**Electromagnetic Motors by Laureen Vermette and Kelsey Beaudry**

**Materials required:**

* Coated Copper wire (approx. 10-15)
* AA batteries (approx. 10)
* Bar magnets (approx. 10)
* Name Tags
* Safety pins (approx 10-20)
* Electrical tape
* D batteries (approx. 10)
* Paper (approx. 10 sheets)
* Thread
* tape
* Paper clips (box)
* Thick rubber bands (approx 10)
* Tin Foil

**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:**

6-3-13 Explore motors and generators to determine that electromagnets transform electricity into motion, and motion into electricity.

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| *Initiating:* | 6-0-1A. Formulate specific questions that lead to investigations.6-0-1C. Identify practical problems to solve.6-0-1D. Identify various methods to solve a practical problem and select and justify one to implement. |
| *Researching:* | 6-0-2A. Access information using a variety of sources. |
| *Planning:*  | 6-0-3A. Formulate a prediction/hypothesis that identifies a cause and effect relationship.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.6-0-5F. Record and organize observations in a variety of ways. |
| 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.6-0-6E. Evaluate the strengths and weaknesses of a consumer product based on pre-determined criteria. |
| Concluding and Applying: | 6-0-7A. Draw a conclusion that explains investigation results.6-0-7D. Propose and justify a solution to the initial problem.6-0-7H. Identify connections between the investigation results and everyday life. |
| 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.6-0-8C. Recognize that technology is a way of solving problems in response to human needs |
| 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 lesson we created an electromagnet. The foundation for electromagnet field has been laid. The foundation to understanding an electric field, magnetic field and the purpose of a circuit in creating the magnetic field has been laid. We will now explore the principles of attraction and repulsion and creating rotational movement in the construction of an electromagnetic motor.

 **Student Engagement/ Assessing Prior Knowledge:**

***Hand on Exploration***

* Give students bar magnets and ask if they can get one of the magnets to spin.
* Explain opposite magnetic forces attract and likes repel.

***Using a prop to engage learning***

* Show a globe. Explain that we have a north magnetic polarity on one end of the bar magnet and this is red. This is attracted to the South Pole Magnetic Field. Explain that we have a south magnetic polarity on the other end of the magnet and this is blue. This is attracted to the North Pole Magnetic Field.
* Explain that all magnets have these two polarities.

***Visual Engagement***

* Show Visual.
* Explain that same polarities (northern or southern) repel or push away one another and opposite polarities attract one another or pull to each other.
* Explain that this push and pull creates a rotational motion.
* Demonstrate using the bar magnets how this works.

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

* + Ask students if they can tell you some ways which magnets are being used in our world today. Refer to the table below or show the video on Magnetism. ( video also mentions the generator (curricular objective) and all information as stated below)

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| Magnets have been very useful and have been utilized in many everyday objects. Many of what we enjoy today uses magnets in one way or another. For instance, magnets are converted into magnetic strips where in information can be stored. In the case of video tapes and audio tapes, the sound and images are stored on the magnetic coating of the tape. Placing these tapes near a strong magnet will destroy the data encoded inside it. ATM, credit and debit cards also employ a strip of magnetic field on its backside. This magnetic strip contains all the information needed to access their accounts and financial institutions that’s concerned with the card. Microphones and speakers also need magnets to make them work. They utilize a combination of permanent magnet and an electromagnet. Speakers use the electromagnet to carry the signals that generate a varying magnetic field that influences the motion of the magnetic fields that is generated by the permanent magnet. This recurring force moves the cone which produces the sound. The microphone has the same concept but is done in a reverse manner. Common television sets and computer monitors also use magnets to generate images. Generators and electric motors also need magnets for proper operation. Transformers also use them. Then there are the other uses for magnets that can be quite fun and amusing, such as the refrigerator magnets.(SearchWarp.com) |

 **Introductory Phase:**

***Using tools in science for hands on experiences***

* Have students play with electromagnetic motors to see if they can get them to work.
* Ask students if they know what they are called and what they are.
* Ask students if they can tell you what they think the purpose is of the electromagnetic motor
* Ask students what would happen if they hook up the lead wires to the battery a different way.

 **Construction Phase:**

* Hand out the narrative booklet entitled, *Electromagnetic Motors*
* Read a-loud, with students following along as you read, the narrative entitled, *The Great Fish Feat*
* Ask interactive questions from the narrative as you go along.
* Put out materials for students to build an electromagnetic motor.
* Use guiding questions from booklet to help students construct and electromagnetic motor.
* Ask students if they can explain how it works.
* Explain that the rotor is an electromagnet and the magnet attached to the battery is called a field magnet. These magnets are attracting and repelling magnetic forces which create rotational motion.
* Have students draw a diagram of their electromagnetic motor and the magnetic field.

**Formative Assessment:**

* Check in with all students to ensure that they have had a chance to demonstrate they can create an electromotor. 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 electromotor and how to draw a diagram of and electromotor 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 electromagnetic motor. Pictures of student electromagnetic motors will be taken, as evidence that students have created an electromagnetic motor.

 **Initial Assessment Phase:**

* Generate discussion about the construction of the electromagnetic motor, using probing questions from the narrative booklet. (consider talking about the power of the motor, how can you strengthen it: coils, battery voltage, increasing the number of field magnets, the conductor, etc.)
* Under the *Assessment of the Electromagnetic Motor* section, have students record the pros and cons of the electromagnetic motor they made.

 **Investigative Phase:**

* Have students identify variables they can alter to improve their electromagnetic motor (batteries, magnets, copper coils)
* Students will make modifications to their electromagnetic motor to determine how they will increase the strength of the motor, using the table in booklet to help them prepare for investigations.
* Students will measure, the amount of paper clips, coiling or number of batteries or magnets, 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 electromagnetic motor in their booklet under *Conclusions/ Reporting Phase*
* Students will share results with others in the group and record in their booklets.

 **Explaining the Electromagnetic motor**

* Ask students, “What have we learned, looking at our results?” Refer to voltage of electric field, coiling or concentrating the magnetic field, and magnetism.
* Ask students if they have any questions about the electromagnetic motor and how it works.
* Review student diagrams with group members. Refer to the electric field, magnetic field and the purpose of the circuit. Refer to the attraction, repulsion and the rotational movement.

**Final Assessment Phase:**

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

Have students watch the video, The Town of Simplicity: An Electromagnetic Generator. Discuss how this is similar and different to an electromagnetic motor.

**References:**

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SearchWarp.com. *Discovering magnets and their many uses*. Retrieved on February 09, 2010 from <http://searchwarp.com/swa24348.htm>

Teacher Tube. *The town of simplicity: An electromagnetic generator*. Retrieved on February 16, 2010 from <http://www.teachertube.com/viewVideo.php?video_id=96498>

**Lesson 3 – Electromagnetic Motor**

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| **Dimension** | **Underdeveloped understanding of concepts** | **Developing an understanding of concepts** | **Developed understanding of concepts** |
| Evidential - Experiential | Unable to of 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. |
|  | 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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**Electormagnetic Motors**  **Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

<http://www.tpub.com/neets/book1/chapter1/1g.htm>

**The Great Fish Feat!**

It was the Louis Riel long weekend, and Mike and Josh were in Gimli doing some ice fishing in Lake Winnipeg. They had packed a cooler full of food and snacks and set off to their ice shack, which they had rented for the whole weekend. The ice shack was equipped with wood and insulated. They would be camping out in the ice shack for the duration of the weekend. Their goal was to catch as many fish as possible, and freeze them, so they could eat fish at least twice a week until spring.

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| Are you familiar with Louis Riel day? What kinds of things do you like to do on Louis Riel day? |

The ice shack was a long way from where they parked their car. Mike had brought two toboggans to put their cooler and all their fishing gear on, to pull out to the ice shack. Mike and Josh packed all their gear onto the toboggans and began their trek across the ice to the ice shack.

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| Have you ever gone ice fishing? Have you ever been in an ice shack, or stayed in an ice shack? |

It was a really long walk to the ice shack. Once they arrived at the ice shack they unloaded the toboggans and ate lunch. They were both very hungry from the long walk.

After lunch, Mike got his fishing rod ready. He decided to use a Pickerel rig with some worms for bait. Josh decided he was going to use a Whitefish rig and frozen minnows for bait. Both types of fish are common fish found in Lake Winnipeg. They are both very tasty.

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| Have you ever eaten Pickerel or Whitefish? If you fish, what do you use for bait? |

Not more than ten minutes had past, and Mike was in a struggle with a big fish. His fishing rod was almost bent in half, and Josh was worried it might break before Mike was able to reel it in. Mike and Josh were so excited; the first catch of the day is always the most exciting. “Grab the net!” Mike hollered to Josh. Mike was working really hard to reel in the fish; he was even starting to sweat. All of a sudden there was water splashing all over Mike’s boots, and there was a great big fish looking up at Mike. Josh scooped the fish out of the hole with the net.

It was a great big Pickerel! It weighed 6 pounds and it was 55cm long. It was the biggest Pickerel Mike had ever caught. This first catch of the day continued on a lucky streak, as the boys reeled in fish after fish after fish.... Mike and Josh were catching so many fish, and so quickly, that in order to have a Coke, they had to put down their fishing rods. It was a great first day of fishing and their final tally for the day was 28 fish!

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| Have you ever caught a fish? How did it make you feel? |

The next day, the boys got up early, after all everyone knows “the early bird catches the worm.” Josh and Mike couldn’t believe how many fish they had caught the day before, and were hoping that today they might catch at least 10 fish. Fishing got off to a slow start, and they began to worry that there might not be any fish left in the lake. Sure enough though, by the end of their second day, the fishing was even better than yesterday. Today’s final tally was 31 fish!

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| Have you ever heard the expression “the early bird catches the worm?” What does this mean? |

That night the boys fell asleep while talking about all the fish they had caught. The sun came up the next day, and the boys shared their dreams of catching more fish. The fishing slowed down on their final day, and they only had a few hours left to go before they would have to hike back to the car.

Josh caught 4 fish, and Mike caught 3, for a total of 7 for the day. Overall, the boys were really happy with the outcome of their fishing trip, and packed up all the gear and fish. The boys loaded one toboggan with all their gear and the other toboggan with all the fish. The toboggan with all the fish on it was really heavy. The boys took turns pulling the gear and the fish. They walked for about two hours and now the car was in sight. They were both really tired. The toboggan with the fish was so heavy, and Mike couldn’t pull it anymore.

“Josh, my legs just won’t take one more step!” Mike said.

“I know, mine are really tired too,” replied Josh.

“What are we going to do; the car is still a long way away?”

Josh thought about it for a few minutes...

Josh jumped up and said “I have an idea!” Josh remembered seeing his dad use a winch to pull the boat up on shore at the lake. A winch or a similar device was exactly what Josh and Mike needed to pull the toboggan to the car. Josh was determined to build one and he knew he could do it because of what he had learned in Science class.

When Mike wasn’t out fishing, he was rock climbing at Vertical Adventures. Josh remembered seeing Mike’s climbing rope in the car. Josh told Mike to wait with the fish while he went to get some things from the car. Josh walked to the car with the fishing gear and the cooler. When he got to the car, he put all the gear in the trunk. Josh popped the hood and unhooked the car battery, he pulled it out from under the hood, he took two forks out of the cooler and he grabbed the electrical tape his dad kept in the glove box.

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| What do think Josh is going to make with all these materials? |

Josh attached one fork to the positive terminal of the battery with the electrical tape and then the other to the negative terminal. Josh made sure to use lots of electrical tape so that it was nice and strong. Josh had a collection of rare earth magnets that he kept in his tackle box just in case he needed to pick up lost lures from the bottom of the lake. He attached one rare earth magnet between the forks. Then Josh searched his tackle box for his thick copper wire. Josh used thick copper wire to make weights for his fishing lures. He took the long copper wire and coiled it around the end of his flash light fifteen times until it formed a big circle. This would be his rotor. He left two straight pieces on either side of the coil and he placed them in the middle of the fork prongs. Then he bent the fork prongs together so that the ends of the copper coil wouldn’t fall off the fork.

Copper coil

(Rotor)

Fork

Magnet

-

+

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| What do you think is going to happen? **With the following materials try this for yourself on a smaller scale.** * D battery (car battery)
* Copper wire
* 2 Safety pins (forks)
* Electrical tape or rubber band
* Rare earth magnet
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| Guiding Questions for Constructing an Electromagnetic Motor:Why do we need to attach one end of the copper wire to each end of the battery?Why are we leaving two straight ends on either side of the copper coil, the rotor? What purpose does this serve?Why are we putting a rare earth magnet on the battery? |

Josh observed what was happening. He knew that his idea worked! Josh took the rotor off the forks. He took one end of Mike’s climbing ropes and set it under the battery. Josh took the other end of the rope and ran to Mike with it. The rope just reached Mike and the heavy toboggan. Josh tied the end of the rope tightly to the handle of the toboggan. Mike had no idea what Josh had in mind.

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| What do you think Mike is attempting to do? |

Josh told Mike to stay with the fish while he ran back to the car. Josh was out of breath when he got to the car, but he was so excited to try his electric motor that he ignored how tired he was. Josh took the end of the rope out from underneath the battery and tied it to the copper coil, his rotor. He placed the rotor on the forks and gave it a gentle push. The coil started spinning, and as it turned, the rope slowly wrapped around the copper coil. Each time the rope wrapped around the copper coil, the toboggan of fish pulled closer to the car.

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| How else might you be able to use a device like this? |

Mike couldn’t believe his eyes. He was so happy he didn’t have to pull the fish any further. It took awhile, but eventually the toboggan reached the car with the help of the makeshift electromagnetic motor. Mike loaded all the fish into the trunk of the car, while Josh took apart the electromagnetic motor. Josh put the battery back into the car and put away the forks, copper and Mike’s climbing rope.

Mike and Josh climbed into the car and drove home, where they had a great big fish fry and froze the rest for the weeks to come.

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| Draw a diagram of the electromagnetic motor you designed and highlight the magnetic field. Draw arrows that indicate the direction the copper coil was turning. |

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

**Assessment of the electromagnetic motor:**

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| What was **good** about your electromagnetic motor? | What was **bad** about your electromagnetic motor? |
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| Investigation: |

You will now try to make your electromagnet stronger. Pretend that you are Mike and Josh, and you have a toboggan with fish on it and you need to pull it to your car. The fish are represented by paper clips and the tin foil is your toboggan. Use the thread for your rope and try to see how you can improve your motor to pull as many paper clips (fish) as possible. Put a check mark next to the factors that you will change and keep the same during your investigation. Choose **Two** factors that will stay the same and 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
* Rnumber of earth magnets
 | * Nnumber of coils
* Nnumber of batteries
* Rnumber of earth magnets
 | * Uuse the graph paper attached to create a bar graph on how many paper clips you can pull on a toboggan with your electromagnetic motor.
 |

Reporting Phase: use a graph to record the average of paper clips for each variable.

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| Planning to Graph |
| How will you graph your best results?* Will you graph, how many paper clips can be pulled, on the y axis or x axis?
* Will you put the number of batteries, coils, earth magnets on the y axis or the x axis?

 30Number of 25Paper clips 20 Pulled 15Y axis 10 5 ----------------------------------------- 0 1 2 3 4 5 6 7 8 9 10 Experiment Test # on  X axis   |

**Conclusion/ Reporting Phase:**

Based on your investigation and the results that you have on your bar graph, what would you say is the best way to increase the power of your electromagnetic motor? 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 batteriesRare earth magnet |  |
| Group 2:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesRare earth magnet |  |
| Group 3:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesRare earth magnet |  |
| Group 4:1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Number of coilsNumber of batteriesRare earth magnet |  |

**Summary of Knowledge**

1.     What materials were needed in order to create an electromagnetic motor?

2. How can you strengthen the force of the electromagnetic motor?

3. What were you able to do with an electromagnetic motor? What other

 purposes could you use an electromagnetic motor for?

4. In your own words, explain how the electromagnetic motor works. What is

 the purpose of using a circuit and what happens when the circuit is broken?

       5. What purposes can electromagnetic motors serve in our world today?