Throughout the guide, teaching tips are in red.

Activity Description &

This activity requires one 45-minute block. Students work in two-person teams to design the lightest piece of paper from which a one-pound weight can be suspended for five seconds.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- The properties of a material must be considered when using that material to accomplish a design challenge.

Students demonstrate this knowledge and understanding by creating, testing, and improving the designs of their paper weight-hangers.

Correlations to NC Science Standards

4.P.2.1 *Compare the physical properties of samples of matter (strength, hardness, flexibility, ability to conduct heat, ability to conduct electricity, ability to be attracted by magnets, reactions to water and fire).*

Brief Science Background

The physical properties of materials determine their usefulness for specific purposes. One property is strength. Different materials have different kinds of strength. Paper, for example, only weakly resists crushing, bending, and folding. However, because it is made of strong fibers, it has surprising tensile strength.

Part 1 — Paper Hangers –45 minutes

Materials

Materials for the whole class

- digital scale
- 3 paper hanger stations
- 3 one-pound weights with hanging hooks
- three-hole punched paper
- a box of hole reinforcement stickers

Materials for groups of 2 students

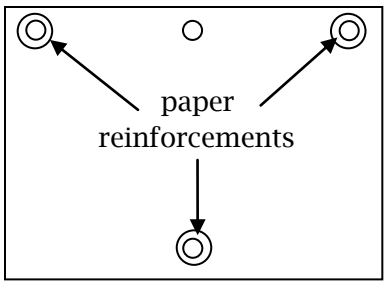
- access to scissors
- access to a single-hole punch
- access to hole reinforcement stickers

Preparation

Find three locations for paper hanging stations. Weight the board with books. Place push pins in the edge of the board so that the corner holes of a piece of 3-hole notebook will easily go over both of them. At each station, leave a one-pound weight, a roll of paper reinforcements, scissors, and notebook paper. Be prepared to demonstrate step 1 described below. In a central location that students can easily reach, set up and turn on the digital scale so that it reads zero with nothing on it.

Procedure

1. Hold a piece of 3-hole notebook paper with the three holes across the top as shown below. Punch a hole that is ¾"-1" from the bottom edge directly below the top middle hole, as shown.



2. Place paper reinforcements on the two corner holes, and on the new hole. Ask students if they think this piece of paper can hold a one pound weight for five seconds (pass the weight around for them to feel). Explain that the weight will hang from the new hole you just punched. Pass the weight around as students discuss and consider their answers.

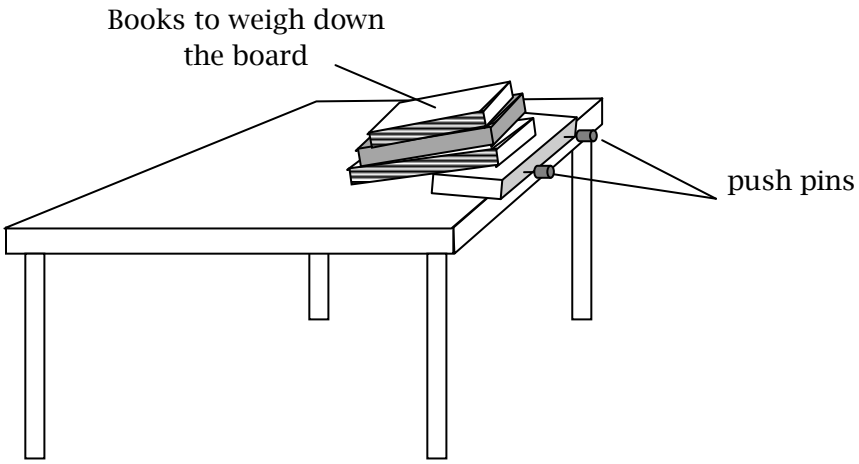
3. After students share their opinions, demonstrate the paper hanging station: place the two top holes over the pushpins, hook the weight in the bottom hole, and count to five slowly (see Diagram 2). **The paper will support the weight as long as the punched hole is at least 3/4" from the bottom edge of the paper (do not tell students this distance).** Then weigh the paper on the scale and report its weight to the class.

4. Inform students that they will work in pairs to find the lightest piece of paper that will hold up the weight for five seconds (approximated by a slow count to five). Give each pair one piece of paper, and tell them to put hole reinforcements on the two top corner holes for placement in the testing station. They can trim the paper however they want, and punch the weight-hanging hole wherever they want. Remind them to reinforce this hole as well, and also remind them that the goal is to find the lightest piece of paper that can hold the weight for five seconds.

5. Distribute the paper and have students and make and test their ideas. Allow enough time, and additional paper if needed, for each team to come up with their best solution. Ask each team to post the weight of its finished product on the board.

Part 1 (cont.)

Paper Hanger Station



Content Wrap-Up

1. Briefly discuss the common characteristics of shapes that worked and those that did not work.

2. Ask students what property of paper they tested with this challenge. **Even after giving them time to think about the question, you might need to ask a few questions before you get the response "how strong it is" or "the strength of the paper". If necessary, ask students what the point of hanging the weight from the paper was. Or, ask them what they would have learned about paper if they had not hung the weight on it. (The only things they would have learned is that paper can be hung from screws, and paper can be cut, neither of which is new or useful information.)**

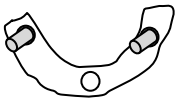
3. Point out that all materials have physical properties that make them useful for certain purposes. As an example, ask students what would happen if you put a piece of paper in the flame of a match. Then ask if all materials will burn if you hold a match to them. Whether or not a material catches on fire easily is an example of a property.

4. Ask students to list some properties of paper in their notebooks. Discuss their answers. **Encourage students to be general, as opposed to specific, by listing characteristics paper *always* has. Give an example, if necessary, such as "paper is always thin, regardless of whether it is used for printing magazines, wrapping gifts, or blowing your nose." Discourage characteristics that only apply to some types of paper, such as "paper is white" or "it is used to make tissues". Valid properties students might come up with include: paper is lightweight, smooth, opaque (except for waxed paper), and folds easily.**

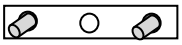
Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write their responses in their notebooks.

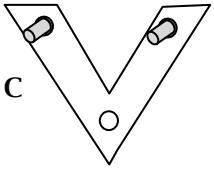
Ask students to predict whether or not each of the papers below would hold up the weight, and if not, where they might break:



A



B



C

D

Answer Key

A. Yes

B. No

C. Yes

D. Yes

Appendix

Common Student Preconceptions About This Topic

Children tend to associate strength with size, a notion they develop in early childhood when they are told to drink their milk and eat their vegetables so they'll grow up big and strong. Their everyday experiences confirm this notion: they can break a stick in half with their hands, but not a log, and it's harder for them to bite into an apple than a grape. As they get older, additional observations about their world begin to dispel this notion. Sewing thread is hard to break – scissors (or teeth) are required; a cereal box tears easily, but the much thinner plastic bag inside it does not. Once children are able to discard the idea that 'bigger' always implies 'stronger', they can accept that the strength of a material is a characteristic of the material itself, regardless of its size.