**Electromagnets by Laureen Vermette and Kelsey Beaudry**

**Materials required:**

* Coated Copper wire (approx. 10)
* AA batteries (approx. 10)
* Light bulbs (2 table top)
* Name Tags
* Clamp wires (approx. 4)
* D batteries (approx. 10)
* Several objects to be used to pick up paper clips (nails, pencils, toothpicks)
* Paper clips (box of them)
* Thick rubber bands (approx 10)
* Magnetic toys
* Narrative Booklets (approx 15)
* Attachment One- Picture of Construction Magnet
* Balloons (approx 2)
* Kleenex (approx 2)

**Safety Considerations:**

* If students are holding the copper wire on both ends of the battery it could burn the tips of the fingers.
* Students should never experiment with electricity from a wall outlet because it could be fatal.

**Curricular Outcome:**

6-3-12– Demonstrate, using a simple electromagnet constructed in class, that an electric current can create a magnetic field.

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| *Initiating:* | 6-0-1A. Formulate specific questions that lead to investigations.6-0-1C. Identify practical problems to solve. |
| *Researching:* | 6-0-2A. Access information using a variety of sources. |
| *Planning:*  | 6-0-3B. Identify variables that have an impact on their experiments and variables to hold constant to ensure a fair test. |
| Implementing a Plan: | 6-0-4A. Carry out procedures that comprise a fair test.6-0-4B. Construct a prototype.6-0-4C. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.6-0-4E. Use tools and materials in a manner that ensures personal safety and the safety of others. |
| Observing, Measuring, And Recording: | 6-0-5A. Make observations that are relevant to a specific question.6-0-5C. Select and use tools and instruments to observe, measure, and construct. |
| Analyzing and Interpreting: | 6-0-6A. Construct graphs to display data, and interpret and evaluate these and other graphs.6-0-6D. Identify and make improvements to a prototype and explain the rationale for the changes. |
| Concluding and Applying: | 6-0-7A. Draw a conclusion that explains investigation results. |
| Reflecting on Science and Technology: | 6-0-8B. Identify examples of scientific knowledge that have developed as a result of the gradual accumulation of evidence. |
| Demonstrating Scientific and Technological Attitudes: | 6-0-9C. Demonstrate confidence in their ability to carry out investigations in science and technology. |

**Questions I am asking in my planning to ensure my lesson is ‘authentic’:**

1. Does the lesson start through engagement? Is the context relevant to students’ lives?
2. Am I using this phase as an opportunity to find out where students are ‘at’ in their thinking?
3. Is there an emphasis on first-hand experiences-an evidential phase?
4. Am I helping students to make sense of these experiences-a psychological phase? Do I ensure my explanations are assisting students in learning? Am I using models illustrations as necessary?
5. Is there a theoretical phase where the essential science knowledge is articulated and consolidated?
6. Is there opportunity for student initiate questions ad follow-up investigations?
7. Is the science lesson a collaborative effort-do we work in group and offer our outcomes to the class as a group?

**Teacher Notes:**

* + Last class we mentioned that electric circuits create a magnetic field. We demonstrated how a balloon has a magnetic field when it has a static electric charge and showed how the Kleenex attracts to the balloon. We can’t see the magnetic field; we can only observe what happens because it is there.

 **Student Engagement/ Assessing Prior Knowledge:**

***Hands on Exploration:***

* Have students play with magnet toys.
* Ask students if they can tell you how these toys work?
* What causes them to come together? (attract)
* What causes them to push away? (repel)

***Visual Engagement:***

* Show students a picture of a magnetic field. What does it represent? Ask them if they know what it is. Give clues as necessary.

***Brainstorming and making connections to our world:***

* Ask students if they can tell you where these magnetic fields exist. Refer to following resource:

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| Natural sources of electromagnetic fieldsElectromagnetic fields are present everywhere in our environment but are invisible to the human eye. Electric fields are produced by the local build-up of electric charges in the atmosphere associated with thunderstorms. The earth's magnetic field causes a compass needle to orient in a North-South direction and is used by birds and fish for navigation.Human-made sources of electromagnetic fieldsBesides natural sources the electromagnetic spectrum also includes fields generated by human-made sources: X-rays are employed to diagnose a broken limb after a sport accident. The electricity that comes out of every power socket has associated low frequency electromagnetic fields. And various kinds of higher frequency radiowaves are used to transmit information – whether via TV antennas, radio stations or mobile phone base stations. |

 **Introductory Phase:**

***Using media, to exemplify electromagnetic fields:***

* Show Video/ or picture of the construction magnet, as an example of how it is literally used in our world. Ask if the students can explain how it works. Key question: How do you think you get the metal off the end of the magnet? (don’t answer……….)

***Using electric circuit model to explain electromagnetic field***

* Show students a table bulb circuit. Remind students that we demonstrated the magnetic field with the balloon from last class. Refer to the circuit model without it fully connected (the bulb not on):

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| Tell students that in this model there is and electric field and a magnetic field. Ask students if they can tell you where the electric field might be. Ask students to examine the battery: Electric fields exist whenever a positive or negative electrical charge is present. (point to negative and positive ends of battery) They exert forces on other charges within the field. The strength of the electric field is measured in volts per metre (V/m). (ask students what the voltage of the battery is) Tell them that this electric field exists even when there is no current flowing. The higher the voltage, the stronger the electric field is. It is the strongest closest to its power source. Now have the circuit running (bulb on) Ask students if they can tell you where the magnetic field is. Magnetic fields arise from the motion of electric charges. (demonstrate with fingers the motion of the particles charged moving through the circuit)The strength of the magnetic field is measured in amperes per meter (A/m). In contrast to electric fields, a magnetic field is only produced once current flows. The higher the current, the greater the strength of the magnetic field. Like electric fields, magnetic fields are strongest close to their origin and rapidly decrease at greater distances from the source.  |

***Explain media example of an electromagnet***

* + Refer students back to the construction magnet and see if they can explain how the magnet works: The steel magnet is part of a circuit. When the circuit is on, the electric charges flow and a magnetic field is created. The steel becomes magnetized and can pick things up. When the circuit is off, the steel is no longer being magnetized and it loses it magnetic force.
	+ Use attachment one if further explanations are needed.

 **Construction Phase:**

* + - Read a-loud, with students following along as you read, the narrative *Gone for Now but not Forever* from the booklet entitled *Electromagnetic Fields and Electromagnets*
* Ask interactive questions from the narrative, as you go along.
* Put materials out, for students to make an electromagnet. Use guiding questions from booklet to help students conduct an electromagnet.
* Explain that the coiling of the wire increases the magnetic strength by increasing the concentration or amount of magnetic charge in one area.
* Ask students to draw a diagram, labelling the electric field and magnetic fields in their booklets.
* Check for understanding and review any theory as earlier explained.

**Formative Assessment:**

* Check in with all students to ensure that they have had a chance to demonstrate they can create an electromagnet. Ask lots of engaging questions to check for understanding of terminology and concepts. Circulate and check in with group members to ensure they are on task and are learning. Have students demonstrate, for their peers, their understanding of how to create an electromagnet and how to draw a diagram of an electromagnet with the fields appropriately labelled.

**Summative Assessment:**

* + Refer to attached outcome based assessment rubric. Students will be assessed as to whether they have achieved meeting the curricular objective by demonstrating they can create an electromagnet. Pictures of student electromagnets will be taken, as evidence that students have created electromagnets.

 **Initial Assessment Phase:**

* Generate discussion about the construction of the electromagnet. Ask students to think about the magnet they created and consider the pros and cons of it and record in their booklet. (consider talking about its strength, distance of wire to coiling, amount of coiling, battery voltage, type of object used to magnetize)

**Investigative Phase:**

* Have students identify the various kinds of things (variables) they could alter to effect the strength of the magnet. How can they improve it? (coiling, the object used to pick things up, the power source, type of wire used to coil, etc.)
* Students will make modifications to their electromagnets to determine how they will increase the strength of the electromagnet, using the table in booklet to help them prepare for investigations.
* Students will measure, the amount of paper clips, coiling or number of batteries, to record the results. Students will do 3 trials for each variable and will average out the outcome.
* Students will graph the average outcomes.

 **Reporting Phase:**

* Students will record the best results of their electromagnet in their booklet under *Conclusions/ Reporting Phase*
* Students will share results with others in the group and record in their booklets.

 **Explaining the Electromagnet**

* Ask students, what have we learned, looking at our results? Refer to voltage of electric field, coiling or concentrating the magnetic field, and conductor properties.
* Ask students if they have any questions about the electromagnet and how it works.
* Review student diagrams with group members. Refer to the electric field, magnetic field and the purpose of the circuit.

**Final Assessment Phase:**

* Have students apply what they know, answering the 5 Bloom’s Taxonomy Questions in the booklet.

**References:**

World Health Organization. *Electromagnetic Fields.* Retrieved on February 6, 2010 from

[**http://www.who.int/peh-emf/about/WhatisEMF/en/**](http://www.who.int/peh-emf/about/WhatisEMF/en/)

Modifications made to the Narrative Discrepant Event. *Gone for now but not forever.* Nicole Lavallee (2010) Faculty of Education, Teaching Science in the Middle Years.

You Tube Video. 15 kw magnet generator. Retrieved on February 6, 2010 from

[**http://www.youtube.com/watch?v=b6MVPYGveeQ**](http://www.youtube.com/watch?v=b6MVPYGveeQ)

**Lesson 2 – Electromagnet**

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| **Dimension** | **Underdeveloped understanding of concepts** | **Developing an understanding of concepts** | **Developed understanding of concepts** |
| Evidential - Experiential | Unable to or poorly performs practical experiences. | Performs activities and experiences with acceptable skill and accuracy. | Performs activities with skill, confidence and accuracy. |

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| **Name:** | **Underdeveloped understanding of concepts** | **Developing an understanding of concepts** | **Developed understanding of concepts** |
|  | Unable to or poorly performs practical experiences. | Performs activities and experiences with acceptable skill and accuracy. | Performs activities with skill, confidence and accuracy. |
|  | Unable to or poorly performs practical experiences. | Performs activities and experiences with acceptable skill and accuracy. | Performs activities with skill, confidence and accuracy. |
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|  | Unable to or poorly performs practical experiences. | Performs activities and experiences with acceptable skill and accuracy. | Performs activities with skill, confidence and accuracy. |

**Attachment One**

**Attachment Two**



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| With kind permission from the National Radiological Protection Board, UK |

**Electric fields**
Plugging a wire into an outlet creates electric fields in the air surrounding the appliance. The higher the voltage the stronger the field produced. Since the voltage can exist even when no current is flowing, the appliance does not have to be turned on for an electric field to exist in the room surrounding it.

**Magnetic fields**
Magnetic fields are created only when the electric current flows. Magnetic fields and electric fields then exist together in the room environment. The greater the current the stronger the magnetic field. High voltages are used for the transmission and distribution of electricity whereas relatively low voltages are used in the home.

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| With kind permission from the National Radiological Protection Board, UK |

Electric fields around the wire to an appliance only cease to exist when the appliance is unplugged or switched off at the wall. They will still exist around the cable behind the wall.

**Electromagnetic Fields and Electromagnets**

**Electromagnets** Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Gone for Now but not Forever!**

Andy and Meredith had been friends since they were toddlers. Together, they did everything from studying, going to the movies, to going on glamorous adventures in the town where they lived. Their town was situated in cottage country and adventures and exploring was a favourite past time activity. That day, Andy wanted to do something different. He had told Meredith that he had planned a top secret excursion and that they would be leaving immediately.

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| Have you ever gone on an exciting adventure with a good friend? |

Andy was staying with Meredith’s family, as his parents were visiting an old friend in the city. He grabbed his backpack out of the guest room, and told Meredith to wear her sneakers. As they left the house, Andy explained that they had to stop at his house to pick something up.

“Where are we going and what do you need from your house?” Meredith asked curiously.

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| What do you think Andy has planned? Where do you think they are going? |

“You’ll just have to wait and see. Stay here,” Andy directed, as he unlocked the door to let himself in.

Meredith waited on the door step wondering what Andy had to pick up. Andy returned, and the pair set out towards the west side of town, where many townspeople and city dwellers owned summer cottages.

After an hour of hiking, Andy and Meredith arrived at Andy’s family cottage. Andy dug in his pocket and pulled out a set of keys. As he played around with the lock, he dropped the keys at the doorstep. As he bent down to retrieve them, he let out a gasp.

“What is it?” Meredith asked with a worried face.

“The keys!” Andy exclaimed. They fell into the crack between the ground and the staircase. Oh great! What am I going to do? My parents are going to be so upset,” Andy sounded alarmed.

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| What would you do if you lost the keys? |

“Well, if you can’t reach them, don’t worry about them. We can come back tomorrow with a spare set. We can even make copies of the set, so your parents don’t even have to know. Don’t worry Andy.” Meredith tried to reassure her friend.

“Well that would be a wonderful idea, if we actually had a spare set. My dad already lost the original set, on our fishing boat. He is not going to be pleased with me. If we have to change the locks, I will probably have to pay for it, and that means getting a summer job!” Andy explained.

“Maybe we can get them out!” Andy got down on his hands and knees to search. “I can see them! But I definitely can’t reach them; can you pass me a stick?”

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| Do you think this will work? Is there something else that might work better than a stick? |

Meredith found a long branch and passed it to Andy. Andy started trying to scoop the keys out with the help of the stick but after twenty minutes it was clear that it wasn’t going to work. “That’s it, they’re gone for good!” Andy said sadly.

 “Let’s go back to my place, maybe my mom can help. She’s always helpful in a sticky situation, let’s go!” Meredith directed Andy, who began to follow reluctantly.

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| Who would you go to for help if you lost something important? A parent, friend, sibling? |

After explaining the scenario to her mom, Cathy, Meredith and Andy waited for a response. “Well, the two of you should know better than to go to your parents’ cottage while they’re away, but I think we can solve the problem. We’re going to make something that will help us out,” Cathy said enthusiastically.

“Yeah, but how will it help us get the keys?” Meredith asked in a confused tone.

“I’ll show you,” Cathy replied, as she went into the kitchen.

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| What do you think they are going to make? How could they get the keys? |

Cathy retrieved a D-sized battery out of a drawer. She took out a long nail and a copper wire from the drawer. She scooped out a few paper clips from her briefcase and exclaimed, “Now, we will build this thing, watch closely!”

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| What do you think they are going to do with all those materials? What would you make? |

Cathy coiled the copper wire around the nail, making sure to leave a long piece of wire at both ends. She then took one of the ends of the long piece of wire and connected it to one end of the battery terminal and then took the other end of the long piece of wire, and attached it to the other end of the battery. She placed the paper clips on the counter in front of them and asked, “Well, what do you think is going to happen when I bring the tip of this nail in contact with these paper clips?”

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| What do you think will happen? Try conducting this experiment. |

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| Guiding Questions for Constructing an ElectromagnetWhy do we need to attach one end of the copper wire to each end of the battery?Why are we putting coil wires around the nail? What purpose does this serve?Where is the electric field? Where is the magnetic field? |

Draw a picture of the device below. Label fields.

 “Look, the nail becomes magnetized and attracts the paper clips!” Andy exclaimed. “That’s absolutely right Andy,” Cathy started, “when the copper wire is wrapped around an iron core, the nail in this case, becomes an electromagnet. The electromagnet becomes energized by the battery and creates a magnetic field just like that of a permanent magnet.” Cathy pointed the tip of the nail towards the paper clips and as she did so, the paper clips started to rise. “Wow, that’s pretty cool mom!” Meredith exclaimed. “Now let’s go get those keys!”

**Reflect on the electromagnet you made. What is good about it? What is bad about it?**

**Assessment of the electromagnet:**

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| What is **good** about this electromagnet? | What is **bad** about this electromagnet? |
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| **Investigation:** |

You will now try to make your electromagnet stronger. Put a check mart next to the factors that you will change and keep the same during your investigation. **Two** factors will stay the same and you will need to choose only **one** factor to change.

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| What factor will I keep the same?  | What factor will I change? | How will I observe it? |
| * Nnumber of coils
* Nnumber of batteries
* Nnail, choose alternative
 | * Nnumber of coils
* Nnumber of batteries
* Nnail, choose alternative
 | * Uuse the graph paper attached to graph how many paper clips you can pick up using your electromagnet. Do 3 trials for each variable.
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Reporting Phase: use a graph to record the average number of paper clips for each variable.

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| Planning to Graph |
| How will you graph your results?* Will you graph, how many paper clips can be picked up, on the y axis or x axis?
* Will you put the variable you are changing (conductor, battery, coiling) on the y axis or the x axis?

 30Paper clips 25 y axis 20  15 10 5 ----------------------------------------- 0 5 10 15 20 25 30 Coils on x axis  **Record Data for each trial for each variable:** Use this sheet to help you record data for each trial for each variableVariable\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial #1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Average\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Variable\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial #1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Average\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Variable\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial #1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Average\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Variable\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial #1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Trial#3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Average\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  |

**Conclusion/ Reporting Phase:**

Based on your investigation and the result that you have plotted on your graph, what would you say is the best way to increase the power of your electromagnet? Discuss your results with other classmates.

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| Group Member Names | Record best result noting these variables. Circle the variable which was experimented with:  |  |
| Group 1:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesNail/ alternative |  |
| Group 2:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesNail/ alternative |  |
| Group 3:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesNail/ Alternative |  |
| Group 4:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesNail/ Alternative |  |

**References:**

Wiese, J. (1995). *Rocket Science 50 Flying, Floating, Flipping, Spinning Gadgets.* New York, NY: Scholastic Inc.

Summary Questions:

1. What materials were needed in order to create an electromagnet? What were you able to do with the electromagnet?

2. How can you strengthen the force of the electromagnet?

3. How is a magnetic field different from an electric field?

4. In your own words, explain how the electromagnet works. What is the purpose of using a circuit?

5. What purposes can electromagnets serve in our world today? Describe how electric magnetic fields serve a purpose in our world today?