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STEM on a Budget: A basic guide for teaching STEM in OPS afterschool Programs

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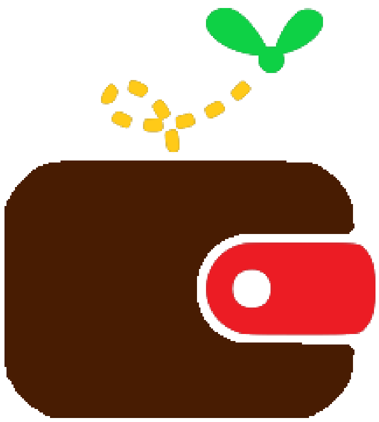


STEM on a Budget

A basic guide for teaching STEM in OPS afterschool programs

Version 1.5

Tyrome Williams

The Author's 2 Cents:

My name is Tyrome Williams. I've had the pleasure of teaching STEM in Omaha Public Schools' (OPS) afterschool programs for 7 years now with the program Building Dreams and the Tyrome Williams Foundation. I have a bachelor's degree in Nonprofit Administration and a Master's degree in Business. I am not a professional teacher, nor do I hold a degree in teaching. However, I do believe: "I have a curious mind, I'm willing to try, and I'm willing to fail when I'm learning new things". These are a few of the qualities I would like to instill into the students of Omaha. **It's ok to be curious. It's ok to try new things. And, it's ok to fail.**

One day, I plan to retire and eventually leave Omaha to pursue a few other things I've always wanted to do, which is one of the reasons why I have written this guide. I hope this guide proves to be useful for new or current site directors or instructors in OPS afterschool programming. I would also like to thank Collective for Youth and the Peter Kiewit Foundation for their supporting STEM programming in Omaha, Nebraska.

Table of Contents:

Intro for this STEM Guide:

This guide was written with the goal of providing a rough lesson plan, which could act as a supplemental guide for sustainable activities at sites in the Omaha area to better serve their students and children. The STEM lessons I chose in this book are engaging, hold education value, and are cost effective if used properly. This book contains valuable information to supplement STEM learning. Whether you're a teacher, instructor, supervisor for children, or a substitute; you will always be the most valuable asset in your classroom. This is a free use document and should not be sold for any monetary gain. Also, please visit, the Tyrome Williams Foundation on Facebook, and see some of our other interesting projects we have going on. Feel free to like as well.

Word of Caution to the Reader:

I attempted to write this book so that anyone would be able to pick it up, understand, and then teach the lessons/activities to an individual or group of students. I highly recommend that you, as the instructor, attempt to do the project(s) prior to teaching the material. While most of these activities are fairly straight forward, I still recommend you attempt them first on your own before doing them in class. If nothing else, you will become more familiar with the activity and will build your confidence, especially if you or a staff member are relatively new. Thus, you won't have to reference the instructions as often and it will allow you answer questions in class or provide assistance to your students if they are having trouble. You will also gain a better understanding of potential issues students may have. The cost of activities noted in this book may vary from location to location. **The cost per activity is based on a class size of 15~30 students.**

Also, something else you should keep in mind and also teach your students is that: "It's ok to fail." Make the learning experience memorable. More importantly, keep your environment safe and make learning fun. You'll inspire your students to imagine, create, and gain an interest in science.

Common Abbreviations within this Book:

Activity: The explanation of what is done for each project.

Continuous: Whether or not the topic should be reoccurring until students achieve mastery. Depending upon difficulty revisiting topics are recommended to stay fresh. **Yes/No.**

Cost: How much does this activity cost to do? **Less than, Greater than, varies, or about (~)** The cost per activity is based on a class size of 15~30 students.

Difficulty: How difficult is this project? **Low, Moderate, High**

Discussion: This part of the activity is used for refining topics with students in a group discussion. Used for associating ELO's (Educational Learning Outcomes) with the task, student reflection, and to refine learning.

ELO's – Educational Learning Outcomes: This is what the students will learn from doing the activity. Often, if you as a teacher, instructor, or employee who has to report to someone higher up, a donor, etc. This is what you tell them your students will be learning in class.

Materials: Some are optional, others are required. Try your best to use recycled materials to keep costs low in your class. Also feel free to try new materials if you think they will help.

Pro-tip: A little section containing my own personal opinion. Labeled in red to get your attention. This advice is meant to save you trouble, time, or as a safety precaution when doing the activities.

Summary: The explanation for the intended activity. This will give you a general idea of what the activity is about.

Time: How much time does this project take to do or preparation involved?

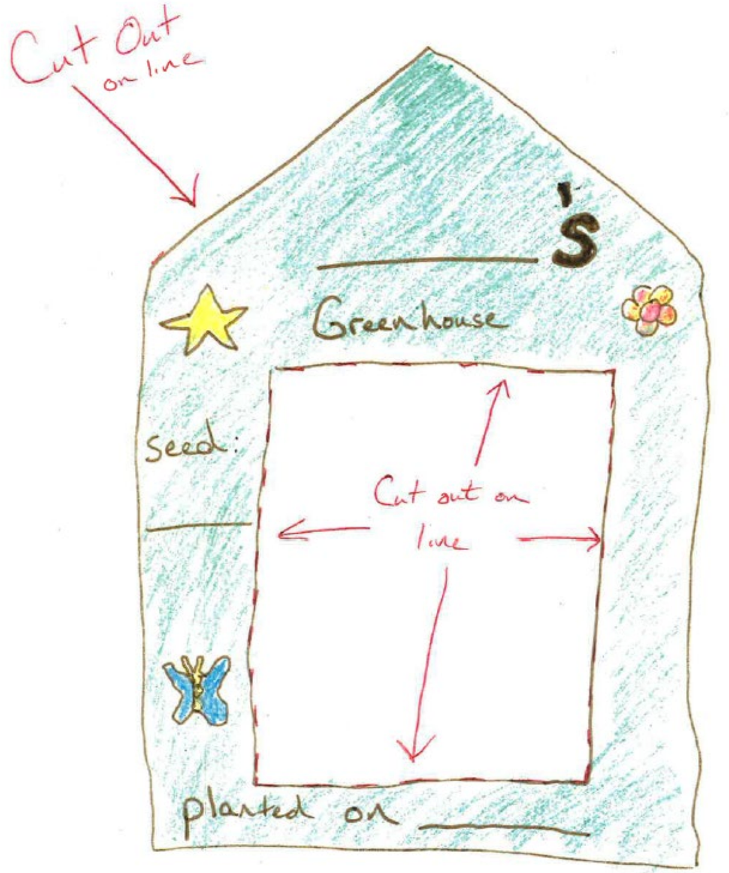
Easy donated items to look for:

These items are generally easy to find or to ask for from your school, site, your own home, or students can bring in. They are usually waste byproduct based, so there is no acquired cost since the products are generally thrown away by the consumers. These are some items that can be useful in your classrooms, with a little imagination.

- Egg cartons,
- newspaper, regular paper, construction paper,
- cardboard sleeves from toilet paper rolls and paper towel rolls,
- plastic lids or caps of soda/water bottles,
- small boxes (including cereal boxes, large pieces of cardboard, juice boxes)
- empty pill containers (with labels off), film containers,
- art supplies (pompoms, straws, cloth),
- empty cardboard milk cartons, bottles, milk jugs, containers, empty soup cans,
- broken crayons or short crayon pieces.
- Ice cream buckets, plastic bins, etc.
- Look for things from the Goodwill, Salvation Army, Dollar Store, Dollar Tree, etc. if you have to buy something.
- Scrap paper of any kind. Ask the art teacher if they have a discard pile for paper that was cut or discarded before it's thrown away.
- Packing peanuts or bubble wrap

Biology/Life Science:

DIY Greenhouses



Cost: less than $10.00 **Difficulty:** Low **Time:** Hour **Continuous:** Yes (several weeks)

Summary:

Students learn the basics of how plants grow. How to grow seedlings. Growing starter plants in a soilless environment. Students will grow basic plants in their own homemade green houses. This project is completed over a week to several weeks. Can be done in conjunction with other projects.

ELO's – Agricultural Science, Life Science, Plant Science, seeds, life cycle, observation, discussion, building a hypothesis, critical thinking.

Supplies needed:

- Paper or construction paper,
- markers or crayons,
- Ziploc bags,
- cotton or paper towels,
- tape,
- a pen,
- a stapler.
- Paper and pen (for students).
- A bowl of water, or large cup, or a spray bottle with water or dampening the cotton balls or paper towels.
- Seeds of your choice

Activity

1) Buy basic plant seeds from store. These plants will grow with the least amount of effort. **If you have never grown anything before, I would recommend beans.** They are almost bullet proof. Seeds are generally measured by weight not quantity. You can buy a 2 ounce bag of bush beans for about $3.58 which will give you about 150 of them. More than enough for your group. Other seeds vary by weight and number and sometimes can be very misleading to how many are inside. Do some research first before picking seeds or try the experiment for yourself (recommended seeds to choose below).

Here is a list of seeds I recommend for starters:

- Green Beans. ...
- Lettuce. ... (easy to grow, but challenging to transplant due to size)
- Cucumbers. ...
- Spinach. ...
- Tomatoes. ...
- Flower seeds (marigolds)

Pro-tip: Allow the seeds you plan to use in class to soak in water up to 24 hours before doing this activity.

Soaking seeds prior is important, due to the shell of seeds are generally hard, and will sprout faster if softened a little bit. When exposed to the environment where it commonly rains or is warm, nature does this for us. Since we are growing seedlings in a closed environment this will help considerably. Gardeners generally soak their seeds to increase the speed of seedling growth at the beginning.

2) Cut out a similar house-shaped templates as shown in the picture for each student. This house outline will be stapled to the Ziploc bag the students' seeds will be placed inside. The important things to write down on each greenhouse template are the student's name at the top Grace's Greenhouse **(replace with the actual student's name),** the "date" in which the seed was planted at the bottom, as well as what type of seed was planted for reference. This is so students can observe change as well as remember when the seeds were actually planted.
3) Explain the activity to your students as well as the importance of growing plants for our survival. The amount of time it takes for a plant to grow is something students may not consider when they go to the store with their parents and buy an apple or use common goods. Pass out the template Greenhouses for students to: write their name, today's date, and for them to decorate the greenhouses however they wish.
4) Take out the seeds you let soak for 24 hours prior to doing the activity. Pass out 3 cotton balls or one paper towel to each the students. Have the students insert the seed into the cotton balls and then moisten them before putting them into their bags.

   Pro-tip: Sometimes seeds are duds.

   Having at least 2 seeds together prevents the risk of a student's greenhouse not having any rewards if a dud seed occurs. Occasionally this information is written on the seed packet, however it is not always. Gardeners typically do this and then **thin** out seedlings if multiple seeds do end up growing. **Again,** paper towels or cotton balls should be moist, there shouldn't be a small swimming pool in the bags.
5) Seal bags and place them behind the Greenhouse frame as shown, staple the bags at the top corners of the house. Be careful not to staple through a seed in a bag.
6) During spring, summer, or fall the bags can be placed immediately into a sunny window for sprouting. If it is winter or still generally cold outside I would recommend initially putting them in a dark warm place for germination until they sprout. Then you can hang them from the window for observation.

7) Seeds will generally sprout within a week or so depending upon conditions. Some take longer.

Your seedlings should look
something like this.

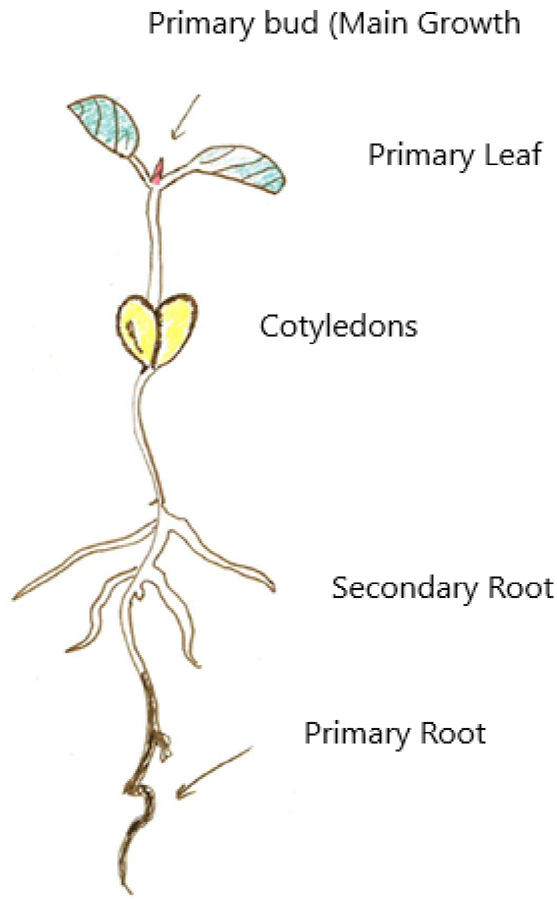
Greenhouse Discussion:

Have students write or draw what they observed on a day to day basis. How much growth occurred? (This could be measured.) The parts of the seedling. Students can describe what their seedlings look like, the parts of a seedling and how much growth occurred or the difference in growth if different windows were used. Discuss with the students what may have caused the difference in growth besides the different types of seeds if different seeds were used. If all the seeds were the same, how was the amount of sunlight different in each window? Heat, etc.?

At the end of the project, allow students to take their projects home. It will allow them to talk to their family members about what they learned. Children often like to share their achievements with friends and family members. If you intend to keep students plants long term (after about 2 weeks or so) to continue observation, they should be removed from baggies and then transplanted into the disposable red cups. See the next section about **Transplanting your Greenhouses and Plants**.

Pro-tip: Extended growth of large seedlings in baggies are prone to mold and rot since the bag is sealed.

Transplanting your Greenhouse(s) and Plant(s)



Cost: About $10.00 ~ $15.00 **Difficulty:** Low **Time:** Hour or so. **Continuous:** Yes several weeks

Summary:

Students continue to learn the basics of how plants grow and the parts of a plant. They should have successfully grown seedlings, if they have done the previous activity, **DIY Greenhouse(s)**. Growing larger plants in soil can be a touchy experience depending upon the group, however it can be a great learning activity and experience for students. The cost is determined by how much soil you must purchase to fill the number of cups. Speak to your local hardware, garden, supply store and they may donate plants for free. This project is can be completed over several weeks. It can be done in conjunction with other activities.

Pro-tip: Be advised. You should practice this step prior to doing it in the classroom. You may experience tremendous success or utter failure. Also, the quality of soil you can find outside varies from location to location. If you do use free dirt from outside to save on cost, test it first. Having lead or other contaminants in soil can kill plants or make them unsafe for consumption.

ELO's – Agricultural Science, Life Science, Plant Science, life cycle, observation, discussion, building a hypothesis, critical thinking.

Supplies needed:

- Red plastic cups (or other recycled containers such as milk jugs),
- a marker (to label the type of plant in the cup and other information),
- indoor/outdoor potting soil for plants and vegetables,
- pencils & paper for writing what the students observed,
- a large tray (to put cups on and catch water),
- a water bottle/spray bottle or source of water

Activity

1) Buy red disposable cups and "indoor/outdoor potting soil" depending upon planned usage. In my experience, I find that soil that can be used for vegetables yield better results.
2) Make sure that your seedling's stem is strong enough for the plant to stand on its own. Refer to your seed packet.
3) **Take a red plastic cup and poke several holes in the bottom of it for water to flow out of the cup.** (Important!) It's important that the cups have a hole in the bottom so water can drain. If there aren't holes in the bottom of the cup, the water will sit, and then go stale. The plant will rot, eventually die and then either you or your student will be sad. When you grow plants outside, water naturally flows in the soil or evaporates into the air.

   Pro-tip: Plants need oxygen in the soil. Growing plants is a process of adding water and letting the roots dry.
4) Give the cup to a student and have student fill it ¾ of the way with soil.

5) Use a finger to make a hole large enough for the plant to fit.
6) Carefully unwrap your seedling if you are using the plant you germinated from the previous project. If you are using store bought plants or other plants, remove from trays and be careful not to damage the plant or the roots.
7) Place in plant in the cup and then use additional soil to make the seedling stand up.
8) Water the plant until water comes out of the bottom. If indoors, use a bucket to catch the runoff water, else do this part outside.
9) Place plants in an area with decent light for most of the day. Refer to your seed packet. Be aware of potential issues if putting plants outside if it's cold or if you have issues with insects or animals.
10) **This is the step that students and adults have the most issues with.** Now for seedlings, they should be watered only about once every other day for most plants unless your soil gets dry quickly. Then, you may need to water every day. Refer to your seed packet. **You want air to be able to get into the soil by letting it dry.** Do not over water your plant! Too much water and your plant will die. Also, do not forget to water! No water equals a sad, dead plant. Choose a time to water it every day so you don't forget.

Pro-tip: Water once a day, until runoff water comes out of the bottom of the cup. Leave the plant be, in a sunny location. If you feel tempted to water it again, try talking to your plant instead. Refer to your seed packet for additional information.

Discussion:

After completing this activity, have the students document what they observe. How fast is their plant growing? What kind of plant was it? Have them draw a picture and then identify the parts of a plant. Have them compare the growth of a tomato versus the growth of beans or whatever else you chose. As the plants get larger you make require additional apparatus. For example, a bean is a vine, vine plants usually need a pole or stick to grow and climb up. Do some research on the plants you used to see what they may need if you allow the students to take them home.

Pro-tip: This is one of those projects where you can use some of the donated goods you received. If you have empty milk cartons from school, milk jugs from home, etc. you can use these as pots for your plants. As the plants get larger, they will need to be transplanted again. Reference your seed packages for more information.

Chemistry:

Extracting Colors from Leaves

(Leaf Chromatography)

Cost: Less than 6.00 **Difficulty:** Low **Time:** Low (hour) **Continuous:** No, but can be.

Summary:

Chromatography is the separation of a mixture by passing it through a solution. Students will extract the *pigments* (colors) out of leaves. Leaves contain different pigments, which give them their color. Green **chlorophyll** is the most common type of pigment, but there are also carotenoids (yellow, orange) and anthocyanin (red). Chlorophyll, which is essential for photosynthesis, usually hides the other pigments, except when autumn comes along and it begins to break down. This is why leaves turn different colors in the fall. Do this project to see some of the hidden colors in a green leaf and predict what color it will be in the fall!

Pro-tip: Rubbing alcohol can be poisonous if consumed, and is toxic if inhaled, adult supervision is recommended.

ELO's – chemistry, solutions, dissolving, solute, solvent, chemistry, molecules, life science, plants, observation, discussion, building a hypothesis, critical thinking. Why leaves change color?

Supplies needed:

- A few green leaves from 3 different kinds of trees (trees with a dramatic color change like maples, work best during Fall). If possible get two of eat so students can see what the leaf looked like prior as well as the results of the same leaf torn up.
- 3 small drinking glasses (or clear containers)
- Rubbing alcohol
- Plastic wrap
- A pan or tall glass of hot tap water (microwave)
- Coffee filters (to make strips to absorb the color)
- Scissors
- Tape
- 3 pencils

Activity:

1) Keep leaves from different trees separate and follow the steps below for each set of leaves, so you can compare results later.
2) Tear the leaves into small pieces and then put the pieces of each leaf into different glasses.
3) Have an adult pour rubbing alcohol into each glass so that all the leaf pieces are covered. Put a piece of plastic wrap over the top of each glass to keep the alcohol from evaporating (getting soaked up by the air).
4) Let an adult set the glasses in the pan of hot water and leave them for about 30 minutes. Check to make sure the alcohol in each glass has turned green before you take them out. If it hasn't, refill the pan with hot water and put the glasses back in until the alcohol turns green.
5) While waiting during step 4, cut your coffee filter into strips. Tap a strip to the middle of a pencil so you can hang into glass. Make sure strips are long enough. Make at least one strip for each glass.

6) Once the alcohol in each glass has turned green, take the glasses out of the hot water. Set a pencil with the paper strip taped to it over each glass so that the paper strip hangs down and the end touches the alcohol in the glass. Make sure the coffee filter paper is long enough to reach the rubbing alcohol in the glass, but not too long. Trim if necessary.
7) Let the glasses and papers sit for about 30 more minutes and then check to see if anything is happening. You should see the green color start to soak up on the paper. Wait even longer to see if any other colors appear on the paper strips. Have the duplicate leaves next to each filter paper as shown in the example picture for comparison.

Discussion:

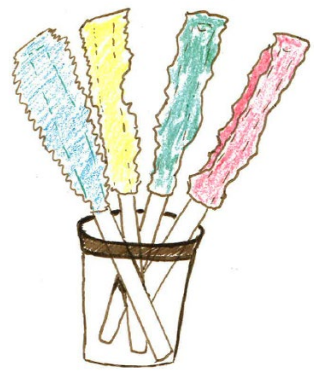
This is a good opportunity for students to write down what they observed and then discuss.

The alcohol and the heat from the hot water made the color in the leaves dissolve so you could see it in the alcohol. Think of what happens when you make tea. When you put a tea bag (filled with tea leaves) in a cup of hot water for a few minutes, the water becomes colored and flavored by the tea leaves. When you put the paper strips into the green-colored alcohol, the colors will be soaked up by the paper allowing you to see a couple different shades of green.

If you waited long enough, you might have been able to see other colors from the leaves appear on the paper – such as orange or yellow. If you saw colors besides green, those are the colors that the leaves will change into in the fall. Were there any differences in the colors from the different kinds of leaves you tested? The reason you couldn't see all those colors in the green leaves or in the alcohol solution is because the chemical that causes the green color is much stronger than the chemical that causes orange, red, and yellow.

When you put the paper into the alcohol solution, the colors had a chance to separate, and the orange or yellow are were no longer covered up by the green pigment. The same thing happens when leaves start to change colors – the chemical that makes them green starts to decrease with the chemicals that make other colors remain. This is why leaves become pretty colors in the fall!

Sugar Crystal Decorations

Cost: $10.00 ~ $20.00 **Difficulty:** Low **Time:** hour **Continuous:** Yes (about 1~2 weeks)

Summary:

Make a supersaturated solution with sugar and learn about crystal formations. If you use cake pop wooden skewers, students can eat these. I don't recommend students eating crystals on pipe cleaners due to metal wire being inside, however advanced shapes can be formed with pipe cleaners such as: animals, letters, etc. The cost of this project depends on size of group.

ELO's – Saturation, solutions, dissolving, solute, solvent, basic crystal formation, chemistry, molecules, observation, discussion, building a hypothesis, critical thinking.

Supplies needed:

- small Mason jars,
- water,
- access to a microwave,
- sugar,
- cake pop sticks (or wooden skewers or pipe cleaners),
- pencils or dowels (if using pipe cleaners),
- a microwave safe bowl or cup (make sure tall enough to prevent boil over),

- food coloring,
- parchment paper,
- a spoon.
- An oven mitt.

Activity

1. Pour 3 cups of sugar into a microwave safe container.
2. Add 1 cup of water to the sugar and stir the container.
3. Microwave your solution on high for 2 minutes. (The required time varies per microwave to due wattage). You can also use a stovetop but a microwave is easier. **Use caution removing the solution from the microwave** (use an oven mitt since it will be hot) and stir it, again.
4. Microwave the solution for an additional 2 minutes on high, stirring afterwards.
5. Add several drops of food coloring and stir it into the solution.
6. Sugar should be dissolved. Transfer the solution into a smaller glass mason jar.

Pro-tip: Allow the solution to cool to room temperature, this is very important before giving students access to jars. Will prevent accidents such as burns if spilled.

Cake pops & skewers: (**If using cake pops & skewers, skip steps 10~14**)

7. After solution is cool, place several cake pops or skewers into each masonry jar and place in a location where they will not be disturbed.
8. Check the jars every day and lightly stir to break up crystals forming on the side of the glass. Be careful not to break off crystals forming on cake pop sticks.
9. Within a few days you should see crystals, after about 1 week you should have a lot of crystals.

Pipe cleaners: Create an ornament shape using pipe cleaners (star, a letter, number, etc.). (**If not using pipe cleaners skip to Step 15**.)

10. Wrap the end of the pipe cleaner around the center of a pencil so it will hang properly in the masonry jar.
11. Dip your ornament into the solution to get it initially wet.
12. Lay your ornament on a sheet of parchment paper to dry.
13. Place the dried ornament back into the solution carefully, avoiding the side and bottom of the jar. (This will allow the sugar to better stick to the pipe cleaner with dried sugar solution already on the pipe cleaner.)
14. Allow the solution and ornament to sit for at least one week.
15. Pull the stick or ornament out of the jars and let it dry on the parchment paper.
16. Have students observe what happened. What do they think happened?

Discussion

A delicious rock candy is ready for eating or a pretty crystal ornament is ready for decorating. Thank you science! But what happened exactly? We put 3 cups of sugar into 1 cup of water; creating a **supersaturated solution**. A supersaturated solution means that there is more solute (the sugar) than the solvent (the water) can usually hold.

We were able to dissolve more sugar (solute) because he heated up the water (solvent). When water is heated, the water molecules spread apart; creating microscopic expansion. This allows the sugar to mix better. Some supersaturated solutions become very unstable. Adding anything to the solution can trigger a reaction. Thankfully, this isn't the case with your sugar solution.

If you used pipe cleaners

Dipping your pipe cleaner ornament into the solution and allowing it to dry creates a small layer of sugar crystals around the pipe cleaner. These crystals dissolve in the solution, but the pipe cleaner gives them a surface they can use to recrystallize onto. When the ornament is dipped back into the solution, this small layer makes a better (and easier) surface for the sugar crystals to crystallize on. Over the course of a week, you can see just how much sugar is crystallized on your ornament… and there's a ton more sugar still dissolved!

As for the sugar pops or skewers, the sugar molecules in it started to join with the sugar molecules on the sticks. The sugar on the sticks are called "seed" molecules and the sugar molecules in the solution attached themselves to the seed molecules.

Meanwhile, as the water in the cup began evaporating (dry up), more sugar molecules were left behind. Sugar molecules form together making larger cystals. Because all of the sugar (solute) molecules are the same, they stick together, making a big crystal chunks!

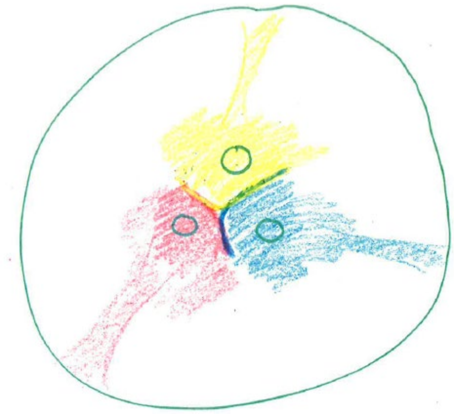
Pro-tip: Never eat any experiment unless it is made entirely out of food and you only used clean dishes to prepare it! Your students' safety is most important.

Other types of crystals that can be grown:

As a general rule, I like to provide additional information on how the experiments can be done, but with a word of caution. Besides sugar, crystals can be grown with Epson salt, Borax cleaner, alum (found in spice aisle), & table salt. Out of all of these I recommend sugar or table salt. Both of these are safe to use in the classroom and you don't have to worry about the students eating it.

Pro-tip: Prevent potentially fatal accidents by avoiding Epson salt and Borax cleaner all together. Even if your students in class understand the danger, they may have younger siblings at home who could potentially ingest it.

The Science of Sugar Concentration and Skittles



Cost: Less than $6.00 **Difficulty:** Low **Time:** Less than an hour Continuous: No

Summary: Teach students about substance concentrations, solvents, solutes, how things dissolve, etc.

ELO's – Concentrates, Saturation, solutions, dissolving, solute, solvent, chemistry, molecules, observation, osmosis, discussion, building a hypothesis, critical thinking

Supplies needed:

- Foam plates (one per student)
- Water source (with cup)
- A bag of Skittles (3 different colored skittles per plate)
- Sugar cubes
- A mess bucket and maybe cleaning materials for afterwards.
- Scrap newspaper (to cover desks if necessary)

Pro-tip: If your students are prone to eat the Skittles or sugar cubes, make sure you have enough on hand.

Activity

1) Fill your shallow foam plate with water (skittles only need to be half covered with water).
2) Arrange the skittles in the center forming a triangle with each of them about an inch or two apart.
3) Do not disturb the skittles or the water; allowing the colors to begin to spread.
4) Have the students observe their plates. Ask the students what happened? [The colors meet equally in the center of the plate.
5) When the three colors meet in the middle and begin to work their way outward, have the students make another hypothesis (guess). If you put a sugar cube in the center of the plate, between the skittles, what will happen? Will the color push inward or push outward?
6) Place a single sugar cube in the center of the skittles and allow everything to dissolve.
7) Have the students observe again.
8) Have the students explain what happened? Why did it happen?

Discussion

This activity covers a fundamental principle of chemistry – molecules move from higher concentrations to lower concentrations; meaning that they disperse over time. This is called a *concentration gradient*. It relates to everything from the smell of a freshly baked apple pie filling the house to concentrated sugar spreading out in water on your plate.

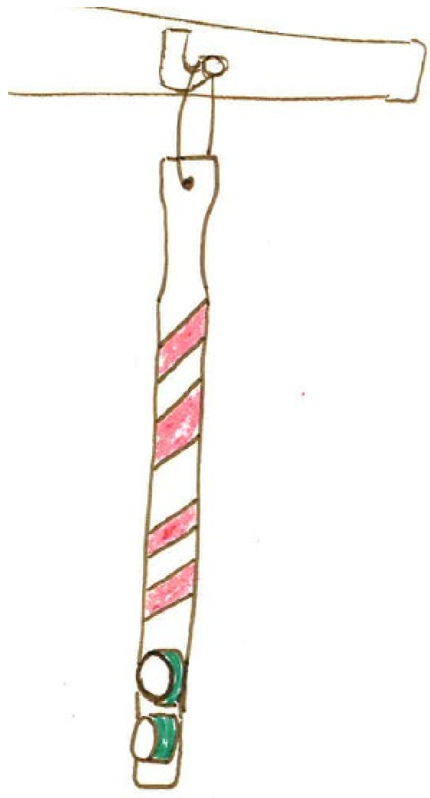
When you first add the skittles they begin dissolving in the water; sending the food coloring outwards as this happens. The reason that the food coloring meets in the middle of the plate and doesn't mix is because each food color has the same amount of sugar dissolved from each skittle. Once you add the pure sugar to the center of the food coloring intersection, the sugar cube begins to dissolve as well. Now most of sugar is found in the center of the plate and the least amount of sugar is found at the edge of the plate, the area containing mostly plain water. As the sugar cube dissolves, it pushed outwards into the rest of the solution, sending the colored water outwards as well.

As a teacher, there are a number of opportunities during this activity to ask your students for a hypothesis or answers. They could try changing the variables and attempt to predict a different outcome (ex, hot water vs cold water or different colored skittles or different sugar types).

Also, try adding hot water to a ring of skittles around the edge of the plate!

Engineering & Design

DIY Back Scratcher



Cost: Varies $3.00~$16.00 **Difficulty:** Low **Time:** 45 minutes to an hour **Continuous:** No

Summary: Students get an opportunity to design and build their own functional back scratcher. The purpose of this activity is for students to build a functional device and gain an understanding that engineers are assigned similar tasks when undertaking real world problems. Being able to recognize a potential problem and design a possible solution. This is a good activity for teaching primary skills, developing motor skills and hand eye coordination, and repurposing & recycling materials.

ELO's – Engineering, design, recycling and green usage, public speaking, how to use creativity and everyday materials to build something useful, utilize designs and sketches in creating a product, measurements, and basic machines.

Supplies needed:

<u>Recycled materials list:</u>

- Scrap cardboard, bottle caps, construction paper

<u>Purchase list:</u>

- Paper for students to make their designs and pencils.
- Popsicle sticks, cardboard, or paint stir sticks(3x for $1 @ Walmart)
- Low temp hot glue or regular Elmer's glue.
- Rubber bands
- Soda or water bottle caps.
- Optional: Plastic forks, scissors for cardboard, markers for decorating.
- Any recycled materials you can think of.

Pro-tip: The DIY Back Scratcher can be made out of anything. This activity provides you will an opportunity to provide your students with creative materials. Try doing this yourself and think of items that could be recycled in order to make something that is functional. This will keep your costs down.

Activity:

Vocab:

<u>Lever:</u> a simple machine that utilizes a ridged bar and a fulcrum (pivot point) to raise or move an object.

<u>Sketch:</u> a rough drawing or plan of an idea

<u>Machine:</u> any device that assists in achieving work advantage. It is not required for it to be mechanical or electric.

Engineers use their creativity to solve everyday problems. Today your students will recognize a problem that they might have had in their lives. Their back itches and they cannot reach it. What will they do? Have students use their creativity to design something with their materials by drawing it first and then try to build it.

1) Why is it hard to scratch your back?
2) How could the students solve this problem? Students may propose several other or new ideas in order to solve this problem which is great.
3) Show students the back scratcher you made.
4) Show them the materials they will have available for use in class.
5) Give students paper and pencils and then explain to them they need to design a backscratcher using the materials you've shown by drawing/making a sketch.
6) Provide them with 10~15 minutes to design their back scratcher. This is their 'sketch' or 'design'. If you made a sketch of your own, show that to them as well. If you cannot draw, that is ok. Why is it important to have an idea on paper? Explaining this concept to students is important too. Some students may not want to draw since they may be embarrassed about their skill level. That's ok. What is important is to have the idea there, with major parts labeled, and that your idea can be easily understood is great. As a teacher if you cannot draw that is great too! If you drawing poorly, students won't feel as bad about their own terrible drawing skills.
7) Talk about material & tool safety before anything out.
8) Pass out materials and necessary items to students.
9) When completed, have students present their invention to the class and demonstrate it. This is a good opportunity for students to gain experience with public speaking by explaining their design and why they chose it.

Discussion:

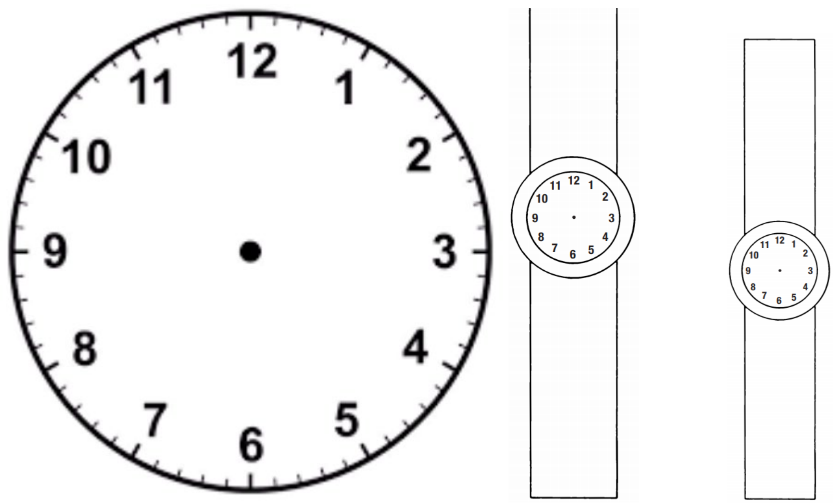
Here are some questions you can discuss with the class:

1) Which available materials seemed best for this activity? What materials would have been better to use?
2) Why are new products made? Why do innovations in technology occur?

3) Discuss why their inventions are useful?
4) Talk about how making a sketch is useful before attempting to make it.
5) What makes a good sketch?
6) Point out how there is more than one way to make something (such as a back scratcher).

Math & Measurements:

Fractions and Time



Cost: About $3.00 **Difficulty:** Low to Moderate **Time:** An hour **Continuous:** Yes

Summary: Teach students math, fractions, counting, and how to read an analog clock. Large print outs are included at the end of the lesson. The number of students that struggle when doing fractions, algebra, or even telling time on an analog clock is higher than you might expect. This is a good activity for teaching primary skills and ELO's that should be refined during in-school time as well.

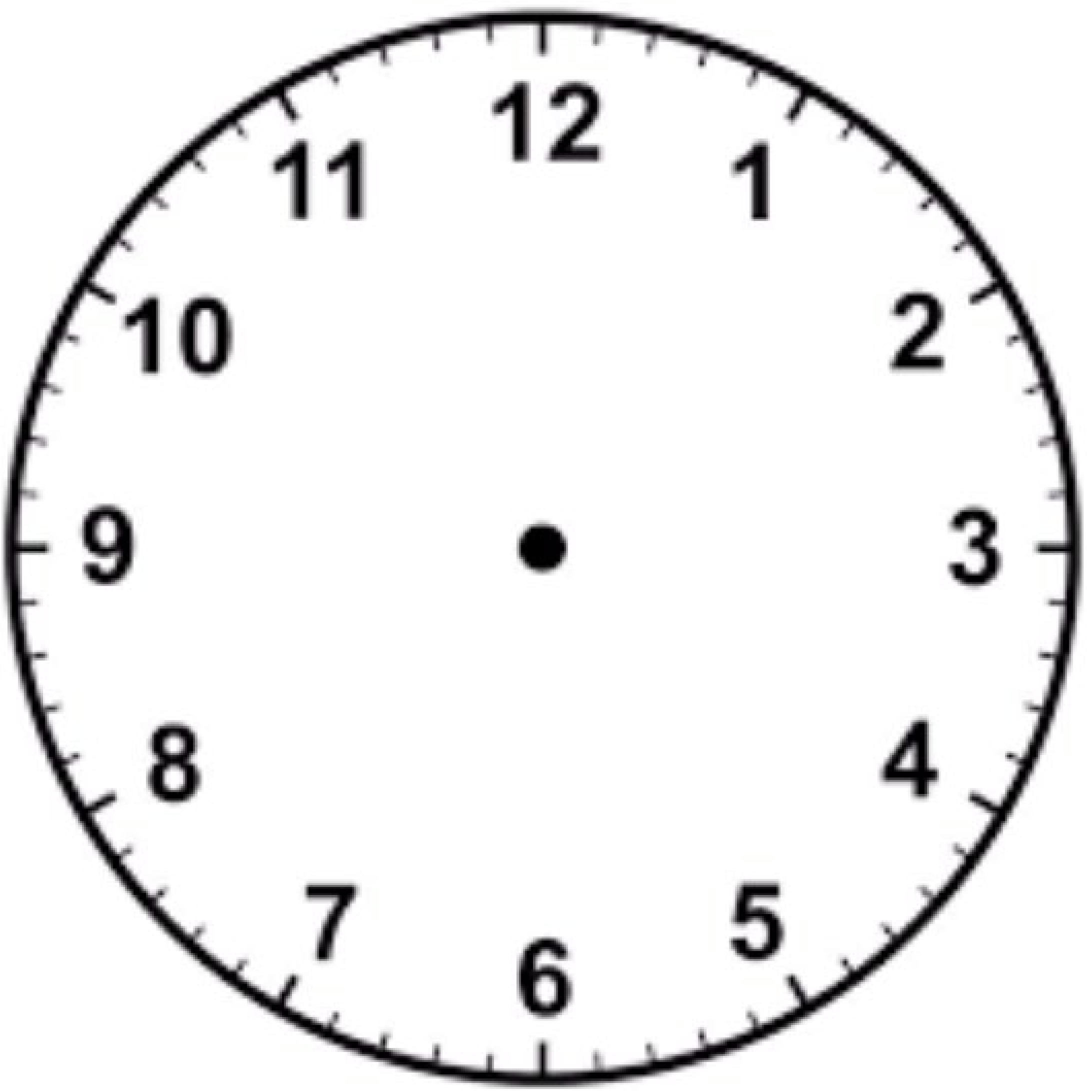
ELO's – Math, algebra, fractions, reasoning, time, punctuality, making a schedule, order, critical thinking.

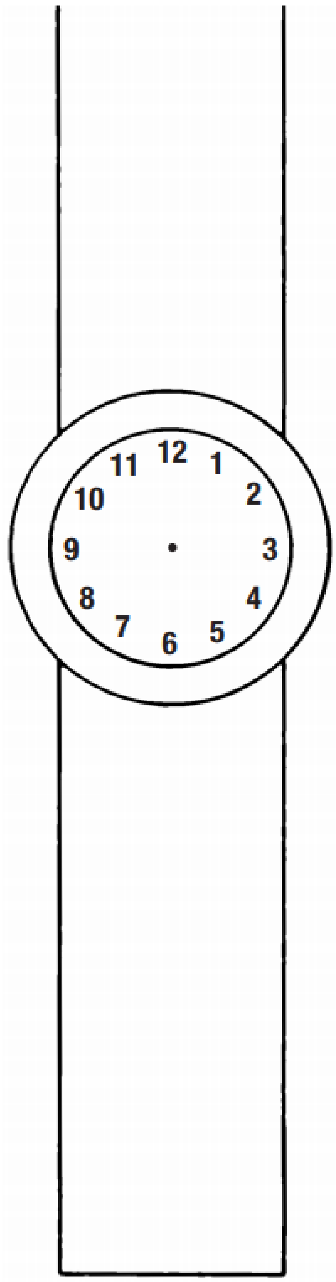
Supplies needed:

- Printed clocks sheet(s)
- Paper watch sheet
- Scrap paper or cardboard
- Optional: laminator, dry erase markers

Pro-tip: Generally most teachers have access to a computer and printer, making this an inexpensive activity. If you also have access to a laminator and dry erase markers it can make this lesson even more effective in class by making the sheets reusable by laminating them.

Simple Clock Templates:

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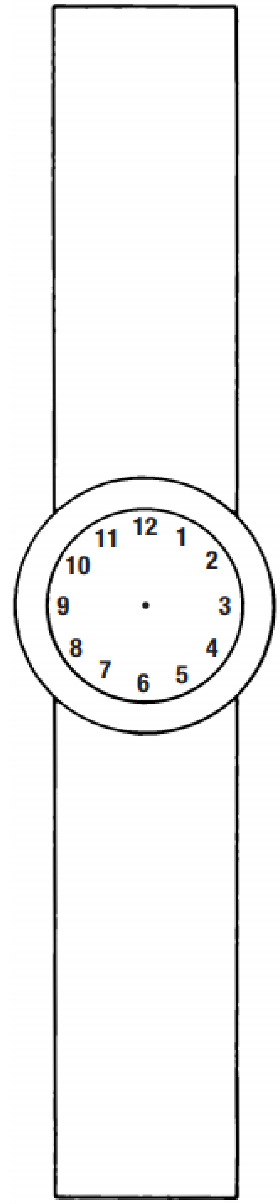
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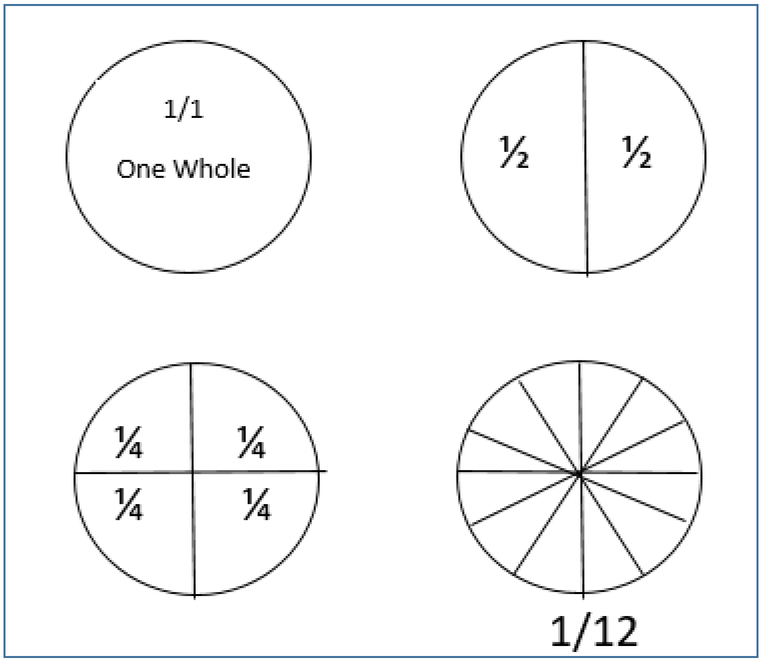
Making the connection between Fractions and Time, then Back again…



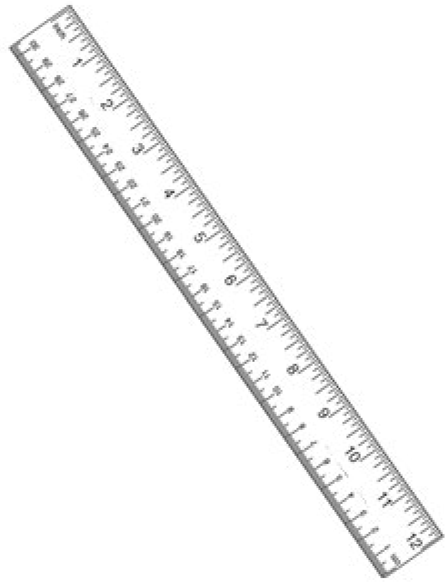
Discussion:

The reason why telling time on an analog clock is important is because its related to fractions. Students who haven't mastered telling time are more likely to also struggle with fractions. Or possibly the reverse could be said, students who struggle at fractions, are more likely to be unable to read an analog clock.

Let's review the diagram above, and see exactly how they are related. 1/1 is one whole or could be represented as one whole hour. While ½ is represented as a half an hour or 30 minutes. This is the same as half past five or 30 minutes until 6. A ¼ represents 15 minutes on a clock, since 60 divided by 4 is 15. Fifteen until 5pm or a quarter after three. And 1/12 represents 5 minutes. Students will improve not only reading the clock faster but making an association of fractions with math & time by practicing to count up or down fives.

If students are struggling, have them break the clock down. Have them say the hour hand first, and then ask the student where is the minute hand. Is it less than ¾'s of the way? Or less than half? Less than ¼? Count by 5's, then add one's. There are many different variations. Find one that works for the student and also use their super cool personalitzed watch.

Measuring in Feet & Inches



Pro-tip: Search google for printable rulers and then print out. Compare with actual ruler to confirm accuracy.

Cost: About $3.00 ~$5.00 **Difficulty:** Low to Moderate **Time:** Hour **Continuous:** Yes

Summary:

Teach students about measurements, fractions, relative size, height, and distance. This will build upon their general understanding of math, by giving numbers meaning. Rather than calculating the side of a triangle, how about measuring the size of that very large tree they climbed. Or a basketball hoop, the size of a student's shoe, the tallest person in class. This project should be done over time. It would be better to buy actual rulers for extended use, however this gives you an inexpensive alternative for providing a useful in class and out-of-class tool. The cheapest price I have found rulers is $0.19 each for the plastic yellow type. You may be able to find them for less than $0.33 cents at general or discount stores. Most rulers have inches on one side and centimeters on the other. Clarify which side you're using.

ELO's – Measurements, Math, understanding relative size & space, spatial awareness & understanding, observation, discussion, building a hypothesis, critical thinking.

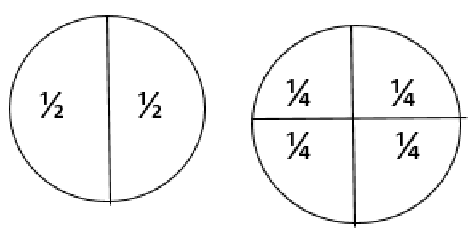
Supplies needed: Paper, construction paper (a ruler shape can be traced onto the paper with inch marks) or actually printed rulers, pencils and scratch paper.

Activity

1) Have students start using the rulers to understand how to make basic measurements and how to identify marks on the ruler. Discuss the parts of the ruler with the class. Why we have them? Which side is inches? Which side is metric? Where is a half inch? Why does the metric system exist?

Pro-tip: If you have never handled a ruler or measuring tape, it would be highly advised that you practice on your own time prior to doing the activity. The inch side is labeled Inch or in.

2) To start off with, just have the students learn how to read the ruler using whole numbers only. How many inches is a random book, a student's foot, or their own hand? Round up or round down. Have students lay down on the floor. How many inches tall are they?
3) As the students become more comfortable with using the rulers with whole numbers, begin basic fractions and decimals. Again have the students either round up or down. 5.25 or 5 ¼, 5.5 inches or 5 ½, and 5.75 or 5 3/4 inches.



Pro-tip: Keep it simple. Students can build upon what was learned in the factions and time lesson.

4) Show each of these on the board first. What does half of something looking like? Draw a pie (circle) and then divide it in half. Draw a pie (circle) divided into ¼'s.
5) Shade in a section of your shape and explain its value to the class. Half of a cookie. Half of a pie. If you eat half of a cookie how much is left? This is associating critical reasoning with basic word problems and arithmetic.
6) Have students count the sections of each pie graph, and then write the fraction or decimal value on the board. This method will help them visualize what they are doing. The primary

difficultly will be for them to memorize and use the correct terminology with what is being asked. Be consistent. If you just started fractions, only do fractions. If you are doing decimals, only do decimals. Don't switch back and forth suddenly; unless you are certain students have a basic understanding of one or the other. They will get there. Once they have mastered one, start practicing the other. After that feel free to mix it up.

7) Repeat **Step 2** again, this time using whole numbers, halves, or quarters.
8) If students have learned the basis of fractions or decimals, repeat **Step 2** using the other. **Example:** If first you did fractions with the class, now do decimals.

Optional Games:

Consider fraction or decimal bingo. Make bingo cards 5 x 5 squares. Fill in randomly with fractions and decimals. This will help students read the fractions on their sheets. Present called numbers on the white board/ chalk board to assist with the learning process.

Sound Traveling through Different Media

Cost: No Cost **Difficulty:** Low **Time:** Hour **Continuous:** Yes

A long time ago there used to be a TV show called Mr. Wizard. It starred an older gentleman who would explain the how-to of science. His guests were always kids in the neighborhood; ranging from 8~13 years old. One of the projects he would do with the kids was called a tin-can telephone. At the time it was common to make these using two soup cans, however any cups can be used. There are many variations to this project that can be done in class, the focus of this activity is: "how sound travels through different media."

Defining Sounds and Stuff

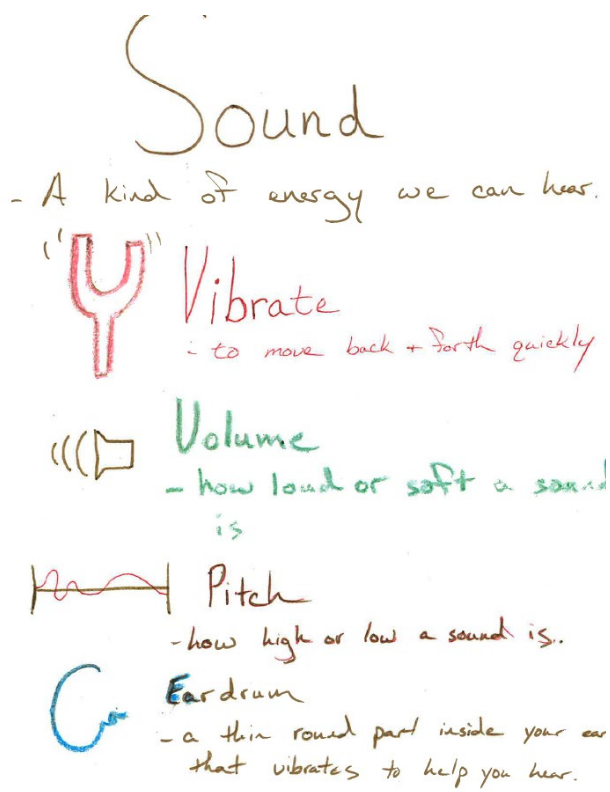
Sound - A kind of energy that helps us hear. Can be described as a wave.

Vibrate – to move back and forth quickly.

Volume – how loud or soft a sound is.

Pitch – How high or low a sound is.

Eardrum – a thin round part on the inside of your ear that vibrates to help you hear



Pro-tip: Write these terms on the board for your students learn visually.

What kind of animal do you hear?

Cost: Varies **Difficulty:** Low **Time:** less than an Hour **Continuous:** Yes

Summary:

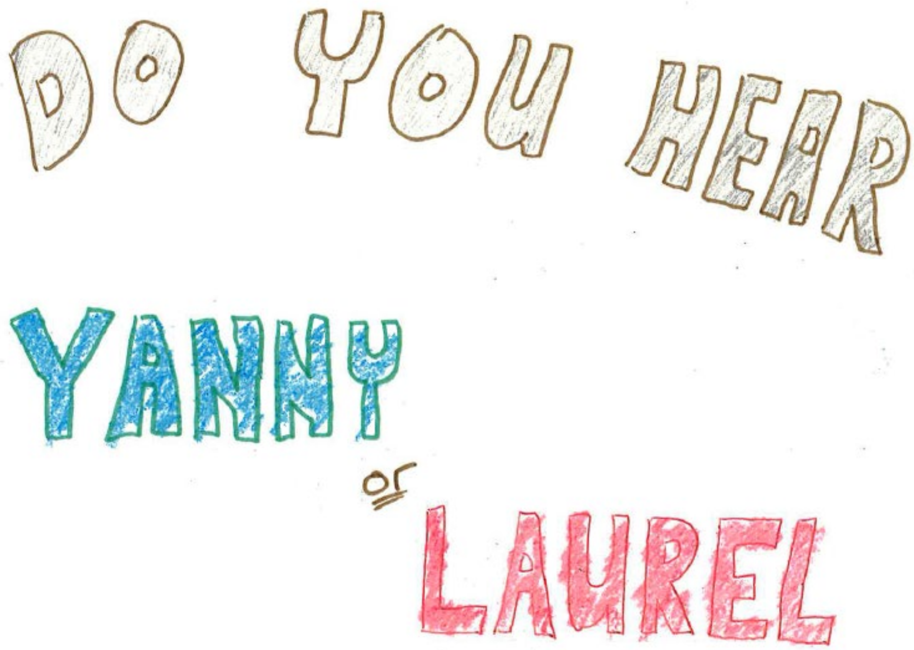
Playing a game such as "what do you hear?" is an easy way to develop students' critical thinking skills as well as their ability to recall sounds and experiences. This activity also helps students describe what they hear, form a hypothesis, and explain how sound works. Also try the Laurel/Yanny Experiment at the end of this section.

ELO's – Understanding sound waves, pitch, how the difference in pitch affects what we hear, understanding & reasoning, observation, discussion, building a hypothesis, critical thinking.

Supplies needed: A computer or something that can play sounds such as an mp3 player with speakers (the quality of your speakers may affect what can be heard), paper, and pencil.

Activity

1) Play different sounds. Have the students document what they think they hear.
2) Even if the student is unfamiliar with what kind of sound they heard, they should make a guess (hypothesis) based on their own experience (what they know). For example, most students have heard a bird chirp or maybe a cat meow. Does the sound they heard sound similar to that or different? Use process of elimination to figure it out.



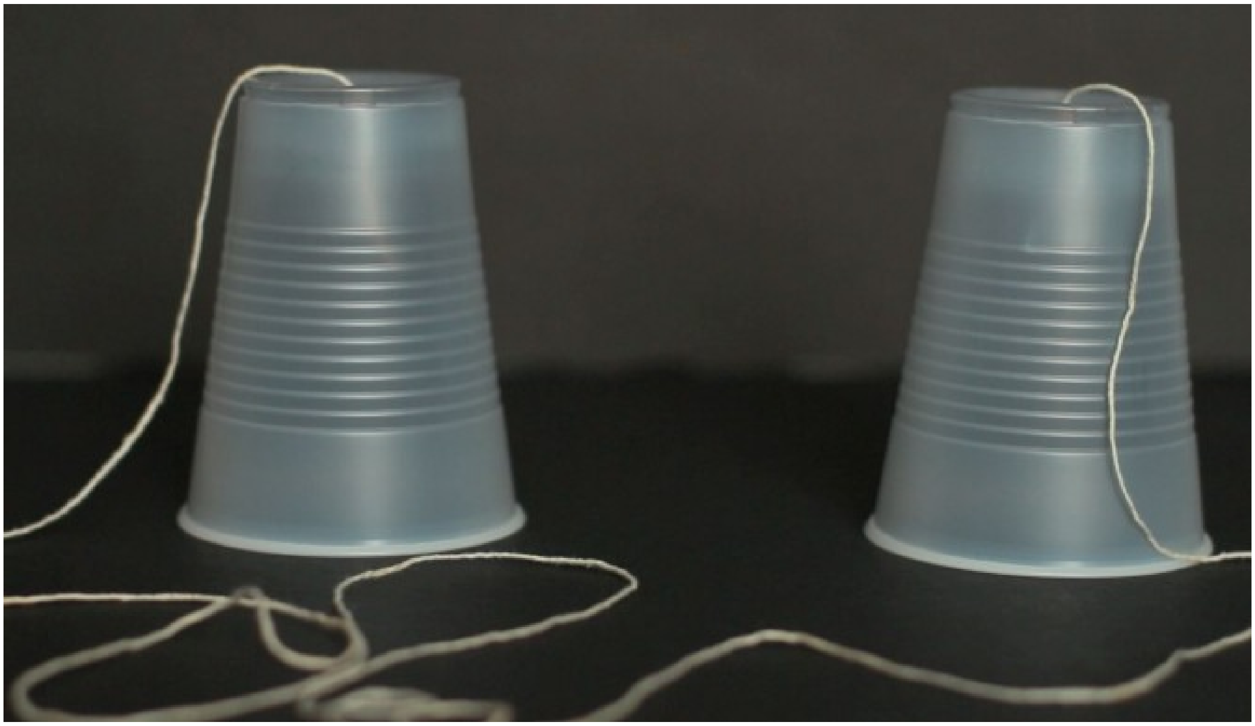
1) You can also try the Laurel/Yanny Experiment. You can find this on YouTube or another source on the internet.
2) Explain to the students the next sound they hear will be a name. Have the students write down the name they hear.
3) Play the Laurel Yanny sound.
4) Have the students write down what they thought they heard.
5) Have students raise their hand if they heard the name "Laurel" or "Yanny".

Discussion

Science explains that depending upon if you can hear more high frequencies or low frequencies will determine which name you will hear. Wired posted a very good video regarding this on YouTube.

Neuroscientist Explains the Laurel vs. Yanny Phenomenon | WIRED
https://www.youtube.com/watch?v=3km896XZ-J0

Tin Can Telephone (with cups)



Cost: Less than $3.00 ~$5.00 **Difficulty:** Low **Time:** Hour **Continuous:** No

Summary:

Students make a function nonelectric telephone that can both send and receive sounds over a predetermined distance.

ELO's – Describe how sound travels through different media, model and analyze a string telephone. Recognize that technology has helped people communicate over long distances, refine understanding of measurements (distance), vibration and sound relationship, observation, discussion, building a hypothesis, critical thinking.

Supplies needed:

- Cups,
- string,
- paperclips (optional),
- scissors

- (Optional): markers, decorative paper, glitter, and paint for making the telephone extra fancy!

Activity

1) Take your string and cut off a fairly long length to create distance between you and your partner. The more length you have the more impressive the activity will be. Make sure you have space. The string will need to be taut for sound to properly travel.
2) Take the scissors and make a small hole in the bottom of each of your cups in order to feed the string through.

Pro-tip: Make sure that the holes are not too big else the string will not stay in place after tying a knot.

3) Tie one end in a knot or tie string to an optional paperclip. The paperclip will prevent the string from pulling back through the hole.
4) Feed opposite end of the string through your second hole.
5) Tie off end similar to that of the first cup.
6) Make sure the string between the cups is taut.
7) One person should try speaking into the cup, while the other person listens. (Try using it in a quiet room).
8) At least some kind of sound should have been heard. If you are having difficulties, check the string and make sure it is still connected between both cups.
9) Pass out copies of the String Telephone Activity Handout on the next page or reference it and write on the board with students.

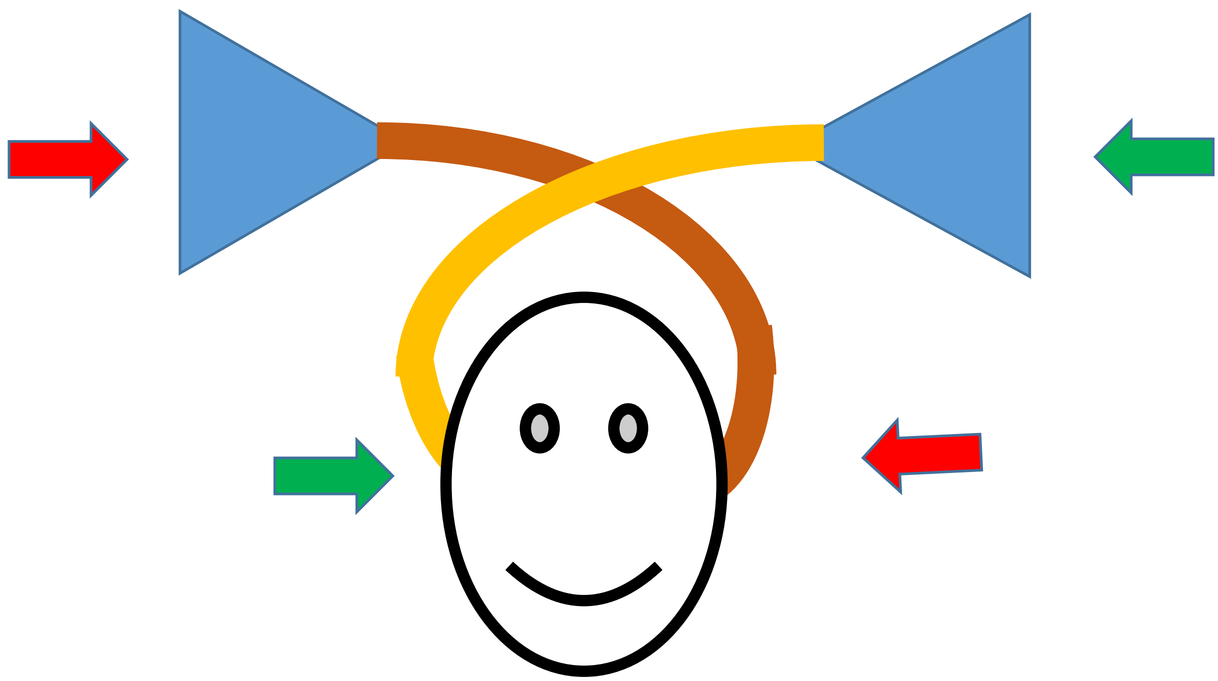
String Telephone Activity Handout for Students

1) How well did you string telephone work? If it didn't work well, what caused the problem?

2) Where do soundwaves travel in their string telephone? Have the students explain the process. Some students may be able to explain it better by drawing than words. Students can also draw in the space below.

3) How could we make this device work better?

Reverse Ear Headphones



Cost: $1.00 ~$10.00 **Difficulty:** Low **Time:** Hour **Continuous:** No

Summary:

Make a pair of reverse headphones that makes it difficult to tell what direction sound is coming from. The cost of this project varies from no cost if you used recycled materials or used store bought materials.

ELO's – Describe how sound travels through Different Media. Vibration and sound relationship, observation, testing & exploration, discussion, building a hypothesis, critical thinking.

Supplies needed: Funnels, plastic flexible tubing, tape.

<u>Free supplies:</u> roll paper to make funnels or use empty paper cups or plastic bottles, flexible tubing or hose, a little bit of tape.

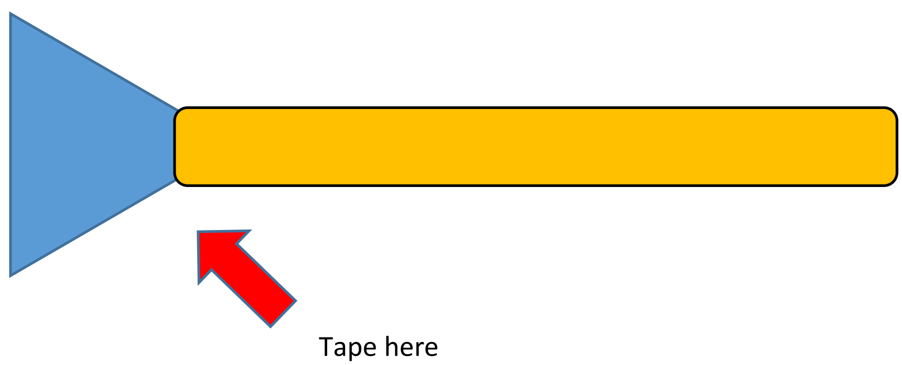
<u>Inexpensive supplies:</u> cheap plastic funnels or store bought disposable cups, plastic tubing from dollar store or Walmart, tape.

<u>Expensive:</u> If you go into an auto parts store for funnels and hoses/tubing, expect to spend a lot.

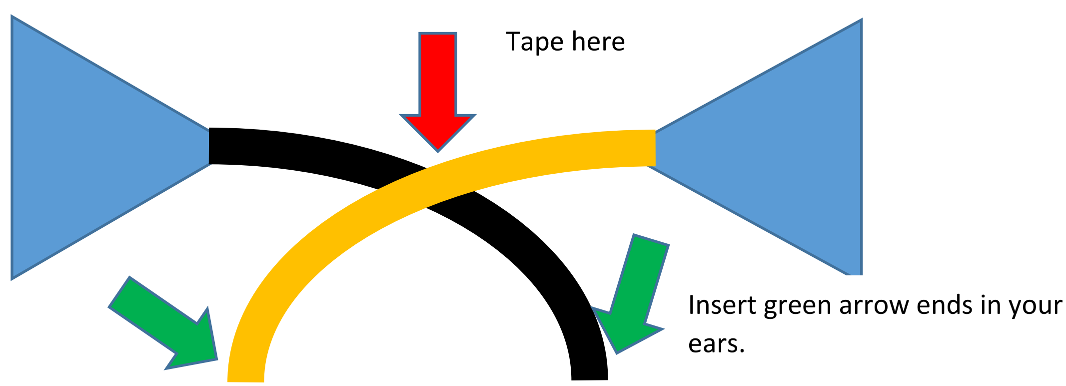
Activity

Warning: Do not yell into the funnel when someone is using! The wearer may suffer permanent ear damage.

1) Take two cups or plastic funnels or make two cones out of paper by rolling it up diagonally. Use tape to secure the shape.
2) Tape a funnel or cone to each end of your plastic flexible tubes and tape one cone to an end of the tube.



3) You will end up with two of the example of the above.
4) Now lay them one over the other and tape them together in the middle of the flexible tube.



Again Warning: Please tell your students, "do not yell into funnel (cone) when someone is using! Wearer may suffer permanent ear damage."

Discussion:

Have the student wearing the device sit down in a chair and then close their eyes. A second student will stand somewhere around the room, preferably behind the student to prevent peaking. When the student hears a sound, they should say, left or right. Also let the student hear several different kinds of sounds to see if they can identify what it is. You left ear and right ear can sometimes hear different pitches and sounds: such as voices, animal sounds, or other noises.

Suggestions for Student Reflection

I try to get my students to reflect or provide input, but they are being… kids! This is common, students will in general provide complaints such as boring or they didn't like something, but can be very reluctant to providing positive feedback unless very motivated. As an instructor you can motivate or provide incentives for feedback both positive and negative such as those they provide feedback get a slime day or something along that line.

Here are some general questions that you can ask students regarding any activity in this book. It is a good way to assist students in reflecting upon what they did, what they learned, and what they hope to learn in the future.

Student Reflection Guide

Name: Date:

I learned that…

Learning this made me feel…

The best part of the project was…

We can make this project better next time by…

Next time I hope I can learn about…

When I grow up, I want to be a…

Science is important because it helps us….

Author Reflection

Well, you finally made it to the end of this guide. It's just about that time to give your students a pat on the back for a job well done! Don't forget to give yourself one too. You should feel proud, especially if STEM was a new topic for you. Whether you're actually a STEM instructor or not, you tried. Hopefully you and your students learned something along the way, and had fun. That's most important. Many students and adults in general feel nervous or even scared when trying new things. They are afraid to fail or look bad in front of their peers or even their own children. What is most important is to have a curious mind and to try your best. Even if you fail, learn from the experience and then try to improve with every opportunity you have.

Hopefully you found this guide useful at your school, site, or in your classroom. I hope it sheds a little bit of light on some of the STEM activities you can do with students, while maintaining a budget for your program. If you have any thoughts you would like to share, feel free to contact me on Facebook, at the Tyrome Williams Foundation. I appreciate your time and consideration in reading this guide.

Best regards,

Tyrome Williams