4-Ingredient STEM Cookbook for the Elementary Classroom

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Rationale:

Many potential advocates in the elementary school avoid teaching STEM because they wrongly assume that teaching STEM in the elementary school requires expensive equipment, training, robots and lasers. In reality, the only thing required is a creative teacher willing to adapt or develop design activities that cause students to explore STEM content while completing compelling STEM design problems. The *4-Ingredient STEM Cookbook* was designed to illustrate how simple materials and tools can be used to deliver engaging STEM lessons in the elementary classroom without expensive tools and materials.

Ideally, any effort to develop STEM design problems would begin with a review to the appropriate grade-level standards and/or frameworks from the STEM disciplines (i.e., Common Core Math, Next Generation Science, Standards for Technological Literacy, etc.). These standards will provide the teacher with the big ideas with which to frame the problem solving activity. After the big idea is identified, the teacher should begin considering and identifying ideas and content that students will need to understand about the big idea (i.e., what will the student need to know when they have concluded this activity?)

After the standards, big idea and required content is determined, the creative juices can begin to flow by answering the following questions:

- What tools and materials do I have available? These could be very simple: Scissors, ruler, pencils, cardstock, craft sticks, hot glue gun, masking tape, etc.
- What problem could I present that would cause the students to apply the concepts I desire while engaging the students?

    - Example: Assuming that you want to teach students about *potential and kinetic energy* (from the standards), you could provide the students with some basic materials (plastic spoons, rubber bands, craft sticks, and masking tape) and ask them to design a catapult that would launch a marshmallow the great distance.
- Does the design problem have the potential for multiple potential solutions? The best STEM design problems leave room for the students to surprise the teacher with a "right" solution that the teacher never considered.
- How will I design this activity to allow for collaborative learning? The best STEM design problems cause student to mirror the work world by requiring them to work in effective teams.
- How will I make sure that the students have learned the content and how will they be assessed? This could include an assessment of the final product (did it solve the problem?), a team performance assessment (did they work as an effective team?), a journal or engineering log (can the students describe the major concepts?), etc.
- How will the final solution be tested? Will a testing area need to be set-up where students can pilot-test and refine their ideas, and then finally demonstrate their team solution?
- How will the students present their solution in a public way? It is very important for the students to defend their ideas and present them publically. Both are important 21^{st} Century learning skills.
- Can the STEM design problem be tied to other standards in other disciplines? For example, is there and informational text (non-fiction) that would support this activity while delivering important ELA standards?

Try the following *4- Ingredient STEM* lessons ***developed by pre-service elementary STEM education students at the University of Arkansas*** and then have fun developing your own. Attend local garage sales seeking basic tools (hand saws, hand drills, screw drivers, etc.) to expand your possibilities and gather recycled materials that can be used to develop new STEM problems. And, keep in mind that the best STEM design problems are ones that students can relate to (solving problems that the students actually face regularly) and problems that have a local community flavor.

Bobby- Pin Build Up

Materials Needed:

- Bobby Pins

STEM Content:

Structure, Gravity, Engineering Design, Resources

Content Brief:

Engineers use the same material for different purposes all the time. Materials are often altered and manipulated to achieve maximum usage. In this activity, you can discuss resources and their scarcity. In this activity you have one resource and must utilize it to create the tallest structure.

Teacher Hints:

Depending on the age of the students, break students into pairs or ask them to work individually. The students must make the tallest structure they can with the amount of Bobby-Pins provided (this amount can vary depending on the students' ages/abilities). Include at least 5 Bobby pins, 10 is preferred for tall structures. The students are allowed to manipulate the Bobby Pins however they please (bending, etc.), but cannot use any other materials. The structure must be free standing. Assess the students on their ability to use the materials to build the tallest structure. You will need a tool to measure the structures in order to recognize a winner (tape measure, ruler, yard stick, etc.). Include a class discussion and track student participation as they discuss what they discovered/ observed in this activity. Assessing student use of the engineering design process can be assessed by asking the students to sketch a design, apply alterations, and reflect on their plans.

Picnic Blanket Catapult

Materials Needed:

- Plastic Spoon
- Scrap Wood
- Tape/or hot glue
- Rubber Bands

STEM Content:

Momentum, Velocity, Elasticity, Projection, Distance, Angle, Altitude, and Trajectory

Content Brief:

Simple Physics. A projectile is a body propelled with an initial velocity in the vertical plane and then it moves in two dimensions under the action of gravity alone without additional engine or fuel. Its motion is called projectile motion. The path of a projectile is called its trajectory. Some examples include: A golf ball in flight, a marble shot from a slingshot, or water spraying from a garden hose. Projectile motion is a case of two-dimensional motion. Any case of two-dimensional motion can be resolved into two cases of one-dimensional motion- one along the x-axis and the other along the y-axis. The two cases can be studied separately as two cases of one-dimensional motion. The results from two cases can be combined using vector algebra to see the net result. It is important to remember is that the motion along the horizontal direction does not affect the motion along the vertical direction and vice versa. Horizontal motion and vertical motion are totally independent of each other.

A body can be projected in two ways:

1. Horizontal projection: When the body is given an initial velocity in the horizontal direction only.
2. Angular projection: When the body is thrown with an initial velocity at an angle to the horizontal direction.

Teacher Hints:

Using these (or similar materials), ask teams of students to construct a portable and adjustable catapult that can be manipulated to shoot for distance or for height. Content should be delivered during and after the catapult is constructed.

Ultimate Umbrella

Materials Needed:

- Coat Hangers
- Aluminum Foil
- Plastic Wrap
- Cloth (fabrics)

STEM Content:

Materials, Durability, Structure, Water Absorption, Water Repellence

Content Brief:

When it comes to staying dry, there are many ways to avoid getting wet. You can either repel or absorb water. Materials that repel water drive the liquid elsewhere and do not absorb the liquid into the material. Materials that do not repel water absorb the liquid into the material. The goal of staying dry will work while being covered with a material that repels water. If you have a material that absorbs water, you will stay dry until the water starts to seep out of a material that has absorbed its maximum.

Teacher Hints:

Have the class break into small groups with approximately three students in each. Tell the students it is their job to build an umbrella that will shield one of their classmates from the rain (mist from a hose, spray from a spray bottle, etc.) The groups will each be given~ 3 coat hangers (already unraveled), and must pick one material for their umbrella (aluminum foil, plastic wrap, or fabric). On trial day, test the umbrellas one at a time by having one student from each group hold their umbrella over their heads, and then add the "rain". If you are using a hose with a mister attachment, measure the amount of time it takes for the water to start seeping through the umbrella. If you are using a spray bottle, record how many sprays it takes to cause water to seep through the umbrella. Assess the students on their attempt to build a working umbrella, their participation in the activity, discussion and follow up questions.

*Note: Depending on students' ages, a different material may need to be exchanged for the coat hangers. A curved or straight dowel rod is less sharp/hazardous.

Terrific Tunnels

Materials Needed:

- Plastic Wrap
- Pencils
- Tape
- Bag of sand

STEM Content:

Tunnels, Materials, Gravity, Structure, Mass

Content Brief:

Tunnels are used in our everyday lives—sometimes you see them and sometimes you do not. This activity will help students understand the concepts used to design tunnels that we use daily. The key to building a successful tunnel is to create a safe area for transportation from one point to another. When constructing this safe area, builders have to consider their surroundings in the tunnel and the effect these have on the structure. If the tunnel is *boring* through something, a mountain for example, then the builder needs to consider the mass of the dirt and other material surrounding and on top of the tunnel. If the mass is too heavy, the tunnel will collapse.

Teacher Hints:

Divide the class into small groups. Tell students that they must create a tunnel that will let the toy car pass through from one side of the "mountain" to the other. The students will only be able to use Saran Wrap, pencils, and tape to construct their tunnel. The number of pencils will be limited (~4). Students will be required to make their tunnel a certain length. This length can vary depending on the grade level/abilities of the students. It is suggested that they make their tunnel at least five inches long. The toy car must fit through the tunnel, but there is no height requirement. The height will play a role in the success of the tunnel, let the students experiment with what they think will work. On trial day, have a clear container ready, and a bag of sand prepared. Each group will take turns placing their tunnel in the container, and the teacher will gently pour the sand over and around the tunnel. If the group passes the first test (no collapsing), the car will be passed through. Assess the students on their participation and their success in building a working tunnel. Discussion about concepts related to this activity should be addressed and students should be able to answer questions related to the topic as well as their findings.

Dino Dig

Materials Needed:

- Straw
- String
- Pencils
- Tape

STEM Content:

Tools, Materials, Archaeology, Dinosaurs, Fossils

Content Brief:

Archaeologists use many tools when they embark on their digs. These tools help them gently and effectively find and uncover dinosaur bones, fossils, and other materials from years ago. One of the tools they use to uncover bones is called a hand brush. This hand brush gently sweeps away dirt and tiny rocks from the surface so archaeologists can examine their findings. This brush plays a crucial role in discovery because it will not damage any valuable objects.

Teacher Hints:

Place members of the class into pairs. Tell the students that they will be embarking on a very important dig. In order for this dig to be successful, they will need to create their very own hand brush. They may only use the materials listed above. Remind students that these brushes must uncover unknown objects gently, and their purpose is to find objects without harming them. On trial day, have a container full of sand or dirt, and hide several objects in the sand/ dirt. These objects can be tiny dinosaur fossils like you see in the toy store, or small objects you find in nature or around the classroom. Include some breakable items like eggshells to test the effectiveness of the hand brush. Have each pair take turns using their hand brush and record what they find during the “dig”. Assess the students on their participation in building a hand brush. Discuss the findings from the activity and concepts or topics related to the activity.

Rapunzel Pull-Up

Materials Needed:

- String
- Paper
- Tape

STEM Content:

Pulleys, Simple Machines, Mass/ Weight, Materials

Content Brief:

One of the major types of simple machines is called a pulley. A simple pulley consists of a rope wrapped around a wheel. The weighted end of the rope dangles on one side, and force is applied by pulling the opposite end of the rope. This causes the weight to be lifted, changing the direction of force used, making the object travel a greater distance. In order for a pulley to be successful, the load to be lifted must be secured appropriately. Even if a pulley can lift the weighted item, the load must be secured during the lift.

Teacher Hints:

Tell the students that Princess Rapunzel is no longer able to use her hair to reach the floor from the top of her tall tower. She has built a pulley system but needs help building a basket that can support weight and be lifted form the ground to the top of the tower with the pulley system. The students should be placed into small groups (~3). They will be required to build a container that can be used to lift ___ pounds from the ground of the top of the "tower". On trial day, the teacher will already have the pulley created (for example, a spool on a hanger), and the students will be required to place their string around the pulley, and lift the basket that they constructed from the ground to the top. If the group can successfully lift the required weight to the top, add weight and record which group lifted the most weigh. Assess the students on their participation/attempt to build a supportive basket and their participation in the discussion of topics related to this activity.

Blow-Mobile

Materials Needed:

- Life Savers Candy
- 2 sheets paper
- Tape
- Straws

STEM Content:

Mass/ Weight, Wheels, Aerodynamics

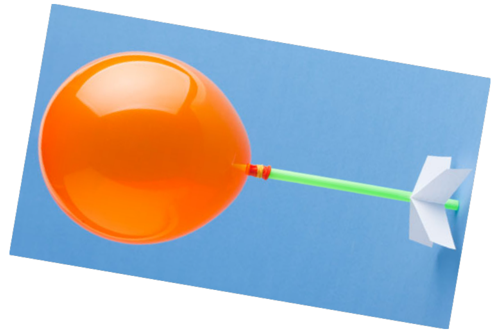
Content Brief:

Mass and weight play a huge role when it comes to making objects move. In this activity, students will find that the heavier their car, the harder it is to power. The sail on the car will need to be constructed in a way that is lightweight, but also catches a great amount of "wind" to push the car. The combination of weight and an the effect of a sail will set the wind powered car flying.

Teacher Hints:

Have the students work in pairs or individually. The students must build a wind-powered car using only the materials listed above. On the trail day, have a tournament racing two cars at a time. The cars may only be powered by students blowing into the sail of their car. The racing sail car that reaches the finish line wins. Continue the races until there is one winner. Have a class discussion about what the students learned from this activity. Students should answer questions about what worked/didn't work and why they think their car was successful or not. Assess the student on their participation and success in building a working sail car.

Ballon Bonkers



Materials Needed:

- Balloons
- Rubber Bands
- Scissors
- Flexible Straws

STEM Content:

Aerodynamics, Force, Directional Force, Action/Reaction

Content Brief:

When the balloon is expanded with air and a straw is attached, the air inside of the balloon will be trying to find a way to escape the inside of the balloon to equalize air pressure. When using a flexible straw, we force the air to turn a corner and change the resulting direction of reaction to the force. By changing the bend in the straw, we can change direction of exhaust air and ultimately the balloon's path.

Teacher Hints:

Distribute the materials listed above to individuals or pairs of students. Tell the students that they must place their straw inside of the balloon, and wrap their rubber band around the neck of the balloon to secure the straw. Make sure the bendy part of the straw is on the outside of the balloon. Have the students inflate their balloons, and pinch the straw to avoid letting air escape. Tell students they will be trying to reach a target at the opposite side of the room. The students will participate in several rounds. They will all (or half of the class/groups) will all release their balloons from a certain point (marking each balloon first would be a good idea). On round 2, they will go to their balloons and change the direction of the bending the straw if necessary. Continue the rounds until someone reaches the target point. Assess the students on their participation in a discussion about the findings from the race trials.

*Note: Assistance in wrapping the rubber band around the straw and balloon may be needed. To make adding the rubber band easier, cut 2 inches off of the straw. You don't need the full length straw.

Up, Up, and Away

Materials Needed:

- Trash Bag
- Tape
- Straws
- Aluminum Foil

STEM Content:

Matter, Density, Buoyancy, Mass/ Weight

Content Brief:

Hot air balloons float because of the density of the air inside of the balloon. The air inside of the balloon is heated, which causes that air to be less dense than the air around the balloon. The lighter air inside the balloon starts to lift and float because the air inside is less dense that the air outside the balloon. This is similar to how a boat floats in water, buoyancy.

Teacher Hints:

Place members of the class into pairs. The students will need to construct hot air balloons with the materials provided. The completed hot air balloons will need to include an inflated balloon and a gondola or basket. The students may use any amount of the materials, but the students will find that the lighter the balloon is, the easier it will be to lift. On the trial day, the teacher will heat each balloon with an electric hair dryer until it rises. The students will watch their balloons rise into the air from a safe distance. If a balloon does not rise, students will have to examine why the balloon did not successfully lift. Assess the students on their participation and attempt to build a hot air balloon. Have a discussion about what did or didn't work for their balloons, and compare the findings to the concepts related to this activity.

Working with Weight

Materials Needed:

- Small Paper Cups
- Recycled Cardboard

STEM Content:

Weight Distribution, Force

Content Brief:

If you try to stand on just one cup, it will break and crush. That is because all of your weight is pushing and compressing the cup. When you arrange the cups, and put a piece of cardboard on top, then the cardboard spreads out your weight. So, each cup supports less weight. This weight distribution means that there isn’t too much weight on any one cup. This also explains why the force exerted on the heel of a women’s stiletto is greater that the force exerted by the foot of an elephant.

Teacher Hints:

Have the class gather as a whole. Arrange one cup (top facing the ground) with a small piece of cardboard (4”x4”) on top. Have one student come up and stand on the cardboard (with the teacher’s support). The cup will smash immediately. Divide the members of the class into small teams and tell them to build a platform that will hold the weight of one student by distributing the weight. Have the students test their solutions (always have teacher spotting the student). The team that uses the least number of cups to support the weight of one student wins the challenge.

Assess the students on their participation in the activity. Ask students what they found from the activity and ask questions about topics related to the experiment.

Pass the Pasta

Materials Needed:

- Different bags of pasta
- Masking Tape

STEM Content:

Materials, Friction, Weight/Mass

Content Brief:

Students will discover the relationship between mass and friction when designing a rolling vehicle made entirely of pasta. The higher the mass, the greater the need to reduce friction. In modern vehicles, bearings and lubricants are used to reduce friction and move heavy loads.

Teacher Hints:

Students should work in small teams to design a vehicle that is made of pasta. The students are allowed to use any amount of the materials listed, but the vehicle must be made out of pasta (they will want to use the round pasta for wheels). The car must fit on a teacher-made test track (plywood) and cannot be longer than 6 inches. On trial day, have a track set up that can race two cars. Conduct a tournament racing two cars at a time until you can declare a winner. Have the students discuss what worked and what didn't work with their cars. Relate their findings to content related to the activity. Assess the students on their participation and ability to answer questions related to the topics.

Buzz-Worthy Bee Hive

Materials Needed:

- Cardboard
- Tape
- Glue
- String

STEM Content:

Natural Science, Habitats, Resources

Content Brief:

Bees live in colonies and work together to produce honey. These social insects create habitats for themselves that are very intricate. These colonies hold hundreds or thousands of bees because of their tiny detailed structure. Bee hives maximize space and contribute to the productivity of the bees.

Teacher Hints:

Break the class into small groups with approximately four students in each group. Tell the students they can only use the materials provided. The students are not limited on the amount of materials they use. The groups have to produce a bee hive that is no larger than 4 inches wide, or 9 inches long. The beehive must be flat, making only one face of the hive. The groups must create a beehive that can support at least 20 bees (beads). The bee's hive must include compartments and the bees will not share these compartments. Assess the students on their participation in the activity. Also have the students discuss what features of their beehives are beneficial to the bees who live there.

Barely-There Bridge

Materials Needed:

- String
- Ball

STEM Content:

Bridges, Structure, Materials, Force/ Gravity, Weight/ Mass

Content Brief:

Rope bridges are a less popular style of bridge today, but they are used extensively in less developed parts of the world. They are cheap, strong, and flexible, and can successfully help someone get from one side to the other. The construction of these bridges is a takes a great deal of practice due to the stability of the materials. Unlike solid bridges, gravity continually shifts as a person takes steps crossing the bridge—shifting weight distribution.

Teacher Hints:

Divide the students up into small teams. Tell students they will make a bridge using only string. They can manipulate and tie the string however they wish, but a ball has to make it safely across the completed structure. The teacher will have a premade course built such as two cardboard boxes with two holes for connecting the structure on each side. On trial day, the students will connect their bridges to each side of the gorge and attempt to roll a ball across. One side of the bridge should be about 4” higher than the other. Assess the students on their participation and attempt to build successful bridge. Ask the students questions about their design and the success of their bridge. Relate the answer to concepts related to this activity.

*Notes: Make sure the ball is at an appropriate size and weight. It should be a size/weight that can be challenging, but can be accomplished with a well-structured rope bridge.

Platform Play-Doh

Materials Needed:

- Play-Dough
- Golf Ball

STEM Content:

Structure, Gravity, Mass/ Weight

Content Brief:

Play-Doh is a flexible material that is not typically known as being sturdy. Students will be challenged to make a structure that will hold a golf ball as far from the surface as possible. Students will find that it is easy to build a tall structure, but not one that will support the heavy golf ball. As the students work with the Play-Doh, they will discover different ways to manipulate the material in order to increase its capacity for load mass. Builders often manipulate their materials and use them in different ways in order to properly support a structure and increase its load rating.

Teacher Hints:

Have students work individually. Each student will have a container of Play-Doh and a golf ball. Have the students try to build the tallest structure they can that will support a golf ball at the top of the structure. The teacher will measure each student's structure (the top of the golf ball). Have the students discuss what they discovered as they build their structures. Assess the students on their participation.

Roche limit Loco

Materials Needed:

- Play-Dough
- Measuring Tape

STEM Content:

Astronomy, Gravity

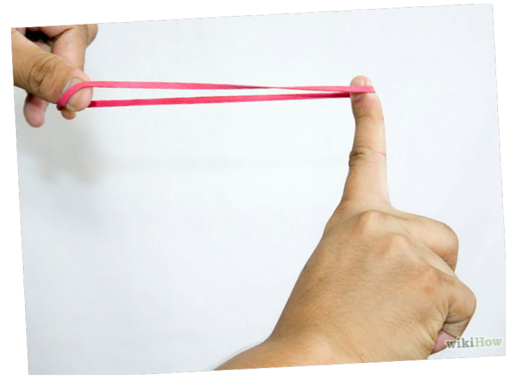
Content Brief:

The Roche limit of a planet describes the distance between an object and that planet before the object will be torn to pieces by the planet's gravity. If you have ever wondered about the specific placement of the Earth's Moon, it is no accident. The reason the Earth does not have objects orbiting the Earth closer than the Moon's orbit is due to Earth's Roche limit. This means that any object that resides in that area will have a mass too heavy to support itself and will be drawn in by the Earth's gravity.

Teacher Hints:

Have students arranged in small groups. Each team will have a cup of Play-Doh. They must roll out the play dough until it is a long, skinny "rope" with a width no bigger than ¼ of an inch. One student will stand on top of a chair (carefully). The Play-Doh rope will be laying on the floor. Another group member will pick up one end of the Play-Doh rope and lift slowly. If the rope doesn't break, slowly hand it to the group member standing on the chair. The group member will slowly lift the rope until it breaks. The remaining group members will measure ALL of the play dough pieces that remain in the air. The length of the play dough rope that was in the air is the play dough's Roche limit. Have the students repeat this process at least one more time (more trials, better data). As a class collect each group's data and discuss the findings. The average of the data represents an approximate estimate of the Play-Doh's Roche limit. Assess the students based on participation and ability to relate this example to real examples in Earth's gravitational pull.

Rubber Band Flinger



Materials Needed:

- Rubber Bands
- Paper Clips
- Straws
- Tape

STEM Content:

Potential Energy, Kinetic Energy, Force

Content Brief:

When an object is at rest, and awaits release, this is called *potential* energy. Something that expands, like a rubber band, is creating potential energy. When you let go of the rubber band, it will shoot forward, and this represents *kinetic* energy. The amount of force applied to this object will determine how far or how fast it will move.

Teacher Hints:

Have students work in pairs. The pairs are allowed to use all of the materials listed above, without limitations. The student's job is to create a launcher that will fling the rubber band the farthest. The students may set up the rubber band on the launcher, but will not be allowed to touch the rubber band after setting up the rubber band, ready to be released. The launcher itself must release the rubber band. On trial day, students will take turns competing against another pair as they test to see who has the launcher that flings the rubber band the farthest. Assess the students on their ability to identify the different kinds of energy and participation throughout the entire activity.

*Note: Each student must have the same style rubber band. Everyone should get a replacement rubber band on trial day.