Community in the Classroom Presentation Plan

Lesson Name THE RACE TO EFFICENT AND CLEAN TRANSPORTATION FUEL

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Grade Level 5 **Standards Connection(s)** Physical Science: All matter is made of atoms, properties of some common molecules used in energy storage

Teaser:

We will discuss a wide range of fuels (including future technologies) for powering transportation. Each fuel (gasoline, batteries, hydrogen gas) will be introduced with hands-on activities. After learning the advantages and disadvantages of each technology, students will have the opportunity to pick a fuel and 'race across the Bay Bridge'.

Vocabulary/Definitions:

Atom – basic unit of matter
Compound – a substance made of atoms held together by chemical bonds
Chemical Bond – the 'glue' that binds atoms together, forming compounds
Fossil fuel – a fuel produced by natural resources, typically the decomposition of dead organisms
Combustion – the process by which something is burned, releasing heat and sometimes water and carbon dioxide (pollution)
Density – the amount of a material per volume
Energy Density – the amount of energy that can be produced by a particular mass or volume of something
Volume – the amount of space something takes up
Nanoporous – describes something that has extremely small holes or vacant spaces, like a sponge but on a much smaller scale

Materials:

1. 9 V and 1.5 V Battery
2. Two # 2 pencils (sharpened on both ends)
3. Salt
4. Thin cardboard
5. Small glass of water
6. Two pieces of electrical wire
7. Tic-tacks
8. Gummy Bears
9. Balloons
10. Unsalted peanuts
11. Sewing needle + cork
12. Pie pan
13. Test tube filled with distilled water
14. Test tube stand/holder
15. Lighter
16. Thermometer
17. Small light bulb
18. Copper wire
19. Small commercial battery
20. Class worksheet
21. Poster displays for some of the stations (types of energy)

What should students have ready (pencils, paper, scissors)?
Nothing but a writing utensil and inquisitive mind!

Classroom Set-up:

After the introduction the students will need to be split into two groups.

We also need an appropriate space for the final activity, a race among four students (details are below). The classroom is the preferred place (to save time) if it big enough and would be safe. But otherwise the gym or a larger space outside would also work. For the race something heavy and big is also needed that is safe for one student to run with (but should be big enough to significantly slow the student).

Classroom Visit

1. Personal Introduction: 5 Minutes

Who are you? What do you want to share with students and why? How will you connect this with students' interests and experiences?

Tom – I work at UC Berkeley as a post-doctoral researcher. I recently finished a Ph.D. in chemistry to become a scientist. I like to use computers, but for more than just games, I use them to model chemical reactions. I work on a wide range of topics including ways to convert the sun's light into electricity and on how to store hydrogen gas as you will learn about today.

Kelley – I am a sophomore at UC Berkeley studying environmental science; this type of science incorporates aspects of many different sciences such as biology and chemistry with a special focus on the environment around us! I'm interested in a variety of environmental issues, but especially how different types of energy can be used without producing a lot of waste or pollution in the process. The various types of energy that we will be discussing today all have impacts on the world around us, and are definitely worth investigating further!

Topic Introduction: 10 Minutes

What questions will you ask to learn from students? Big Idea(s), vocabulary, assessing prior knowledge…

"Today we are going to learn about four different ways to power transportation. We all know that transportation is important, without it you wouldn't be here today." Ask how the students got to school, and then ask where the energy came from to power the mode of transportation they used. Ask the students to brain storm on all the possible ways we could power transportation. Next focus on how transportation is not just important for moving people, but also moving food, supplies, etc. (About 25% of all the energy used in the US is for transportation). Discuss the definitions of density and energy density. Discuss that the need of energy for transportation is special (compared to the energy needed for industrial or residential uses) since the energy density must be high [exactly lay out exactly why this is the case]. Handout and explain the worksheets, explain the race at the end, and split the students into two groups.

2. Learning Experience(s): 30 Minutes

What will you do, what will kids do? Demonstrations, hands-on activities, images, games, discussion, writing, measuring… Describe in order, including instructions to kids.

Students will be split into two groups. Each group will be given a 15-minute lesson comprised of two parts. The four (five minute) lessons will be on the four potential fuels for transportation.

Battery:
Ask: does anyone know what a battery is or how it works? Introduce the basic concept behind how a battery works by lighting a light bulb through a small commercial battery and wire circuit system [demonstration]. Explain that a battery makes electrical energy from chemicals reacting inside the battery. Electrons, tiny charged particles, need a complete pathway to navigate in order to create electricity that can be used as a source of energy.

Explain that batteries contain a specific amount of stored energy, and that they can be big or small depending on how much energy they need to provide [show photos from poster of different sized batteries, ask what could each battery be used for based upon its size?]. Try to convey that even though batteries can be very big in size and very heavy in weight, their relative output of energy is restricted because the amount of energy produced is dependent

on just the movement of tiny electrons. Also, note that not all of the materials that make up a battery are needed to make energy, but they are needed to safely store the material contained within it.

Since a battery contains a supply of energy that can be used up, what happens after a battery can no longer generate electricity [brief discussion of pollution/negative impacts of batteries on environment]?

Gasoline:
Discuss gasoline, a commonly used fossil fuel, as an energy source. Briefly explain how fossil fuels are made (basically, compression of dead, organic matter – like peanuts! See demonstration - over long periods of time) and as a result, they are non-renewable in the short run. Also possibly discuss how gasoline requires lots of processing between raw and final products. What do we use gasoline for? Compared to other types of energy, gasoline and fossil fuels are the most commonly used because of their high energy density. Lots of energy is contained in the chemical bonds that connect atoms to make up the molecules of gasoline. Since it is a liquid, these molecules are closer together than gaseous molecules are. As a fuel, they are light-weight, relatively easy to store, and burn easily to produce energy.

Burning, also known as combustion, is how fossil fuels release the energy it stores. It breaks chemical bonds to produce water and carbon dioxide (what we breathe out when we exhale). How does this contrast with how batteries work, and the amount of energy they can produce? Demonstrate the energy that can be released through combustion process by burning a peanut (which has a composition that is similar to a fossil fuel), and seeing its effect on the temperature of water held above the flame. Ask: what observations can you make? Does the temperature of the water increase, decrease, or stay the same? Why? How is the energy being used?

However, gasoline produces pollution as direct result of this combustion processes. How does pollution from fossil fuels hurt the environment? Can you think of any examples of pollution you have seen that is related to gasoline?

H_2 gas
Introduce how hydrogen gas can be burned (in a similar fashion to fossil fuels that are used in cars) to produce heat or be used to create electricity. Explain that in contrast to fossil fuels, the burning of hydrogen gas with oxygen produces just water, which does not pollute the environment.

Demonstrate hydrogen production from the electrochemical splitting of water:
Dissolve some salt into the glass of water. Poke the pencils through the cardboard and connect to the battery. Hydrogen evolution will occur on the pencil connected to the positive (cathode) while chlorine gas is evolved at the negative (anode) end of the battery. Explain how electricity is being used to split hydrogen-oxygen bonds in the water to form H2. Talk about how the process is 'energetically expensive'. Demonstrate by trying the same experiment but with a 1.5 V battery.

Finally explain how it is hard to store hydrogen and how much space it takes up. Explain the concept of density and go through examples by discussing the three phases: solid, liquid, and gas.

Hydrogen Storage Device
Reiterate how hydrogen storage is a major problem because hydrogen gas (and gases in general) have such a low density, thus it is hard to pack hydrogen close together. Explain how current research efforts are underway to solve this problem. Discuss using a nanoporous material to condense the molecule. With the students' participation, illustrate with tic-tacs. First make it clear that each tic-tac represents a hydrogen molecule, and that by themselves, they aren't allowed to get near each other. Then have students take tic-tacs and stick as many as they can into a gummy candy. Explain that hydrogen molecules prefer to interact with the gummy candy, thus more can pack closer together. If there is enough time, show some real computer models of these storage devices on a laptop.

3. Wrap-up: Sharing Experiences _____10____ Minutes

Putting the pieces together – how will students share learning, interpret experience, build vocabulary?

In this final exercise the students will choose a technology for transportation: fossil fuels, batteries, pure hydrogen gas, or hydrogen gas condensed in a nanoporus storage device. Students will vote on which technology they believe is the best for crossing the Bay Bridge. Four student volunteers will participate in the race (of approximately ~100 m or whatever space is available). Each student, however, will have a handicap according to the technology

they represent. It is important to explain each handicap so that the students can connect the race to each technology. The student racing with pure hydrogen gas will have to carry a large number of balloons without dropping them. This illustrates that hydrogen gas is light, but because it is a gas and has a low density, it is awkward to transport and concentrate to use as a fuel. The student racing with batteries will have to carry an object that is large and heavy, illustrating that batteries are too heavy and bulky to be practically used in cars (with the current technology, but it's always important to explain that many scientists are working on improving these technologies) The student racing with fossil fuels will carry a small bottle of colored water. This shows that fossil fuels (namely gasoline) are light and easy to carry. Finally, the student representing the hydrogen storage device will have to carry the sponge packed with tic-tacs from section D of the activities. With these handicaps, the students picking fossil fuels and the hydrogen storage device should be evenly matched. However, when the students get halfway across the "Bay Bridge" in the race, the one using fossil fuels will have to pay a toll to since their technology is harmful to the environment. All the other students will be free to cross the bridge without having to stop. This should insure that the student with hydrogen gas storage should win, thus illustrating the advantages and disadvantages of each technology.

4. Connections & Close: 5 Minutes

What else might kids relate this to from their real-life experience? How can they learn more? Thanks and good-bye! Clean-up.

Ask the students what they learned from the race and how this could be applied to current transportation. Ask how they think transportation will change in the future. Explain the results of the race. Emphasize the role of innovation and that future transportation will most likely be powered by a combination of fuels.

At the very end tell the students that if they enjoyed thinking about this problem, it is important for them to take math and science classes when they get older and do well in all of their classes.

TOTAL 60 - 70 Minutes

Follow-up – After Presentation

Suggest students write a letter explaining "How we learned about _____?"
List or attach examples of activities, websites, connections for additional learning.
Attach worksheets, hand-outs, visuals used in classroom presentation.

Ask students to write a letter to the volunteers/CRS explaining what was their favorite fuel and why.

Tell the students that with parents help, they can try the battery and electrochemical splitting of water experiments at home. For the electrochemical splitting of water they can try changing the amount of salt added or changing the voltage of the battery used. These results could be included in the letter to CRS.

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