

STEM Activities

for

Middle School Students:



Special Focus on Girls



Illinois Valley Community College
Oglesby, IL 61348

www.ivcc.edu/nsf



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Acknowledgments

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FOR MORE INFORMATION ABOUT MIDDLE SCHOOL STEM ACTIVITIES,
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A middle school team works on a can construction project (See Construct-I-Can)

Table of Contents

Buoyancy and Surface Tension	1
Candy Math	5
Communication Games	10
Construct-I-Can.....	15
Edible Car Contest for Kids.....	18
Frozen Treat in a Bag	23
Geometry: Polygons and Polyhedra	26
Geometry: Surround, Enclose, Cover, and Fill.....	30
Paper Rockets – Building and Launching	36
Soda Geysers	38
Team Building Exercise:	42
Assessment Examples.....	43
Pre-Activity Assessment Example – Participant Survey 1	43
Pre-Activity Assessment Example – Participant Survey 2	45
Post-Activity Assessment Example – Participant Survey 1	47
Post-Activity Assessment Example – Participant Survey 2	48
Post-Activity Assessment Example – Participant Survey 3	49

Buoyancy and Surface Tension

Overview

Participants will explore and discuss buoyancy and surface tension.

Category: Science, Engineering

Learning Goals

- Experiment using the scientific method
- Discuss and use buoyancy and surface tension terminology
- Participate in the engineering design cycle

Participants

The activity can be conducted with almost any number of participants and one session leader.

Materials

<ul style="list-style-type: none">• Water• Bins or Tubs (to hold water)• Objects to test (e.g. ping pong ball, penny, cork, ice cube, paper clip, lead weight, non-dissolving packing peanut, raisin, apple, etc.)• Straws• Foil	<ul style="list-style-type: none">• Pennies (Dependent upon the amount of foil and straws participants are allowed to use)• Pencil/ Pen• Activity Sheet, one per participant• Towels for clean-up and drying objects after use
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Activity Time: 90 minutes

Setup

Set up station(s) with bin(s) of water to test various objects

Sink or Float?

Have each participant record the object(s) to be tested on their activity sheet.

Also, have them hypothesize (predict) whether each object will sink or float.

Allow the participants to test their objects and record the results.

Discuss why they think that some objects floated, while others sank. Also, introduce the appropriate terminology:

Density – a measure of the “heaviness” of an object for a given volume. For example, a small dish of popcorn is less dense (“heavy”) than the same dish filled with raisins.

Buoyancy – the tendency of an object to float or rise when placed in a liquid. The liquid exerts an upward force on the object. If the object's density is low enough, it will float.

Continue with a demonstration and discussion of surface tension.

Demonstrate that a paper clip will sink if just dropped into the water. However, it can be made to float if it is placed very carefully onto the surface of the water. Why does this happen?

Surface Tension – the molecules of a liquid are pulled together at the surface of the liquid, thus allowing the liquid to resist external forces.

Ask participants about other things that may “float” due to surface tension? (e.g. canoes, kayaks, fishing boats, water striders, etc.)

Introduce the Raft Competition.

Raft Competition

Task participants with an engineering task: design, construct, and test a raft that will hold the most number of pennies.

It is up to the session leader to determine whether participants can use as much foil and straws as they would like, or if there are restrictions. The task is more realistic if all participants are restricted to the same number of straws and the same amount of foil. After all, in engineering design and construction there are typically cost and resource limits to building things.

To encourage participants to model the engineering design process and use the scientific method, have them complete their design and hypothesis *prior* to beginning construction on the raft. Suggestion: Release materials to participants only after review by the session leader of the design and hypothesis.

Upon completion of the construction and testing, discuss the results. What raft shapes were used? Which worked better? How does surface tension factor into the results? (e.g. spreading the weight of the pennies across the surface of the water through use of the foil)

What different folding methods were used to connect the straws to the foil? What kind of boat(s) use structures similar to the straws in our rafts? (e.g. pontoon boats, catamarans)

What was the most number of pennies that a raft held?

Buoyancy and Surface Tension
Participant Activity Sheet

Sink or Float?

<u>Object</u>	<u>Hypothesis (Sink or Float)</u>	<u>Experimental Result</u>

Why do you think that some objects floated, while others sank?

Raft

Describe and sketch your raft design:

Hypothesis:

The designed raft will hold _____ pennies.

Experimental Result:

The raft held _____ pennies.

How could you modify the design of the raft so it would hold be stronger (i.e. hold more pennies)?

Credits

Activity packet developed by Dawn Wiggins.

Candy Math

Overview

Participants will explore and discuss statistics: terminology, mean, percents, frequency distributions, histograms, and pie charts.

Category: Math

Learning Goals

- Discuss and use statistics terminology
- Calculate mean and percent
- Represent data using frequency distributions, histograms, and pie charts.

Participants

The activity can be conducted with most any number of participants and one session leader.

Materials

<ul style="list-style-type: none">• Candy – Small packets or a scoop (~1T) of small candy (e.g. M&Ms, Skittles, Smarties, etc.) for each participant• Pen/Pencil• Crayons, Markers, or Colored Pencils	<ul style="list-style-type: none">• Activity Sheets (one of each for each participant)• Candy Math Activity Sheet• Grid Paper for the Histogram• Polar Paper for Pie Chart (http://www.incompetech.com/graphpaper/polar/)• Calculator
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Activity Time:

Suggested time: 90 minutes

Introduction

Introduce and review rounding, as needed.

How might we be able to make predictions about the number of candies in each package? The number of each color in each package?

“Experiment” - tally the number of each candy color for several packages.

Calculate the mean (average): take the total number of a particular color from all of the packages and divide by the number of packages.

Calculate the percent: take the total number of a particular candy color from all of the packages and divide by the total number of candies from all of the packages; then multiply by 100.

How might we represent the number of each color in each package?

Frequency Distribution - Write the number of each color of candy in a table

Histogram - Draw a picture where the height of the bars representing each candy color

Pie Chart – Draw a circular picture and color sectors to represent each candy color

Instructions

Complete the frequency distribution for each individual.

Divide participants into small groups (about 5) to report their frequency distributions. Record the results in the table for the group.

Compute tallies, means, and percents for the group table.

Create a histogram using the group data.

Create a pie chart using the group data.

Summary Comments and Discussion

How many candies could we expect in each package (or scoop)?

What is your favorite color? How many of those candies could we expect in each package? What did you use to make your determination?

Using your histogram, for which color would we expect to find the *least* number of candies?

Using your pie chart, for which color would we expect to find the *most* number of candies?

Candy Math
Participant Activity Sheet

Individual Activity

Create a frequency distribution: Record the candy colors. Then, count the number of each colored candy and record it in the table.

Candy Color	Number in the Bag
Whole Bag Total:	

Group Activity

Record the candy colors.

Tally: Record the number of each colored candy from several people (or packages).

Total: Add the tally for each color and record the sum.

Total Candies: Add up the Total column and record the sum.

Mean Column: Calculate the mean for each color. Take the total for the color and divide by the total number of people (or packages). Round to the nearest whole number.

Percent Column: Calculate the percent for each color. Take the Total for each color and divide by the Total Candies. Multiply by 100. Round to the nearest percent.

Candy Color	Tally	Total	Mean (nearest whole number)	Percent (nearest percent)

Total Candies:

Mean Number of Candies in Each Package (or Scoop) - Divide the Total Candies by the total number of people (or packages); round to the nearest whole number.

Histogram

Create a histogram using the Mean column in the group table. The colors go along the horizontal axis. The number of each color of candy goes along the vertical axis.

Assign each of your candy colors to a column. Write the color name at the bottom of the rectangle.

Shade rectangles in each column to correspond to the number of candies for each color.

Give the histogram a title.

Title:

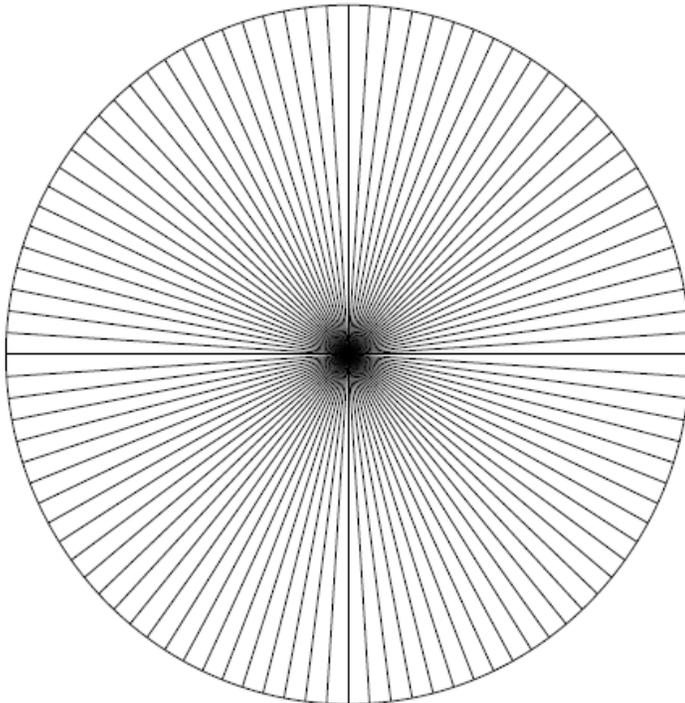
Frequency							

Candy Colors Pie Chart

Create a pie chart using the Percent column in the table for the Group. Each sector (slice) of the pie chart corresponds to 1%. Include a key that lists the candy color and the color or pattern that is shaded in the chart. Give the pie chart a title.

Title:

Key:



Credits

Activity packet developed by Dawn Wiggins.

Communication Games

You Want Me To Do WHAT?

Overview

There are many aspects of communication and this session touches only briefly on a few. In this session participants will practice communicating in writing. And, verbal communication is included, as time permits.

Category: Communication

Level: Explore

Learning Goals

- Practice communicating in written forms
- Discuss other means of communication
- Practice other means of communication, as time allows

Materials

- Packets of building supplies; contents include things such as pipe cleaners, mini craft sticks, straws, yarn, etc. Other inexpensive materials can also be used: Legos, Lincoln Logs, Tinker Toys, etc.
- Paper bags
- Stopwatch or Clock
- “You Want Me To Do What?” participant worksheet
- Pencil/Pen

Activity

Suggested time: 20 minutes

Explain, “It takes various teams to move projects through design, development, testing, and production. The teams may be located in different buildings, different states, or even different countries. It is also possible that members of a single team may be separated. So, it is important when communicating, to be clear and concise.”

Divide the group into teams consisting of about 3 members per team.

Explain, “Each team will have 3 minutes to construct a prototype object out of the materials in the packets. Then, each team will take 5 minutes to write a description of the object and how to make it. Finally, the teams will trade descriptions and attempt to build a ‘production’ recreation of the prototype object in 5 minutes.”

Give one team a packet of A building supplies and the other team a packet of B building supplies.

Explain, "Each team should gather, separate from the other team(s), to construct a prototype object out of the packet of building supplies. You have 3 minutes. I'll provide a one-minute warning. Begin."

Call time and get the group's attention.

Give each team an activity sheet, a writing instrument, and a paper bag.

Explain, "Each team will now write a description of the prototype object and how to make it. Only words and numerals may be used. Symbols and diagrams are not allowed. All abbreviations must be defined either at the beginning or when the abbreviation is first used. You have 5 minutes. I'll provide a one-minute warning, at which time you'll need to finish your description and conceal your prototype in the paper bag. Begin."

Call time and get the group's attention.

Explain, "Okay, be sure your prototype object is hidden in the paper bag provided."

Give the A team a fresh packet of B building supplies and give the B team a fresh packet of A building supplies.

Explain, "All right, trade descriptions and attempt to 'produce' the other team's prototype object. You have 5 minutes. I'll provide a one-minute warning.

Begin."

After the 5 minute limit, the teams may look at each other's work, comparing the original prototype object from the bag and the 'production' recreation.

Lead the group in discussion:

What was difficult for each team during the activity?

What was easy?

What communication, besides only written words and numerals, would have been helpful? (e.g. diagram, verbal discussion)

How might you have done this differently if you had been able to plan ahead?

Extension: Verbal Communication

Select two participants. Have one participant construct a small prototype; this person is the designer and should not let the builder see the prototype.

Then, provide the same materials to the builder; the builder should not see the prototype just constructed by the designer. Have the designer and builder sit back to back in front of the rest of the group.

Communication options that can be explored (supplemental sheet can be printed, cut up, and used for random selection by participants):

- Builder asks questions of the designer that can only be answered with Yes or No.
- Builder is free to ask open-ended questions of the designer.
- Designer verbally describes to the builder how to construct the model. The builder *is not* allowed to ask questions.
- Designer verbally describes to the builder how to construct the model. The builder *is* allowed to ask questions.

Provide a time limit for the activity.

Have the designer and builder compare the resultant prototypes. Discussion topics:

How close were the resultant prototypes?

What other communication may have been helpful?

Explore as many of the communication options as time, and attention, permits.

You Want Me To Do WHAT?

Participant Worksheet

Materials Packet (circle one) A or B

Directions

Write a description of the prototype object and how to make it. ONLY words and numerals may be used. Symbols and diagrams are NOT allowed. All abbreviations must be defined either at the beginning or when the abbreviation is first used.

Description of Prototype and Building Instructions

Communication Exploration

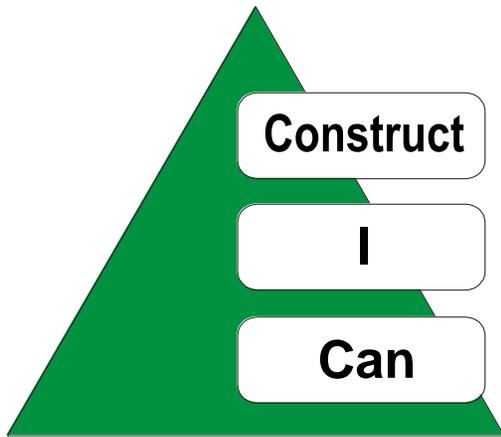
Supplemental

<p>Builder asks questions of the designer that can only be answered with Yes or No.</p>	<p>Builder is free to ask open-ended questions of the designer.</p>
<p>Designer verbally describes to the builder how to construct the model. The builder <i>is not</i> allowed to ask questions.</p>	<p>Designer verbally describes to the builder how to construct the model. The builder <i>is</i> allowed to ask questions.</p>

Credits

Activity packet developed by Dawn Wiggins

Construct-I-Can



Guidelines for Organizing

Construct-I-Can is an engineering design exercise in which teams build structures from food cans and boxes. The exercise provides students with a hands-on exercise in engineering technology, the teamwork typical of the field, and the creativity necessary for good design and effective problem solving.

Category: Engineering

Learning Goals

- Discuss and employ the engineering design cycle
- Practice communication and teamwork skills
- Practice problem-solving skills
- Demonstrate an understanding of principles underlying the design of structures

Supplies for Construct-I-Can

- Non-perishable food items, both canned goods of various sizes and boxed goods of various shapes and sizes. (Can be limited to certain types of food items.)
- Sketching or graphing paper for participants to draw designs.
- Pens/pencils
- Copies of participant instructions
- Prizes, possibly computer generated certificates.

To make the activity as cost –effective as possible, combine it with a food drive for a local food pantry and donate the food items after the event. Ask participants to assist with the drive. Approach grocery stores and civic organizations for donations.

Organizing the Activity

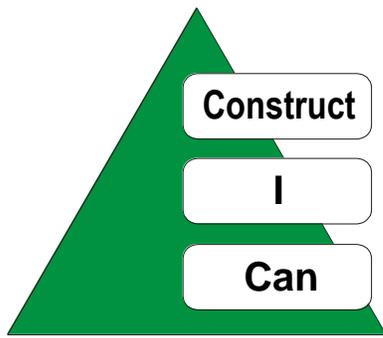
- Find a location for storing the food before the activity. Solicit volunteer help to move the food to the activity location.
- Capitalize on the promotional possibilities, especially if the activity is combined with a food drive for a pantry.
- Determine number of teams before the activity begins, and if possible, assign participants to teams ahead.
- Divide the food items before the activity begins, providing each team with a variety of sizes and shapes.

Activity Schedule: Half a day for sketching and building, explaining designs, judging and announcing winners.

Credit: Activity packet developed by Dorene Perez.



A bridge (right), ferry (lower center) and tower (left) designed by a middle school team.



Participant Instructions

Welcome to Engineering Technology!

Engineering Technology (ET) is a career field which focuses on the applications of engineering and modern technology.

Today, you will experience what it might be like to be an engineering designer. Engineering designers help design buildings, machines, robots, bridges, cars, trains, musical instruments, parts, programs, controls, almost anything you can think of, down to the tiniest nuts and bolts. You will be working on a team since that is the way engineering designers work.

Your team's challenge is to utilize the food items you are assigned and to create something, some sort of a structure, from them. As a team:

1. Look at the food items you have and discuss possible structures.
2. Decide what type of structure to build and make a sketch of it using the sketch paper in your packet.
3. Organize your materials (food items) and build the structure.
4. If your team decides to modify your design while you are building it, revise your sketch before you modify or finish the structure. Build from your design. Ask for additional sketch paper if you need it.
5. Prepare to explain your structure's design – why you used certain food items as you did, etc. Everyone on your team will be expected to participate in that explanation during the judging of the structure.
6. When your structure is complete, notify an instructor

Rules:

- You may barter and/or exchange materials (food items) with other teams.
- You may NOT just take materials from another team.
- You may use a limited amount of some other materials in building your structure, including the flats or boxes your food items came in, and tape or paper made available to you.
- You do not need to use all of the food items you have been assigned in building your structure.

Judging:

Structures will be judged and prizes awarded to Best Design and Most Creative Design. The team's explanation of design choices will be considered in the judging.

The food items you are using today will be donated to a food pantry.

Edible Car Contest for Kids

Overview

Participants will have fun employing the engineering design cycle to build an edible car. They will work in small groups and have the opportunity to hone their communication and teamwork skills. After constructing their edible car, they will race the cars down a ramp and calculate the average velocity. In conclusion, they will reflect upon the iterative nature of the design process and propose ways to improve the car design through best practices.

Category: Math, Engineering

Learning Goals

- Discuss and employ the engineering design cycle
- Practice communication and teamwork skills
- Practice problem-solving skills
- Demonstrate an understanding of scientific principles underlying the design
- Calculate average velocity

Location

The activity can be conducted indoors or outdoors.

Participants

The activity can be conducted with almost any number of participants and one session leader.

Materials

Car Materials:

- Body Materials (e.g. rice crispy bars, cucumbers, bananas, loaves of hard bread, hot dogs, ice cream cones, celery, Twinkies)
- Wheels (e.g. mini chocolate donuts, cookies, fruit loops, gummy rings, pinwheel pasta, life savers)
- Axles (pretzel rods, pretzel sticks)
- Adhesives and Adornments (gum drops, mini marshmallows, marshmallows, thin licorice rope, cake icing, sprinkles)

Construction Tools and Other Supplementals

- Plastic knives
- Paper towels or wipes for clean-up

Additional Materials

- Ramp, ~3ft in length (e.g. board, inclined table)
- Masking tape
- Plastic garbage bags

- Spatula
- Measuring device (e.g. ruler, yard stick, tape measure)
- Timing device
- Calculator

Optional

- Camera for documentary purposes

Prizes for various categories (e.g. speed, design, creativity, detail, nutritional value, etc.). Can utilize computer generated certificates.

Activity

Suggested time: minimum of 60 minutes.

Setup

- Incline a board or table about 3ft in length to form a ramp.
- Use masking tape to mark the start and stop points along the table.
- Place garbage bags at the bottom of the ramp to collect any mess that may result from racing the cars.

Introductory Discussion

What do we need to think about when designing an edible car? (e.g. constraints, materials availability, etc.)

One possible engineering design process includes the following iterative steps:

- State the problem, including any constraints
- Brainstorm ideas for a solution, based upon constraints
- Select a solution
- Identify and collect materials
- Construct a prototype
- Evaluate the prototype
- Present the results
- Redesign the solution to improve the prototype

Inform participants whether they will provide their own food to construct their vehicles or if the materials will be provided.

Other questions or comments.

Constraints for the Edible Cars

The cars must be built entirely from food items edible to humans.

Entries must look like cars.

Entries must have at least two axles and at least three wheels, all edible to humans.

To be eligible for a speed prize, the entry must roll down a ramp approximately three feet long.

Planning: Design the Edible Cars

Arrange participants into small groups to form teams. Each team should come up with a name for their team or their car.

Participants should brainstorm ideas for their edible car design, based upon the constraints, and select a design.

After selecting a design, participants should identify and collect the needed materials.

Construction: Build the Edible Cars

Once planning is complete, participants are ready to construct their vehicles.

Have participants identify challenges encountered during the construction of the prototype.

Evaluation: Race the Edible Cars

Discuss velocity:

- Why are there speed limit signs along streets and roads?
- How do you know if you are within the speed limit when driving or riding in a car?
- If the speed limit is 55 mph, what does “mph” stand for?

- How do you calculate the average speed (or velocity)? $v = d/t$
- So, if I could walk three miles in one hour, what is my speed? 3mph

To calculate the speed of the edible cars, the distance traveled is needed.

Measure and record the distance between the start and stop tape lines on the ramp.

Race the cars:

Two people are needed to record race times: a racer and a timekeeper.

The racer should hold the car on the ramp at the start line using the spatula.

When ready, the timekeeper shall announce “Go!”, at which time the racer shall release the car. It is the timekeeper’s responsibility to start the timing device when the car is released and stop the timing device when the car passes the stop line on the ramp.

Each team should record the amount of time it took their car to traverse the ramp and then calculate the car’s average velocity.

Optional: Award prizes.

Summary

Which car was the fastest?

What “best practices” would you recommend for building an edible car?

Credits

Activity packet developed by Dawn Wiggins.

For additional suggestions on offering edible car contests:

Download a “How to” Handbook for Organizing Edible Car Contests at www.ivcc.edu/nsf. Click on Edible Car Contests or Resources for Teachers.



Edible cars designed and built by middle school student teams.

Edible Car Contest for Kids

Participant Activity Sheet

Constraints for the Edible Cars

- The cars must be built entirely from food items edible to humans.
- Entries must look like cars.
- Entries must have at least two axles and at least three wheels, all edible to humans.
- To be eligible for a speed prize, the entry must roll down a ramp approximately three feet long.

Team/Car Name:

Edible Car Design:

Materials List:

As you build the prototype for your car, identify any challenges that you encounter and how you overcome them.

Calculate the average speed of your edible car:

Edible Car's Average Speed = (Distance Traveled)/(Time to Travel the Distance)

=

What challenges did you encounter when building the prototype for your car? And, how did you overcome them?

Did your car successfully make it down the ramp?

How fast did your car go?

How would you change the design of your car to make it better?

Frozen Treat in a Bag

Overview

Create an ice cream or sorbet treat. While the treat is freezing, discuss the properties of the ice cream, freezing, and freezing points.

Category: Scientific Exploration

Learning Goals

- Practice measuring techniques to support future scientific experimentation
- Practice following instructions
- Practice critical thinking skills

Location

This activity is best conducted at a table in, or near, a kitchen.

Participants

The activity can be conducted with almost any number of participants and one session leader.

Materials

Provide the following materials for each participant

<p>Treat</p> <ul style="list-style-type: none">• ½ cup milk or half & half (ice cream).• Optional: use fruit juice to make a sorbet)• ¼ t vanilla• 1 T sugar <p>Participant Activity Sheet</p>	<p>Supplemental Materials</p> <ul style="list-style-type: none">• 1 resealable sandwich bag• 1 resealable gallon bag• 1 tray ice cubes• 6 T salt (rock or table)• Towel, gloves, or potholders• 1 spoon
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Activity

Suggested time: 30 minutes

Treat Preparation

Mix treat contents in the sandwich-sized resealable bag; then, seal the bag.

Add the treat bag, the ice, and the salt to the gallon-sized bag; then, seal the bag.

Protect your hands from the cold bag using the towel, gloves, or potholders.

Shake the bag back and forth until the liquid thickens; this should take 5 to 10 minutes.

Remove the sandwich bag from the gallon bag. Wipe the wet salt mixture from the outside of the sandwich bag.

Use the spoon to eat the treat right from the sandwich bag.

Discussion

Complete while shaking the bag and eating the treat.

What contributes to the smooth texture that you feel in your mouth when eating ice cream? (fat content)

At what temperature does water freeze? (32° F)

Why do we add salt to the ice? Why not just use ice? (As the ice melts, a water-salt solution results: a saline solution. The freezing point of saline is lower than the freezing point of plain water. This creates an environment cold enough to freeze the ingredients to form the frozen treat.)

What is freezing point depression? (lowering the freezing point of a liquid by adding something to it)

Why else might we want to lower the freezing point of water? (to melt ice from roadways and sidewalks in the winter)

What other questions might we ask? What other experiments could we do? (Check the temperature of the treat mixture over time with solutions containing different concentrations of salt. Explore how other additives (e.g. sugar, epsom salt, ...) affect the freezing point.)

Credits

Activity packet developed by Dawn Wiggins

Frozen Treat in a Bag

Participant Activity Sheet

Materials

Treat	Supplemental Materials
<ul style="list-style-type: none">• ½ cup milk or half & half (ice cream).• Optional: use fruit juice to make a sorbet)• ¼ t vanilla• 1 T sugar	<ul style="list-style-type: none">• 1 resealable sandwich bag• 1 resealable gallon bag• 1 tray ice cubes• 6 T salt (rock or table)• Towel, gloves, or potholders• 1 spoon

Treat Preparation

- Mix treat contents in the sandwich-sized resealable bag; then, seal the bag.
- Add the treat bag, the ice, and the salt to the gallon-sized bag; then, seal the bag.
- Protect your hands from the cold bag using the towel, gloves, or potholders.
- Shake the bag back and forth until the liquid thickens; this should take 5 to 10 minutes.
- Remove the sandwich bag from the gallon bag. Wipe the wet salt mixture from the outside of the sandwich bag.
- Use the spoon to eat the treat right from the sandwich bag.

Discussion: Complete while shaking the bag and eating the treat.

- What contributes to the smooth texture that you feel in your mouth when eating ice cream?
- At what temperature does water freeze?
- Why do we add salt to the ice? Why not just use ice?
- What is freezing point depression?
- Why else might we want to lower the freezing point of water?
- What other questions might we ask? What other experiments could we do?

Geometry: Polygons and Polyhedra

Overview

Participants will explore and discuss polygons and polyhedra.

Category: Math, Science, Engineering

Learning Goals

- Discuss and use polygon, polyhedral, and solids terminology
- Experiment using the scientific method
- Construct and test space figure models

Participants

The activity can be conducted with almost any number of participants and one session leader.

Materials

Construction Materials <ul style="list-style-type: none">• Pieces: Toothpicks, straws, or some other material for constructing• Connectors: Mini marshmallows, raisins, gum drops, modeling clay, or some other connector material Activity Sheet, one per participant	Scissors Solids (e.g. die, rectangular box, can of food, ball, pyramid, etc.) Supplemental Shapes and Solids Sheet Pencil/ Pen
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Activity

Suggested time: 90 minutes

Setup

Have various solids and/or pictures of shapes and solids placed around the tables or work areas for participants to see as they arrive.

Polygons

What is a polygon? (a 2-dimensional shape made up of straight lines)

Have each participant match the name of the shape with the picture of the shape.

How many sides does a “googolgon” have? (10^{100} sides)

What shapes are on the surface of a soccer ball? (black pentagon and white hexagon)

Have participants make a square out of pieces and connectors. Stand it upright.

Is it sturdy? (no)

Have participants make a triangle out of pieces and connectors. Stand it upright.

Is it sturdy? (yes)

Polyhedra

What is a polyhedron? (a 3-dimensional space figure made up of flat faces; there are no curved surfaces)

List some space figures (solids) that are polyhedra. (Polyhedra: Cube, Rectangular Space Figur, Pyramid with Square or Triangular Base)

List some space figures (solids) that are not polyhedra. (Cylinder, Cone, Sphere)

Have participants construct a tetrahedron (pyramid with a triangular base).

Have participants hypothesize about the number of tetrahedral it will take to support a book. Then, put them in small groups to test their hypothesis.

Discuss the results of their experimentation with using tetrahedra to support a book.

What shape is common to both the triangular pyramid and the square pyramid?

Where else do you see this shape? Take a walking tour, if feasible. (The triangle is a “strong” shape. It can be found in roof construction, supports under tables, wheelchair ramps, etc.)

Credits

Activity packet developed by Dawn Wiggins

The Shape of Things

Participant Activity Sheet

Polygon:

List the number of sides for each shape; then, match the name of the shape with the shape.

Triangle

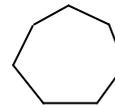
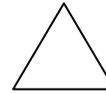
Quadrilateral

Pentagon

Hexagon

Heptagon

Octagon



How many sides does a “googolgon” have?

What shapes are on the surface of a soccer ball?



Make a square out of pieces and connectors. Stand it upright. Is it sturdy?

Make a triangle out of pieces and connectors. Stand it upright. Is it sturdy?

Polyhedron:

List some space figures (solids), polyhedra or otherwise.

Construct a tetrahedron (pyramid with a triangular base).

Supporting a book with tetrahedra.

Hypothesis: A book can be supported with _____ tetrahedra.

Form small groups and experiment to see how many tetrahedra it takes to support a book.

It takes _____ tetrahedra to support a book.

What shape is common to both the triangular pyramid and the square pyramid?

Where else do you see this shape?

Supplemental Shapes and Solids



Geometry: Surround, Enclose, Cover, and Fill

Overview

Participants will explore distance, perimeter, circumference, area, and volume. They will make calculations using analytic techniques and experimental techniques.

Category: Math

Learning Goals

- Use the terminology
- Identify common shapes and solids
- Calculate perimeter, circumference, area, and volume

Participants

The activity can be conducted with almost any number of participants and one session leader.

Materials

Objects <ul style="list-style-type: none">• cubes (e.g. dice, sugar cubes, etc.)• rectangular solid (e.g. shoe box, brick, etc.)• solid right circular cylinder (e.g. canned goods, pill bottle, etc.)• hollow right circular cylinder (e.g. vase, drinking glass, water bottle, etc.)• circular object (wheel, lid, etc.)• spherical object (ball, balloon, etc.)	Water Liquid measuring device (e.g. a measuring cup that measures in ounces) Distance measuring device (e.g. ruler, tape measure, etc. that measures in inches) Calculators Participant Activity Sheet
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Activity

Suggested time: 75 minutes

Setup

Set out solids and other objects in advance to pique the interest of the participants.

Surround: Distance, Perimeter, and Circumference

Begin with a discussion of distance and how far away things are. (e.g. How far is it from here to your house? How long is the pencil/pen you're holding? How far is it over to the door? etc.)

Discuss dimensions: 0D – point; 1D – line or path; 2D – plane; 3D – space
Classify the items as 2D or 3D. (Use the items that you brought, such as: ball, square, triangle, Egyptian pyramid, brick, circle, rectangle, drinking glass, can, etc.)

What is perimeter? How do you calculate it? (It is the distance around the outside of a 2D shape. Add the distance along each edge of the shape and add them together.)

What is circumference? How do you calculate it? (It is the distance around a circle. Measure the distance from the center of the circle to the outside, the radius, and multiply by 2π : $2\pi r$)

Measure and calculate.

Enclose: Area

Area is a measure of the size of the region that is enclosed by the shape. Some common shapes are squares, rectangles, circles, and triangles.

Area of a rectangle: $l \times w$ or $w \times h$

Measure and calculate.

Cover and Fill: Surface Area and Volume

Surface Area is a measure of the amount of area that it takes to cover a solid. Some common solids are cubes, rectangular solids, spheres, right circular cylinders, and pyramids.

Surface area of a rectangular solid: add the area of each face of the solid.

Volume is a measure of the amount of space that a solid takes up or can hold.

Volume of a right circular cylinder: let r be the radius for the circle and h be the height of the solid; then, the volume is $2\pi r h$.

Measure and calculate.

Summary Comments and Discussion

Distance , Perimeter, and Circumference

1. What type of measurement is this? (1D)

2. How can you use this type of measurement?

Area and Surface Area

1. What type of measurement is this? (2D)
2. How can you use this type of measurement?

Volume

1. What type of measurement is this? (3D)
2. How can you use this type of measurement?

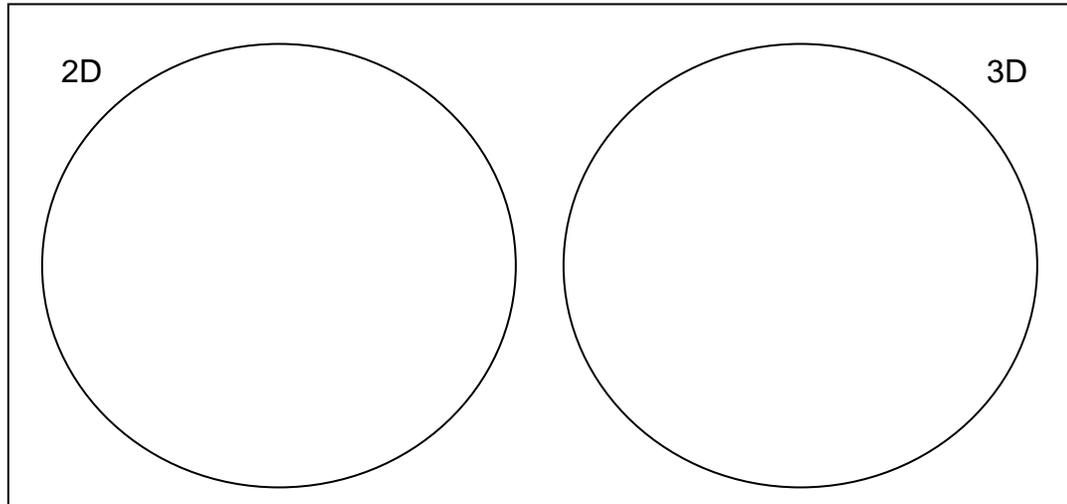
Credits

Activity packet developed by Dawn Wiggins.

Geometry: Surround, Enclose, Cover, and Fill Participant Activity Sheet

Dimensions

Classify the items as 2D or 3D. Write the name of the object in one of the circles.



Surround – Measures of Perimeter and Circumference

Perimeter:

Circumference:

1. How much fence would it take to go around a small plot for spring and summer flowers that is 8 feet long and 4 feet wide?

Draw the plot:

Amount of Fence: _____

2. How far would a bike move its tire made one rotation and the distance from the center of the tire to the outside of the tire was 18 inches? (2 decimal places)

Draw the tire:

Distance Moved: _____

3. Given a wheel, measure its radius; then, calculate its circumference. (2 decimal places)

Radius:

Wheel Circumference: _____

Enclose – Measure of Area

1. What area would be enclosed by a small plot for spring and summer flowers that is 8 feet long and 4 feet wide?

Draw the plot:

Area of Plot: _____

2. Given a can of _____, respond to the following to find the minimum amount of paper it took to make the label.

If you were to remove the label from the can and lay it flat, what shape would it be? Draw it.

Height of label - Measure the height of the label on the can:

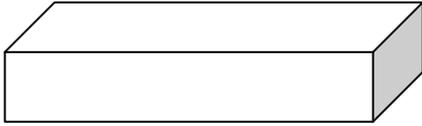
Width of label - Measure the radius of the can and calculate the circumference of the can:

Calculate the minimum amount of paper needed to make the label, which is the area of the label.

Area of Label: _____

Cover and Fill – Measures of Surface Area and Volume

1. Given a box that contains a present for your friend's birthday, find the minimum amount of paper it would take to wrap the box. Label the box with its dimensions (width, height, depth) and calculate the surface area.



Top and Bottom:

Front and Back:

Right and Left:

Amt of Wrapping Paper: _____

2. Volume of a Vase

Experimental: Use a measuring cup to find the amount of water the vase holds; use fluid ounces.

Experimental Vase Volume: _____

Analytic: Calculate the amount of water the vase holds. Make measurements in inches.

- Measure the radius of the vase:
- Measure the height of the vase:
-
- Calculate the volume of the vase ($2\pi r^2 h$):
- Convert the volume of the vase from cubic inches to fluid ounces. Multiply the volume in cubic inches by 0.5541.

Analytic Vase Volume: _____

How close were the experimental and analytic values for the volume of the vase?

Paper Rockets – Building and Launching

Overview

Participants will explore aerodynamic design and math applications as they build and launch paper rockets.

Category: Mathematics with the activity included below. Aerodynamic design (engineering) in the design of the rockets.

Learning Goals

- Practice mathematical calculations related to angles, distances
- Discuss PSI
- Explore aerodynamics

Materials and setup:

See instructions by NASA for constructing paper rockets at:

http://www.nasa.gov/pdf/295789main_Rockets_High_Power_Paper_Rocket.pdf

And for constructing an air compressor paper rocket launcher at:

http://www.nasa.gov/pdf/295788main_Rockets_High_Power_Launcher.pdf

Mathematics activity:

- After the launch, have students get their rocket and stand where it landed. Readjust your baseline to approximately 90 degrees.
- Measure the angle from the far end of the baseline to the person holding the rocket and record.
- To estimate distance, take the adjusted baseline (see above) and multiply by the tangent of the angle estimate.

Additional suggestions:

- Have students work in teams.
- Use card stock paper for rockets for best construction and launching.
- A PSI of 20-40 is best for paper rockets. Higher PSIs will cause destruction of the rockets.
- Utilize this opportunity to discuss PSI.

Credits: Paper rocket and rocket launcher instructions developed by NASA. Math activity and additional suggestions developed by Jim Gibson and Sue Caley Opsal.

Paper Rockets – Building and Launching

Participant Activity Sheet

Names _____

Location _____

Weather conditions: _____

Launch #	PSI	Baseline distance	Angle	Distance traveled	Notes
1					
2					
3					

Mathematical calculations:

Soda Geysers

Overview

Drawing on the scientific method, participants will construct hypotheses about the reactions of various sodas with various items. Then, experiments will be conducted to test the hypotheses. Finally the results will be analyzed to determine if the hypothesis is true, partially true, or false.

Category: Scientific Experimentation

Learning Goals

- Practice scientific method
- Practice safety in experimental situations
- Practice communication and team-building skills

Location

This activity is best conducted outdoors.

Participants

The activity can be conducted with four participants and one session leader. But, it is recommended that there be at least five participants.

Materials

<ul style="list-style-type: none">• Two-liter bottles of soda for comparison of possible reaction agents; one bottle of Diet Coke for each reaction agent (four agents for this activity). Or, four two-liter bottles of any particular soda.• Two-liter bottles of soda for comparison of sodas; one each of Canada Dry Ginger Ale, Coke, Sprite Zero, Diet Coke. Or, any four, different two-liter bottles of soda.	<ul style="list-style-type: none">• Reaction agents (twenty Mint Mentos Candies, five mini boxes of Nerds, three rolls of Smarties, thirty Runtts. Or, any four reaction agents.)• Goggles for the session leader and each participant• Pencil/ Pen• Activity Sheet, one per participant
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Activity

Suggested time: 45 minutes

Compare Reaction Agents

Discuss the properties of soda: Flat or carbonated? What does it mean to be carbonated? What does carbonation do for the soda? Do you want to open a bottle of soda if it has been dropped? Why or why not? What happens when you drop ice into soda? What do you think would happen if we dropped some of the reaction agents into the soda?

Using the activity worksheet, each participant should hypothesize which reaction agent will cause the most bubbling and which the least. Rank them in order from 1 to 4, with 1 being the most bubbling and 4 being the least bubbling.

Discuss safety: What do we need? Why?

Be sure the session leader and all participants have goggles on before proceeding.

Select four participants to conduct the experiment; they are the scientists. The other participants will observe. They will be responsible for reporting the experimental results for the bubble rankings.

Each scientist should select a different type of candy and take about the same amount of each (e.g. four Mint Mentos Candies, half of a mini box of Nerds, half of a roll of Smarties, six Runts).

Next, each scientist should select a two-liter bottle of Diet Coke.

Line the bottles up with sufficient space in between.

Have the scientists remove the caps from the bottles.

The observers will conduct a countdown, at which time the scientists will drop their reaction agents into their bottle of soda. Upon release of the reaction agents, the scientists should step away from the bottles. The observers should pay close attention to identify the bubble rankings for the experiment.

Using the activity worksheet, all participants should record the results.

Compare Sodas

Which reaction agent caused the most bubbling? It will be used to compare different sodas for the best bubbling action.

Using the activity worksheet, each participant should hypothesize which soda will cause the most bubbling and which the least. Rank them in order from 1 to 4, with 1 being the most bubbling and 4 being the least bubbling.

Be sure the session leader and all participants have goggles on before proceeding.

Select four participants to conduct the experiment; they are the scientists. The other participants will observe. They will be responsible for reporting the experimental results for the bubble rankings.

Each scientist should select a different a different two-liter bottle of soda.

Next, each scientist should select some of the candy that served as the best reaction agent (e.g. four Mint Mentos Candies or half of a mini box of Nerds or half of a roll of Smarties or six Runts).

Line the bottles up with sufficient space in between.

Have the scientists remove the caps from the bottles.

The observers will conduct a countdown, at which time the scientists will drop their reaction agents into their bottle of soda. Upon release of the reaction agents, the scientists should step away from the bottles. The observers should pay close attention to identify the bubble rankings for the experiment.

Using the activity worksheet, all participants should record the experimental results.

Summary

Lead the group in discussion:

- Which candy and which soda produce the best soda geyser?
- What other questions could we ask about soda geysers? What other experiments could we perform?
- Are there other things that you can think of that cause violent bubbling? (e.g. shaken soda, hot soda, pasta or potatoes boiling over, ...)
- So, *WHY* did the identified candy reaction agent produce the most impressive soda geyser? (Nucleation is localized, extreme bubbling. Soda has carbon dioxide gas and Mentos are covered with numerous pits. So, the gas in the soda is “encouraged” to escape from the liquid at the nucleation sites on the surface of the Mentos, thus resulting in the extreme, vigorous bubbling.)

Activity Extensions

Availability of extra soda and reaction agents for individual participant experimentation.

Allow participants to bring their own reaction agents. Safety first, however.

Credits

Activity packet developed by Dawn Wiggins.

Students test soda and reaction agents.



Soda Geysers

Participant Activity Sheet

Compare Reaction Agents

When the specified candy reaction agent is dropped into the Diet Coke, rank how its bubbling reaction will be in comparison to the other candy reaction agents.

Rank the candy reaction agents in order from 1 to 4, with 1 being the most bubbling and 4 being the least bubbling

Candy Reaction Agent	Hypothetical Result (Most Bubbling, 1; Least Bubbling 4.)	Experimental Result

Circle the candy reaction agent that produced the most bubbling.

Compare Sodas

Enter candy reaction agent that produced the most bubbling in the blank below.

When the _____ candy reaction agent is dropped into each of the sodas, rank how its bubbling reaction will be in comparison to the other sodas. Rank the sodas in order from 1 to 4, with 1 being the most bubbling and 4 being the least bubbling

Soda	Hypothetical Result (Most Bubbling, 1; Least Bubbling 4.)	Experimental Result

Summary

Which candy and which soda produce the best soda geyser?

What other questions could we ask about soda geysers? Other experiments?

Take Away – Can you find out *WHY* the identified candy reaction agent produced the most impressive soda geyser?

Team Building Exercise: Arm Wrestling for Candy

Overview: Participants will work in teams in an exercise illustrating competition versus teamwork

Learning goal: Demonstrate the benefit(s) of teamwork

Participants: Almost any number of participants and one session leader.

Materials: A number of very small pieces of candy to use as rewards.

Procedure:

- Have students pair up at tables and get into arm wrestling position.
- Explain that they will earn points (don't use the word "win") when their "partner's" (don't say "opponent's") arm touches the table.
- Tell them they have one minute. Each team will keep their count.
- Signal them to begin and time the exercise.

Typically, at least one team will figure out that not competing, but just taking turns touching the table on each side is the best strategy for earning the candy.

- Distribute candy as earned

Discussion:

- Discuss who "won." Did some individuals "win" the arm wrestling but didn't win much candy? And their partner earned none and lost the arm wrestling (win/lose)
- Did some teams win/win by cooperating?
- Discuss competition vs. cooperation. Is competition always good?

Credits: Activity designed by Dorene Perez

Assessment Examples

Pre-Activity Assessment Example – Participant Survey 1

	Adapt the questions below to the career focus / learning goals of the activity.	Strongly agree	Agree	Disagree	Strongly disagree
1.	I know what (name science, technology, engineering, math field) is and what (name science, technology, engineering math people) do.				
2.	I believe _____ is a good career for a girl.				
3.	I believe _____ is a good career for a boy.				
4.	_____ need to be creative.				
5.	_____ work in teams.				
6.	_____ must be good at math.				
7.	_____ must be good at science.				
8.	I feel confident in my technical ability.				
9.	Girls are... (adapt to activity) ...good at science ...good at technology ...good at engineering ...good at math				
10.	Boys are...(adapt to activity) ...good at science ...good at technology ...good at engineering ...good at math				
11.	Girls can design and build things.				
12.	Boys can design and build things.				
13.	I believe _____ is a “cool” job.				
14.	I like math.				
15.	I like science.				
16.	FOR ACTIVITIES THAT TARGET GIRLS: Girls can be as good as boys in math. Girls can be as good as boys in science.				

17.	I like to think about how things work.				
18.	I like to explore how things work.				
19.	I have thought about a career in science.				
20.	I have thought about a career in technology.				
21.	I have thought about a career in engineering.				
22.	I have thought about a career in math.				
23.	My parent(s) have suggested I consider a career in science, technology, engineering or math.				

21. I am _____female _____male

22. FOR ACTIVITIES FOCUSING ON GIRLS: How many women do you know who are in science, technology, engineering and/or math careers?
 _____ None _____ 1 or 2 _____ 3 to 5 _____ more than 5

22. Comments:

Pre-Activity Assessment Example – Participant Survey 2

1. Do you plan to go to college?

YES

NO

I CONSIDERED IT, BUT NOT SURE

2. Do you have a career in mind? If so, what is it?

3. Rate your confidence level in the following areas by circling the number that most closely reflects your feelings.

a. Completing hands-on tasks individually

Not confident at all

1

2

3

4

Extremely confident

5

b. Completing hands-on tasks with a team

Not confident at all

1

2

3

4

Extremely confident

5

c. Understanding science

Not confident at all

1

2

3

4

Extremely confident

5

d. Performing science experiments

Not confident at all

1

2

3

4

Extremely confident

5

e. Understanding mathematics

Not confident at all

1

2

3

4

Extremely confident

5

f. Performing mathematical computations

Not confident at all

1

2

3

4

Extremely confident

5

g. Understanding _____ (topic or category of activity)

Not confident at all

1

2

3

4

Extremely confident

5

h. Performing _____ (topic/category of activity)

Not confident at all
1

2

3

4

Extremely confident
5

4. Are you looking forward to _____(today's activity)? Explain

5. Do you have concerns about _____(today's activity)? Explain.

6. Are you _____male _____female.

Post-Activity Assessment Example – Participant Survey 1

	Adapt the questions below to the career focus / learning goals of the activity and to questions asked in a pre-activity survey.	Strongly agree	Agree	Disagree	Strongly disagree
1.	I believe _____ is a good career for a girl.				
2.	I believe _____ is a good career for a boy.				
3.	_____ need to be creative.				
4.	_____ work in teams.				
5.	_____ must be good at math.				
6.	_____ must be good at science.				
7.	Today's activity improved my confidence in my _____ skills.				
8.	Girls are... (adapt to activity) ...good at science ...good at technology ...good at engineering ...good at math				
9.	Boys are...(adapt to activity) ...good at science ...good at technology ...good at engineering ...good at math				
10.	Girls can design and build things.				
11.	Boys can design and build things.				
12.	FOR ACTIVITIES THAT TARGET GIRLS: Girls can be as good as boys in math. Girls can be as good as boys in science.				
13.	After today's activity, I would consider a career in _____ (science, technology, engineering, or math)				
14.	I am planning to go to college.				

Comments:

Post-Activity Assessment Example – Participant Survey 2

Write your thoughts to the questions below.

One thing I learned today was....

One question I have is....

Today's activity is related to STEM because....

Before the start of (name the activity), I was _____ that I could (build / complete/etc.)

- A) Not confident
- B) Somewhat confident
- C) Very confident
- D) Neutral

After today's activity (or name the activity), I felt _____ that I had done a good job.

- A) Not confident
- B) Somewhat confident
- C) Very confident
- D) Neutral

I am _____ building things after today's activity.

- A) Not interested in
- B) Somewhat interested in
- C) Very interested in
- D) Neutral about

The best part of today's activity was:

The most difficult part of today's activity was:

Suggestions for future activities:

Comments: