



**Problem Solving,  
Persistence, and Patience:  
The Three P's of Science Research**

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**Grade Level:**  
Middle-High School

## **Problem Solving, Persistence, and Patience: The Three P's of Science Research**

### **Purpose:**

I recommend this lesson as the first lab/activity for the year. It is appropriate for students in grades 6-12. By building a Rube Goldberg-type machine with limited materials and time designed to solve a specific problem, students will learn that problem solving, patience, and persistence are all an integral and inherent part of science research. This will help to counter the common student misconception that there is always one correct answer that can be found by following a series of procedures in a lab activity. The lesson is structured according to the Learning Cycle, with engage, explore, explain, elaborate, and evaluate components.

### **Objectives:**

Students will understand that:

- while involved in research, scientists are continually using problem-solving skills in every aspect of experimentation.
- scientists have to be patient as they await results, and as they see errors in their multitude of trial and error attempts.
- persistence is needed in order to help scientists focus on their goals as they think and rethink through lab protocol.

### **Materials** (per group of three-four students):

Please note that this list of materials can be adapted to fit the materials that are readily available at your school. American Science and Surplus (see References and Resources) is a good resource for similar materials. If your materials change, your list of criteria may need to be modified, as well. Since this lab requires a variety of materials, it may be helpful to have a scavenger hunt at the beginning of the year. Students who bring in the materials listed may receive bonus points or a homework pass.

- *Apollo 13* video, TV, VCR
- Each team needs a box/container of:
  - five straws
  - four rubber bands
  - two batteries with cases
  - four wires with alligator clips
  - two pulleys
  - string
  - ring stand
  - spools
  - electric motor/buzzer
  - wooden “ice cream” sticks
  - rubber tubing
  - buttons
  - magnets
  - three cylindrical containers (film canisters, powdered drink cans)

**Preparation and Procedure:**

1. Fast-forward the *Apollo 13* video to the segment concerning the NASA scientists trying to solve the carbon dioxide problem on board the ship (approximately 45 minutes into the movie).
2. Collect materials to place in boxes/containers. Another option would be to put different items in each box while keeping the criteria for each group the same. Be prepared to guide teams who are frustrated. Prepare thought-provoking questions in advance in order to give guidance without telling the group specifically what to do.
3. You may want to type out the NASA scenario mentioned in procedure three, as well as the criteria the device must meet. Please modify the criteria as you see fit, based upon supplies available that you could place in boxes. Instead of retyping, you could photocopy the Explore section of the lesson, cut apart, and distribute the parts you want the students to read and keep.
4. Prepare a place for the demonstrations to be held. Make sure students know in advance how large the surface is and what type of surface they will be dealing with in order to deal with friction of various surfaces. Provide a ramp for teams who attempt the bonus criteria.
5. Consider using an Internet screening software program such as *Net Nanny* (see References and Resources) to block any materials from the Internet to which you would not want your students to have access.
6. Familiarize yourself with locating and accessing information about the Purdue Rube Goldberg project (see References and Resources) on the Internet as well as similar projects at MIT and various other institutes.

**Engage:**

Explain that students will view a video clip that they have probably seen before. The clip is from *Apollo 13* and shows NASA scientists trying to use parts available to the astronauts onboard the ship to solve a carbon dioxide problem. As students view the clip, they should record the number and type of objects with which the astronauts have to work. Following the video, ask questions such as:

1. What types of objects were available to the astronauts?
2. Did they have an unlimited supply of each?
3. Did the NASA scientists and engineers work separately or as a group?
4. Was the scenario in this clip realistic?
5. Would scientists and engineers have to accomplish tasks such as this?
6. How often and under what circumstances would scientists and engineers be faced with problem-solving tasks such as this? (Point out the recent accident on the Mir space station!)

At this point, I share with students my APS summer research experience and the types of problem-solving I encountered in the biomedical research laboratory.

**Explore:**

Ask teams to brainstorm as many examples as possible (in a two-minute time limit) of situations when they have been involved in or seen others problem-solving. Share results.

- What were the outcomes of the problems?
- Were you satisfied with the outcomes?
- How could you have improved your problem-solving approach?

Since life, as well as scientific research, is full of opportunities for us to use problem-solving strategies, explain that students will work in teams to accomplish a task similar to what they saw in the video. Each team will receive a box of materials as well as the following scenario:

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*NASA is now receiving applications for four young people who are adept in teamwork, problem-solving, and divergent thinking. NASA has voiced a complaint that the adults they hire are simply inadequate in these areas. You see this as an opportunity of a lifetime, and you desperately want the position. You have passed the first round of interviews, and you are now placed in a team with other students your age. Your team assignment is:*

- Build or construct a device that accomplishes the tasks mentioned below. The only materials you may use are the materials found in your box. The only exception would be the use of basic desk supplies such as tape, scissors, etc. Each and every item you use, as well as the quantity of each, has to be approved by your teacher and recorded by your team.

Your device must:

- move a horizontal distance of 12 cm
- move a vertical OR diagonal distance of eight cm
- move an object from its original position to a second position of at least five cm away
- make a sound
- complete one additional task of your choice
- climb a ramp (optional challenge)

Your device must complete these criteria in any order within a seven-minute time period. Once the seven minutes begin, the device cannot be touched without a deduction of points.

Your team must:

- submit a plan prior to the demonstration that shows the predicted order of events for your device.

- keep a daily log that reveals the progression of the construction of your device as well as problems/successes that arise in the process.
- complete a self-evaluation form as well as an evaluation of other teams as they present. (See sample evaluation form.)

### **Expand**

Students will access the Internet to:

- find out more about Rube Goldberg and the Rube Goldberg contest at Purdue University.
- interview a scientist or engineer to hear specific examples of problem-solving.

Before contacting these sources, students need to generate questions to which they want to find answers. This list should be submitted to the teacher for approval and suggestions prior to gaining access time on Internet. Students will present a visual display of their findings. (e.g., a poster) If time permits, an oral presentation may accompany the visual.

### **Safety:**

- Discuss use of batteries, wires, circuits, etc.
- Have periodical approvals of techniques used in design.
- Monitor teams who need to place holes in objects.
- All assembly must be done at school under teacher's supervision.

### **Questions to Ask:**

During design time:

- What additional materials might you consider using in order to complete the criteria?
- Can you think of a device that behaves in a similar manner? How is your device similar? How can you make improvements on your device based on these observations?

### **Following presentations:**

1. How does this task relate to tasks you have accomplished in the past? What similar tasks might you tackle in the future?
2. What advice would you give to next year's students prior to their beginning this process?
3. If you had this to do all over again, what changes would you make?

### **Where to Go From Here:**

This is the first activity for the year. After completing this assignment, I want students to approach each lab from a problem-solving and/or inquiry-based approach. The one exception to this would be the very next lab we do which would be a typical "cookbook" lab of your choice. After completion of the cookbook lab, discuss advantages/disadvantages, similarities/differences, applications of each. Since most research is done from a problem-solving approach, challenge the students to critique your labs and give suggestions as to how the labs may be modified to meet this standard.

At the end of the year, students can assemble kits and write a challenge for the next year's class. They will see how far they've come in their problem-solving skills. This could also be used as an assessment for problem-solving.

### References and Resources

1. Be sure to check with local machine shops; they may donate parts for assembly.
2. American Science & Surplus, Mail Order Warehouse, 3605 Howard Street, Skokie, IL 66076, Phone (847) 982-070, FAX (800) 934-0722, <http://www.sciplus.com>.
3. Net Nanny Internet screening software, see <http://www.surfwatch.com>.
4. *Apollo 13* (1995). Universal Studios, Brian Grazer (Producer).
5. Rube Goldberg homepage, includes the design for a self-operating napkin, designed by Rube Goldberg (<http://www.anl.gov/OPA/rube/>).
6. Rube Goldberg contest at Purdue University; competition is open to the public (<http://www.purdue.edu/uns/html4ever/9612.Rube.one.html>).
7. Science olympics site; teams of up to six persons create a device that puts quarters into a physics bank. (<http://quark.physics.uwo.calsfair/events/rube.htm>).
8. Design a machine. At this site, high school students design a machine that inserts and plays a compact disc (<http://www.anl.gov/OPA/rube/ruberules.html>).
9. Toothpaste contest. In this competition, participants must develop a device to place toothpaste onto a toothbrush (<http://www.engr.uky.edu/student.orgs/hkn/rubegold.html>)

### Suggestions for Assessment:

- Grade written data from video clip, as well as participation/answering questions.
- Check ideas brainstormed during two-minute time limit.
- There are many possible options for assessment in this procedure. A few are:
  - Daily data log showing team design ideas, trial and error, persistence, patience, attempts to accomplish criteria, cohesiveness of groups, etc. Taking up this data log periodically affords you the excellent opportunity to provide feedback to the teams concerning any or all of these areas.
  - Teacher evaluation of teams' completion of each criteria by device during seven-minute time limit.
  - Student evaluations of other teams.
  - Team evaluations of their own teams.
- Questions generated prior to Internet access as well as the answering of those questions.

**Evaluations:**

Scoring: / = Completed criteria; x = Did not complete; + = Excelled in some way  
 Students should evaluate their own team and at least two other teams in the class (listed as “A” and “B” on the rubric below.

**Evaluation Rubric for Teachers and Students**

<b>Criteria: Did the device:</b>	<b>Evaluation by Teacher</b>	<b>Evaluation of our Team</b>	<b>Evaluation of Team A</b>	<b>Evaluation of Team B</b>
<b>Move a horizontal distance of 12 cm?</b>				
<b>Move a vertical distance of eight cm?</b>				
<b>Move an object from its original position to a second position of at least five cm away?</b>				
<b>Make a sound?</b>				
<b>Challenge: Climb a ramp?</b>				

**Supplementary Evaluation Rubric for Teachers**

<b>Criteria</b>	<b>Evaluation by Teacher</b>	<b>Comments</b>
<b>Team submitted plan showing predicted order of events for device</b>		
<b>Turned in daily log</b>		
<b>Kept within seven-minute time period</b>		
<b>Did not have to touch device once time began</b>		