Inquiry Science

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Science Teaching Models

Direct Instruction

A. Anticipatory set
    1. Focus/capture attention
    2. Connect to prior knowledge
    3. Connect to students' lives
B. Objective and purpose
    1. State objectives
    2. Explain why they are important to students
C. Instruction
    1. Provide information
    2. Use variety of methods
D. Model, provide examples
E. Check for understanding
F. Provide guided practice and feedback
G. Closure – summarize
H. Independent practice

Inquiry

I. Pose a question that can be investigated
    1. Conduct a demonstration or
    2. Have students do brief hands-on activity or
    3. Describe discrepancy that you and students have observed or
    4. Ask question relate to topic
J. Have students form several hypotheses or possible solutions.
K. Have students identify variables.
L. Help students operationally define the variables and plan controls.
M. Have students design an experiment or identify resources to answer their question(s).
N. Have students conduct the experiment or collect data from resources.
O. Have students organize their data and draw conclusions.

Conceptual Change Teaching

P. Assess students' preconceptions.
Q. Facilitate sharing of understandings and explanations.
R. Build on past experiences.
S. Provide concrete experiences, hands-on activities.
T. Allow sufficient time.
U. Provide opportunities for students to apply their new ideas in new ways.

Learning Cycle

V. Exploration Phase
1. Hands-on activity
2. Motivates learners
3. Develops common experiences

W. Concept Development Phase
1. Provide information
2. Introduce vocabulary
3. Construct concepts

X. Concept Application Phase
1. Apply newly learned concepts to new situations
2. Extend understanding of the concepts

Investigation and Problem Solving

Y. Provide students with a realistic problem.
Z. Provide time to gather data over extended period.
AA. Provide resources and opportunities for collaboration.
BB. Require a product and/or presentation of a solution.
CC.

II. Constructivist Teaching Model

A. Invitation
- Observe surroundings for points of curiosity.
- Ask questions.
- Consider possible responses to questions.
- Note unexpected phenomena.
- Identify situations where student perceptions vary.

B. Exploration
- Engage in focuses play.
- Brainstorm possible alternatives.
- Look for information.
- Experiment with materials.
- Observe specific phenomena.
- Design a model.
- Collect and organize data.
- Employ problem-solving strategies.
- Select appropriate resources.
- Discuss solutions with others.
- Design and conduct experiments.
- Evaluate choices.
- Engage in debate.
- Identify risks and consequences.
- Define parameters of an investigation.
- Analyze data.

C. Proposing explanations and solutions

- Communicate information and ideas.
- Construct and explain a model.
- Construct a new explanation.
- Review and critique solutions.
- Utilize peer evaluation.
- Assemble multiple answers/solutions.
- Determine appropriate closure.
- Integrate a solution with existing knowledge and experiences.

D. Taking action

- Make decisions.
- Apply knowledge and skills.
- Transfer knowledge and skills.
- Share information and ideas.
- Ask new questions.
- Develop products and promote ideas.
- Use models and ideas to illicit discussions and acceptance by others.
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Source: Yager, R. (1991). The Constructivist Learning Model*. The Science Teacher, (Sept. 1991) p. 55.*

Cooperative Learning For Secondary Learners

In working science learners it is important to remember that:

- Group members are responsible for the performance of each individual learner.
- Group members are individually accountable and must be able to report on or explain the team's results.
- The groups are to be assigned by the teacher. Their make-up should be heterogeneous with respect to sex, race, socioeconomic status, ability/learning styles, cliques, and other important factors.
- Leadership is shared on a rotating basis. Each team member has a job and responsibilities.
- The teacher is a resource; students are in charge of their own learning.
- Time must be allowed for group processing and self-evaluation.

The job assignments I use for traditional grouping are these:

Group Leader

1. Reads all directions to group
2. Leads the discussions
3. Checks the data sheet
4. Helps with clean-up
5. Is the only one who can ask a question of the teacher

Materials Manager

1. Is responsible for collecting and returning all materials & supplies to the appropriate place(s)
2. Is the only one who can get up for materials and supplies
3. Makes sure the everyone in the group has equal access to the materials and supplies
4. Checks the data sheet
5. Helps with clean-up

Time Keeper

1. Holds the team stopwatch (or watches the clock)
2. Keeps group on task and reminds them about time
3. Is responsible for getting the group to finish on time
4. Checks the data sheet
5. Helps with clean-up

Data Collector

1. Collects the data for the activity
2. Records data on the appropriate form or sheet
3. Returns data sheet to teacher and/or records group data on class data sheet
4. Makes sure all other team members check the data sheet
5. Helps with clean-up

Since this is not a perfect world, and all class populations are not divisible by four, I have a fifth job that can be assigned in a group:

Encourager

1. Monitors other team members to make sure they do their own jobs
2. Takes responsibility for praising and affirming jobs that are well done
3. Records comments and actions that show positive interpersonal communication
4. Reports recorded data to group at de-briefing session
5. Helps with clean-up

If a group of four has one member absent, two of the jobs can be combined for that day.

Part of the group's participation grade is based on how well each team member performs her/his job. Points are deducted if one team member does another team member's assigned responsibility.

Group Participation Number Line

Date: ____________________

Group Number: ___________

Group Members Present: ______________________________________

____

____

100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0

Participation Points Earned: ___________

Nut Case

(from *Doing Good Science in Middle School – A Practical Guide to Inquiry-based Instruction*, National Science Teachers Association Press)

Objectives:

- Students will make observations
- Students will develop a classification system for a bag of nuts.

Focus Questions:

- How do we organize our world?
- How do we categorize and classify items in out environment?
- How do we select characteristics to use to categorize the things that surround us?
- How to we distinguish between members of a similar group?

Background:

In this activity, we ask students to categorize and classify the nuts they get in a bag of mixed nuts in a shell (or various bags of beans, or a few bags of mixed bean soup mix – or other materials, such as bolts or pasta). This is a foundational concept in science that is applied in the classification system in biology as well as the Earth and space sciences. This activity reveals a lot of information about the cognitive stages of your students. We suggest you ask the students to sort the nuts, and give a creative name to each sorted group. The vast majority of students will sort the nuts by type. Ask students to write out the sorting rules they used. Communication is a critical part of science, and the ability to describe the rules is very important to help others understand the sorting process.

Generally, you want a minimum of choices to make each step in the sorting process. Depending on the level of your students, you may have them share with each other to end up with 20 of the same nuts. Then ask the students to sort the 20 almonds (for example) into groups. (Groups might include, for example, cracked shell, smooth shell, rough shell, length, flatness or thickness of shell, or shade of color.) This is where the activity gets to the heart of the matter. "How do we distinguish between members of similar groups?"

Tips:

This activity involves an initial expense (mixed nuts in the shell can be pricey), but the materials have a long shelf life and can be repeated year to year.

- Use hard-shell nuts (e.g., pecans, walnuts, filberts) for durability.
- Students should not attempt to open the shells or eat the nuts. Explain to the students that the nuts are very old, and past the date for eating. The nuts are usually difficult to crack under normal student use. However, prudent classroom safety and management considerations will prevent injuries from shell fragments.

Preparation and Management:
Prep time: 45 -60 min to set up the bags of nuts. Use a minimum of four nut varieties. The more the better. Use 1-gallon zip-closure plastic bags. We use a paper punch to make a few clean holes in the bags. This helps air circulation for the nuts over the years, and helps the bags of nuts pack into a box for next year.

Teaching Time: 45 min., plus 5 min. to put the nuts back in the bags.

Materials:
For teacher demonstration: 1 lb. bag of whole mixed nuts (shells on).
For additional groups: 1 bag of whole mixed nuts (shells on) per group.

Procedures: Before you begin this activity, engage students in a discussion about how they can tell the difference between different skateboards, soft drinks, or anything else that interests them. Once the students are engaged, move on to the "Nut Case" activity. You may introduce the activity based on something like, "Based on your comments, I think you will develop a clearer understanding of scientific classification if we start with some common objects, nuts. We call it the Nut Case Lab."

Extensions:
- Ask students to develop Venn diagrams to depict the sets and subsets they used.
- Ask students to identify a classification system for something in which they are interested (e.g., celebrities, sports, skateboards, music).
- To take the discussion idea further, small groups of students may create expanded classification systems for a number of different groups of objects. For example, they may combine their system for nuts, and add music, candy bars, and so forth – one's edible, one's inedible . . .
- Ask groups to explain their expanded classification systems to the rest of the class; have the other class members critique the presentation.

Assessment:
1) Have student teams exchange classification systems, and test the system with another team. How many nuts were correctly classified when students used other teams' classification rules? This can be a springboard for discussing the need for agreed-upon rules for classification so we can communicate with each other and classify newly discovered organisms or phenomena. This is where you could introduce a new variety of nut and have students classify it at each step of the classification process.
2) Student lab reports should focus on analysis, classification, and description based on observations (rather than testing a problem).
3) Students can create a poster or diagram of their classification system – perhaps developing a dichotomous key for variety, at a level of complexity appropriate to the student ability.

Why Use Inquiry-Based Learning?

The **Buck Institute For Education** has done in-depth research on Project Based Learning (PBL) and Inquiry-Centered Curriculum. They report that teachers agree that using studented-centered inquiry:

- Overcomes the dichotomy between knowledge and thinking, helping students to both "know" and "do."

- Supports students in learning and practicing skills in problem solving, communication, and self-management.

- Encourages the development of habits of mind associated with lifelong learning, civic responsibility, and personal or career success.

- Integrates curriculum areas, thematic instruction, and community issues.

- Assesses performance on content and skills using criteria similar to those in the work world, thus encouraging accountability, goal setting, and improved performance.

- Creates positive communication and collaborative relationships among diverse groups of students.

- Meets the needs of learners with varying skill levels and learning styles.

- Engages and motivates bored or indifferent students.

Retrieved from:
http://www.bie.org/index.php/site/PBL/pbl_handbook_introduction/#classroom

Wrist Taker

(from *Doing Good Science in Middle School – A Practical Guide to Inquiry-based Instruction*, National Science Teachers Association Press)

Want to see some puzzled middle schoolers? Ask the following questions: “How many wrists equal one neck?” “Wrist Taker” is an eye-opening activity that provides an introduction to nonstandard units of measurement and why there is a need to have a consistent, common system for measuring and communicating measurements. It also provides opportunity to investigate proportionality and fractions in a unique way

Objective:
Students will collect and analyze data and become familiar with nonstandard units of measure.

Focus Questions:
- What is *proportion*?
- Is the circumference of a human wrist proportionate to the size of the neck? Or the size of the head, knee, or ankle? (Is there a mathematical relationship between these body parts and the wrist?

Background:
Students will need to have an understanding of the concept of *median* prior to doing this activity. Also note that.

1. The string should be neither stretched nor lax.
2. Most students will have the same proportion of wrists to neck: 1 neck = 4 wrists.
3. After students cut a string equal to each body part listed on the “String ‘Em Up” worksheet, have them tape the strings to the worksheet. Caution students to line up one end of each string with the line under each subheading at the top of the page.

Preparation and Management:
Prep time: 5 min.
Teaching time: 45 min
Materials (per group of 4):

String (appx. 30 in. per student)
Scissors
Tape
“String ‘Em Up” Worksheet

Procedures:
Note- You may want to avoid waist measurements, which can be embarrassing to some middle school students.

1. Have each group member cut a piece of string to match the circumference of his or her wrist. This will be used to measure other body circumference.

2. Cut pieces of string to match the circumference of each person's neck. Use wrist strings to measure the length of the neck strings. Record the data on the **Body Parts Chart**.
3. List the neck measurements of each group member in order from "least wrist" to "most wrist."
4. Have students determine – in "wrists" – what the median (or middle neck size is for the group.
5. Cut a piece of string for the circumference of the body parts listed in the chart. Measure each in "wrists."

Body Parts Chart for "Wrist Taker"

	Student 1	Student 2	Student 3	Student 4		Median
Neck						
Head						
Ankle						
Upper Arm						
Knee						
Other						
Other						

Discussion:

Discuss with students the results of their data. Is there a similarity in their results? Can they see a pattern? Can them make an inference based on the data? Do they need to collect more data? You may want to paraphrase or rephrase some of the following questions:

1. Which strings are nearly the same length?

2. Which string, when folded in half, would be nearly the length of another?

3. Which string, when folded in half and in half again (quartered) would be nearly the same as another?

4. Can you find any other body circumference relationship?

You and your students may be astonished to see the consistent proportionality in the human body. This activity is rick with possible discussion topics; be prepared to cultivate interesting digressions and then bring them back to the lesson objective.

Extensions (applications and inquiry opportunities):

- You may want your students to continue study of proportion relating to other areas, such as art perspective, or to hypothesize about proportionality in other members of the animal kingdom.

- Have students construct a ruler with increments of "thumbs," or "hands" and have them measure their desks and classroom. This can be done with a string hat has a black mark to indicate each thumb. They may opt to tie a knot for each increment. Display the various "measuring tapes" in the classroom for all students to see.

- Students can research the origins of measurement and the various methods that were used throughout history and in different cultures.

- Some middle school students are ready to consider the remarkable findings of scientists studying Fibonacci numbers, Phi, and related examples of proportionality in nature.

Name- ________________________________

Bubble Gum Physics

(from T. Trimpe 2001)

Obtain a piece of bubble gum from your teacher and start chewing to get ready for the experiments!

Part A: Chomper Challenge

(1) For this experiment you will conduct five trials to determine the numbers of chompos you can do in 30 seconds. A chomp is defined as a "big chew," or the kind that usually causes you to get caught with gum!

(2) Use a timer to determine the number of chomps you can do in 30 seconds. Record your data in the chart. Repeat the same process for the other trials.

Trial	Chomps	Time	Speed

Speed = # of Chomps ÷Time
Round speeds to the nearest hundredth!

(3) What is your average speed? Round answers to the hundredth.

_________ chomps/second.

(3) Based on your average chomping speed, how many chomps could you do in five minutes, one hour, or one day? Show your work!

5 min = ________chomps 1 hour =________chomps 1 day=_______chomps

Part B: Speedy Chompers

(1) Use a timer to determine the number of chomps you can do in 1 minute. As the time reaches each point, record the number of chomps you have completed. Do not stop the timer as you record your data. You may want to practice a few times before running an "official" trial.

TIME	CHOMPS
20 seconds	
40 seconds	
60 seconds	

(2) Calculate your chomping speed at each point (20 sec, 40 sec, 60 sec) using the data from your experiment. Show your work! Round all answers to the nearest hundredth!

(3) Did you maintain a constant rate? Explain.

THINK ABOUT IT!

Write a paragraph to summarize the results of your experiment.

Are your results accurate and reliable? Why or why not?

What other experiments could you do with bubble gum?

Bubble Gum Trivia Challenge

Name- ____________________________________

Test your knowledge of bubble gum!

___ 1. How many sticks of gum does an average American chew in a year? **A. 200 B. 300 C. 400**

___ 2. How many tons of gum are chewed every year?
A. 50,000 B. 75,000 C. 100,000

___ 3. If all the 5-chunk packs of Bubble Yum were ever chewed in the U.S. since it's introduction in 1975 were laid end-to- end, how many times would it circle the earth at the equator? **A. 2 B. 5 C. 7**

___ 4. San Luis Obispo, CA, is the new home of "Bubble Gum Alley." What is it?
A. An alley with brick walls covered with ABC (already been chewed) gum wads.
B. The place where bubble gum was invented.
C. The home of the largest collection of bubble gum machines.

___ 5. Richard Walker holds the record for the Chomp Title by chewing 135 sticks of gum for the longest time. How long did he chomp?
A. 5 hours B. 6 hours C. 8 hours

___ 6. The Topps company holds the record for having made the largest single piece of bubble gum. How many pieces of normal-sized Bazooka did it equal? **A. 5000 B. 8000 C.10,000**

___7. The 1952 Mickey Mantle rookie card is the most valuable Topps Company card. How much did it sell for at auction?
A. $75,000 B. $120,000 C. $1,000,000

___ 8. What is the Official Gum of Major League Baseball?
A. Bubble Yum B. Bazooka C. Topps

___ 9. When was the first successful bubble gum invented?
A. 1891 B. 1906 C. 1928

___10. Susan Mont"Gum"ery Williams is in the Guinness Record Holder of the World's Largest Gum Bubble. How big was it?
A. 19 inches B. 23 inches C. 27 inches

Gobstoppers

(from *Doing Good Science in Middle School – A Practical Guide to Inquiry-based Instruction*, National Science Teachers Association Press)

Objectives:
- Students will be able to describe matter and its changes.
- Students will be able to infer what happens when matters interacts.
- Students will be able to observe and infer patterns of change in matter.
- Students will be able to communicate concepts involved with matter and its change.
- Students will be able to operationally define a mixture.

Focus Questions:
1) Does the color of a Gobstopper change?
2) How does the color change?
3) How quickly does the color change?
4) Does the color change more than once?

Background:
Gobstoppers are jawbreakers that change colors and flavors three times. Each dye and flavoring is sealed with several coats of dextrose syrup. The dyes that give this candy its distinct appearance begin as a solution since moisture is needed to develop the color in the dyes. The dye solution is placed in a spray dryer that uses air to drive off the moisture, resulting in dry tablets called *lakes*. These lakes are then attached to aluminum and termed *aluminum lakes*. The aluminum lakes are not water soluble but are water dispersible. It is these dispersions of color that can be seen when the Gobstoppers are placed in water. The aluminum lakes also account for the spectacular patterns observed in the container as the dyes sink in the water due to the fact that they are denser than water.

Preparation and Management:
You will need to purchase at least one Gobstopper for each student in your classroom. Gobstoppers are sold nationally by K-Mart and Wal-Mart and are usually available at convenience stores.
- Prep time: set-up is about 10 min
- Teaching time: 45 min.
- Materials (per group of 4 students):
  - 4 different-colored Gobstoppers
  - 100 ml room-temperature water
  - 1 clear plastic cup or other clear container
  - paper to record observations
  - crayons or colored pencils

Procedures:

1. Explain to the students that they are going to do an experiment with Gobstoppers that will allow them to practice making scientific observations. Have the class think of different ways a scientist might record their observations (e.g. drawings, tables, graphs).

2. Show the students what they will be doing to make sure they understand. Hold up a clear plastic cup. Tell them that theirs will be filled halfway with water. Tell them to gently place four different-colored Gobstoppers into the water, placing them around the edges, as far away from the others as possible, as on a face clock at 12:00, 3:00, 6:00, and 9:00. Stress the importance of not disturbing the container of water.

3. Divide the class into groups of four.

4. Give each group one clear cup and four different-colored Gobstoppers.

5. Tell students that as soon as they place the Gobstoppers into the water they are to begin making observations. Tell them to write down everything they see and to make at least two drawings as the reaction takes place.

6. Once students begin their experiments, make sure they are making observations and drawing pictures as the reaction takes place.

7. After students have completed their observations (appx. 20 min) have them individually write at least two questions they had about the reaction. (They tear sheets of notebook paper in half, and write one question on each half.) A sample question: Would this happen if a different liquid were used?

8. When students have finished writing, collect all their questions.

9. Discuss with the students what an experiment is. What is necessary to perform an experiment? Explain that a variable is something in the experiment that you can change to get a different outcome. Ask for examples from the activity (e.g. temperature of the water, amount of water, kind of water, size of container, number of Gobstoppers, type of liquid).

10. Explore with students what they think are a "testable" question is. Explain that a testable question is one about which you can create an experiment, and change only one variable, in order to find an answer. A testable question cannot be answered by looking up the topic in an encyclopedia! To reinforce the idea of testable questions, explain that you and the class are going to read through the questions they wrote, and decide as a class

whether or not each question is testable. It may be helpful to create a chart to which you can tape the questions.

11. During class discussion of testable questions, ask students how they might test their questions – what experiment would they perform? What results would they expect to see?

Discussion:

Have groups report their results to the whole class. Consider using or paraphrasing the following questions:

- What happened to the Gobstopper?
- What happened to the water?
- How did the Gobstopper and water interact?
- Describe patterns of change in the water.
- What did you observe to indicate that a Gobstopper is a mixture of different dyes and flavors?

Extensions (application and inquiry opportunities):

1) Discuss with students what a hypothesis is and its function. Explain to students that a hypothesis is an attempt to explain an observation, and it is *not* a prediction. Provide and discuss examples with the students.

2) Explain to students that they are going to design and perform their own experiments using the Gobstoppers. Many students will surely have thought of other experiments they would like to perform while doing the original experiment.

3) Ask them to limit their needed materials to common household items to make it easier for you. **SAFETY NOTE: Do not allow the students to use bleach in their experiments.** Gobstoppers and bleach react somewhat violently, and it is not suitable for the students to perform such and experiment.

4) Do chromatography with M&M's, Skittles, or other sugar-coated candies to discover that the different-colored coatings are actually three pigment mixtures. Cut coffee filter strips 2.5 cm x 10 cm. Dip the candy in the water and rub the color off so it makes a line on a coffee filter strip 2 cm from the bottom. Use a pencil to label the top of the strip with the color of the candy. Put water in the bottom of a plastic cup so it is 1 cm deep. Tape the coffee filter strip to a pencil or straw and set the pencil across the top of the plastic cup so the strip hangs into the plastic cup with only the end (below the color line) touching the water. Repeat this procedure for the other different-colored candies.

Rubric For "Gobstoppers"

Score	Criteria
4	**Full Accomplishment** Student correctly performs the activity. Student is able to observe and record every change in the Gobstoppers. Student is able to observe and record every change in the water.
3	**Substantial Accomplishment** Student correctly performs the activity. Student is able to observe and record most of the changes in the water. Or student is able to observe and record every change in the Gobstoppers and most changes in the water or most changes in the Gobstoppers and every change in the water.
2	**Partial Accomplishment** Student correctly performs the activity but needs help to do it. Student is able to observe changes in only the Gobstoppers or only the water.
1	**Little or No Progress Toward Accomplishment** Student misunderstands the task or makes little or no effort to perform the activity.

"Gobstoppers" was adapted with permission from an activity created by Dr. Karen Oslund.

Questions for Science Exploration

From a handout from the Exploratorium Institute for Inquiry, written by teacher Marilyn Austin. These questions are intended for teachers to pose as they interact with students engaged in inquiry processes.

- What does this make you think of?
- In what ways are these different?
- In what ways are these the same?
- What materials did you use?
- What would happen if you ...
- What might you try instead?
- Tell me about your ...?
- What does it look like?
- What does it remind you of?
- What does it feel like?
- What can you do next time?
- What can you tell me about it?
- Tell me what happened.
- What could you do instead?
- Which one do you have more of?
- Is one object longer/shorter than another?
- What do you call the things you are using?
- What can you tell me about the things you have?
- Tell me what it looks like.
- How are you going to do that?
- What do you feel, see, hear, taste, smell?
- How did you do that?
- What will you do next after you finish that?
- Is there anything else you could do/use?
- How do you know?
- What are some different things you could try?
- What is it made of?
- Show me what you **could** do with it?

The Indy Card Car

The Cooperative Group Challenge:

(from Cathi Cox & Missy Wooley @ Louisiana Tech University)

Putting Design into Motion

Objective:
Using only materials provided, students work cooperatively while developing problem solving and critical thinking skills. A limited number of materials are made available therefore providing a certain level of difficulty that the students must overcome in order to compete the challenge: construction a functional car.

Getting Started:
1. Gather the materials needed for the experience.
2. Identify additional supplies that may or may not be available for students to use.
3. Determine whether students will work in groups of two, three, or four.
4. Identify an appropriate workspace for car construction, as well as an adequate place for testing the final products.
5. Construct the ramp that cars will be tested on
6. Prepare a data table to collect class data.
7. Determine the timeframe required to complete the challenge.
8. Develop an appropriate means of assessment for the project.
9. Identify appropriate concepts to be developed using the learning experience.

Materials Needed:
3 X 5 index cards
Plastic straws
Cubic inch rubber erasers (or similar size)
Tape
Additional classroom supplies (optional)
Test ramp
Measuring tool (meter stick or tape)
Data table for class results

Teacher Notes:
The learning experience can be used for cooperative learning, consensus building, problem solving, and/or critical thinking exclusively; or identified science concepts can be connected and developed. Examples of science content to be addressed are as follows:
- because the ramp used during the test inclined planes and simple machines may be an appropriate connection
- calculations for speed, momentum, and other measurements associated with force and motion may be used
- different surfaces at the base of the ramp may be used and friction explored

Teachers are encouraged to be creative in their use of this type of learning experience and make as many connections as possible. Because data can be collected, it may be appropriate to include graphing and graphical analysis in connection with this activity. Students can be challenged to list what additional materials would have made the construction of the car easier for them.

The Indy Card Car

The Cooperative Group Challenge:

(from Cathi Cox & Missy Wooley @ Louisiana Tech University)

Using the materials provided, design and construct a car that adheres to the following guidelines:

- the car must be made from only the approved materials
- the car must be able to roll down a ramp, its distance traveled beyond the ramp being measured
- the car must be able to carry a one cubic inch rubber eraser

The cooperative group must perform according to these guidelines:

- all members of the cooperative group must participate
- the members of the group must come to a consensus on the design and construction of the car
- the car design and construction must be completed within the timeframe stated
- the group's car must be tested in front of the whole group, passing the same test as all other cars

The car measuring the greatest distance wins the challenge!

Safety Notes:
Exercise caution when moving around the test ramp and be sure the area is clear for testing the cars. Be careful with scissors.

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Assessment:
List two things that you would be like to change about your index car and describe how and why you think these changes will cause your car to go faster.

Change One:

Change Two:

Friction, What a Drag

(from John J. Miller, Maine East High School, Park Ridge, IL)

Objectives:
At the end of this lab students will be able to:

1. recognize that weight and surface type affect friction.
2. recognize that surface area does NOT affect the friction.
3. Control variables.
4. Recognize that some things are hard to measure (like friction because the spring scale needle vibrates).

Materials Needed:

- 4 wood blocks for each lab group (appx. 2” x 3” x 6” is a good size because the ratio of areas of the different sides is simple – 6 sq. inches by 12 sq. inches by 24 sq. inches).
- Small screw hooks that can be screwed into the blocks to hook the blocks together.
- 1 spring scale for each group (if spring scales are not available you may substitute a rubber band and note the amount the rubber band stretches.)
- Various surfaces for testing blocks

Strategy:
Ask the students what factors they think affect the size of the frictional force. Give the students the equipment and let them try various combinations. At this point DON’T TELL THE STUDENTS WHAT COMBINATIONS TO TRY. Let them explore combinations such as different sides, different surfaces areas, a train (one hooked after the other), stacking on top, or combinations thereof. Regroup the students together as a whole class after approximately 15 minutes of experimentation to discuss preliminary results. At this point you can remind students to control variables, remind them that they should not pull the spring scale at an angle and the different sides of the block might have a different grain, which can affect results. Let the students go back into their groups so that they can fine-tune their results. Have one representative from each group make a brief, final presentation of their results.

Performance Assessment:
Each group can be assessed informally by the lab work they do. I award extra points for each clever idea I see. The presentation can also be used to determine that they have the correct concepts. Also good questions to ask are:

1. What happens if I double the weight by stacking one block on top of the other? (The friction doubles.)
2. What happens if I keep the weight the same but double the surface area? (The frictional force stays the same.)
3. What happens if I double the surface area and double the weight? (The frictional force is doubles because the increase in weight doubles the force, and the surface area has no effect.)
4. How does the surface type affect the frictional force? (The answers will vary. Typically the smoother the surface, the less the friction. However, glass, which is very smooth, will produce a large frictional force, specifically if it is very clean. FYI: There is a weak vacuum that is formed that pulls the blocks together when there is little or no air between the surfaces.)

How Do I Hover?

(from Cathi Cox and Missy Wooley @ Louisiana Tech University)

The Cooperative Group Challenge:

Using the materials provided, design and construct a hovercraft that adheres to the following guidelines:

- the craft must be made from only the approved materials
- initial ideas, sketches, and hypotheses must be completed before beginning construction of the craft
- the craft must be able to float or “hover” on air above the table top

The Cooperative Group must perform according to these guidelines:

- all members of the cooperative group must participate
- the members of the team must come to a consensus on the design and construction of the hovercraft
- the craft design and construction must be completed within the timeframe stated
- the team’s craft must be tested in front of the whole group

Materials:
Old or used CD
Pop-up top
Hot glue gun with glue
Assorted supplies (tape, meter sticks, yarn, plastic wrap, paper clips, pipe cleaners, foil, clay, straws, etc.) *Optional*

Safety Notes:
Extreme caution should be used when working with hot glue guns. If students are constructing their own CD apparatus, teachers may still want to handle the gluing process themselves. However, if students will be gluing the caps to the CDs, be sure to demonstrate the appropriate procedure as well as what to do should a burn occur. Have a first aid kit available in case of burns or accidents.

It should also be noted that students tend to get excited when any type of hovercraft begins to move. Therefore, exercise caution in the classroom environment; make sure that students are monitored, aisles and pathways are clear, and students are adequately spaced throughout the work environment.

Teacher Notes:
If the student have no previous experience with hovercrafts, it may be helpful to present an appropriate engaging experience. An excellent film montage could include clips from *Star Wars*, *Back to the Future II*, and *The Matrix Revolutions*.

This will provide students with a foundation to work from when designing their own hovercraft models.

The model can be designed to “hover” by doing the following: after gluing the pop-up top to the CD, pull the top up in the “open” position; fill a balloon with air and without releasing the air, secure the balloon opening over the pop-up top; release the air and watch as the CD “hovers” across the table top, much like an air hockey puck on its table top.

When discussing the homemade hovercrafts, several concepts can be introduced and developed: among them, friction, Newton’s laws, and aerodynamics. Based on the goals and objectives for the class, you will want to plan student-centered strategies for developing and connecting the concepts related to the learning experience.

There is a lot of history that can be included in a study of hovercrafts, both history of science and our culture as well. A classroom timeline is an excellent way to incorporate history into your science lesson, adding to it as you cover different topics throughout the year.

Furthermore, NASA has many resources that can be added to the study of hovercraft vehicles and their related concepts, as well as how the concepts affect space travel.

Extensions for the exploration include the following:

- Have students measure the distance that the hovercrafts travel, as well as the time of the flight; students can then calculate speed (speed = distance ÷ time).

- Build a larger hovercraft that will hold more weight; there are many internet sites with simple directions on how to make one.

An excellent site to use with this learning experience is:
http//wwwnasaexplores.com/show2_article.php?id=03-071

How Do I Hover?

(from Cathi Cox and Missy Wooley @ Louisiana Tech University)

Procedure:

1. Assemble students into cooperative groups; indicate whether students are to work in pairs within the group.
2. If appropriate, present engaging experience.
3. Have materials managers obtain the necessary materials; if students are to begin construction on the apparatus all materials should be included and the following steps followed:
    a. Place the CD on the table, shiny side up
    b. Position the pop-up top over the center of the CD
    c. Hot glue the water bottle cap to the CD by gluing around the cap to the CD within the ridge
    d. Allow the hot glue to dry for about 10 – 15 minutes
    e. If the exploration begins with the caps already glued to the CDs, only the CD/cap apparatus and balloons will be needed
4. Challenge students to design a way to make the CD apparatus float on air; inform students that only the materials provided can be used and initial ideas, hypotheses and sketches should be completed in learning logs.
5. Present the materials available but do not allow students to obtain materials until a procedure, design, sketch, or some other type of evidence that supports their thought process is documented in their learning logs; once the design has been approved instruct the materials managers to gather the needed supplies.
6. Allow students to explore, testing their hypotheses and design plans; when the CD apparatus has successfully "hovered," have students summarize their conclusions in learning logs.
7. Facilitate a discussion based on the student findings and experiences; if students failed to successfully make their craft hover, allow another student to demonstrate or provide the following instructions:
    - Place a balloon over the top of the bottle cap so that it covers the ridge on it (if there is one).
    - Blow up the balloon through the hole in the CD on the other side of the CD while holding the balloon onto the cap.
    - Pinch the balloon closed to keep the air from escaping.
    - Place the hovercraft on a flat surface, and release the balloon.
8. Challenge the students to test their hovercraft over different surfaces as well as with different amounts of air.

Introduce the term "hovercraft;" have students discuss what they think causes the hovercraft to float above the surface, as well as move forward. In addition, challenge students to list things they could have done differently in order to have a more successful flight.

Paper Airplane Lab Experiment

Laurie Melanson GMS 2006

Questions:
- Have you flown a paper airplane before? (Hopefully not in this class)
- Do you always use the same type of paper?
- Do you always use the same design?
- Do you want it to fly straight or do tricks?

We are going to design an experiment to test paper airplane flight distance.
We want the planes to fly as far as they can.
We need to think about how we are going to design and perform the experiment.
What things do we need to think about? (Think about the steps of the Scientific Method)

Problem:
What question are we trying to answer?

We want to design an experiment to test how the addition of paper clips will affect the flight distance of the paper airplane.

How does adding paper clips to a paper airplane affect its flight?

What do you think is going to happen?

How do you think the addition of paper clips to the paper airplane affect its flight distance?

Does the placement of the clips matter?

Hypothesis:
If paper clips are added to the ___________*(location)* **of the paper airplane,**

then ____.

Materials:
What do we need to perform this experiment?

Procedure:
How are we going to perform the experiment?
What do we need to do?
What needs to be kept constant?
What is our control?
What is our independent variable going to be?
What are we going to observe? How? (This should be written as a list of numbered steps.)

Observations:
Data Table with measurements from the experiment.

Include headings and labels.
5
6
4
3
2
1
0

Flight Distance (m)
of **paper** clips

Experiment:
Get paper clips, lab notebook and a meter stick.
Make the paper airplane. Make sure you follow directions.
Gather materials and head out to your assigned runway.
Fly your airplane, measure flight distance, and record your data in your notebook.
Remember to add a paper clip each time.

Lab Report Write Up:
Must include:
<u>Title page:</u> Title, name, period, date due
<u>Introduction:</u> one paragraph about why we did this experiment
<u>Problem:</u> What question did we want to answer?
<u>Hypothesis:</u> What you think will happen and why?
<u>Materials:</u> A list of materials used
<u>Procedure:</u> Step by step explanation of what you did to perform the experiment.
(Include airplane picture with paper clips)
<u>Data Table and Graph:</u> Include labels
<u>Conclusion:</u> Explain your results
<u>Questions:</u> Answer the questions about the **lab** in complete sentences.

Making a graph of your data:
Let's review independent and dependent variables.
The independent variable is what the scientist changes during an experiment.
The dependent variable is what happens due to what is changed.
Making the graph for "How adding paper clips affects paper airplane flight distance."
1. Create a title.
2. Determine interval and label for x-axis.
3. Determine interval and label for y-axis.

4. Plot your data.

1
2
3
4
6
5
0

Number of paper clips

2
4
6
8
10
0

Flight Distance (meters)

5. Connect the data points.

Conclusion:

What did you learn during the experiment?
Does your data make sense?
Was your hypothesis correct? Explain why or why not?
Did you do anything wrong?
Is there anything that you would have or should have done differently?
Your conclusion should be 3 to 4 paragraphs long.

Questions:

What is a control? What was the control in this experiment?
What is a constant? What were the constants in this experiment?
What is an independent variable? What was the independent variable in this experiment?
What is a dependent variable? What was the dependent variable in this experiment?
Should your results be the same as others? Why or why not?

The answers to the questions must be in complete sentences!

How does adding **paper** clips to a **paper airplane** affect its flight distance?
If **paper** clips are added to the wings of the **airplane**, then the **airplane** flight distance will decrease because the plane will weigh more and not fly as far.

Questions About the Paper Airplane Lab:

A control is-
____.

The control in this experiment is-

____.

A constant is something that _________________________________ during an experiment.

The constant in this experiment is-___________________________________.

An independent variable is-

____.

The independent variable in this experiment is-

____.

A dependent variable is-

____.

The dependent variable in this experiment is-

____.

True or False: My results should be the same as everyone else because we used the same *paper* and the same design. (Why or why not)

____

____

____

____

This lab is available as a PowerPoint presentation at: http://www.gloversvilleschools.org/gms/teachers/lmelanso/documents/Paper%20Airplane%20Web.ppt.

Problem Solving – A Part of Everyday Thinking

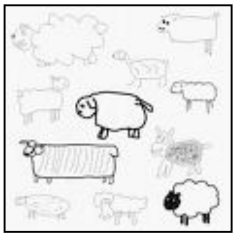
By Octaviano Garcia, Cuba Elementary School, Cuba, NM

Purpose:
The purpose of this activity, used as an introduction to a course at the very beginning of the year or an introduction to any unit of study, is to help students master the process of applying critical thinking to each and every problem/task that confronts them in their daily undertakings. Further, this activity can serve as a reference and model for every problem/task assigned or any problem a student or students might bring up.

Objectives:
As a result of this activity, each student will:
1. Demonstrate her/his knowledge of the six basic steps to problem solving by listing them or reciting the orally.
2. Demonstrate his/her mastery of the six basic steps to problem solving by actively applying them in problem solving when the task lends itself to such a process.
3. Demonstrate her/his ability to apply these six basic steps to problem solving by guiding other students in the solution of a given problem or set of problems.

Materials:
Large writing chart paper may be used for group work if assigned to small groups. Overhead transparencies may be use for easy viewing if the teacher works the solution through with the total class.

Procedure:
Set the stage by explaining the purpose of this story problem to the students. Orient students as to the expectations. Review with students the basic strengths of a “good” problem solver Emphasize a student’s ability to think critically; to identify, group, and classify information in an order and form that makes it relevant and applicable to a given solution. Alert them to the fact that one’s ability to solve daily problems, simulated or real, depends on one’s ability to separate useful from useless information; separate necessary from unnecessary information, and then apply the pertinent information to the problem/task at hand. Tell them the story problem you are about to share with them contains many fabricated distractors together with pertinent and necessary information that they will need for solving the problem that the story poses for them as listeners.



The Story: The Shepherd and the Harvard Boys

A few years ago, not counting those that came later, two Harvard sophomore students decided that they would spend their summer break traveling across the United States of America, the same country that they had studied for years in books. In preparation for this long journey they were careful to pack the necessary credit cards, which their generous parents provided for them, maps, some light casual traveling clothes, and the friendliest Harvard smiles they could muster. Their mode of travel was to be by the way of an old 1961 Chevy panel truck that one of the boys had gotten as a gift from an uncle upon graduating from high school. The vehicle had made many trips between New Port, CT, their hometown, and the Harvard campus in Cambridge, MA. Therefore, the two agreed that the panel truck would make it to the west coast and back. All due caution was taken in preparing the vehicle for the trip also. Once all of these preparations were in place their journey was underway.

Traveling thought the mid-west and southwestern states did not provide much in the way of entertainment or challenge to their superior Harvard-trained minds. The real fun began when they reached the far west coast in California. They spent four weeks in Hollywood, two weeks in the San Diego Zoo, a few days in San Francisco, and many days in Disney Land. All too soon, it appeared, their summer had come to an end, and it was time for them to start back to more familiar territory. So after picking up some supplies for the trip in Sacramento they headed east on Interstate 80. On the second day the panel truck made only 150 miles during a ten-hour day. Repairs had taken up most of that day. On the third day the two decided to abandon the vehicle and hitch a ride home after having to stop six times for repairs within a sixty-mile stretch on I-80.

The hour was marching on to four o’clock in the afternoon when they said good-bye to their panel truck. Both boys were silent for the first hour of walking, but each was thinking of the night ahead and having to round up a meal or go without. The more timid of the two was re-experiencing fears he thought he had left behind at the age of twelve when he was in the seventh grade. He began envisioning attacks by wild lions, tigers, panthers and the like. When he spoke up his first question to his partner was, “Where are we going to sleep tonight, and what are we going to eat?” “Fear not, my friend,” responded his partner, “I shall teach you how the pioneers of the frontier survived in these desolate plains long before there was even a highway through here. Just keep your eyes alert for sheep, and when you spot some, hopefully their shepherd will be with them. Just let me do the talking, for I fear that in your condition you might jeopardize our chances for an evening meal and perhaps even a bed to sleep in.”

Our timid friend did not speak up, but he did not much fancy chasing and wrestling a sheep down for their dinner -- not to mention having to butcher and prepare it over an open fire. He was deep in his thoughts when his traveling companion’s shout of glee brought him back to reality. “There, there, by those trees on that other slope," he shouted as he pointed with excitement at some white spots that, in Mr. Timid's eyes looked like rocks. "Those are nothing but rocks," he retorted with the air of certainty that he often used on the Harvard campus. Nonetheless, he was very happy to accept his error when they approached the white spots, and they turned out to be sheep as his companion had predicted from the opposite side of the valley.

No sooner had they arrived at the herd's northern most edge than out of a scrub oak thicket came two Australian Shepherd dogs. Both stopped and scouted the valley for the whereabouts of the shepherd. Sure enough, from under the tallest pine tree, there emerged what looked like a person. As they got closer they could recognize him as the lone shepherd of this large herd. The man looked as if he had needed a shave, a haircut, and probably a bath for several weeks, but they left all that aside and decided that here was a good opportunity for them to cash in on that evening meal they so badly needed and perhaps even a place to spend the night if they applied their best manners and savvy.

Mr. Timid's partner took a quick glance over the entire heard, and his mind made the best estimate of the number of sheep in the herd that his bright mind could compute in the time he had. When they were a dozen or so yards from the shepherd he greeted him, "A very good afternoon to you, Mr. Shepherd to two thousand sheep," he offered, not knowing the man's name. "Your greetings are kindly accepted, my traveling friends, but you are in error, Mr. Bright Boy." I am not the shepherd of two thousand sheep. If I had that many sheep out there plus another herd as large as that then half again as many as I have out there, I should be the shepherd of two thousand sheep."

Mr. Timid immediately set his mathematical mind to the problem. By the time they had arrived at the shepherd's tent, which was a few hundred yards away, he had figured out how many sheep the shepherd actually had in that herd.

Question to students: How many sheep were in this shepherd's herd?

1. Direct students to apply the six basic steps to problem solving in solving this problem. To do so, students must list each step and next to it or immediately following, they must list the information from this story that applies and is pertinent to that particular step. Remind students that at the outset you warned them that the point of the story was to see how well they can separate useful information from useless information given a particular task/problem to solve.

2. You may wish to accept a solution that is arrived by guess and test (trial and error) method, or you may direct the students to apply their algebra skills and produce an algebraic formula/equation:

   Example: $1X + \frac{1}{2} X = 2{,}000$ sheep.

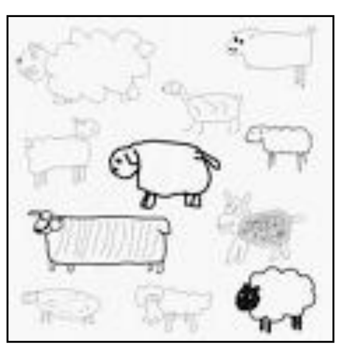
3. You may wish to have students attempt the solution to this problem on an individual basis or on a small group basis. If you feel the group is very unfamiliar with the six basic steps to problem solving you may want to use this story problem to establish familiarity with these steps and do a total group problem solving exercise. This problem lends itself well to any of the above approaches in arriving at a solution.

4. Use the story problem to introduce or review the problem solving process with any lesson, unit or course. Remember you can vary it by level. Example: the number of sheep that Bright Boy, as the shepherd calls him, may be 20, 200, or 2,000, etc.

What Are The Six Steps In Problem Solving?

Six Steps to Effective Thinking and Problem-Solving:

Identify the problem. — "What's the real question we're facing here?"
Define the context. — "What are the facts and circumstances that frame this problem?"
Enumerate choices. — "What are our most plausible three or four options?"
Analyze options. — "What is our best course of action, all things considered?"
List reasons explicitly. — "Let's be clear: Why we are making this particular choice?"
Self-correct. — "Okay, let's look at it again. What did we miss?"



Bubble Gum Trivia Challenge

ANSWER KEY

1. How many sticks of gums does the average American chew in a year? B. 300

2. How many tons of gum are chewed every year? C. 100,000

3. If all the 5-chunk packs of Bubble Yum ever chewed in the U.S. since it's introduction in 1975 were laid end-to-end, how many times would it circle the earth at the equator? 7 (and a little more)

4. San Luis Obispo, CA is the home of "Bubble Gum Alley." What is it? An alley with brick walls covered with ABC (already been chewed) gum.

5. Richard Walker holds the record for the Chomp Title by chewing 135 sticks of gum for the longest time. How long did he chomp? C. 8 hours. The first person to win "Chomp Title" was Sue Jordan, who chewed eighty pieces of Doublemint gum for 5 hours and 12 minutes. Clyde Steward McGehee, of NC, broke that record by chewing 105 sticks of Juicy Fruit for 6 hours. And Richard Walker broke that record.

6. The Topps company holds the record for having made the largest single piece of bubble gum. How many pieces of normal-sized Bazooka did it equal? C. 10,000. Topps presented the gum to baseball player, Willie Mays, in 1974. Mays then cut it into small chunks and gave it to children in nearby hospitals.

7. The 1952 Mickey Mantle rookie card is the most valuable Topps Company card. How much did it sell for at auction? B. $120,000.

8. What is the official gum of Major League Baseball? A. Bubble Yum.

9. When was the first successful bubble gum invented? C. 1928. The first known bubble gum, "Blibber Blubber," appeared in 1906. It failed to catch on because it was too sticky and too brittle so it didn't hold together when it was chewed. The first successful bubble gum was invented by Walter E. Diemer in the summer of 1928. A 23-year-old accountant who knew nothing about chemistry, Diemer created his invention in a tiny laboratory in Philadelphia. The only food coloring he had on hand was pink. "It was an accident," Mr. Diemer said in an interview with The Lancaster Intelligencer Journal in 1996. "I was doing something else and ended up with something with bubbles."

10. Susan Mon"Gum"ery Williams is the Guinness Record Holder of the World's Largest Gum Bubble. How big was it? B. 23 inches

Many of the facts for the questions were found at Bubble Gum Fact Page at http://www.northville.k12.mi.us/STUDENTS/2005/dugganla/Hpage4.htm.

Helpful Science Internet Sites

ICT Teaching and Assessing Science
http://ecs.lewisham.gov.uk/talent/secsci/TaLENT_SC5.htm
Ideas for teaching and assessing secondary science through ICT

New Teacher Resources
http://www.teachersfirst.com/unitlist.htm
Articles by and for new teachers. Suggested lesson plans with attention to the planning and management issues concerning new teachers

Problem Solving in Elementary Schools
http://www.indiana.edu/~reading/ieo/bibs/probele.html
ERIC resources that address problem solving. Useful links to other Internet resources.

Science Lesson Plans
http://www.col-ed.org/cur/science.html#sci1
This site, sponsored by the Columbia Education Center in Oregon provides a tremendous collection of elementary/middle level science lessons.

Sensational Science Activities
http://www.tufts.edu/as/wright_center/fellows/jbm_info/jbm6.html
Home page created for secondary science educators by John Banister-Marx. Good stuff!

Supplements to Science Lessons
http://www.monroe2boces.org/programs.cfm?sublevel=350&subsubpage=82&subpage=54&master=3
BOCES2 website provides an array of elementary science lesson supplements. Excellent resources for teachers trying to differentiate instruction on particular topics.

Teachernet Science Resources
http://www.teachernet.gov.uk/teachingandlearning/subjects/science/primaryscience/
One of the best sites on the internet for all kinds of activities, ideas, and integrated lesson plans for primary school science.