Magnets:

posing and testing questions about the properties of magnets

Grade Levels: 2-4

Time:
3 class periods

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Overview

After engaging students by a watching a demonstration of "floating objects" (ring magnets repelling each other) or videos about magnets, students will freely explore magnets and magnetism with a variety of objects. The teacher will guide students as they generate and identify their own testable questions that can be answered in the classroom, or provide an investigation question. Then students will design a method to test the questions for investigation and record their data. Students will use their data as evidence to answer the question under investigation before presenting their findings to the class.

This lesson was developed through the "Introduction to Inquiry: A Professional Development Model to Reform Teacher Practices" project directed by *Science by Inquiry at Sweet Briar College* and funded by the *Virginia Department of Education Math Science Partnership Grant (MSP) 2012-2013*.

Context

Students are first exposed to magnets and magnetism in Kindergarten. Their understanding of this concept is deepened in second grade, reviewed in third grade in preparation for the Science Standards of Learning assessment, and again covered in more depth in fourth grade by linking electricity and magnetism.

This lesson is designed to be an introduction to magnets, tapping first into students' prior knowledge about magnets before allowing them to explore. If used in second grade, additional activities should follow this lesson to delve further into the subject of magnets and their properties. If used in fourth grade, the lesson should be followed by information on electromagnets and famous inventors.

This lesson should be taught after several weeks of instruction and allow students to continue to develop their science inquiry process skills with emphasis on identifying conditions that influence a change and making multiple trials to ensure accuracy.

This lesson plan is written as an open inquiry, with students developing their own questions to investigate related to magnets and magnetism. An option to make the lesson a guided inquiry, using a teacher proposed question for investigation is presented. Students then use their question for investigation to devise the methodology and means of collecting data to attempt to answer the question.

"The students were very engaged and excited about this investigation. Most were following accurate investigation procedures and required only a moderate amount of intervention from the teacher. It was encouraging to me that students this young can be in control of an investigation and make discoveries that I intended them to make, on their own, without elaborate instructions and procedures from an adult."

~Kim Hunnicutt

"I was pleased with the quality and quantity of writing I got from the students this time. It was both informative and relatively detailed, making it useful for assessment. In future inquiries I will continue to emphasize narrative note-taking. One thing that I wish I'd done this time is to have the students look back over their data and determine which warranted multiple trials. I had a perfect opportunity to highlight this idea with the group that was measuring the strength of magnets with a spring scale. They took two measurements, which sometimes diverged wildly. I should have brought this to the attention of the whole class. It would have been a good opportunity to have everybody brainstorm ways to make the data more accurate."

~ Scott Strang

Objectives

Know

- Vocabulary includes: magnet, magnetic, nonmagnetic, magnetic field, attract, repel, poles, bar magnet, horseshoe magnet, ring magnet, natural magnets, lodestone, magnetite, iron.
- Magnets have 2 poles. Like poles repel each other. Unlike poles attract each other.
- Magnets have a magnetic field that applies force to certain metals at a distance. The force of the magnetic field can operate through solids, liquids, and gases.
- The strength of a magnet is more closely correlated with the type of magnet (material) than the size of the magnet.
- The metals attracted to magnets are primarily iron (primarily), nickel and cobalt. Steel is attracted to magnets if it has iron in it.
- The Earth has a magnetic field. A compass aligns with the magnetic field of the Earth.
- When investigating a question, a fair test must be devised in which only one variable can be manipulated.
- Multiple trials ensure greater precision in a set of data.

Understand

- Properties of magnets and magnetic fields as a force.
- Students will understand the importance of the usefulness of magnets and their properties and how they relate to everyday life.
- Investigation practices are used to understand content and the nature of science.

Do

- Develop and classify questions according to whether they can be tested in the classroom.
- Plan an investigation to answer an inquiry question.
- Conduct multiple trials to ensure precision in data collection.
- Analyze and interpret data to answer the inquiry question.
- Present the results orally to the class.

Standards

Virginia Standards

Science 2.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) observations and predictions are made and questions are formed;
c) observations are repeated to ensure accuracy;
g) conditions that influence a change are identified and inferences are made;
k) observations and data are communicated.

Science 2.2 The student will investigate and understand natural and artificial magnets have certain characteristics and attract specific types of metals. Key concepts include

a) magnetism, iron, magnetic/nonmagnetic, poles, attract/repel; and
b) important applications of magnetism.

Science 3.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

a) predictions are formulated using a variety of sources of information
c) objects with similar characteristics or properties are classified into at least two sets and subsets
g) questions are developed to formulate hypotheses
h) data are gathered, charted, graphed or analyzed
j) inferences are made and conclusions are drawn
k) data are communicated
m) current applications are used to reinforce science concepts.

Science 4.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) distinctions are made among observations, conclusions, inferences, and predictions;
b) objects or events are classified and arranged according to characteristics or properties;
e) predictions and inferences are made, and conclusions are drawn based on data from a variety of sources;
f) independent and dependent variables are identified;
g) constants in an experimental situation are identified;
h) hypotheses are developed as cause and effect relationships;
i) data are collected, recorded, analyzed, and displayed using bar and basic line graphs;
j) numerical data that are contradictory or unusual in experimental results are recognized;
k) data are communicated with simple graphs, pictures, written statements, and numbers;

Science 4.3 The student will investigate and understand the characteristics of electricity. Key concepts include

e) simple electromagnets and magnetism; and
f) historical contributions in understanding electricity.

National Standards

Science as Inquiry (4ASI)

Abilities necessary to do scientific inquiry (4ASI1)
Ask a question about objects, organisms, and events (4ASI1.1)
Plan and conduct a simple investigation (4ASI1.2)
Use data to construct a reasonable explanation (4ASI1.4)
Communicate investigations and explanations (4ASI1.5)

Understandings about scientific inquiry (4ASI2)

Asking and answering a question (4ASI2.1)
Types of investigations and doing a fair test (4ASI2.2)
Develop explanations using observations (evidence) (4ASI2.4)
Scientists make the results of their investigations public (4ASI2.5)
Review and ask questions about results (4ASI2.6)

NSES Physical Science Standards, Content Standard B, Grade K-4 – light, heat, electricity, and magnetism

Preparation

What You Need

For the class (or teacher):

- ☐ Pencil
- ☐ Ring magnets
- ☐ String
- ☐ Tape
- ☐ Paperclips
- ☐ Graph paper
- ☐ Rulers
- ☐ Compasses
- ☐ Appropriate measuring tools requested by students, such as spring scales
- ☐ Cups made of various materials (optional – see note)
- ☐ Various types of liquids - milk, juice, etc. (optional – see note)

Note: Some students chose to investigate whether magnetic fields would work through various materials, including liquids. Having these options available may allow older students to explore things they have not been able to investigate in the past.

For each group:

- ☐ Assorted objects, some of which are attracted to magnets and some that are not. Be sure to include metal items that are not attracted to magnets. Some sample objects are – coins, aluminum foil, steel can, aluminum can, and wooden sticks.
- ☐ A variety of magnets of different shapes, sizes, and materials; including natural and artificial magnets

Getting Ready

The following resources can help you brush up on your own understanding of magnets and magnetism:

http://scienceforkids.kidipede.com/physics/electricity/magnet.htm

http://en.wikipedia.org/wiki/Lodestone

http://www.magnet.fsu.edu/education/tutorials/museum/lodestone.html

The day before the inquiry

Give one of the Pre-lesson Assessments

- Students work a math problem in which someone has spilled a box of different kinds of tacks and uses a magnet to try to pick them up. The magnet only picked up some of them. Students write down why they thought that the magnet had not picked up all of the nails.
- A pre-lesson assessment with at least the following questions can be used to group students and the results be compared with a post-lesson assessment to determine student achievement in content understanding.
    - What can be attracted by a magnet? (items to sort)
    - How can mass/weight be measured? (multiple choice item)
    - How can magnets be used in everyday life? (open ended question)

"The pre-assessments I gave (the question of why a magnet wouldn't pick up certain nails, and the KWL) were effective at revealing what the students knew at the outset of the investigation. Only two of the fourteen discussed the interaction of the poles of magnets. None of the students expressed any notion of a magnetic field or that magnets would not attract certain metals."

~Scott Strang

The pre-lesson assessment will provide the teacher valuable information about the students' readiness to begin the inquiry lesson, and will inform the teacher about students' prior knowledge and any misconceptions that need to be addressed.

Day One: Generating the Investigation Question

Engagement/Accessing Prior Knowledge

• Define “properties,” using as an example the properties of several balls which can be compared. Introduce properties of magnets. Ask students to think about what the “properties” of magnets might be (i.e. things that are true for all magnets). Also discuss how magnets are used everyday (credit cards, computers, speakers, microphones, compasses, lifting, etc.).

• Have students start the *Know* part of a KWL about magnets in their science notebooks.

• At this time, consider showing videos from Brainpop Jr. and/or YouTube in order to stimulate students’ thinking, providing them with information and ideas for carrying out their own inquiries on magnets; OR consider showing the videos a little later, in the Engagement phase, in order to allow students own ideas to come forward at the start of the lesson.

This lesson is described as an ***open inquiry****: Students are prompted to pose questions to investigate, related to the properties of magnets. They choose a single question to investigate, and then work to devise the methodology and means of collecting data to attempt to answer the question.*

“They shared their ideas and we looked at photographs and talked about different applications for magnets are used in contemporary life. Several of them knew something about magnetic fields and how magnets can attract or repel other magnets.” ~Scott Strang

Exploration

• Group students in twos or threes. Give each group a plastic bag that has a couple of different magnets and other materials, both magnetic and non-magnetic. Set a timer for 15 minutes and allow students to explore with the magnets. Encourage them to come up with as many ideas and questions as they can for the *Know* and *Wonder* parts of the KWL, recording in their notebooks as they explore.

• When time is up, have students share ideas about properties of magnets - “things that seemed to be true for all magnets.”

For third or fourth grade students, you may consider shortening the time discussing “properties” as long as students seem comfortable with this concept.

Engagement

• Demonstrate ring magnets repelling each other on a pencil while prompting students to think about questions they have.

• Alternatively, show videos from Brainpop Jr. and/ or YouTube.

Recommended videos are listed in the Acknowledgements section.

• Model questioning strategies by starting with an "I wonder…" prompt and converting the "I wonder…" statement to a question. Emphasize questions that might be answered experimentally in the classroom.

• Give students an example of a question that would be testable and an example of one that would not. Then, explain that questions with certain key words, such as, "how" and "affect" could usually be used and/or modified to become a good, testable question. Also explain that questions with one word (or number) answers, while testable, are not ideal.

• Classify all students' questions as to whether they are testable in the classroom, need expertise that we don't have to be tested, or are research questions rather than testable questions. Have students identify the testable questions that could be tested in the class.

• If your goals do not include having students generate their own testable questions, making the lesson a guided inquiry, then provide students with the following testable question: "How does the size of a magnet affect its strength?"

"I put two ring magnets on a pencil to demonstrate the repellent force, and added more magnets to get them to think about a relationship between the number of magnets and the strength of the magnetic field. We talked about how magnets could be strong or weak, and I asked them to brainstorm with a partner different ways to measure the strength of magnets."

~Scott Strang

"I found that developing a good, testable question was difficult and time-consuming for them and I would like to allow them more time for this portion of an open inquiry lesson… In the future, I would have an entire class period devoted to teaching students how to develop good "testable" questions."

~Kim Hunnicutt

Some questions students developed that they determine were "testable" were:
**How does the size of a magnet affect the distance it will repel and object?*
**How does the strength of a magnet affect the distance it will attract an object?*
**What materials will a magnet go through in order to move a paperclip?*
**What liquids will a magnet go through to pick up magnetite?*

Day Two: The Investigation

Beginning the Investigation

Grouping Students

- Have students choose the question they want to investigate and pair the students according to interest.

- If you are doing a guided inquiry with a single teacher- derived question, use the results of the written pre-assessment questions to group students based upon similar strengths and weaknesses to allow scaffolding of support.

Planning the investigation

- For younger students, have them write a plan for their investigation, individually, in a sequence frame (first…, next…, then…., last…) with drawings and captions in their science notebooks. Then share their plans with their group/partner and collaborate to come up with one plan to investigate their question.

- For older students, you may have them write their plan step-by-step or use a visual graphic organizer like a Flow Map or post-it notes.

A Flow Map is very similar to the storyboard idea. It allows for written or drawn responses and can also include sub-boxes for specifics.

- When students are paired, they should work together to merge their plans into one plan for investigation.

- Meet with the pairs and/or groups as they are planning and monitor their progress, interceding with guiding questions as needed in order to help them be productive. Discuss what kind of data will be collected, how it will be collected, and how it will be recorded. Have them come up with a draft of a sheet in their notebooks on which they will collect data.

- Once each pair's plan is ready, and if there is time, have the students set up and begin to conduct their experiment.

> *"Once all of the groups had formulated a plan to investigate their question, I turned them loose. I relish this moment. The teacher is no longer in control, and the students are ENGAGED! It is a scary thing to cede control in your classroom to the kids, and I'm fortunate to have only 14 students. What I've found is, this is when most of the "teachable moments" occur. My weakest student had to do his investigation on his own because his partner was absent. Not a problem. He needed some support from me to get organized, but once he started collecting data, there was no stopping him."*
>
> *~Scott Strang*

Day Three: Conclusions

Data Collection and Data Analysis

• Allow students to complete their approved experiments using the methods they designed. As the students are working, listen to student discussions. Use a rubric (Appendix C) or a checkbric (Appendix D) to formatively assess students as they are working. Remind students to write their findings in their Science Notebook.

• When students complete their experiments, have them each write a response sheet to prepare for their presentation. The response sheet should include:

- My question
- My answer
- My data
- How I know that my data answers my question

"One of my groups had a hard time keeping track of their data. They were so involved in generating data that they forgot to discuss how to write it down in an organized way. I had to intervene to bring their attention to the fact that they really didn't know which numbers in their data corresponded to which magnet. They decided to re-do their measurements. Lack of teamwork has been an issue in the investigations we've done this year. I had another pair where one member just couldn't share the magnet duties with the other. I decided to make a point of extolling the value of teamwork as I met with each group."
~Scott Strang

Presentations to the Class and Wrap-up

• Have student pairs use their response sheets to share their findings with the entire class.

• Then, complete the class KWL chart, noting any of the "Wonder" items that have not yet been addressed as these could be items for next investigations or research. Allow students to complete the KWL chart in their own science notebooks.

Have students write in their notebook a narrative of what they did while investigating, how useful they thought their data was at answering their question, and what data they thought they should measure more than once.

As students are working, monitor and support students as needed.
Some students may need more support with articulating the question. Other students may need more help with developing the method. Still others may need assistance with how to organize their data as they are conducting their experiment.

Assessment

Objectives

The overall learning objective of this lesson (The Big Idea) is for students to review their knowledge and learn more about the properties of magnets and magnetism. Learning goals also include practice at: posing a testable question, controlling experimental variables, and analyzing data to answer the investigation question. A deeper understanding of the nature of science including collaboration and communication skills is also a primary aim.

Pre-lesson Assessment

Have the students write an explanation to the scenario:

> *A box of tacks has been spilled on the floor. A magnet is used to pick them up. Not all of the tacks are picked up by the magnet. Why do you think some of the tacks weren't picked up?* Each student will also begin a KWL in their science notebooks on what they know about magnets.

Alternatively, use the extensive pre-assessment (Appendix A) to assess student prior knowledge in depth including the best uses for a magnet and how valuable magnets can be used in our everyday lives. Or use the shorter six-question assessments (Appendix B) to easily compare pre-post lesson content gains.

Assessment Plan

- Assess students' ability to come up with questions with the "I wonder" part of the KWL. Use digital recorders for students who are reluctant writers.
- Use their initial plan of investigation to demonstrate students' ability to envision a means of testing their question.
- Listening in on student group discussions will help assess engagement and the degree to which their thinking extends beyond the most concrete (active) level. It will also allow the teacher to monitor their collaboration skills.
- The post-assessment student response sheet explaining how their experiment did (or didn't) answer their question, as well as their presentations with the class show individual understanding of how data supports conclusions.
- Students' science journals, where they record their data and complete the "Learn" part of the KWL on their own along with any other "wonderings," can be used to determine students' understandings of investigation post-lesson.
- Optional six-question assessment (Appendix B) can be used as a post-assessment.

Formative Assessments:

While the groups plan their investigations and collect data, the teacher should circulate, observing the groups in action and asking questions to assess whether their process of investigation is leading towards their goal. Teacher should re-direct groups as needed by asking pointed questions and by having them converse with the other groups that are investigating the same or similar questions.

Listening in on their group discussions will help assess engagement and the degree to which their thinking extends beyond the most concrete level. It will also allow the teacher to monitor students' collaboration skills. Teacher may choose to use the Teacher Rubric (Appendix C) or the Checkbric (Appendix D) to record observations and determine whether individual students are achieving the desired skills.

The student's science notebooks will contain their data collection sheets, which will reflect their ability to use the tools to measure length, volume and temperature. It will also demonstrate their ability to record data and make observations.

Summative Assessments:

The student response sheets and their presentation to the class of their findings are assessed using a simple chart with the following headings:

- Will the investigation answer their question?
- Is the data organized and accurate (multiple trials where needed)?
- Did the student analyze the data logically and assess its accuracy?
- Properties of magnets discovered.

A written post-assessment, similar but not identical to the six-question pre-assessment, can be used to pair student understandings pre- vs. post- lesson. This may be used as a grade, but if the grades do not seem adequate, the teacher may choose to generate a rubric for the science notebook and use this as a grade instead.

"Their oral presentations showed me what had stuck in their minds, both in terms of the properties of magnets and more importantly, how to collect and interpret data. The presentations also gave the students an opportunity to share their insights with the rest of the class, and acted as a pre-writing activity for the final assessment piece, their written description of what they'd done and the analyses of their data."

~Scott Strang

"My pre-assessment proved to give me valuable information on the students' pre requisite knowledge of magnets, their properties and their usefulness in our everyday lives. Based upon this data, it helped me to know what and how to perform the review lesson with them prior to the investigation. This enabled me to not waste valuable time reviewing information they had already mastered. I was able to lead them into learning that was at a "higher level" of thinking which in turn gave students a strong basic knowledge (and confidence) which led them to successfully developing their own questions and performing their own investigations on magnets."

~Kim Hunnicutt

Acknowledgements

VA Science SOL Curriculum Framework

Weaving Science Inquiry and Continuous Assessment, *Carlson, Humphrey, Reinhardt; Corwin Press 2003.*

Recommended Videos:

"Magnets" on BrainPop Jr at Brainpopjr.com/science/forces/magnets

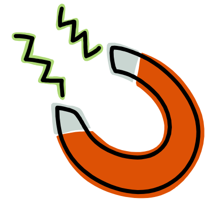
"Magnet Mania" by Kipkay, at http://www.youtube.com/watch?v=2QiyiWLm2FY

"Magnets and Magnetism" by Bill Nye at http://www.youtube.com/watch?v=ak8Bh9Zka50

Appendices: Handouts

1. Appendix A - Optional Written Pre-assessment
2. Appendix B - Optional Pre-Assessment Questions with Pre- / Post- Assessment Item Analysis Table
3. Appendix C - Teacher Rubric
4. Appendix D – Target Skills from Observations

Name:____



Magnets Pre-Test

1. What happens if I drop a magnet?
   A. Magnets that are dropped hard or often can lose their magnetic properties. Always handle magnets with care!
   B. They are very strong, you can drop them and nothing happens to them.

2. Are the poles of a magnet like the North and South poles of the earth?
   A. The earth has two poles, just like a magnet does. They are also magnetic. If left to swing freely, a magnet will point its north end towards the earth's north pole, and its south end towards the earth's south pole.
   B. The poles of a magnet are very different from the poles of the earth and have nothing in common.

3. Describe how can you tell something is a magnet?

4. Do all objects stick to a magnet?

5. Are there certain objects that will stick to magnet better than others?

6. If so, name some objects that stick to a magnet:

Name some objects that do NOT stick to a magnet:

Set A

N S	N S

Set B

N S	S N

7. Circle the set that shows two magnets *attracting* each other?

8. Put an "X" on the set that shows two magnets *repelling* each other?

9. When the magnets are *attracting*, what is true about the two ends that are together?

10. When the magnets are *repelling*, what is true about the two ends that are together?

11. What happens when the *opposite* ends are placed near each other?

12. What happens when the *same* ends are placed near each other?

How would you solve each of the following problems?

1. Bobby dropped some thumb tacks into a fish tank. Describe a way he could get the thumb tacks out of the fish tank without getting his hands wet.

2. Jill said that she could make a paper clip move across her desk without touching the paper clip or the desk. Describe a way she could do this that would make it seem like a magic trick.

3. Jenny's dad dropped a screw down the rain gutter and cannot reach it with his hands. Describe a way you could get the screw without destroying the rain gutter.

Appendix B - Optional Pre-Assessment Questions with Pre- / Post- Assessment Item Analysis Table

What is a magnet? (Open ended question)

What can be attracted by a magnet? (Sort)

How can mass/ weight be measured? (Multiple choice item)

How can magnets be used in everyday life? (open ended question)

From what are magnets made? (open ended)

What are the parts of a magnet? (labeling activity).

Magnet Investigation- Student Records:
(Item Analysis: check or x skills from assessments)

Student Name	Overall Pre-assessment score	Target skill 1: **attract**	Target skill 2: **find weight**	Target skill 3: **using magnets**	Overall Post-assessment score	Target skill 1: **attract**	Target skill 2: **find weight**	Target skill 2: **using magnet**	Change in Overall Score: (+/ -)

Appendix C

Teacher Rubric

Group: Category:	4-Met all expectations	3-Met most expectations	2-Met some expectations	1-Met very few or no expectations
Did students **interact with each other** in order to develop questions that they could investigate?				
Were the students developing questions that were **appropriate for investigation**?				
Were the students conducting appropriate investigations using magnets?				
Were students making important discoveries, connections and conclusions about the **usefulness of magnets in our everyday life**?				
Were students able to communicate their investigations with the teacher and class using the data they collected during their investigation?				

Appendix D

Target Skills **from Observations** (check or x to show skill demonstrated)

STUDENT:	Target skill 1: **attract**	Target skill 2: **weigh magnet (mass)**	Target skill 3: **using magnets**	Target skill 4: **data/ graph**	Target skill 5: **variable/ constants (steps)**	