Teaching Physical Properties of Water using Hydraulics

Tabatha Dye[1] Beth Todd[2] Pauline Johnson[3]

Abstract – This paper describes an activity for the second grade that will teach students about liquids and force. The lesson is to teach the students about how water or liquid can be moved or pushed. The objective is for the students to better understand the physical characteristics of water. The students will make their own water gun out of plastic cups, drinking straws, and other materials. Then they will discuss how it is different if air, a solid, or another liquid is put in the water gun. The paper will discuss how the topics are covered, how the water gun is built, and a list of the necessary supplies. The lesson will be taught to a second grade class and evaluated on the level of knowledge learned and how much the student enjoyed the activity.

Keywords: Force, pressure, water, hands-on activity, second grade

INTRODUCTION

Water Guns

Water guns are a popular children's toy. Squirt guns use a simple pump to turn a reservoir of water into a fast moving stream (Fig. 1). The pump mechanism is basically a piston-cylinder system with little else added. A trigger lever is used to push a piston. The piston uses the push on the lever trigger to reduce the volume of the cylinder, thus forcing the water out of the gun barrel. This force on the trigger causes a fast moving stream of water due to the constricted size of the barrel. Water guns also use one-way valves to prevent the water from flowing from the cylinder to the reservoir. More advanced water guns use motors to pump or plungers to build water pressurization. [1,2] In the case of this module, our water gun is a simple piston.

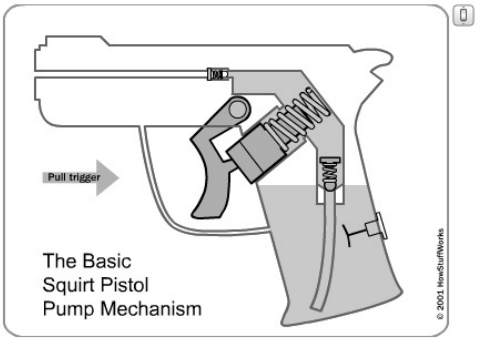

Figure 1—The Basic Squirt Pistol Pump Mechanism [2]

Pistons

The basic piston is a mechanical device that can increase pressure in its container, a cylinder. The pressure is equal to force over the area. When a slow moving force is applied to a piston, the piston can transfer this force over a large area into a fast moving stream of liquid if the area of the outlet of the cylinder is relatively small compared to the piston. [3]

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WATER GUN MODULE

Purpose of Water Gun Module

Whilst participating National Science Foundation GK-12 project, this module was developed to facilitate second grade education in regard to liquid properties and introduce concepts on force and pressure. The module was developed with the intention of introducing early physics concepts using the basic knowledge of liquids that was learned in previous lessons. This module can be completed in one or two fifty-minute class periods depending on the number of students. The lesson is broken up into a lecture, activity, and a post lecture with a question period. It is much easier to ensure all students learn the concepts if two teachers (or one teacher and one adult volunteer) are available so that the students can be broken into small groups to perform the activity.

Pre-Activity Lesson

Before the activity, the students need to be taught basic concepts of how their water gun works. This will include introducing topics, such as, force, pressure, and liquid characteristics.

Force: A push or pull like Tug-of-war.

Pressure: A force over an area like what is forecasted on the weather segment of the local news.

Liquid characteristics: Water, like air, conforms to its container and can be pushed. Unlike a solid, water will be able to fit in a straw.

Required Materials (per student)

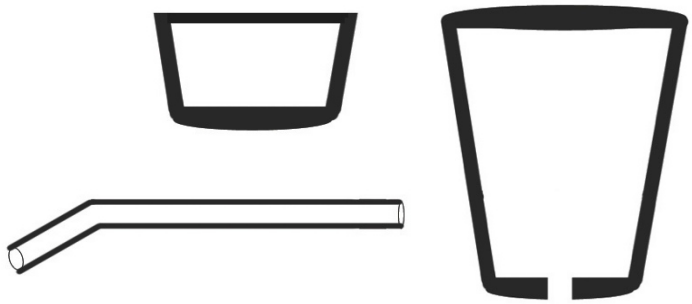
1 Pre-cut plastic cup (small cup)

1 Pre-drilled plastic cup (big cup)

1 Plastic Straw

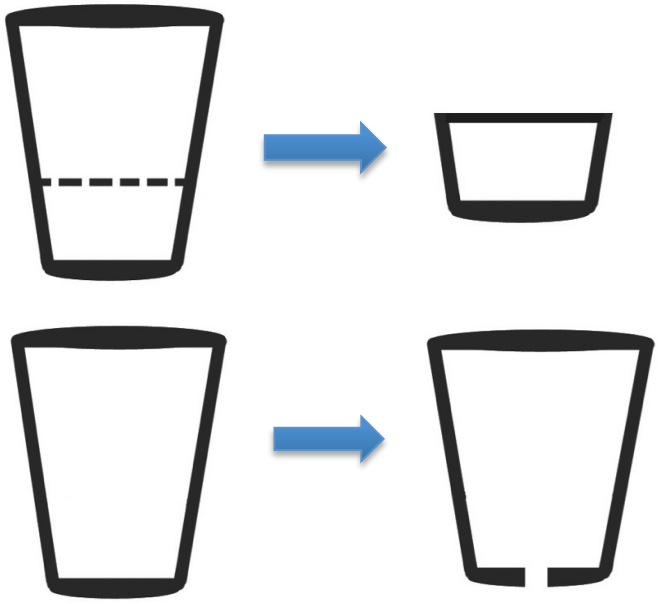
1 Cup of water

Duct Tape (optional)



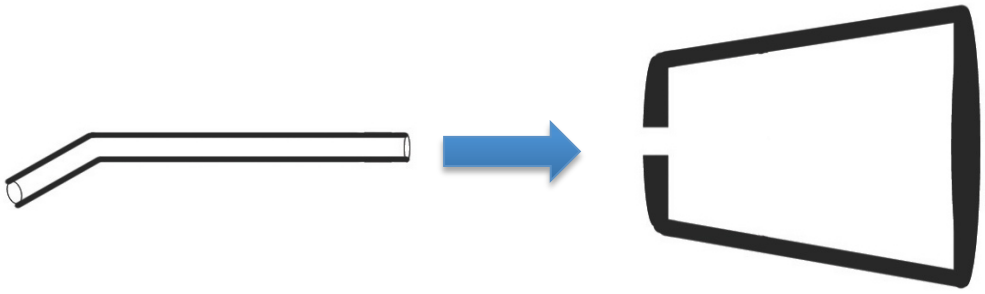
Activity Procedure

1. Before coming to class, the teacher needs to drill a small hole on the bottom of half of the plastic cups and cut the other half of cups around the middle, so it can fit in the pre-drilled plastic cups.

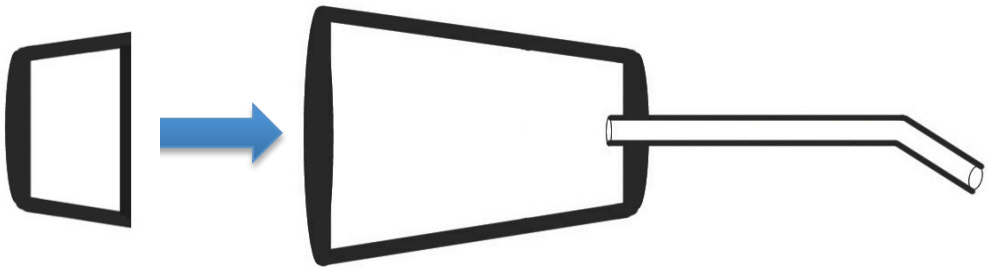


2. Have three students help you pass out the big cups, small cups, and straws.

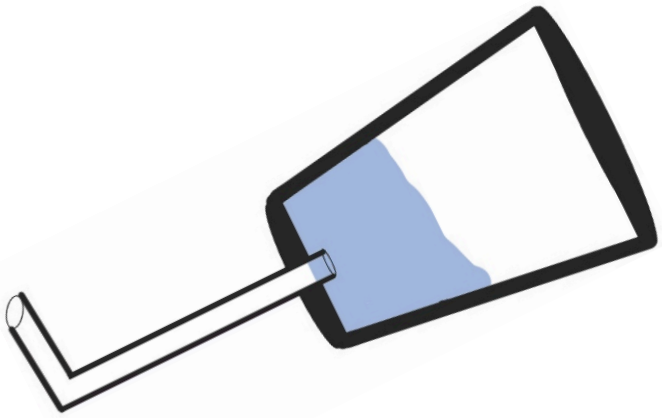
3. Instruct the students to insert the straws into the drilled hole in the big cups; be sure to have the straw at the same level as the bottom of the plastic cup or the water won't go down the straw. If the straw is loose, then duct tape may be necessary to seal the straw in the cup.



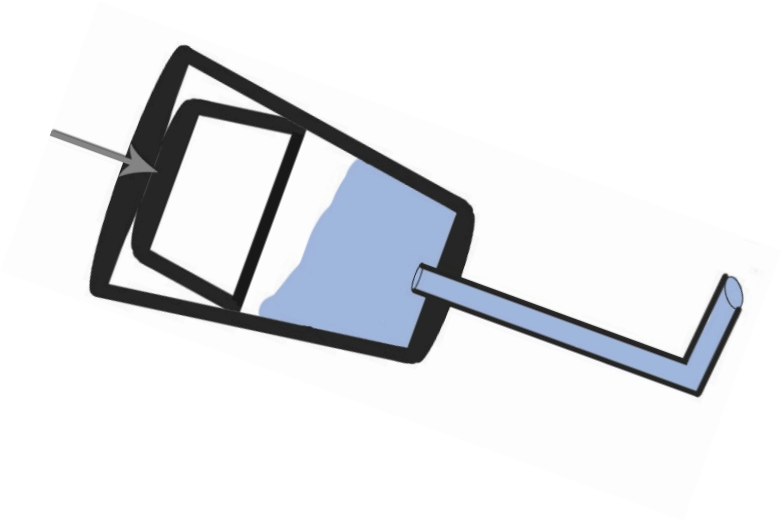
4. Ask the students to put the small cup inside the big cup, but make sure that the small cup does not bend when pushed in.



5. Ask the students to pull and push the small cup into big cup; there should be a little airflow coming out of the straw.
6. Take a group of the students outside to test their water gun.
7. Hand them each a cup of water to put in their water gun.
8. Help them put the water in their water gun by holding it while they pour the water in. Be sure to either cover the straw or hold the cup at an angle that the water does not fall out through the straw or the top.



9. Once they all have water, ask the students to push their small cup into the big cup.



10. There should be a little squirt of water out of the straw, see Figure 2. You may need to help them push the water out as a stream.
11. Let them repeat this a few more times and then switch out groups.

Figure 2--Water Gun in Use

Handout Version

A one-page handout was also developed for teachers wishing to use the activity with their class. It is included on the following page.

Water Gun Lab

(One or two fifty-minute sessions)

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The University of Alabama

NSF GK-12 Grant No.0742504

Pre-Activity Lesson

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1 Cup of water

Duct Tape (optional)

Activity Procedure

1. Before coming to class, the teacher needs to drill a small hole on the bottom of half of the plastic cups and cut the other half of cups around the middle, so it can fit in the pre-drilled plastic cups.
2. Have three students help you pass out the big cups, small cups, and straws.
3. Instruct the students to insert the straws into the drilled hole in the big cups; be sure to have the straw at the same level as the bottom of the plastic cup or the water won't go down the straw. If the straw is loose, then duct tape may be necessary to seal the straw in the cup.
4. Ask the students to put the small cup inside the big cup, but make sure that the small cup does not bend when pushed in.
5. Ask the students to pull and push the small cup into big cup; there should be a little airflow coming out of the straw.
6. Take a group of the students outside to test their water gun.
7. Hand them each a cup of water to put in their water gun.
8. Help them put the water in their water gun by holding it while they pour the water in. Be sure to either cover the straw or hold the cup at an angle that the water does not fall out through the straw or the top.
9. Once they all have water, ask the students to push their small cup into the big cup.
10. There should be a little squirt of water out of the straw. You may need to help them push the water out as a stream.
11. Let them repeat this a few more times and then switch out groups.

Post-Activity Lesson

After all of the students have completed the activity, refer back to the topics discussed previously. Ask them what force means and what happens when you use force on the small cup. Ask them how the water came out of the straw, if they need help remind them of pressure. Then tell them that the air they pushed using the small cup put pressure on the water and forced it out of the cup. Then ask them what would happen if they put blocks in the cup or if they only had air in the cup.

RESULTS

Student Enthusiasm

The students enjoyed being able to put together the water gun and were excited about being able to go outside. It was found that it was much easier for the students to put the water gun together while watching the teacher put their water gun together. After completing the activity, the students were excited about showing their parents the water gun they made in class and wanted to repeat the activity before going home. There were some issues with students wanting to get each other or themselves wet with their water gun. There were also some issues with them wanting to go on the playground while they were outside. Weeks following the module, the students asked if they could again rebuild the water gun and were more receptive to the activities that followed, such as asking more questions.

Student Learning

By asking the students questions after the activity and in subsequent lessons, the amount they learned can be examined and the concepts reinforced. The concept of force was very easy for the students to understand and some of them already knew what it meant. The concept of pressure was a little more difficult for them to understand, but most understood that it was a “bunch of forces” on an area. The liquid characteristics were understood before the lesson and helped them further understand how liquid conforms to its container in not only a static situation, but also while moving. The pre-activity is a bit difficult for them to process since they are very excited about making a water gun and going outside; however, the post activity showed that they could relate to force concepts and liquid characteristics easily. A month later, the students better understand these concepts and we have used other lessons to reinforce them.

CONCLUSIONS

After testing the module on a second grade class of about 18 students, the students said enjoyed it and it follows the requirements of primary education. This module covers both force and physical properties of liquids, so it covers objectives 2.1.2 and 2.4 in the Curriculum Guide to the Alabama Course of Study: Science Grades K-12 [4]. It was a fun activity that introduced the kids to introductory physics concepts and helped further their understanding of liquids. This module has generated interest in science for these elementary school kids and encouraged further participation in following modules.

REFERENCES

[1] D'Andrade, Bruce M., and Lonnie G. Johnson. Pinch Trigger Pump Water Gun. Patent 5074437.24 Dec. 1991.

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[4] Morton, Joseph B. Curriculum Guide to the Alabama Course of Study: Science Grades K-12, Alabama Department of Education, 2006. <http://alex.state.al.us/specialed/curriculum/cgscience.pdf >

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