Fire Innovations

Objectives

The students will:

- Develop a prototype of a tool that uses air movement to extinguish a fire.
- Use technology to customize a fire alarm.
- Develop a practical, functional, compact, and efficient scale model of an aerial ladder.
- Observe physical and chemical properties of different elements.
- Develop a procedure to make an effective product.
- Develop a plan to test products in order to make them more efficient
- Develop new products by improving current products Explore strategical thinking process
- Analyze advantages and disadvantages aspects of a given situation
- Explore engineering principals

Standards

SEP 1	MP 2	5-PS1-3	CCSS.MD.A.2
SEP 2	MP 4	MS-ETS1-1	5-PS1-4
MS-ETS1-2	RI.5.7	SEP 3	MP 5
SEP 4	MP 6	4-PS3-1	RI.5.10
SEP 5	MP 7	4-PS3-2	SL.4-5
SEP 6	4-PS3-4	W.3.1	CCSS.MD.A.1
SEP 7	5-PS1-2	W.6.1	

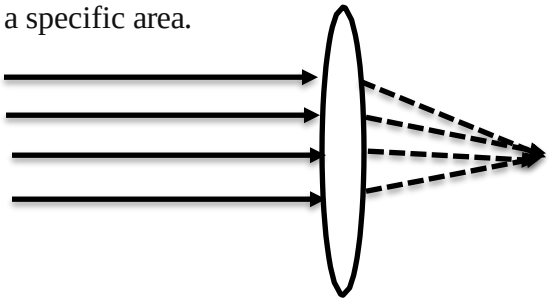
Background

Have you noticed some similar signs in your classroom or by the elevators in schools, library, movie theaters, train stations, airplanes, and many more places in your community? All these places share one common goal, which is “Safety”. All of these places will display posters or signs indicating what to do in case of an emergency or who to contact. Some other places will actually perform emergency drills or practices to ensure that everything is up-to-date to ensure the safety of their visitors, personnel, students, or community members. Technology is

improving every day. We have better phones, better cars, better homes, and better food. However, fire science technology is not as innovative as a medical or engineering field. Numerous universities offer bachelor degrees, master degrees, and even PHD's in fire science. Unfortunately, not many firefighters go for the engineering, chemistry, or physics aspect of the fire science. Think about the title of this curriculum "Fighting Fire with STEM", this curriculum focuses on the STEM (science, technology, engineering, and mathematics) behind the fire. One of the primary goals of the curriculum is to demonstrate to the students how important is STEM in the study of fire safety. Students need to understand how elements work and behave in nature in order to control nature and create applications for those elements. Our students today, could be our engineers of tomorrow, developing new fire science cutting edge protocols or apparatus to save more lives than now.

During this unit students will be exposed to four activities each one of them will introduce a new fire science innovation.

The first innovation is the Instant Fire Suppression System (IFSS). This innovation is coming from Proffesor Bae, Myung-Jin, the director of the Sori Sound Engineering Research Institute part of Soongsil University in South Korea. Professor Myung-Jin developed a fire extinguisher based on the ability to control low frequency sound waves to put out fire. This is not a new concept, in 2012, the American National Institute of Science demonstrated that fire could be put out by using a tube to amplify the sound waves coming out of a speaker. In theory, it is a simple principal that sound waves cause the air to move, therefore the oxygen molecules in the air vibrate and separate from each other creating gaps between them. As a result, the fire becomes weak just enough for the fire to cool down. At the end, the oxygen molecules from air will be totally blocked from the fire that extinguished it. Unfortunately, the American National Institute of Science did not finish the development of this concept. However, this demonstration inspired more entrepreneurs to develop similar prototypes with better practical applications. For example, professor Myung-Jin improved the concept of the sound wave fire extinguisher by adding a convex lens idea to help the sound waves focus on a specific area.



As much as 100 Hz of sound power is created by the sound wave fire extinguisher (normal for a human to hear is 20 Hz). This is enough for the fire to extinguish using sound waves. It weighs 1.5 kilograms making it very practical for the home or any other place.

The second innovation is the Fire Alarm Sound System. Fire alarms have been around since 1852, in Boston, Massachusetts. The fire alarm systems have used many contributions from innovative technology keeping it more up to speed with the necessity of the community members. Now a days, there are alarm systems that work independently providing more reliability and safety for the users. Moreover, the new concept of fire alarms include smart alarms providing specific information about where the fire is located and how it is spread for the individuals to have a better chance to escape the fire. Also, smart fire alarms are linked to the user cellphone keeping an open communication channel with the user even if the user is not at the place. The company, "First Alert" is one of the main innovating American companies, which creates and tests materials, apparatus, and procedures to ensure that the product is reliable and genuine according to the manufacture's specifications. In other words, First Alert is the FDA of fire safety. Smart fire alarm systems include: smoke alarms, CO_2 alarms, independent thermostat systems, and many more innovations that are great features to ensure our safety. **However, in order for individuals to take advantage of these systems they need to hear them first.** Sadly, individuals are having a hard time recognizing what is real versus just another sound at home or at school. Our life is full of sounds such as microwaves, cellphones, video games, TV, beepings inside the car, fire alarms, tornado alarms, and many more sounds, ignoring the sound of a real emergency because everything sounds the same.

The third activity will be the Foam Suppression System (FSS) or Self-Expanding Foam System (SEFS). There are two main reasons why fire science have been looking for alternatives for the water usage in dealing with fire. Reason number one, is that water is not as accessible to the community anymore in places like California, Texas, Arizona, and even Chicago and New York; water is limited. The water store for emergencies is not yet a problem, but it still must be replenished for the next emergency. The second reason is that the water usage on fires damage the private property while controlling the fire. Unfortunately, in many cases if the fire is on the third floor and water is used to control the fire more than likely, water damage will be made to the first and second floor. The FSS or SEFS is a very reliable alternative for the water usage in a fire event. The fire foam is a thick layer of a stable mass of small air filled bubbles with a very low density (less than water, oil, or gasoline). The fire foam is created by combining three elements: water, air, and foam concentrate. The key ingredient is finding the correct proportion in order to create a foam homogeneous blanket or layer that will self-cover the fire blocking the oxygen from the air and extinguishing the fire. One of the main features of the fire foam is that it is not toxic and it will be broken down for the soil to observe. The FSS or SEFS is being used primarily in wild fires and oil fires because it can cover a large area at once because it will spread over the fire. Additionally, most of the regular fire extinguishers have the fire foam available. However, water will still be the number one choice for regular community fires, and the hydrants are the number one source of water supply.

Fighting Fire with STEM

Inquiry Overview

Students will explore the mechanism of the instant fire suppression system by creating a model demonstrating how to control and manipulate waves in order to push the air around them.

Suggested Inquiry Approach

Students will be presented to background information about the instant fire suppression system from the student pages providing some key elements for them to build their model.

Activity One ***Instant Fire Suppression System.***

Work in Pairs

Estimated Time: 180 minutes

Introduction: 10 min.
Model assemble: 40 min.
Model examination: 10 min.
Model design #1: 40 min.
Model test #1: 30 min.
Model redesign #2: 20 min.
Model test #2: 20 min.
Debrief: 10 min.

Materials

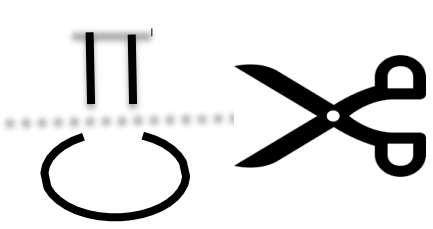
Activity #1 for each pair of students:

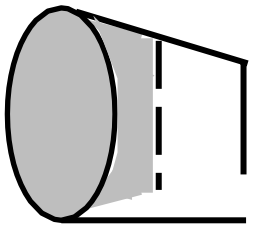
- Balloons
- Plastic Cups (with hole at the bottom)
- Masking Tape
- Scissors
- Ruler
- Paper

After the background information and the introduction to the model students will build the model using the materials provided by the teacher.

The reason why every team is using the same model is just to keep the main model's mechanism the same. The first step for the building of the model is to cut the balloon somewhere at the bottom of the neck just to make it easier when the students insert the balloon over the cup. Then the students will place the balloon over the open side of the cup. It does not have to be extremely tight. Next, ask the students to secure the balloon to the cup by using masking tape.

NOTE: advise the students to be careful with the cup because if they apply too much force the cup will bend or break.

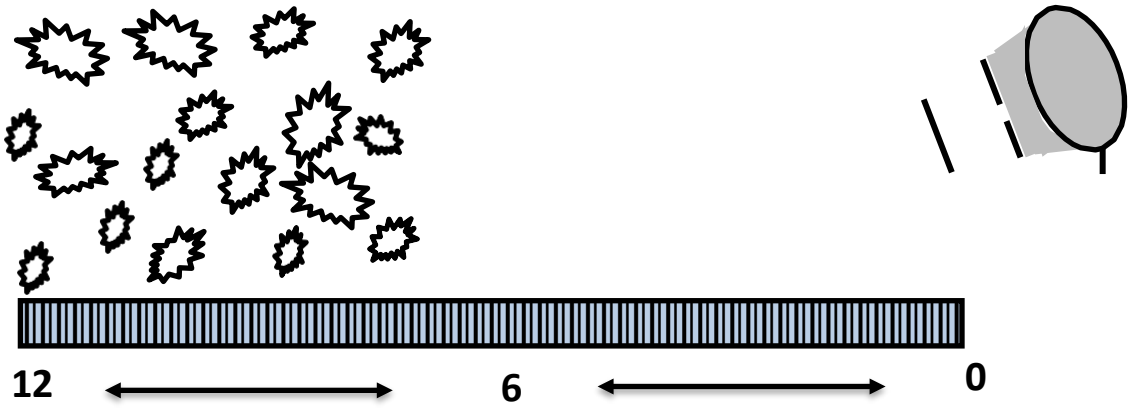




After the model is done allow some time for the students to analyze the model and find out how it works. Remind students to focus on the model's mechanism.

For the next part of the activity, students will have the challenge to adjust their prototype, add more elements to it or create a new one with the goal of being able to move 20 pieces of paper at 6 inches in the least amount of time. STUDENTS ARE ALLOWED TO CHANGE THE DIMENSION OF THE HOLE LOCATED AT THE BOTTOM OF THE CUP ACCORDING TO THEIR DESIGN.

The model must be 6 inches away from the paper at all times.



Students will have the chance to test their models before the main test stage. The main test stage will take place in front of the class. Every team will test the model's performance in front of the class. After that, students will have a chance to improve or redesign their models before retesting. Advise the students to make sure they write down what worked and what did not work for every trial to create a log throughout the activity. There are two main variables with the model. The first one is the strength of the balloon and how it effects the impact of the waves on the paper. The second one is the hole at the bottom of the cup because it changes the range of waves leaving the cup. There are other variables as well but these are the main two.

Debrief

Ask the students to have a class discussion about their model's performance and its connection to the real research. This is the link of the real model it is optional for the teacher if they want to show the students the real prototype as well as its inventor. If the teacher is showing the video please ask the students to write down how would they take it to the next step, meaning how would they adjust it to make it better for commercial use?

https://www.youtube.com/watch?v=VhLOskCdM10

Suggested Inquiry Approach

Students will be exploring how to create their personal fire alarm sound system by applying their own voice and emergency sounds into an alarm system to alert the students at their school as well as their family members.

Activity two ***Fire Alarm Sound System.***

Work in Pairs

Estimated Time: 180 minutes

Introduction: 10 min.
Popular sound analysis: 20 min.
Sound system creation #1: 50 min.
Sound system presentation #1: 20 min.
Sound system creation #2: 50 min.
Sound system presentation #2: 20 min.
Debrief: 10 min.

Materials

Activity #2 for each pair of students:

- Computer with internet access
- Microphone
- Headphones

Students will start the activity by hearing some popular sounds providing a possible source of the sound as well as a description of the sound. The reason for the identification of these sounds is to introduce the fact that when students are so used to some sounds they are more than likely to ignore the sound because it is not relevant to them anymore. After every sound, allow a couple of minutes for the students to write down their guess on the table provided in the student pages. At the end of the ten sounds go back and provide the answer to the students to see if their guess was correct. There is a Power Point presentation included providing the sounds and the answer for the students to see.

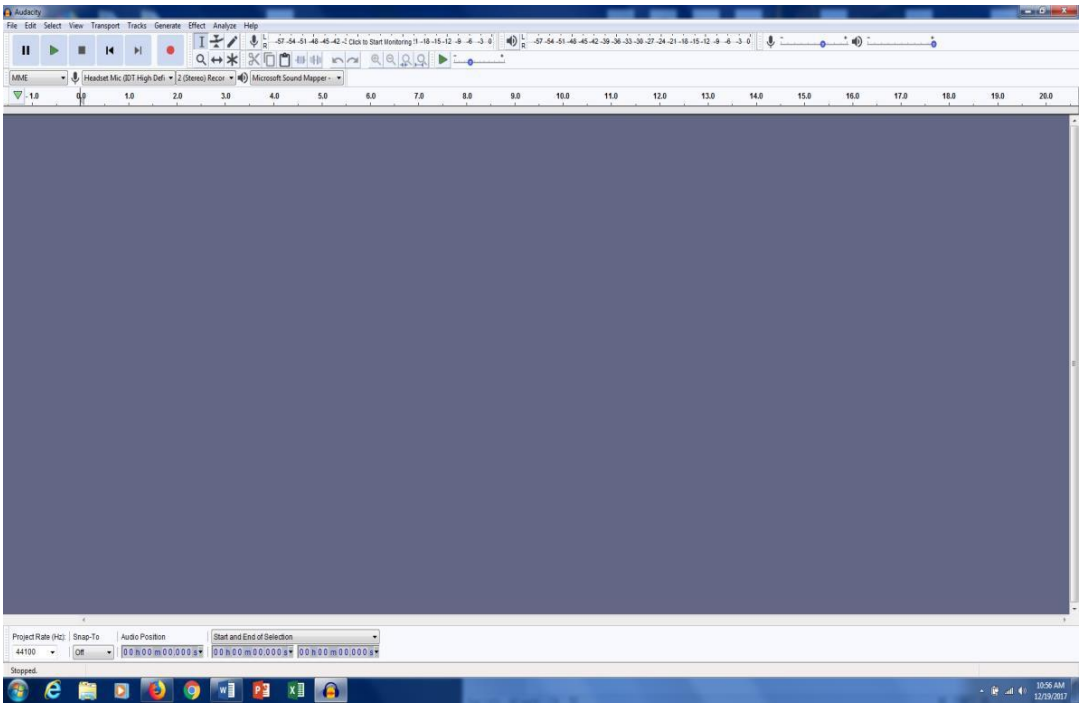
For the next part of the activity the students will be using a recording software called "Audacity". This is a very safe web based program for the students to use. The only disadvantage is that it has to be downloaded in the computer. On the other hand, many schools already have this program built into their computer labs. In case the school does not have "Audacity" built in, here are the steps to follow in order to install it:

1. Go to http://www.audacityteam.org/
2. Click on Download Audacity 2.2.1 sign.
3. Click on your operating system either Windows or Mac OS (if you are not sure ask your teacher).
4. Click on Download Audacity Windows Installer - 23.25 MB | version: 2.2.1 | SHA256 signature or Download Audacity macOs DMG - 31.13 MB | version: 2.2.1 | SHA256 signature according to your operating system either Windows or Mac.
5. Click Run and follow the steps to complete the download of the program into your

computer.

6. Ask your classmates or your teacher if you are having difficulties downloading the program.

7. After the installation is complete, open the audacity program.



8. Plug in your microphone and headphones into your computer and complete the set up if necessary.

When all the set-up is done students are ready to create their personal recordings for them to alert the school in case of a fire. The students will record two different alarm sounds, one for their school and one for their home. The key component is to personalize the recording by thinking on a unique way to address the specific group of people in order for them to know that this is not another drill or another sound system. They must know that this is real. At the end of each recording students will present their recording to the class explaining their reasoning behind it and explaining what unique elements they focused on.

The program has numerous features that could be a little complicated for the students. However, as long as they are familiar with the following features they will be fine:

- Click the red dot button to record whatever you need by using your microphone.
- Click on the black square button to stop the recording.
- Click on the tracks tap, then click add new, then click on stereo track to record a second sound or voice. You can have numerous tracks on the same page but just for now keep it between 3 and 4 tracks.
- You can merge the tracks, cut and paste, alter the tone, and volume by exploring the different tabs on the top of the page.

The easiest way for students to record sounds is to use a cell phone or another computer as a sound producer and record it into the computer with the audacity program or they can just merge audio files into the audacity program as well. Provide plenty of time for the students to create their recordings. AS ALWAYS ADVISE THE STUDENTS TO BE PROFFESIONAL AND RESPONSIBLE, AVOID ANY BAD LANGUAGE OR MISLEADING INFORMATION.

Debrief

- Why do you think people react differently to information coming from a familiar source? And have you experienced something like that?
- How would you implement the fire alarm sound system for your town?
- How would you implement the fire alarm sound system for someone who speaks a different language? Is there a universal language that you can use?

Suggested Inquiry Approach

Students will explore different chemical reactions to find the most efficient composition for the fire foam to spread across an area reaching the fire location. They will compare ratios and proportions through the activity performing a series of experiments. At the end, they will present their findings to the rest of the class.

Activity Four ***Foam Suppression System (FSS) or Self-Expanding Foam System (SEFS).***

Work in Pairs

Estimated Time:

Introduction: 10 min.
Procedure test #1: 40 min.
Fire foam test #1: 20 min.
Procedure test #2: 40 min.
Fire foam test #2: 20 min.
Procedure test #3: 40 min.
Fire foam test #3: 20 min.
Fire foam presentation: 30 min.
Debrief: 20 min.

Materials

Activity #4 for each Pair of Students:

- Hydrogen peroxide
- Dishwashing soap
- Aluminum tray
- Food coloring
- Dry erase markers
- Yeast
- Water
- Plastic Cups
- Measuring cup (medicine cup)
- Spoons
- Foam suppression system tester template
- Foam suppression system analysis template

Students will start the activity by reading the background information statement providing basic knowledge about the fire foam such as its behavior and purpose.

Later on, students will be presented with the challenge of creating the most efficient fire foam (FSS) or (SEFS). Ask students to have a conversation about what "efficient" means. Remind the students that the consistency of the fire foam must be thick enough for it to be able to spread across a specific area. It should also research for the fire location creating a foam blanket-like-layer over the entire fire area.

Next, students will follow a set of instructions to set up a series of experiments in order to find the most efficient combination of elements for their fire foam. Two variables will be active at all times, these variables are water and hydrogen peroxide. It is very important for students to take good notes so they can use them as guidance for the following experiment. Explain to the students that this is not a trial error experiment. They must follow a sequential, logical, and strategical process in order to find the most efficient fire foam.

Fighting Fire with STEM

NOTE: THE COMBINATION OF ELEMENTS WITHOUT THE PROPER PROCEDURE WILL CREATE A BIG MESS OVER THE FLOOR OR THE TABLE. HOWEVER, IT IS JUST WATER AND AIR BUBBLES NOTHING TO BE CONCERNED ABOUT.

The experiment set-up will be as follows:

1. Label one of the plastic cups with a number 1 and cut a "V" shape perforation of about 1 inch on it.
2. Place between 75 mL and 125 ml of hydrogen peroxide in it. Write the amount of hydrogen peroxide you decided to choose _____ml.
3. Add 20 mL of dishwashing soap to cup number 1.
4. Add some food coloring to cup number 1.

Cup #1 Observations	
Substance	**Observation**
Hydrogen peroxide H2O2	
H2O2 + Soap	
H2O2 + Soap + Food coloring	

5. Label another plastic cup with a number 2 and place 7 grams of yeast in it.
6. Add between 55 mL and 65 ml of water to cup number 2. Write the amount of water you decided to choose _____ml.

Cup #2 Observations	
Substance	**Observation**
Yeast	
Yeast + water	

7. Mix the element in cup number 2 with a spoon.
8. Place cup number 1 over the yellow circle on the foam suppression system tester template pointing the "V" cup to the fire picture.
9. Pour cup number 2 into cup number 1.

Cup #1 + Cup #2 Observations	
Substance	**Observation**
Cup #1 + Cup #2	

Students will have charts available at specific points of the experiment for them to make observations about the chemical reaction if any when combining elements. One of the main goals for this activity is for the students to identify the different parts of a chemical reaction such as reagent (a substance or compound added to the system to produce a chemical reaction), catalyst (a substance that increases the rate of a chemical reaction), reactants (elements or substance that are taking place in a chemical reaction), and product (the resultant of a chemical reaction).

Students will perform three different experiments using different ratios of water and hydrogen peroxide. There is enough material for every team to perform more than three experiments if necessary. Make sure students are taking proper data so they put together their final presentation.

After each experiment students will analyze the distance and shape of the foam on the tester template. They will count the number of squares the foam traveled and the shape it took. Teacher will model a couple of points for the class. Start by counting column "A" from the edge of the template (by the fire) to the foam. Then, transfer that information to the analysis template by placing a mark by the square "A 10" for example. Repeat this process for all the columns until the foam's shape is completed. Students will end up with three curves one for each experiment.

Ask the students to find a relationship between the foam's shape and the amount of reactants they used for each experiment.

The final presentation will take place at the end of the experiments. Students will present their findings explaining their reasoning thought process to the rest of the class.

There is a very interesting video about the actual test for the foam suppression system made in Germany. Have a class discussion after the video.

https://www.youtube.com/watch?v=OxLPvNdv2t4

Debrief

- **How would you implement the FSS in an oil spill over the ocean?**
- **How would you implement the FSS in the automobile industry?**
- **How would you implement the FSS in the camping/outdoor industry to prevent forest fires?**
- **What is the main disadvantage, if any, about the FSS?**