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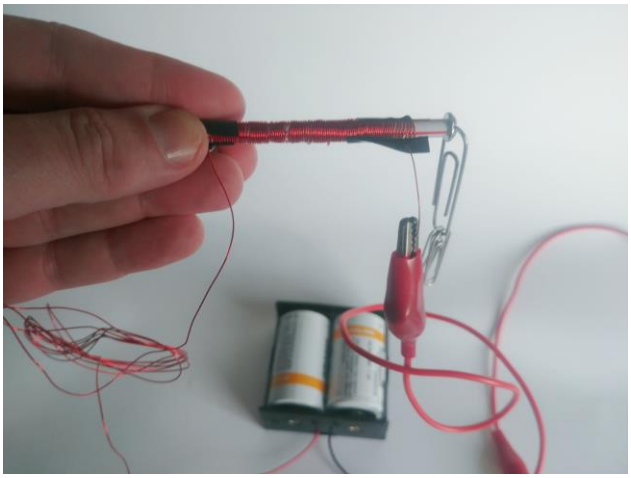
SOSSENA WOOD
Building Electromagnets to Learn About Being a Great Engineer
STEM Lesson Plan for Grades 6-8

Helping all students, especially girls, 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 a satisfactory solution is what makes an engineering project.
In this lesson plan, students will watch a video where Sossena Wood explains how she became a successful engineer. After figuring out what she says are some key factors to being a great engineer, they will embark on an engineering project where they will try to make and improve an electromagnet. Finally, they will look back at their work habits to determine how closely they matched skills that the engineer suggested were important.

NGSS Standards
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution
PEMS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between
objects exerting forces on each other even though the objects are not in contact.
PEHS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Part I: Watching the Sossena Wood 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

Sossena Wood said that she had to overcome the obstacles of _____

Sossena Wood 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:

- Sossena Wood is an engineer because she wants to help people.
- Sossena Wood has made engineering her career.

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

I didn't give up when something didn't go the way I planned	𝍸 I| |

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 a good engineers.

Part II: Engineering Cycle

In groups of about four, have students build the electromagnet described below. For younger students, you may need to do things like strip the wire in advance. Help students build the first electromagnet and then have them stop. I know that will be hard. Promise that they will get to come back to the project afterwards.

Making an Electromagnet

Running electricity through a coiled wire can create an electromagnet. Electromagnets are used in many devices including doorbells and electric motors.

Materials

- 2 meters of magnet wire (20 to 24 AWG works well)
- Small square of sandpaper approximately 2 cm x 2 cm
- 2 or more 1.5-V D or C cell batteries (do not use rechargeable batteries)
- Battery holder
- Iron or steel nail
- Straw that fits the diameter of your nail
- Tape
- 2 alligator clips
- 10 standard paper clips
- Assorted other materials to try. Options include other size steel nails, stainless steel nails, aluminum nails, different diameter wire, longer or shorter wire, more batteries, etc.

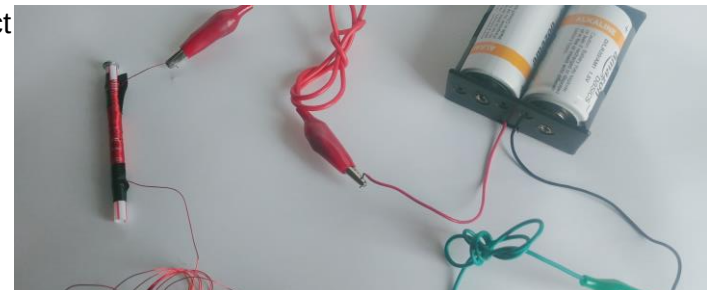
Assembly

(Note this assembly hasn't been optimized! This is just enough to pick up a paperclip.)

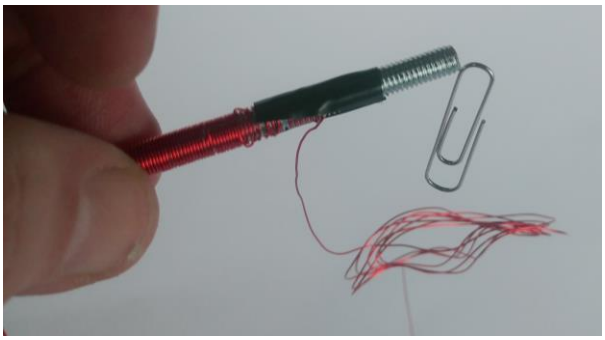
1. Using the piece of sandpaper, scrape approximately 2 cm of insulation off the end of the wire.

2. Mark a spot 1 cm from the end of the straw with a marker or pen. Measure 10 cm from that point and mark another spot on the straw.
3. Leaving approximately 5 cm free from one end of the wire, wrap the the wire around the straw. Each loop around the straw is called a “turn”. Have them make hundred turns. If they get to the second mark before having done 100 turns, have them start wrapping back the other direction, overlapping the wire. They may need to use tape to hold the wire in place. Be careful not to crush the straw. When they have done a hundred turns, tape down the magnet wire to hold it in place. Give the remaining wire a twist to keep it from getting tangled, but don’t cut it off. Students might want to add more turns to their electromagnet.

4. Connect one alligator clip lead to each end of the magnet wire.
5. Connect



6. Check to see if the electromagnet will lift a paperclip.



Note: The magnet wire can get very hot, so only connect it to the battery for a few seconds at a time.

Improving the Electromagnet

As a class have the students make a goal for improving their electromagnet. The first step though is deciding what it means for the electromagnet to be better. For less experienced students, you might want to offer some suggestions like

- Our electromagnet should be able to hold many paper clips.
- Out electromagnet should be able to hold a long string of paper clips end to end.

Have each group determine how well their electromagnet does. For example, they could determine how many paper clips can it currently hold.

Next, have students try to think of ways that they could change the electromagnet to fulfill their goal. Some students will need suggestions for improving their electromagnet. They might consider:

- Using more or less magnet wire.
- Using thicker or thinner wire.
- Using additional batteries (be careful because the wire can get very hot).
- Using something other than a steel nail (an aluminum or stainless steel nail) as a core.
- Rewrapping the magnet wire on the straw so that it has a different number of turns.
- Rewrapping the magnet wire so that it is tidier or messier.
- Rewrapping the magnet wire so that the bundle of magnet wire is shorter but has more layers.
- Moving the magnet wire do a different part of the nail.

Collect their ideas on the board and then assign groups to try them out. Explain that they need to keep careful track of what they did in each experiment and the their results so that they can share with their classmates. This isn't a competition. Success will be measured by how well all the electromagnets work.

You should assign each possibility to more than one group to get replication of the results. When students get different results (and they will), the details of what they did will become important for figuring out what caused the difference. If students didn't write down enough information, they will just have to repeat the activity, recording it better this time.

After the data is collected and distributed, have the groups work on improving their electromagnet by using the data from above. If any of the groups have significantly more or fewer paper clips than other groups, have the groups present what they did and have the class try to figure out what made one group do better or worse than others.

Ask the students what other ideas that they want to test. Repeat the above.

Help students to understand that this is the engineering process. Engineering uses a cycle of

- determining a problem
- identifying what's needed to solve the problem
- trying and testing possible solutions

- optimizing
- iterating

If time is available, you can have students solve their own problem using an electromagnet. Have each group determine a project that uses an electromagnet to solve the problem. For some students you will need to give them some suggestions. They might consider:

- Lifting a metal car to move it like cranes do
- Sorting iron and steel materials from mixed metals like in recycling
- Ringing a chime like in a door bell
- Moving a toy to make it pop up

While many teachers would be inclined to assign a single task for the class, letting each group set its own goal has many advantages. Students tend to be more invested in the design and work harder. Groups don't just copy the work of other groups. Voices that are less often heard get a chance to shine.

The groups to work on their projects to get them functioning as they'd like. Once they can get them to work, have them repeat the project to try to minimize the amount of wire and batteries used. Optimizing so that the cost of project is lower is key part of engineering.

Some ideas may end up being impossible. An electromagnet won't work without a battery and no reasonable design from typically available materials will lift tens of kilograms. The struggle can still be worthwhile, and sometimes you may be surprised by what students will come up with. Have students keep track of what they have done so that their classmates can over suggestions if they get stuck.

Part III: Evaluation

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

In addition, each group should report out on how well they worked together. Even for classes that didn't have time for the groups to work on their own project, 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