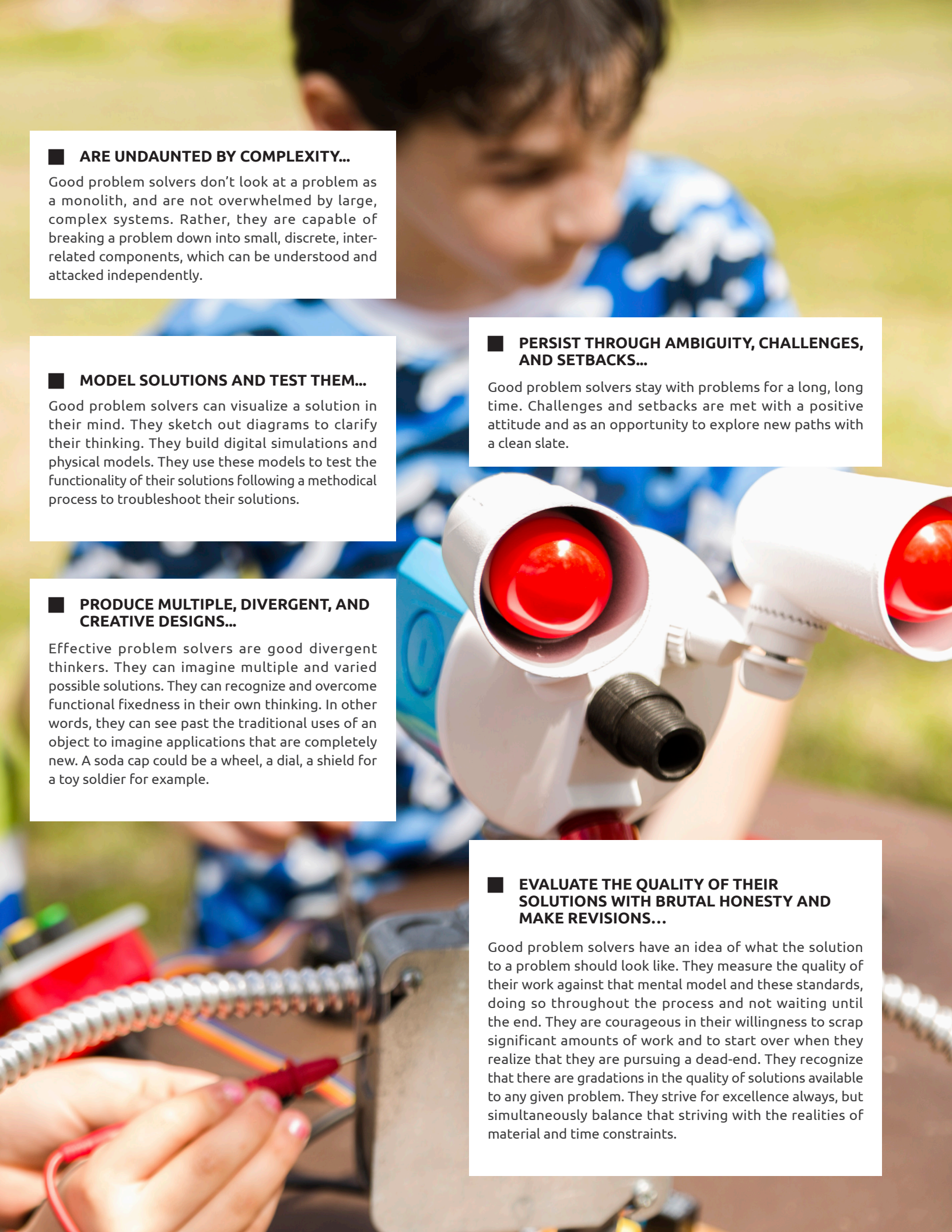
Good problem solvers can identify gaps in their own understanding, and articulate those gaps in the form of questions. Such questions include both over-arching questions that get to the solution of a particular problem (how can I design an alarm system that uses a laser beam as a trigger?) as well as more tactical, informational questions (what does a pull-down resistor do, and why are they important in a circuit that uses digital logic?) good problem solvers are constantly asking themselves "what don't I understand about this system, and what do I need to learn in order to understand it better?) Good problem solvers recognize when their existing schema and mental models must be updated, revised or abandoned.

CAN EFFECTIVELY AND EFFICIENTLY FIND THE INFORMATION THEY NEED…

Good problem solvers are expert researchers. They are well versed and comfortable using all manner of information resources (including classmates). Not only are they able to distinguish between reliable and unreliable sources, but they can also identify high quality sources that are understandable at their reading level.

COLLABORATE…

Good problem solvers view teammates as sources of information and talent. They help teammates to divide tasks equitably and according to one another's strengths. Good problem solvers help their team to work through conflict and to value the contributions of all team members.



ARE UNDAUNTED BY COMPLEXITY...

Good problem solvers don't look at a problem as a monolith, and are not overwhelmed by large, complex systems. Rather, they are capable of breaking a problem down into small, discrete, inter-related components, which can be understood and attacked independently.

MODEL SOLUTIONS AND TEST THEM...

Good problem solvers can visualize a solution in their mind. They sketch out diagrams to clarify their thinking. They build digital simulations and physical models. They use these models to test the functionality of their solutions following a methodical process to troubleshoot their solutions.

PRODUCE MULTIPLE, DIVERGENT, AND CREATIVE DESIGNS...

Effective problem solvers are good divergent thinkers. They can imagine multiple and varied possible solutions. They can recognize and overcome functional fixedness in their own thinking. In other words, they can see past the traditional uses of an object to imagine applications that are completely new. A soda cap could be a wheel, a dial, a shield for a toy soldier for example.

PERSIST THROUGH AMBIGUITY, CHALLENGES, AND SETBACKS...

Good problem solvers stay with problems for a long, long time. Challenges and setbacks are met with a positive attitude and as an opportunity to explore new paths with a clean slate.

EVALUATE THE QUALITY OF THEIR SOLUTIONS WITH BRUTAL HONESTY AND MAKE REVISIONS...

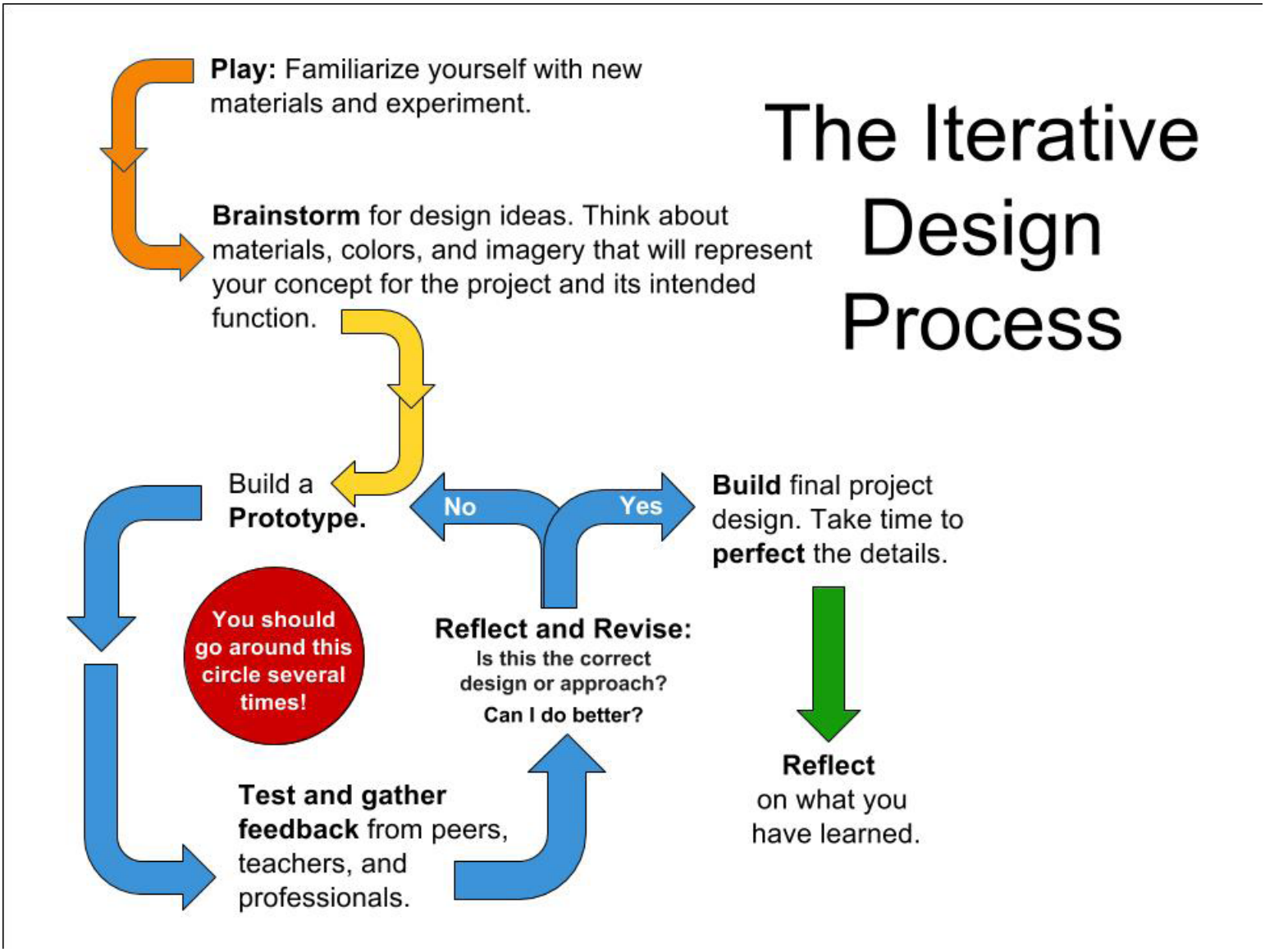
Good problem solvers have an idea of what the solution to a problem should look like. They measure the quality of their work against that mental model and these standards, doing so throughout the process and not waiting until the end. They are courageous in their willingness to scrap significant amounts of work and to start over when they realize that they are pursuing a dead-end. They recognize that there are gradations in the quality of solutions available to any given problem. They strive for excellence always, but simultaneously balance that striving with the realities of material and time constraints.

A Good Project Should have...

- Authenticity & Relevance
- Autonomy (Student Choice and Voice)
- Extended inquiry and self-directed research
- No single “right answer”
- Reflection
- Public Product
- An enduring understanding that gives it context

Design Thinking

It is important to blend periods of free exploration with purposeful, creative activities. Students need the former to become familiar with what is possible, to discover where their interests align with the possibilities, and to deepen their understanding of how materials and tools work. Without the latter, however, students will often rush to build the final product and never refine a design idea through quality feedback. The chart below outlines our proposed design process, but there are many others that could be used. Consider posting a version of this process on a classroom wall and using it to guide student activity throughout the project



Project Launch--Tips

The purpose of the project launch is to generate student interest and enthusiasm and to establish relevance for a project. There will always be some tension between how much of a project is teacher-driven and how much is driven by student intrinsic motivation. To maximize student motivation, the project launch should create a context of tension and interest among students. Students should feel some sense that a problem exists. To the greatest extent possible, the project launch should get students to care about the problem.

The best project launches use an emotional appeal to engage student interest and to form a personal connection.

There are numerous strategies for designing a project launch:

- Highlight a community issue of concern that affects students or their families
- Stage or spark an argument or conflict over a controversial topic
- Share a compelling narrative -- Mysteries often work well
- Demonstrate the creative or innovative work of others in a category -- wearables, kinetic sculptures

Project Launch -- Closet Critters

For this project, we will use a narrative in the form of a short, animated story made on goAnimate.com. We will attempt to create some empathy among students for the plight of a young boy about their age (8 or 9) who has discovered some evidence that something is living in his closet and coming out during the night while he sleeps. We will tap into this emotional connection to inspire students to innovate a solution to the boy's problem in the challenge statement.

Of course, if you have another way that you would like to launch this project, go for it!

WATCH THE VIDEO:

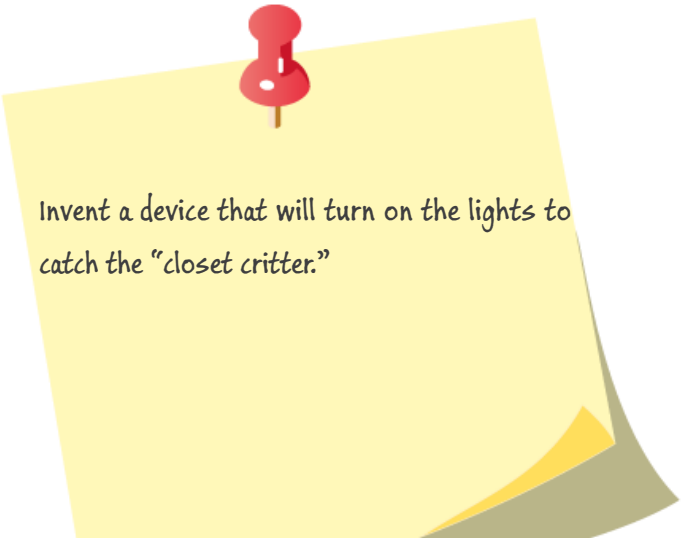
https://youtu.be/KeQIh3hCa0I

Team Handout -- Closet Critters!

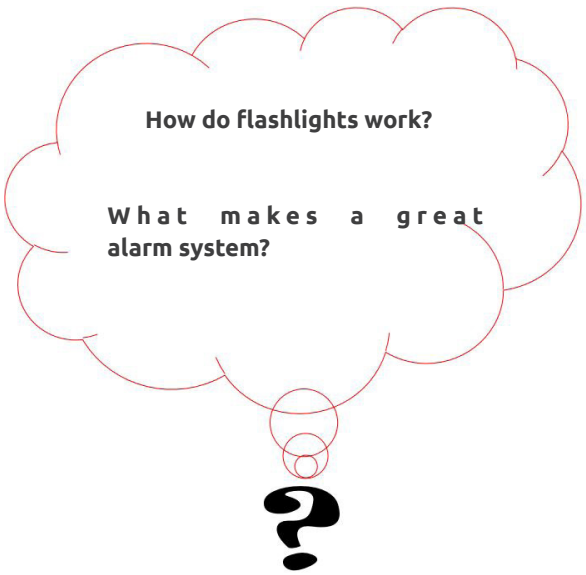
TEAM Members _____

In the video, you saw that Jake has a big problem in his closet. Jake is a pretty smart and brave kid. Even though he's afraid, he is going to invent a way to find out what is terrorizing his closet.

Task



Driving Questions



	SKILL / OBJECTIVE	EVIDENCE OF UNDERSTANDING / MASTERY	STANDARDS
THE BIG IDEA	I can apply creativity and some knowledge about electricity to invent something that solves a problem.	Use a good process and collaboration to build a light that is triggered by something leaving the closet.	Next Gen Science: ↘ 3-5-ETS1-1 ↘ 4-PS3-4 Common Core ELA: ↘ W.4.7 ↘ W.4.9 ↘ W.5.7 ↘ W.5.8 ↘ W.5.9 Common Core Math: ↘ MP.2
IMPORTANT TO KNOW AND DO	↘ Complete a circuit ↘ Avoid short circuits ↘ How an LED works ↘ How a switch works	Build a complete and functioning circuit including an LED and a switch.	
NICE TO BE FAMILIAR WITH	↘ Various types of switch designs.		
HABITS OF MIND	Perseverance	You push through difficulty without complaining; You stay focused on results in the face of challenges.	
	Creativity	Your idea for your project is new or unique. You use materials in unexpected ways.	
	Self Awareness	You can describe what you know and what you need to learn to get your project done..	
	Self Reliance	You can find tools and materials without help from the teacher; You can research information on your own.	
	High Quality Standards	You work neatly, demonstrating good organizational strategies; you uses tools correctly to ensure work is neat	

Materials	Annotated Sketch

↘ Coin Cell Batteries
↘ Copper Tape
↘ LEDs
↘ Piezo Buzzer
↘ Various insulating and conductive recycled and crafting materials to build with :
  ↘ plastic bottles
  ↘ binder clips
  ↘ brass fasteners
  ↘ paper clips
  ↘ paper towel rolls
  ↘ construction paper
 	
List any other materials you think you will need:	

In the space below, record the results of your initial prototypes...

What do you already know that might be helpful in this project?	What do you need to learn or find out? What are you stuck on?

Circuit Basics

CIRCUITS 101 --

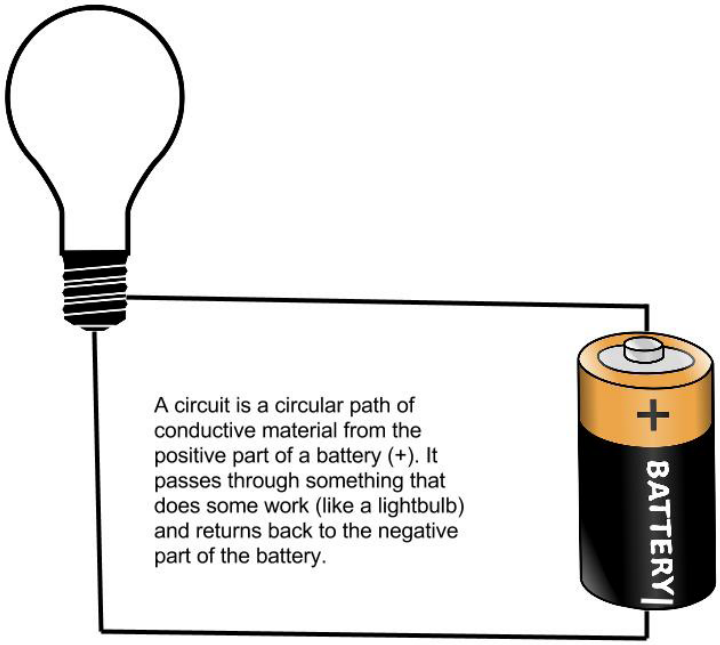
Electricity is the energy created by the flow of electrons.

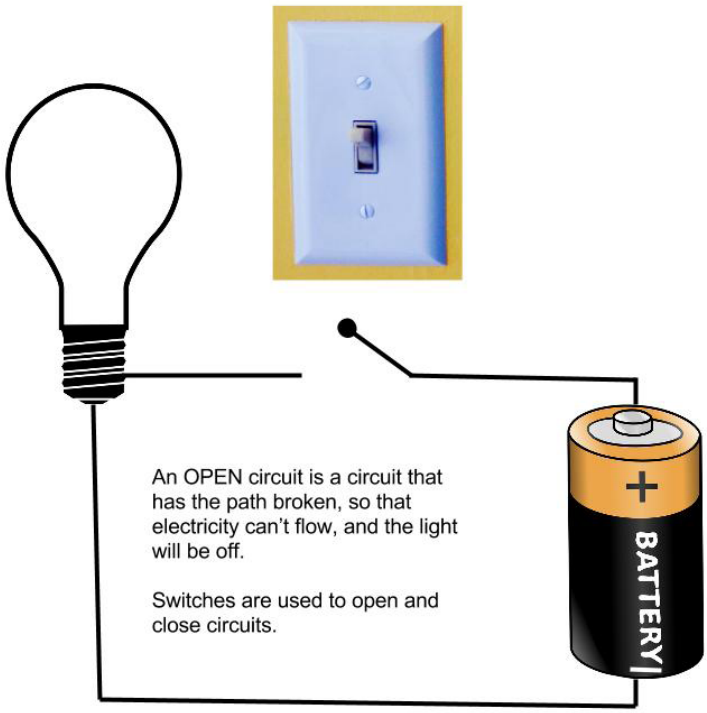
Some materials are conductive. They allow electricity to flow through them like metal. Other materials are insulating. They have a high resistance to the flow of electricity like rubber or plastic.

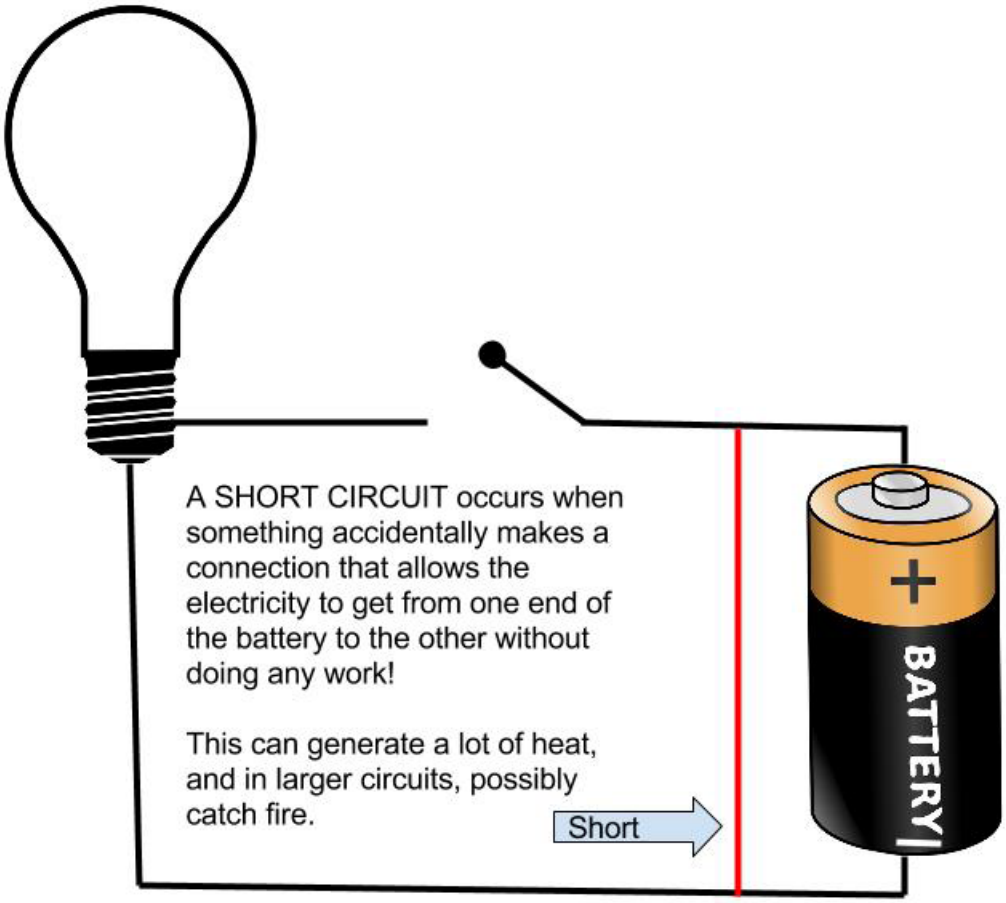
A CIRCUIT is a complete path of conductive material that allows electricity to flow to a component that does some work. A light bulb that provides light is an example of a component doing work. An open circuit has a break in the conductive path. A closed circuit is one where the path is complete and current can flow.

A switch is often used to open or close a circuit.

Electricity will generally take the path of least resistance. If wires accidentally come together and allow the electricity to move through the circuit without going through the component doing the work, we say that there is a SHORT CIRCUIT. Short circuits are never good. They can cause the battery to get very hot and in high voltage circuits could cause a fire.

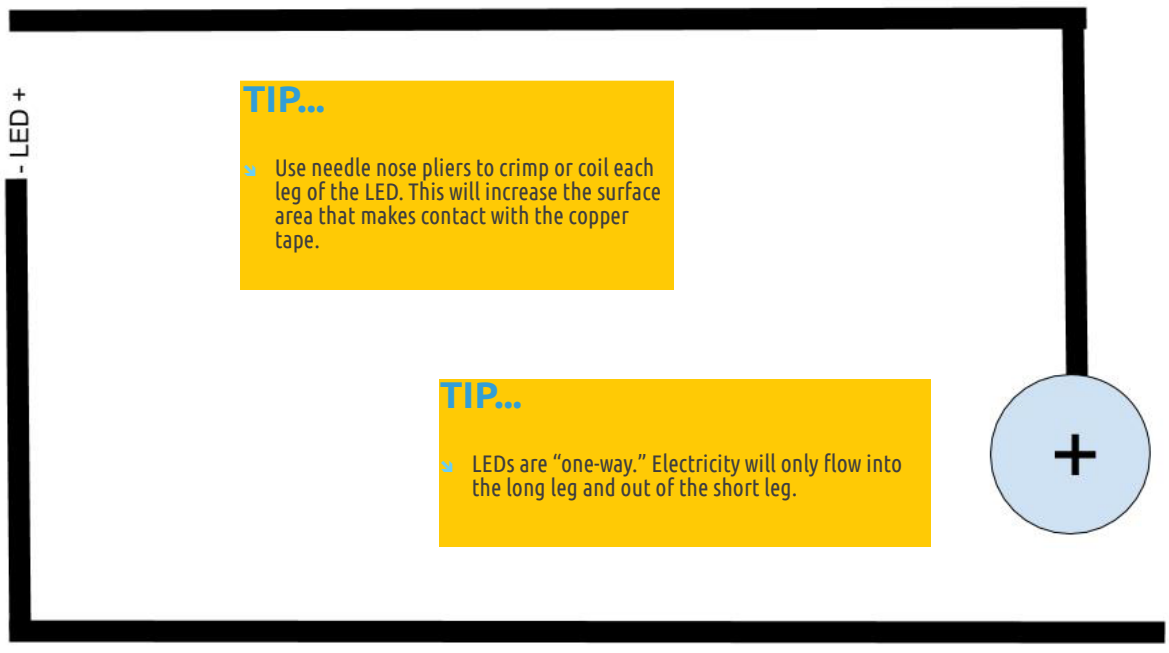






Play -- Build a Paper Circuit

Use the template below to build a paper circuit using copper tape, a coin cell battery, and an LED. Make a switch by folding the corner of the paper to complete the circuit. Use a binder clip to hold the switch in the On position.



Teacher Notes

OUTLINE OF INSTRUCTION

PLAY

Students will need some time to simply play with materials and tools to get familiar with what they can do. Before you let them make assumptions about how they will design or build something, which will be based on a naive understanding of how a circuit works, require a couple of lose activities where they can explore how things work. You might do a Take-apart activity with a flashlight. Ask them to speculate about how the switch of the flashlight works and then have them disassemble the flashlight to really find out. You might also have some old household light switches for them to take apart.

Another good play activity is to create a simple paper circuit using the template on the previous page. Ask them if they can imagine other ways to open and close the circuit besides the folded corner method.

BRAINSTORM

Once students have had the chance to explore the tools and to learn some circuit fundamentals, they can be placed into groups to brainstorm how to help Sam. If they need some guidance, the teacher might prompt them with some questions such as 'how the light will be triggered -- a pressure switch on the floor? a contact switch on the door? Where will the lights be positioned? How will you store batteries and wires out of sight?"

The final stage of the brainstorm will be for each group to agree on the criteria for a successful project. I like to keep such things very general, but if your school requires rubrics, this is the time to build it. In any case, it is critical for the students to have a very strong voice in the process of defining how you will define success.

RESEARCH

During the process of Play, Brainstorming, and Prototyping, students will engage in a minimal amount of research.

Most of the information they need will be provided on the circuitry basics handout.

Teachers are encouraged to point students in the direction of information that they need, but to refrain from giving them direct answers to questions they can look up themselves.

PROTOTYPE

After brainstorming ideas, each group should select their favorite design idea and build a prototype. Emphasize that prototypes are intended to be rough drafts. Teachers may want to require students to draw a quick sketch of their design idea in the chart provided on the handout. They should then start building quickly to see if their idea could work. The idea is to "fail fast" so that design problems can be addressed or an entirely new design concept can be tried. As students work on their prototypes, the teacher should circulate giving design feedback and asking probing questions. Push students to consider the characteristics they are looking for in their design. If they are trying to build a pressure switch to be triggered by being stepped on, they will need to design a circuit that is normally open and where the switch has some spring to it -- plastic straws, paper clips, and binder clips could all be modified in some way to meet that need.

Additionally, the instructor should be doing formative assessment and recording evidence of understanding and mastery whenever she sees it. Most importantly, the instructor should be noting areas where students do not yet understand important concepts, noting items that may need to be re-taught or followed up on later.

TEST & GATHER FEEDBACK -- CRITICAL FRIENDS PROTOCOL

A protocol is a set of rules for having a very structured conversation. When you first start to use protocols in your class, they can sometimes feel forced and artificial, because they are. I like to use them, because their structure can make it easier to have a conversation that can otherwise be difficult or awkward to have. It also helps to generate ideas and information in a really efficient way. The more you make protocols a part of your classroom routine, the more students will get used to them, and they won't feel quite so artificial. There are many different protocols out there. For this activity we will use one called "Critical Friends."

If most students are finishing their prototypes at the same time, you might decide to devote a specific class to using the Critical Friends protocol where everyone is doing it at the same time. Often, however, you will find that some groups are finished with initial prototypes early an are ready for feedback when most other groups are still working. If your class has not done many protocols, it might be worth while to do the first one or two as a class. Later in the year, when they are more comfortable with the process, you can leave it up to them to complete the protocol on their own.

Here is what the Critical Friends protocol looks like when you are doing it as an entire class with groups:

- Each group should select a representative to present their project
- Other members of the group travel to one of the other groups. No group should have more than 4 people at the table, and each table should have ONLY ONE of its original group members left to present.
- Select a time keeper for each group.
- The presenter begins by stating the grade level and the challenge statement (from the post it note). S/he then states any particular aspects of the project that his/her group would like specific feedback on. (1 minute)
- The presenter then describes the design process in detail being sure to include: (3 minutes)
  - How you settled on the particular design chosen
  - Notable problems with early prototypes -- and what you did to fix them
  - What big breakthroughs or ah-ha moments did you have?
  - What are your current concerns with the current design?
  - Are there any skills or concepts you didn't know that might have made your work easier? Is there anything you still don't understand?
  - If you had more time to work on this, what would you do
- Reviewers then get a turn to speak using the following prompts (6 minutes)

  I Like.... A genuine statement about something that is good about the project.

  I wonder... Raise a concern about any perceived weak areas of the project.

  I would... Make a specific suggestion about how to make the project better.

- The presenter should be taking notes as critical friends are giving their feedback.
- Everyone should return to their original group, and the presenter should share the feedback that the group project received. (5 minutes)

REMEMBER...

Before students begin giving each other feedback, remind them that good feedback is always:

- **Honest** - Never tell someone that something is great when it isn't
- **Kind** - Express feedback constructively. You might have the best advice in the world, but it won't be heard if the person has hurt feelings
- **Specific** -- Saying something is "good" or "could be better" is the same as saying nothing at all.

BUILD AND PUBLISH FINAL VERSION

After several prototypes, each group should settle on a design that they like and build the final version. Be careful. Many students will get stuck thinking that their initial design is the best or the only design they can produce. They will waste a lot of time trying to make something work when another design would be easier or more effective. Other groups will settle for something that simply works rather than taking the advice of their critical friends to really make something that is excellent.

Once they finally get their design down, however, it is time to start building the final version. Encourage students to take their time and pay attention to detail here. Unlike prototypes which should be built fast and with less attention to the way it looks or neatness, the goal here is to make something that is of high quality.

It is also important to find some way for students to publish their work beyond their classmates. Having some form of authentic audience is an essential component of any Project Based Learning Activity. It adds authenticity and meaning to the project. There are many ways to "publish" student work. The key element here is that the students know that their work will be seen by people outside of their class. Here are a few ways to do this:

- Have students create a short ending to the video showing what Sam discovers in his closet. Play these videos for a different class or at a grade-wide film festival.
- Allow students to use their invention as a science fair project
- Create a working display of the inventions in the school library
- Invite a community member who might work in the Home Alarm or electronics industry to come in and hear a "Shark Tank" pitch of the various inventions

AIM FOR "MEDIUM FRUSTRATION."

If a kid can't see any path to solve a problem or the effort required to solve it begins to outweigh the benefit of solving it, she will become frustrated and eventually quit. This is "high frustration."

If a kid isn't struggling at all, there isn't any learning going on. He's simply following directions. This is "low frustration."

Always try to have your students working somewhere in between these two extremes. You want the kid to always see the path to the answer, but that path should be really hard and steep. Be careful not to answer too many questions in a way that let's kids off the hook for learning. BUT be mindful of the kids who are approaching the shut-down level of frustration.

TEACHER TIPS - CLOSET CRITTERS:

- It's really hard even for adult fingers to get the backing off of the copper tape. Younger students will probably need help.
- You can test an LED by pinching it onto a coin cell battery.
- LEDs are polarized. The long leg goes to + and the short leg goes to -. If it doesn't light up, flip it around.
- Use needle nosed pliers to crimp a zig-zag pattern in the leg of the LED. This will increase the quality of the contact with the copper tape.
- Some copper tape is not conductive on the adhesive side. Be sure to buy the kind that conducts on both sides.
- You can also purchase paper LED stickers if you don't want to deal with the regular ones.
- Blue LEDs often require higher voltage than other colors. Some might not light up with only a 3v coin cell