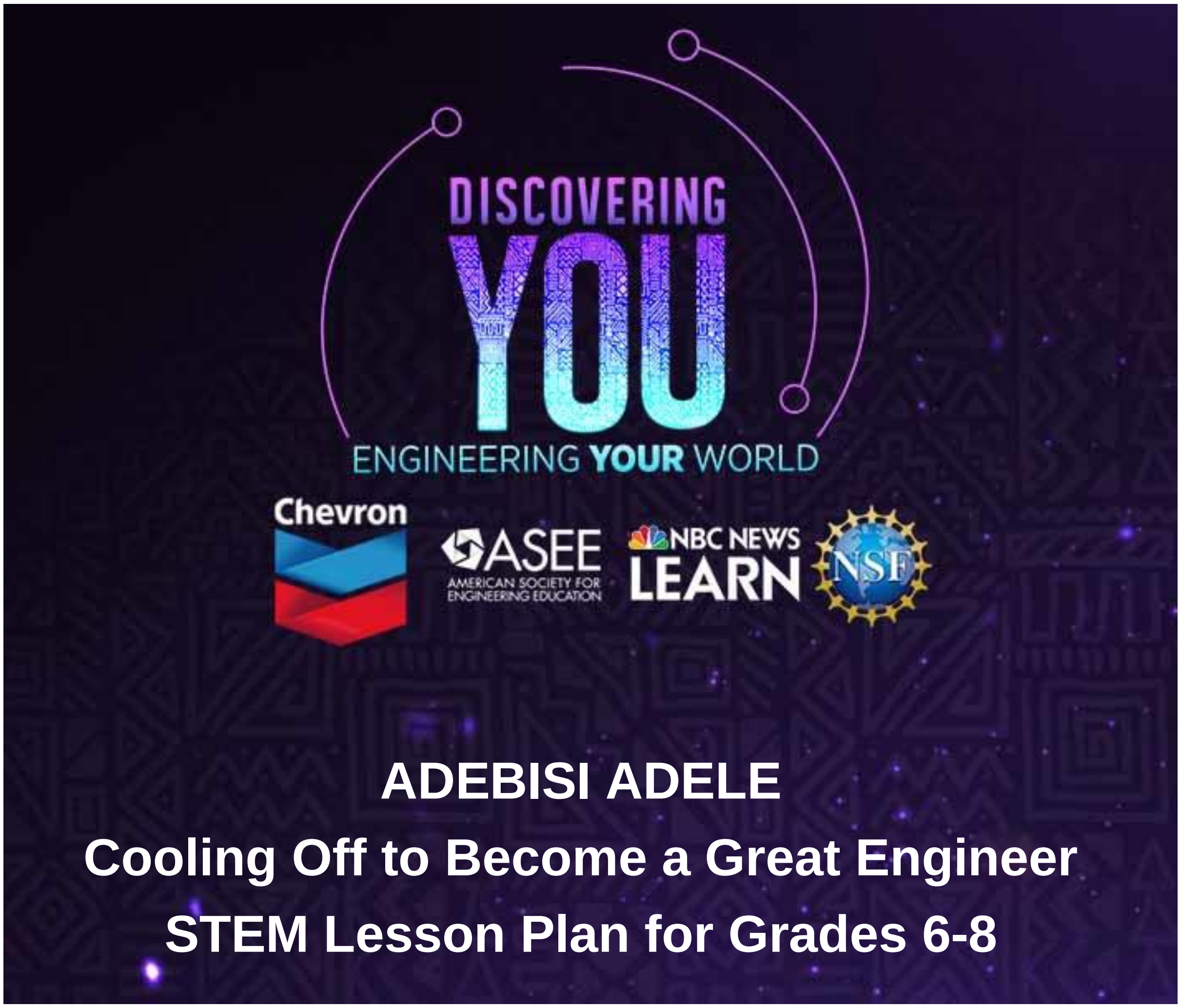


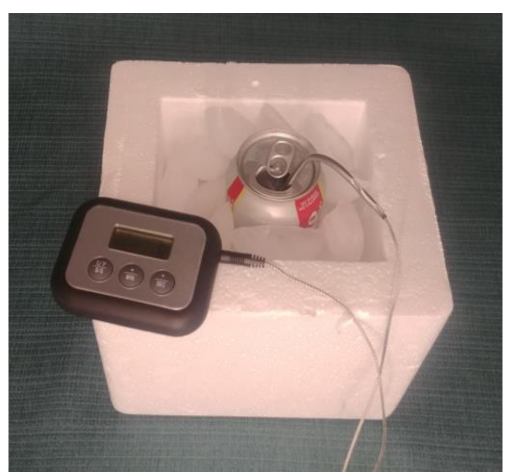
ADEBISI ADELE

Cooling Off to Become a Great Engineer

STEM Lesson Plan for Grades 6-8

NGSS Standards
CCC: Structure and Function
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design

Helping all students, especially underrepresented groups, to be interested in engineering as a possible future can be challenging. Research suggests that role models are important for helping students to see themselves in a jobs where they have been underrepresented. In addition, having challenging and fun engineering experiences help students to want to become engineers.



Many engineering projects though are focused on competitions, but that isn't the essence of engineering. The cycle of determining a problem, identifying what's needed to solve the problem, trying and testing possible solutions, and optimizing and iterating to find an adequate solution is what makes an engineering project.

In this lesson plan, students will watch a video where Adebisi Adele explains how she became a successful engineer. After figuring out what she says are some key factors to being a great engineer, they will investigate an intersection to see if the yellow light is the right length of time. Later they will compare their work with what is accepted in the field. Finally, they will look back at their work habits to determine how closely they matched skills that the engineer suggested were important.

Part I: Watching the Adebisi Adele Video

Before the students watch the video, the teacher should explain that in this video an engineer will explain what makes her a successful engineer. The teacher should ask students to record what personality traits, desires, and behaviors are important to becoming an engineer.

For younger students, you may need to use sentence starters like

Adebisi Adele said that she had to overcome the obstacles of _________

Adebisi Adele said that she wants to _______

The video has on-screen icons that will help students when she is saying key components of her success. For some students, pausing the video at those moments will help them better record what is going on.

In small groups have the students summarize what they saw and then make sure that the entire class has all of the points. While they may have more than these, they should at least note:

- Adebisi Adele succeeded as an engineer because she was put on the right career track.
- Adebisi Adele loves engineering because she gets to be creative.
- Adebisi Adele succeeded as an engineer because of teamwork.

Making a Great Engineer Checklist

Students now should now make a checklist of things for themselves to do if they want to be a good engineer. Then when they do something on the checklist, they should mark it off. For example

Activity	
I helped someone	𝍸 |
I didn't give up when something didn't go	𝍸 |||

the way I planned	

Students will use this checklist several times in the following projects. Don't assign points or give too much praise, otherwise students will just game the system. We just want them noting when they are doing something a good engineer does, helping them to internalize that they can be an engineer. Alternatively, you can make it the task of one of the members of the group to note when their groupmates are being good engineers.

Part II: Engineering Cycle

Designing a modern heat exchanger is perhaps too complicated for a secondary school project, but figuring out ways to move heat from one material to another is well within the wheelhouse or most students.

Materials

- 12 ounce (350 mL) can of diet soda or water
- 12 ounce (350 mL) plastic bottle of diet soda or water
- Soda can lid (optional) or plastic wrap and rubber band
- Ice
- Salt
- Sugar
- Aluminum foil
- Small spoon or other stirrer
- Insulated or polystyrene cup or small ice chest

Characterizing

Ask students to explain how they get drinks (water, soda, juice, etc.) cold. Many will note, of course, that many drinks can be purchased already cold (refrigerated or on ice) from the store, but help them consider how they get drinks cold if they are already at room temperature. You may wish to note their answers on the board.

Have the students come up with some pros and cons of each method. Some common answers include

Method	**Pros**	**Cons**
Refrigerator	Easy	Very slow
Freezer	Faster than fridge	Can freeze or explode the drink Still kind of slow
Add ice to the drink	Very fast	Hard to put in a bottle

		Dilutes the drink Makes sodas foam Requires having ice
Putting the drink on ice	Medium speed	Requires having ice Needs a bottle

Ask students to determine a protocol for determining how fast these methods work. For example, they might suggest that a student open a soda and measure its temperature before it is put on an excess of ice. After being put on ice, the temperature is recorded every two minutes until its temperature levels off. Another group might add ice to a bottle measuring the temperature every two minutes until its temperature levels off.

Help the students consider problems with their protocols. Should they stir? What happens if there isn't enough space for the ice in the can? How do you measure the temperature in a refrigerator or freezer when opening the door heats it up? While the teacher might give the students a complete protocol ahead of time, having students work through these kinds of questions helps them to understand better what scientists need to do to get repeatable, accurate data. In addition, students are more likely to follow protocols of their own devising.

Emphasize the importance of writing down what they did. Frequently groups will get different results from using the same method because what they did or the initial conditions were different. It is likely that some or even all the groups will have to repeat some of their runs because they won't remember exactly what they did. Nothing helps students understand the importance of lab notebooks and good note-taking like extra work.

A possible result might be

Method	**Protocol**	**Time (h:m)**	**Notes**
Refrigerator	Placed in refrigerator that was at 4 °C. Probe thermometer inserted with wire to outside of refrigerator. Can started at 18 °C. Door opened twice. No stirring. Timed until 4 °C.	3:10	Top of soda in the can, 5 °C.
Freezer	Placed in refrigerator that was at -17 °C. Probe thermometer inserted with wire to outside of freezer. Can started at 18 °C. Door not opened. No stirring. Timed until 4 °C.	1:01	Top of soda in the can, 6 °C.
Add ice to the drink	Can started at 17 °C. Poured out 3 ounces of soda. Added 3 ounces of ice at 0 °C. Reached 0 °C	0:04	Only cooled 9 ounces

Putting the drink on ice	Buried can in ice. Inserted lab thermometer. Can started at 16 °C. No stirring. Clay placed around thermometer to keep water from entering. Timed until 4 °C.	0:14	Top of soda in the can, 5 °C.

Students may need to characterize more than once to get the data they need. For example, since it is hard to add ice to a full can, the students may need to pour out liquid from the can to fit the ice in. That makes the cooled volume different for this run compared to other runs. They may wish to pour the same liquid out of the other runs so that all the variables are the same.

Can we make cooling faster?

How important it is to make cooling faster depends on the situation. For example, a restaurant might need cold drinks almost right away, where in your house you might be more patient. Have each group create a situation where they would need to get room temperature drinks cold and have them try to develop a system that will work for that scenario. In engineering, designs only have to work well enough for the situation. They don't have to be the best or perfect, but you do want to encourage your students to pick a challenging project.

Next have students think of a method to improve cooling. Some ideas will try to remove a method's disadvantage like the dilution that comes from ice melting, while others will try to enhance a current method. Students will often invent new novel methods. Some typical ideas include

- Placing ice into bags to prevent dilution when melting.
- Adding cold rocks to the drink to avoid dilution.
- Stirring the drink while cooling.
- Stirring the surrounding ice, liquid, or air to increase contact.

Allowing students to do research first may bring them additional ideas.

- Putting the drink in a plastic bottle.
- Putting the drink in a flat container with more surface area.
- Mixing salt with the ice before submerging the can to make the ice colder.

Not all the ideas that the students have will work well. You should consider letting them try things that will fail, because often more learning happens in failure than in success. Help students to understand that evidence comes from well-planned experiments. In the above examples, cold rocks won't dilute the drink but they don't cool very well either since it is the phase change of the ice rather than its temperature that does most of the cooling. Plastic bottles work fine if the cooling is by radiating the heat away like in a cold refrigerator or freezer but work less well in ice since plastic conducts worse than aluminum. But don't take our word on it, try it out yourself.

At the end of testing each idea, have the students summarize what they have learned. Have groups evaluate how close they have gotten to the goal that set for themselves at the beginning. Students should then make new plans to revise what they are doing to try to improve on their result.

Over the years some of the most successful projects have involved submerging a can in an ice water slurry with a student or a machine rapidly stirring the slurry and another student stirring the soda. We have seen a 12 ounce can brought to 4 degrees Celsius from 20 Celsius in under six minutes.

Part III: Evaluation

While many kinds of assessment work, the students and the teacher should assess how well they improved their rocket launch. You could write an assessment that offers possible changes and asks students to predict how that will improve or hurt rocket launch.

In addition, each group should report out on how well they worked together. Having the students briefly present their work to their classmates tends to give the best opportunity to figure out what happened in their group. They should explain

- What their problem/goal was
- What they tried
- Whether or not it was successful
- How they could tell if it was working
- What they did if they didn't all agree on what to do
- How often did they get to put a mark on their checklists