Bringing Water Quality into the Eighth Grade Science Classroom

***Richard Forehand*[1] *Beth A. Todd*[2] *Pauline Johnson*[3]**

Abstract – Multi-step equations can be a challenge in teaching eighth grade math as students often do not see the real world applications of these mathematical tools. A clean water and aging infrastructures project is underway in three counties in rural Alabama including the setting of our GK-12 project where STEM graduate students take their work into K-12 classrooms. A scenario from this project was used as an activity in eighth grade mathematics to show how the solution of equations can be used in the real world. Students were asked to consider a community of six houses with different sized families connected to a water tank. They discussed ways water is used and developed an estimate of average daily water consumption per person. Then students were asked to design an adequate tank to meet the needs of this community and evaluated water quality by finding pH of water in the school.

Keywords: water quality, aging infrastructure

INTRODUCTION

Operation and maintenance problems in piped drinking water systems can be detrimental to the water quality in households and negatively impact public health [1]. Rural systems may be particularly susceptible to problems as infrastructure ages [2] and have been linked to a disproportionate number of disease outbreaks [3]. There are approximately 50,000 rural water supply systems in the United States, so challenges to small water system infrastructure sustainability have significant public health implications. Domestic investment in water supply infrastructure is currently insufficient to meet ongoing needs for maintenance and expansion [4], which may lead to increasing failures [5,6].

Figure 1. Alabama's Blackbelt region in gray. Studied counties in blue.

An EPA Science to Achieve Results (EPA-STAR) funded a study of 900 households in 14 rural water systems over three counties in Alabama. It is being performed by researchers at the University of Alabama. Figure 1 shows the study area. The households are located in Hale, Sumter, and Wilcox Counties. The Alabama Department of Public Health (ADPH), local non-profit organizations, water utilities and a UA pilot study documented problems with water quality and aging infrastructure in the past. However, the systematic collection and analysis of a large data set not been performed to date. Problems with water quality in the area have normally been attributed to failing or non-existing septic systems [2]. In the Blackbelt area, failing septic systems are not uncommon. In the Blackbelt, the deep Selma Chalk that is typical in the area has a very low infiltration or "perc" rate which makes local piped water systems more susceptible to contamination through infiltration due to leaking pipes, low pressures, service disruptions, and other problems [7].

[1] University of Alabama, Box 870205, Tuscaloosa, AL 35487-0205, rwforehand@crimson.ua.edu

[2] University of Alabama, Box 870276, Tuscaloosa, AL 35487-0276, btodd.eng@gmail.com

[3] University of Alabama, Box 870205, Tuscaloosa, AL 35487-0205, paulinej@eng.ua.edu

The following modules aim to engage students in real problems presented to environmental engineers.

DRINKING WATER INFRASTRUCTURE MODULE

Purpose of Drinking Water Infrastructure Modules

Through the National Science Foundation GK-12 program, a number of engineering and math graduate students at the University of Alabama work with mathematics and science teachers at Sumter County schools by presenting and developing projects that aid in the understanding of their current topics as it relates to the graduate student's research. These modules were developed to help middle school students become more familiar with pertinent topics in the research of their graduate fellow and develop skills in the area of engineering design. These lessons were also intended to help students better understand concepts in their curriculum, such as solving multi-step equations, graphing, supply/demand, and using math as a tool to solve real problems in engineering design. These modules were designed to be completed in one (or two) fifty minute lecture periods. They incorporate problems faced by environmental engineers in areas such as the Blackbelt. First, systems must be designed to meet the needs of community members. Second, these systems must be maintained by implementing regular assessments such as pH measurements.

MODULE 1

Materials

No materials are required for this module.

Pre-Activity

1) With the students, discuss the different ways that they use water on a daily basis.
2) Within their groups, have the students estimate how much water they use on a daily basis.
3) Guide the students through the types of infrastructure that comprise a drinking water system such as treatment plants, storage tanks, pipes, and finally access points at households.
4) Introduce the students to the simple system shown in the figure below that consists of one water tank and six households.

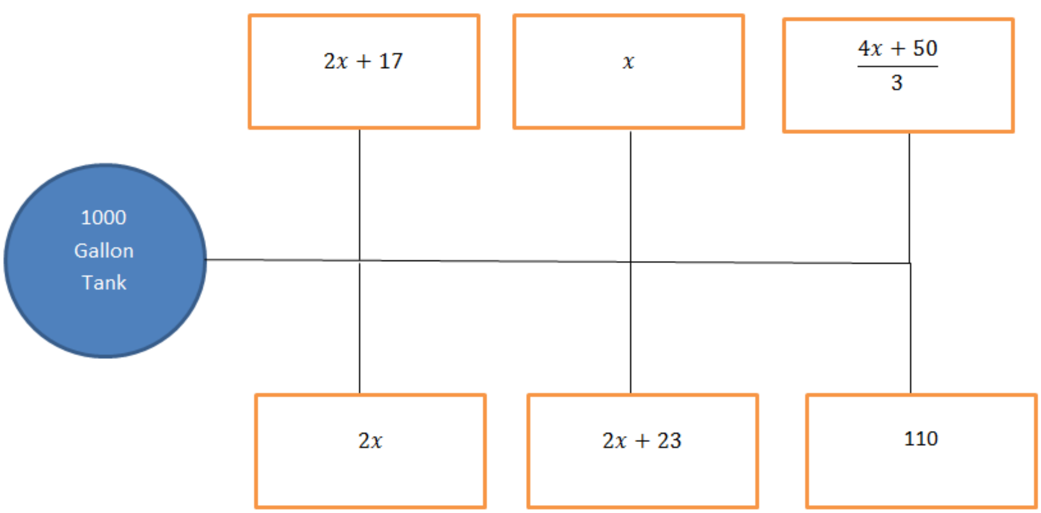

Figure 2. Set amount of water in tank with equations for household consumption

Activity

1) Show that the tank is filled with 1000 gallons of water, and fill in the households with different equations.
2) Have the students decide how much water each household uses from the equations in the households of figure 2.
3) Now that the students were introduced to the system, slightly change the problem to figure 3 by asking them to design how much water the tank should hold based on a given number of people in each household and their estimates for daily water consumption at the beginning of class.

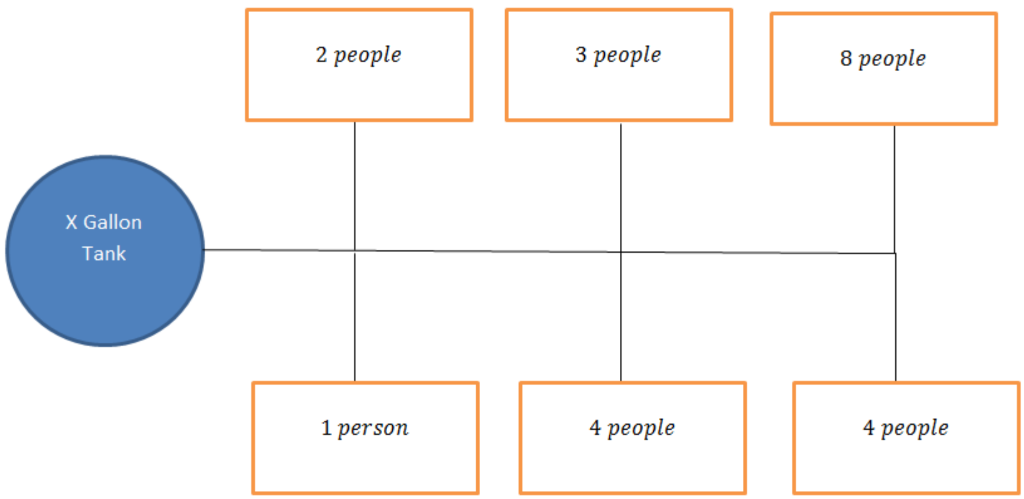

Figure 3. Designing tank to meet the needs of the households

4) Have a representative from each group record on the board how much water they think the designed tank should hold.

Post-Activity Lesson

1) Compare the results of the different groups.
2) Compare the results to the result obtained with the typical design demand of 100 gallons per day per person.
3) Discuss how systems are designed to meet the needs of people rather than selecting a random tank size and hoping it is sufficient to meet the needs of the consumers.
4) Ask the students about sources of water, and discuss how most of the water in the world is not potable.

MODULE 2

Materials (per group)

1) pH strips or pH meter
2) 200 mL beaker with sample of water
3) funnel
4) one additive or filter (e.g lime, vinegar, salt, filter paper)

Preparation

1) Take water samples from different locations for each group. (Water fountain, bathroom sink, outside spigot, etc)
2) Bring electronic pH meter or pH strips to classroom.

Procedure

1) The samples of tap water will be drawn from the faucets before the students arrive in the classroom.
2) Demonstrate the use of the pH strips or pH meter at the front of the classroom.
3) The groups will then test the pH of their samples and record results and observations on their data sheets.
4) After the samples have been tested once, the students will then filter or add one of the available chemicals to the sample. Then, they will perform the pH test again. They will record their results and observations on their data sheets.

Post-Activity Lesson

1) Compare the results between the groups and discuss how pH and other water quality parameters affect drinking water and drinking water infrastructure.
2) Discuss how the second process affected the pH of the samples.
3) Graph the results of the different samples before and after the secondary process. An example graph can be seen in figure 4.

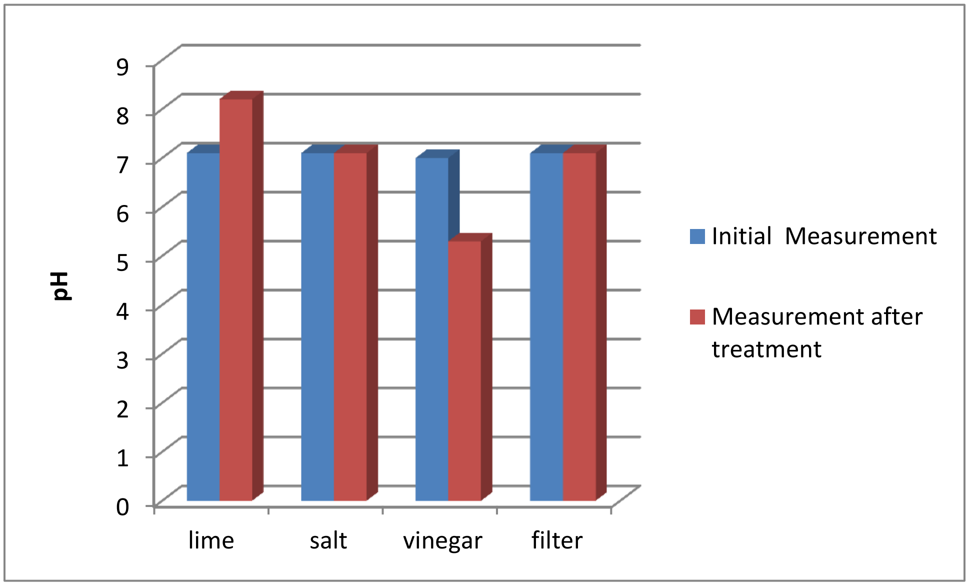

Figure 4. pH of water before and after treatment

4) Map the locations of the samples and attempt to correlate relationships between the location of the sample with the outcome of the pH test.

STUDENT REACTION AND LEARNING

Students reacted to both modules positively as a whole. The pre-activity lessons set the stage by explaining the importance of drinking water infrastructure in the United States and focused on trying to make the students feel like they were doing something important to help people instead of doing another activity that does not make a difference in the world. The students were actively engaged in the lessons and the activities. Each activity was short enough (approximately 30 minutes each) to keep the student attention but long enough to explain the importance of engineering design and water quality. The modules were split into two separate class periods. The first module introduced an application to reinforce solving multi-step equations and helped students visualize that the equations actually had meaning.

The students designed tanks widely varied in size, but many students were excited that they designed a tank for a community. Students seemed to pick up on the reference of supply/demand as it relates to equations. The students stated that equations make more sense when used in practical situations.

In the second module, the students tended to be distracted by the materials in front of them, so the materials were not distributed until it was time to begin the measurement procedure. The second module opened up the opportunity for students to learn about the capabilities of Microsoft Excel. After some classroom discussion on what type of graph would be the most suitable graph for the exercise, one girl suggested bar graphs. While the students did not know how to make the graph using Excel, the teacher created the graph based off of their input of what it should look like.

CONCLUSION

These modules proved to be successful in introducing basic principles in engineering design. They also helped reinforce the concepts of equations and graphing within the math curriculum. These concepts can be elusive to many middle school students, but students seemed to grasp them better within the context of engineering. These modules help students understand ideas from the broad field of science, technology, engineering, and mathematics. They may have even planted an idea for the students to consider careers in a STEM field because of the opportunity to relate mathematics to local issues and experience solving problems that benefit their community.

ACKNOWLEDGEMENTS

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Rick Forehand

Mr. Forehand is from Nashville, Tennessee. He has a B.S. in Mechanical Engineering from Lipscomb University and is pursuing his M.S. and Ph.D. in Environmental Engineering at the University of Alabama. He is interested in the effects of aging infrastructure in small, rural water systems on water quality.

Dr. Beth Todd

Dr. Todd is currently an Associate Professor and the Undergraduate Program Coordinator for the Mechanical Engineering Department at The University of Alabama. She is also the principal investigator for the University of Alabama's NSF GK-12 program. She has a B.S. in Engineering Science from Pennsylvania State University and has a M.S. in Applied Mechanics and a Ph.D.in Mechanical & Aerospace Engineering from the University of Virginia. Dr. Todd's research deals with applying principles of mechanical engineering design to problems of the human body. This includes both the design and analysis of devices, particularly assistive technology, and the study of the body itself as a mechanism.

Dr. Pauline Johnson

Dr. Johnson is a professor of civil, construction and environmental engineering at the University of Alabama. She received her bachelor's degree from Salford University in England and her doctoral degree from Queens University in Northern Ireland. Johnson's teaching and research interests are in the areas of alternative water and wastewater treatment systems and green building. She is currently co-principal investigator on two National Science Foundation projects – NSF-GK12 (Sustainable Energy) and NSF-Research Experience for Undergraduates (Grand Challenges). She is also a principal investigator on an EPA funded project that is examining water infrastructure sustainability in Alabama's Black Belt.