



Outreach Playbook

Girls are S.M.A.R.T.

Metrics:

Grade Levels: 1 st -5 th	# of Student Participants: 56	Duration (hrs): 4	# of SWE Volunteers: 45	Partner orgs (if any):
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Event Overview

Girls are S.M.A.R.T. (Studious, Mighty, Amazing, Resilient, Talented) is a half-day conference for elementary-aged girls (grades 1-5). During this first annual event in April 2022, the SWE section at Colorado School of Mines welcomed 56 girls to campus for four hours of STEM-based activities. These activities incorporated artistic concepts to interest the young target audience. Each participant experienced seven activities that were designed to teach a STEM topic, and the girls were able to take their creations home. At the end of the event, they were able to explain scientific concepts they learned and possible fields of study from their favorite activities.



Overview of Activity

Activity 1: Binary Bracelets (grades 1-5)

Binary code is a number system comprised of zeros and ones. Every letter, number, and symbol on your computer keyboard is represented by eight digits, also known as a byte. Each of those digits is a zero or one. This binary code is how computers communicate and represent information.

In this activity, students will use black and white beads to represent their initials in binary, and they will string their beads onto a bracelet. This teaches students background knowledge of computer science as they learn how to transform a letter into an eight-digit code. For example, if a student's first initial is A, which is 01000001 in binary, they would string black beads to represent zeros and white beads to represent ones in the specific order.

Activity 2: Circuit Bugs (grades 1-2)

This activity uses LED lights, clothespins, batteries, and pipe cleaners to create a bug with glowing eyes. Students will learn how circuits function by lighting the "eyes" (LED lights) of their bugs, recognizing how wires' connections to positive and negative sides of the battery dictate if the LED will light. This activity will elucidate how lightbulbs work, and it can be connected to a discussion about switches in a circuit.

Activity 3: Cotton Ball Launcher (grades 1-2)

The cotton ball launcher is used to explain the physics of projectile motion. Students should understand how the angle of launch correlates to the distance traveled by the projectile, and they gain this knowledge by testing their invention created in the activity. A connection can be made to sports, in which a player must throw or kick a ball with accuracy, or to space travel, in which rocket scientists must accurately chart the path a rocket must fly to meet its intended target.

Activity 4: Lava Lamp (grades 1-2)

Creating a lava lamp in a bottle helps students understand density and miscibility. Students will mix oil and water in a bottle, and adding Alka Seltzer creates bubbles that mimic a lava lamp. Students should understand why oil and water do not mix, and why some liquids rise to the top of the bottle.

Activity 5: Magnetism (grades 1-5)

Students will create a magnetic field in a bottle or with putty, and they will experiment with a magnet to observe these properties. Students should develop an understanding of magnetism, which is produced by electric charges from electrons existing in continuous motion.

Activity 6: Marshmallow Constellations (grades 1-2)

Students will create their own constellation using marshmallows and toothpicks. They can choose to invent a constellation, or they can refer to a star chart and choose their favorite. This activity relates to the sky maps used by sailors and explorers centuries ago, and this activity can be used to discuss how the night sky seems to change during Earth's revolution.

Activity 7: Pinecone Painting (grades 1-2)

This activity will allow students to use their creativity to decorate pinecones. Takeaways



include learning how to mix colors and talking about math in nature, including references to the Fibonacci sequence as observed in pinecones.

Activity 8: 3-Dimensional Drawings (grades 3-5)

Blue and red colors are used in combination with glasses to create the illusion of three-dimensional shapes on flat paper. Students will learn about parallax in vision caused by the space separating our eyes and how brains process images.

Activity 9: Chromatography Flowers (grades 3-5)

This activity uses coffee filters and colors to demonstrate the properties of water. It can be related to chromatography experiments in determining the components of a marker or pen or to the forensic science of identifying a suspect's writing utensil. Students should understand the difference between a mobile phase and a stationary phase that results in the separation of the mixture's components.

Activity 10: Circuit Wands (grades 3-5)

Students create a magic wand using the science of circuits. Using their knowledge of batteries and switches, students will create the wand using popsicle sticks and LED lights. This relates to how light bulbs can be switched on and off.

Activity 11: Fizzy Turtle Eggs (grades 3-5)

Students will discover a turtle egg hidden in a moldable paste of baking soda and water. This activity demonstrates chemical properties with a fun twist of a turtle hidden inside.

Activity 12: Pantograph Drawing Machine (grades 3-5)

This activity addresses the design aspects of engineering with a tool to assist engineers and scientists in creating accurate drawings. Students will learn how a pantograph can trace images to reduce or enlarge drawings and retain the scale needed.



Outline and Script

Activity 1: Binary Bracelets (grades 1-5)

Gather black and white beads and string that can be stretched (for comfort while wearing). Students will spell their initials on a worksheet that lists the binary code for the twenty-six letters. They will place beads onto the string starting with the first digit of their first initial, adding black beads to represent zeros and white beads to represent ones. Their bracelet should be tied when they have twenty-four beads (eight per letter). Each letter represents a byte, and each bead represents a bit.

Activity 2: Circuit Bugs (grades 1-2)

Gather two LED lights, a battery, pipe cleaners, and a clothespin. If desired, the light can be turned on and off using a copper wire connected from the battery to the LED, but it might be easier to place the LED legs directly onto the battery for simplicity. The longer leg of the LED should correspond to the positive end of the battery. The lights and battery are held in place with the clothespin. The clothespin is wrapped in decorative pipe cleaner to appear like an insect or other bug. Some students enjoyed making butterflies and bees. Each bug's eyes should be glowing because two LEDs are used for eyes.

During the activity, a brief lesson about circuits can be given. If the copper wire is used, the fact that silver and copper wires are good conductors can be discussed. Electrons flow from the negative end of the battery to the positive end, which is why it is important to align the LED to match the flow of electrons; otherwise, it would not light. A circuit is complete when the path of electricity is unbroken (there are no gaps or open switches), and the electricity must originate from a source, such as a battery.

Activity 3: Cotton Ball Launcher (grades 1-2)

Gather a toilet paper tube (or construction paper and tape), rubber band, pencil, and scissors. Create a tube that is smaller than a cotton ball's circumference. Poke two holes through the end of this small tube using a pencil or a popsicle stick, and leave the pencil. This smaller tube should be placed inside a larger, longer tube. In the larger tube, two slits should be cut, and a rubber band should be looped through the slits and taped. The rubber band should loop around the pencil, which is the bottom of the launcher. Pulling the pencil back will create space to insert a cotton ball, and releasing the pencil will allow the cotton ball to fly.

Talking points include projectile motion and potential and kinetic energy. Students can test how to make their cotton ball launch the farthest, and they can understand how elastic potential energy is converted to kinetic energy when they release their pencil.

Activity 4: Lava Lamp (grades 1-2)

Collect a bottle or mason jar and fill it a quarter full with water. Add vegetable oil until an inch is left empty at the top. Add the desired color using food coloring. Add a quarter tablet or teaspoon of Alka Seltzer for as often as desired.

Talking points include explaining how oil is less dense than water (causing it to float on top of the water), and how the oil does not mix with water due to density differences and forces between molecules (depending how experienced the students are, a discussion of hydrophobic and hydrophilic molecules can proceed).



Activity 5: Magnetism (grades 1-5)

Option 5.1: Magnetic Putty

Gather putty, iron oxide, gloves, and magnets. Add putty to a quarter of a teaspoon of iron oxide using gloves and a placemat. Thinner putty functions better for this activity than thicker putty. Students can place their magnet close to the putty to observe the putty's attraction.

During this activity, instructors can discuss magnetic fields, including Earth's magnetic field, and electromagnetism.

Option 5.2: Magnetic Field in a Bottle

Add approximately one teaspoon of iron filings to the bottle, and fill the bottle completely with vegetable oil. Seal the bottle with duct tape. Use three neodymium magnets (supervised, since these magnets are small and potential choking hazards) to observe the magnetic fields in action.

Instructors can discuss how a magnetic field is the area around a magnet that has magnetic force. All magnets have a magnetic field, no matter how big they are. Things that are attracted to magnets are called magnetic objects. All magnetic objects are made of metal, but not all metals are magnetic.

A magnet has two ends, called poles. One end is the north pole, and the other is the south pole. Earth is a lot like a magnet! Compasses work by magnetizing the rotating hand, so it lines up with the magnetic poles of the planet.

Activity 6: Marshmallow Constellation (grades 1-2)

Students will use marshmallows and toothpicks to create a constellation, either invented or existing. The marshmallows can be glued to black or blue construction paper to create a night sky.

Instructors can discuss star maps, constellations, hemispheres and seasons, and the history and myths of constellations. Star maps help guide people at night, there are 88 different constellations that are divided into the northern and southern hemispheres, and the sky is seen to turn as the Earth moves around the sun.

Activity 7: Pinecone Painting (grades 1-2)

Students will paint pinecones in a design of their choice. Talking points include relating Fibonacci's sequence (0, 1, 1, 2, 3, 5, 8, 13, ...) to the telltale spiral found in some areas of nature, including pinecones, flower petals, hurricanes, and seashells.

Activity 8: 3-Dimensional Drawings (grades 3-5)

Students will draw pictures in blue marker and overlap their shapes in red marker. They will create their own three-dimensional glasses using a paper outline with red and blue cellophane lenses. Students will view their drawings through their glasses and see the three-dimensional images drawn on two-dimensional paper.

For 3D sight to function, two eyes must see a different picture. Since humans' eyes are spaced apart, each eye sees a different setting, and brains piece together the two images into

one. If students would like to know more about the brain's visual cortex, the instructor can discuss the ocular nerve, the optical chiasm, and how the brain's left hemisphere sees the nasal side of the right eye and vice versa.

Activity 9: Chromatography Flowers (grades 3-5)

Students will flatten a coffee filter on a plate. Using washable markers, draw multiple concentric circles on the coffee filter halfway between the middle and edge of the paper. Leave plenty of white space between the circles and the edge of the paper.

Add approximately one teaspoon of water to the middle of the coffee filter to watch the colors spread outward. Using less water is more beneficial to allow the colors to separate and the paper to dry.

Once the paper is dry, lift the circle from the middle and roll it into the shape of a flower. Use a clothespin to keep the flower in its desired shape. Place or glue the flower into a pot.

Students will learn that chromatography is useful in separating components of a mixture. The mixture is first dissolved into the mobile phase, a substance that carries the mixture through the stationary phase. Different components travel through the stationary phase at different speeds, which results in the separation observed. Larger molecules travel more slowly than smaller molecules.

Activity 10: Circuit Wands (grades 3-5)

On two popsicle sticks, place a strip of copper tape over the entire length of both, leaving a small gap in the middle of one stick for the on/off switch. Where the gap ends, wrap copper tape all the way around the stick. With a third stick, cut an inch off one end and keep both pieces. Place copper tape on the small piece. Add LED lights to the upper end of the first two sticks using copper tape. With the small piece, create a hinge using electrical tape and attach it to the piece to cover the space between the sticks. Slide the battery into the space between the sticks at the opposite end, and tape around the outside of the sticks to hold the wand together.

This activity concerns circuits and switches. Instructors can discuss the conductive properties of the copper tape and why it is important to match the anodes and cathodes of the LED to the appropriate ends of the battery.

Activity 11: Fizzy Turtle Eggs (grades 3-5)

Mix a third of a cup of baking soda with just enough water to create a moldable paste. Add food coloring to the paste if desired. Use half of the paste to form half of a ball, and place the turtle figure into the half-ball. Mold the remainder of the paste into the other half of the ball, and place the entire egg into a bowl. Using a pipette, add vinegar dropwise to the turtle egg to watch the turtle hatch.

When baking soda is mixed with vinegar, the mixture foams with carbon dioxide gas. If enough vinegar is used, all the baking soda can react and seemingly disappear into the vinegar solution. In this reaction, sodium bicarbonate (baking soda) and acetic acid reacts to form carbon dioxide, water, and sodium acetate. This activity can also address how gases are formed in chemical reactions and how foams are liquids or solids containing gas bubbles.

Activity 12: Pantograph Drawing Machine (grades 3-5)

Cut two pieces of cardboard 10"x1". Cut two more pieces of cardboard 6"x1". Connect the longer pieces together at the top with a metal brad. In the center of the long pieces, connect the smaller pieces with metal brads. Overlap the smaller pieces at their other ends, and create a hole large enough for a pencil or marker to go through. Poke holes at the bottom of each of the long pieces. The one on the right will hold a pencil or marker, and the one on the left will connect with a metal brad to a larger piece of cardboard or paper sheet. Insert two markers or pencils through the open holes, and use the center one to draw. The other marker will create a larger picture.

A pantograph is a simple machine that was used anciently by the Greeks to trace images. There are two pencils that draw identical images, but different sizes. The pantograph uses a lever to move in and out or back and forth as you draw with it. They are used by engineers and artists to reduce or enlarge their drawings.



Lessons Learned

For the Circuit Bugs activity (activity 2), instructors learned that it was much more difficult to use copper wire to connect the LEDs to the battery. Often, this method did not light the LEDs at all. Instead, instructors placed the LEDs directly onto the battery, eliminating the need for copper wire but removing the possibility of turning the lights on and off.

For the Fizzy Turtle Eggs activity (activity 11), students and instructors experienced a messy work station. The addition of a tablecloth on the table and a tarp on the floor would be helpful as well as access to a sink after the conclusion of the activity. This activity was a huge success, largely due to the students taking their turtles home with them.

For the Lava Lamp activity (activity 4), younger students enjoyed it greatly, and it can also be expanded to older students. They enjoyed watching the bubbles as a result of the Alka Seltzer and choosing their lamp's color.

All activities were scheduled for 15-minute rotations. Marshmallow Constellations (activity 6) consistently finished sooner than the rest, so instructors helped students with another constellation or with decorating the first.

Accessibility Adaptations

If students were completely virtual, most activities would be available to ship to the participants and instructors with an explanatory component given over pre-recorded video or live on a platform such as Zoom. Participants would receive a box containing materials in the mail before the meeting date, and instructors would log on to the desired platform to interact with students and lead the activity virtually. One activity that might have an issue with the virtual format is the magnetism activity since the iron oxide and iron filings are toxic.

To accommodate a smaller budget, some activities include unnecessary materials. For example, Chromatography Flowers (activity 9) does not need a pot to accompany it, and Marshmallow Constellations (activity 6) does not require a construction paper backdrop.

While our section did not encounter any accessibility requests, it is possible to move the entire event to a virtual setting (mailing the materials and meeting through a virtual platform) if necessary. All activities accommodate wheelchair needs. If students did not finish an activity, they were welcome to take the materials home with them to finish (except for the magnetism activity). Space for parents, guardians, or translators was available for students with an accommodation request.

Materials and Costs

Activity	Name of Product	Price	Quantity	Link
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Cotton Ball Launcher	Rubber Bands	8.99	1	https://www.amazon.com/Rubber-Bands-Band-Depot-Pound/dp/B082WMN7PF/ref=5fde09d96d48&pd_rd_w=BeBtQ&pd_rd_wg=wMKue&pf_rd_p=3feacbbb-bf22-4bbb-spons&smid=A3DDEVBY0MMX5J&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzOVFHSTxvZ0NsaWNrPXRydWU&th=1
Magnetic Putty	Mini Putty 96 Pack	24.99	1	https://www.amazon.com/Mini-Noise-Putty-Assorted-Container/dp/B08NWD9M1G/
	Gloves	11.97	1	https://www.amazon.com/PRIDE-Synthetic-Nitrile-Vinyl-Gloves-Medium/dp/B08Y98
Pinecone Painting	Pinecones	9.99	2	https://www.amazon.com/Apipi-Ornaments-Christmas-Christmas-Decoration/dp/B0
	Paper Plates	8.7	1	https://www.amazon.com/Hygloss-Products-69106-Plates-Decorative/dp/B00JXBILE
Lava Lamps	Bottles	29.99	2	https://www.amazon.com/Reusable-Beverage-Containers-Smoothies-Beverages/dp/
	Alka Seltzer	13.95	1	https://www.amazon.com/SCS-Alka-Seltzer-Original-Antacid-Analgesic/dp/B00CEEYL
	Funnels	6.99	1	https://www.amazon.com/Perfumes-Essential-Laboratory-Chemicals-Supplies/dp/BC
	Glow in the Dark Pigment	17.99	1	https://www.amazon.com/YSMNDE-Pigment-Luminous-Bottles-Non-Toxic/dp/B08QV
	Clothespins	12.39	1	https://www.amazon.com/Jumbo-Wooden-Clothespins-Large-Photo/dp/B074NXN71
Circuit Bugs	Electrical Tape	14.99	1	https://www.amazon.com/HEYSTYLE-Electrical-Waterproof-Listed-Rated-Multi-Color-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFBVETBNFpPQ081V08mZW5j
	Batteries	19.09	1	https://www.amazon.com/Pkcell-Battery-CR2032-Lithium-Cell/dp/B06XK4STG5/ref=
	Wire	9.8	1	https://www.amazon.com/Remington-Industries-28SNSP-25-Enameled-Diameter/dp/
	LED Lights	12.99	1	https://www.amazon.com/DiCUNO-450pcs-Colors-Emitting-Assorted/dp/B073QMYK
Marshmallow Constellations	Toothpicks	10.09	1	https://www.amazon.com/1000-Count-Natural-Bamboo-Toothpicks/dp/B0892TG1ZF
	Elmer's glue	5.49	2	https://www.amazon.com/Elmers-Washable-No-Run-School-Bottle/dp/B012UHCYHM
	Yellow Markers	4.89	1	https://www.amazon.com/Crayola-Count-Original-Markers-Yellow/dp/B0044SB35U/
3-D Drawings	red cellophane	\$8.89	1	https://www.amazon.com/Cellophane-Transparent-Wrapping-Christmas-Anapoliz/d-spons&psc=1&smid=A14SZFZ97ROYVQ&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyYljaz10cnVl
	blue cellophane	\$8.49	1	https://www.amazon.com/Cellophane-Transparent-Wrapping-Decorations-Anapoliz-spons&psc=1&smid=A14SZFZ97ROYVQ&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyYlPXRydWU=
	red markers	\$4.99	1	https://www.amazon.com/Crayola-Count-Washable-Bulk-Markers/dp/B00934NHS6

	blue markers	\$6.79	1	https://www.amazon.com/Crayola-Count-Washable-Bulk-Markers/dp/B00934NGFA
Binary Bracelets	elastic beading string	\$8.59	2	https://www.amazon.com/Senkary-Elastic-Beading-Jewelry-Bracelets/dp/B0738PNC
	black beads	\$7.99	2	https://www.amazon.com/MAHITOI-1000-PC-Projects-Ornaments-Diameter/dp/B09
	white beads	\$7.99	2	https://www.amazon.com/MAHITOI-1000-PC-Projects-Ornaments-Diameter/dp/B09spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzVjFMQ082VU9ETkJCmVuY3J5cHR
	colored beads	\$12.99	2	https://www.amazon.com/Changing-Sensitive-Plastic-Reactive-Crystal/dp/B08ZJ9H8
Chromatography Flowers	coffee filters	\$9.97	1	https://www.amazon.com/Nicole-Home-Collection-02083-Filters/dp/B07G1NZTDJ/r
	pipettes	\$7.99	1	https://www.amazon.com/G2PLUS-Disposable-Essential-Graduated-Transfer/dp/B0
	mini clay pots	\$21.99	2	https://www.amazon.com/Terracotta-Ceramic-Pottery-Drainage-Succulent/dp/B07S
	washable markers	\$13.64	1	https://www.amazon.com/AmazonBasics-Broad-Washable-Markers-Colors/dp/B07V spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUF5M0I0OU9PRlgwNDYmZW5
	clothespins	\$6.99	1	https://www.amazon.com/DECORA-Heavy-Duty-Clothespins-Booking-Wrapping/dp/
Circuit Wands	colored craft sticks	\$12.79	1	https://www.amazon.com/Colored-Creative-Designs-Children-Education/dp/B087M spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExRIJCSVZLU0dIRFRHJmVuY3
	copper tape	\$10.98	2	https://www.amazon.com/Conductive-Shielding-Repellent-Electrical-Grounding/dp/
	LED lights	\$6.99	1	https://www.amazon.com/CHANZON-PC-59042-Emitting-Assorted-Arduino/dp/B01
	CR2032 batteries	\$19.09	1	https://www.amazon.com/Pkcell-Battery-CR2032-Lithium-Cell/dp/B06XK4STG5/ref=
	electrical tape	\$4.51	1	https://www.amazon.com/Gardner-Bender-GTPC-550-Electrical-Easy-Wrap/dp/B00
Pantograph Drawings	brads	\$5.49	2	https://www.amazon.com/Fasteners-8x17mm-Plated-Scrapbooking-Projects/dp/B0 spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFIQ0dGVINET05BNUUmZW5jcnlwdG
Magnetic Field Bottles	neodymium magnets	\$6.99	2	https://www.amazon.com/TRYMAG-Refrigerator-Multi-Use-Cylinder-Whiteboard/dp spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExNjNDMVFENjVMExKJmVuY3J5cHR
	bottles	\$10.99	2	https://www.amazon.com/YsesoAi-Plastic-Containers-Toiletries-Conditioner/dp/B08 18&th=1
	iron filings	\$9.99	1	https://www.amazon.com/Filings-Experiments-American-Heritage-Industries/dp/B0
Fizzy Turtle Eggs	baking soda	\$11.16	1	https://www.amazon.com/ARM-HAMMER-Baking-Soda-POUND/dp/B0722NB764/re
	mini turtle figurines	\$11.99	2	https://www.amazon.com/Miniature-Figurines-Multicolor-Birthday-Decoration/dp/



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