K-12 STEM Experiment: Filtration Fun
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Abstract

Clean, reliable water sources are a worldwide problem that consume many resources and negatively impact the health of those individuals that lack access. This iSTEM Education experiment aims to teach children aged 7-11 the importance of clean water, side effects of consuming contaminated water, and techniques for purification. Additionally, it focuses upon filtration as a key technique and gives students hands-on experience filtering water. This experiment was performed in collaboration with Universidad de Nariño in Pasto, Colombia in March 2015. Positive results were seen as students and professors engaged well with the experiment and showed competencies in alignment with the learning objectives. This experiment utilizes materials that are easily accessible and low cost – most being recycled materials. This concept of purifying water with the use of recycled materials was also applied in developing a University-level experiment. Future impacts of these experiments will be seen through a continuation of the iSTEM Education program at The Ohio State University and outreach projects put on by Universidad de Nariño utilizing the concepts. Education surrounding water purification is crucial to improving the health and living conditions of millions around the world. These experiments aim to provide engaging and interactive experiences with the purification techniques of filtration and coagulation that will ideally lead to continued interest by the students in the future.

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I. Introduction

Contaminated drinking water can have extreme effects on one's health. It is estimated that 10% of the world's diseases could be prevented with improved sanitation and water management.[1] Contaminated drinking water can include viruses and bacteria that cause health implications such as vomiting and diarrhea. Finding clean water is also a time-intensive process as it is estimated that over 140 million working hours are spent each day traveling to and from water sources in addition to preparing the water for use.[1] Access to clean water is an epidemic and early education on its importance can help change this in the future.

This experiment is designed for children between the ages of 7-11. The experiment was performed with 10-year-old students in Pasto, Colombia and taught to teachers in Bogota, Colombia in March 2015. The experiment aims to introduce the importance of clean water and commonly used filtration techniques. The experiment was created with inspiration from many different sources including Water.org, University STEM education sites, as well as Ohio State University faculty and staff.

[1] Water.org

II. Learning Objectives

The following were established as the main learning objectives for the Filtration Fun experiment.

- Students will understand the harm of unclean water and importance of continued research and development in clean water processes.
- Students will learn different types of contaminants commonly found in water such as bacteria, chemicals, and viruses.
- Students will understand different water purification techniques and what contaminants each technique removes. Techniques discussed will include chemical additives, filters, and temperature techniques.
- Students will gain hands-on experience with different filters and develop an understanding of the size of particles which they can remove from water.

III. Materials

A main goal of this experiment was affordability. All materials chosen were considered to be easily accessible and free or low cost.

Materials required:

Clean 2-liter bottles

Rocks

Sand

Cotton balls

Paper towels

Small cups

Food coloring

Styrofoam

Plastic bugs (other “larger” items)

There is flexibility in the design of this experiment depending on each classes’ needs. When this experiment was performed in Pasto, Colombia, each student was given 2 small cups. Students formed groups of 3-4. For each group, a filter was created using the materials listed above.

Filters

The filters were created by cutting out the bottom of the 2-liter bottle and then flipping them upside down so that the cap was on the bottom. Cotton balls were packed tightly into the bottom 4-5 inches of the bottle. A layer of sand was added to fill the next 3-4 inches of the bottle and finally a layer of rock was added – deep enough that the sand was not exposed from the top.

“Dirty Water”

In addition to the filters, a large quantity of “dirty water” was created using food coloring, Styrofoam, and plastic bugs. A few drops of food coloring were added to approximately a gallon of water (which students will be able to see being filtered out by the cotton balls). Additionally, varying sizes of Styrofoam and small plastic bugs were added to model debris and bacteria in real water. Students will be able to see where in the filter these items are stopped based on their varying sizes.

IV. Procedure

Class Introduction

As this experiment aimed to engage students of the ages 7-11, it was crucial to include an interactive overview to introduce the experiment and key concepts. The following is the script utilized in the classroom in Pasto, Colombia. The Spanish translation of the classroom script can be seen as **Appendix A.**

> "There are a lot of places where people don't have access to clean water in the world. **750 million people in the world do not have access to clean water.**
>
> **That's 15 times the number of people in Colombia.**
>
> Drinking dirty water can make you sick - diarrhea, parasites, bacterial infections, etc. Water can be contaminated in several ways:
>
> - Dirt particles
> - Bacteria
> - Chemical
> - Viruses
>
> Water can also be cleaned in many ways:
>
> - Adding chemicals additives
> - Running it through a porous filter
> - Boiling water and collecting the clean condensed water

Each method removes different types of contaminants. *(Engage class in conversation on the three different methods to clean water and ask them what contaminates they believe will be removed each way.)*

Filtration works by sending water through tiny holes – so what contaminants do you think it would remove best? **Dirt**!
Chemical additives work by combining/bonding with things in the water – what contaminants do you think it would remove best? **Chemicals**!
Boiling works by getting so hot it kills living things in the water – so what contaminants do you think it would remove best? **Bacteria**!
Viruses are hardest to remove, but filters with very small holes can keep them out of your drinking water.

Today we are going to try out a couple of those methods of filtration to clean some dirty water.
We are going to filter with a coffee filter and test it.
We are going to filter it through a rock-and-sand filter and test it.
We are going to filter by adding a chemical Alum which was made for us out of aluminum cans by the students at the university.
We are not going to boil water today as that can take some time and with all of us boiling our own pots of water it will get very hot!
We are going to talk about what we saw and which techniques are best for which type of contaminant."

During this presentation in Pasto, interactive posters were used to allow students to engage with the information and visually see which methods removed which contaminants. The poster templates used are attached as **Appendix B.**

Detailed Procedure

After students had been introduced to the principles of water purification and varying methods, the hands-on experiment was performed. Detailed instructions for the teacher can be seen below.

1. Split students up into groups of 3-4
2. Prepare the workspace by laying down plastic on the table (plastic trash bags work great) to allow for easy cleanup later
3. Give 2 small cups to each child and place an assembled 2-liter filter (prepared as described in III. Materials) to each group
4. Distribute 2 cups to each child. One cup is filled with clean water which they will make “dirty” using food coloring, Styrofoam, and plastic bugs. One cup should remain empty to catch the water coming through the filter.
5. Instruct students to take turns slowly pouring their “dirty water” through the filter, catching the clean water at the bottom of the filter.
6. If time allows after all students have used the filter, the instructor can come around and carefully dump out the filter so that students can investigate at which point in the filter different materials were stopped.

Follow-up

The class was then lead through a short concluding discussion to solidify the key learning outcomes. The poster templates can be seen in **Appendix B**. A script of the discussion can be seen below.

> "Raise your hand if your water looks cleaner now than it did before you put it through the filter? Now that we've seen our filter in action, we are going to discuss which sections of the filter removed which contaminants.
>
> What got filtered out in the rocks? (plastic bugs, large Styrofoam)
>
> Did anything get filtered out in the sand? (small Styrofoam)
>
> What about in the cotton balls? Were any particles removed in this final layer? (food coloring)
>
> Now we've seen with our own eyes how water can be made cleaner through filtration! This principle is used all over the world to turn dirty water into clean water that people can drink safely. Remember that the other techniques that we talked about – boiling and chemical additives – are also used depending on what contaminants you want to remove."

In Pasto, previous work with a University-level experiment resulted in the addition of an Alum demonstration at the end of this experiment. Alum is a popular coagulant utilized in the water treatment process.

V. Conclusion

This experiment engages students ages 7-11 in an interactive and fun way as they learn about the importance of clean water and some of the purification techniques that are widely used around the world. This experiment is also highly adaptable and can be simplified or made more complex as the student's age range changes. Basic principles of chemistry and physics were solidified through conversations surrounding particle size and its ability to travel through different layers.