Einstein for 3rd Grade

Introduction

Growing up in a small, family-owned electrical factory, Albert Einstein learned a great deal by observing, playing, thinking, and wondering. He was often surrounded by magnets, wires, and electrical hardware. What really sparked his interest in science was the day his father gave him a compass. Its mysterious behavior captivated his mind and put him on a path of exploration that he would pursue throughout his long and productive life.

The activities in this module are designed to accompany a reading of the book *On a Beam of Light - A Story of Albert Einstein*, by Jennifer Berne and Vladimir Radunsky.

The pedagogy behind these activities is examined in-depth in an online learning module titled *Einstein for 3rd Grade*, available for your professional development through the Illinois Mathematics and Science Academy's Center for Teaching and Learning.

Einstein himself devoted some thought to the art of teaching and learning. Infuriated by the constraints of traditional German schooling, he advocated for a completely different approach which contemporary educators might call "learning through inquiry in a student-centered classroom". His expressions on pedagogy are fully compatible with the Next Generation Science Standards and form the basis of this learning module.

Objectives:

Although these activities all involve magnets or electricity, this is not an attempt to master those topics. Neither is the idea to turn your class into a small army of Einsteins. That would benefit no one. He was a unique individual. So is each of your students.

The objective for students is to understand how forces interact with motion and stability.

The objective for teachers is to experience the joy of teaching through inquiry. Student's curiosity will be at the top of the agenda. Your lesson plans, including these meticulously crafted activities, will take a back seat as often as not.

Science and Math Standards:

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (Activity 2)

- 3-PS2-2. Make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion. (Activity 1)
- 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. (Activity 3)
- 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets (Activity 4).
- CC.3.MD.4 Represent and interpret data. Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. (Activity 1)

Activity 1: Magnets and Compasses

Objectives: In this activity, students will

- measure the distances at which a compass reacts to an approaching magnet.
- predict the behavior of the compass in response to a different, but similar magnet.

Background Information:

The Earth is a very large magnet, but it isn't very strong. A typical refrigerator magnet is much stronger, but, being small, its effects are only felt nearby. We call these "permanent magnets" because, they have no on/off switch. They are always "on", putting forces on other magnets and some types of metal.

A compass is a small magnet balanced on a pin. It is very sensitive to the presence of other magnets. Even the Earth's weak magnetic field will pull the red pointer northward. If a stronger magnet is nearby, however, the compass will respond by pointing toward or away from the stronger magnet, seemingly ignoring the Earth's much weaker pull.

When compasses are exposed to strong magnets, they often become "ruined" and can no longer be expected to point north. This is not a problem for this activity, but you may need to explain to students why their compasses don't necessarily point north. Even these "ruined" compasses will react appropriately to the presence of the strong magnets used in these activities. That's good enough.

If you have a nice compass that you want to reliably point north, be sure to store it several feet away from magnets or any large metal object.

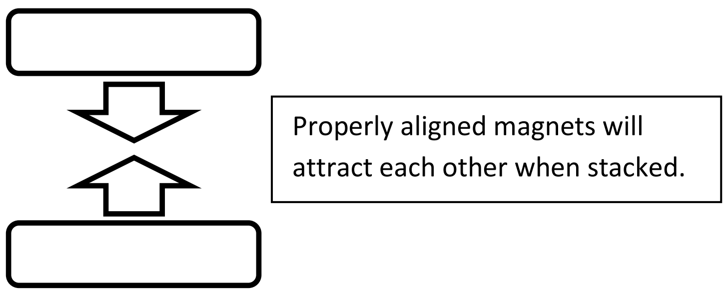
Materials Needed for a class of 30:

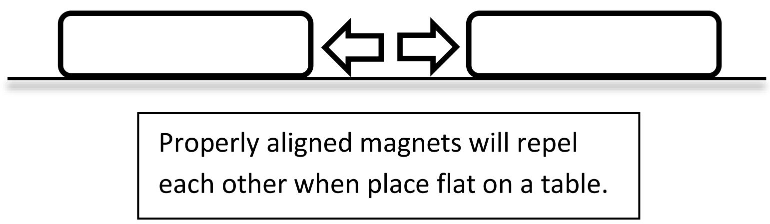
- 30 refrigerator magnets, rare earth (neodymium), disc-shaped, 15 mm diameter, 3 mm thick, generally cost about 50 cents each
- 30 wooden circles, 1" in diameter, roughly 1/8" thick
- Glue (white glue works fine)
- Small, cheap compasses (look for those that cost less than $1 each, sold in packs)
- 15 plastic rulers, with ¼" increments, **no metal parts** (most wooden rulers have a metal edge that will interfere with compass readings)
- Print 15 copies of the Student Card.

Advanced Preparation:

Each magnet has a north face and a south face. These faces are not labeled. When stacked, they will naturally align so that all magnets in the stack have the same face upward. When two magnets, with the same face upward are positioned on a table side-by-side, the magnets will repel each other. This is the desired alignment for these activities.

It doesn't matter whether the upward faces are "north" or "south" so long as they are all the same.

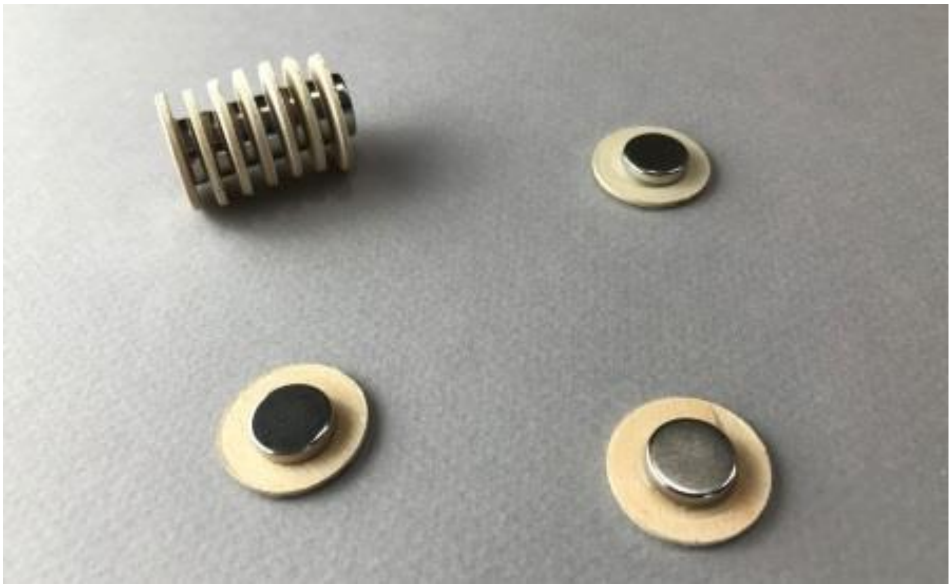




As they arrive from the store, these magnets cling together too tightly for small hands to easily separate.

To prepare magnets for student use, glue each one to the center of a wooden circle. Be sure that the magnets all have the same face upwards. If using white glue, they made need a few hours to dry. Keep the wooden circles several inches apart while drying or the magnets may push against each other and slide before the glue hardens. Although this activity requires only 15 magnets, the next one requires 30, so go ahead and make them all.

In the course of the activities, it is not uncommon for a few magnets to pop-off from their wooden circles. They can be reglued later, but make a few extras beforehand to give students as replacements.



Implementation:

Organize students into groups of two. Give each group a compass. Let them explore its behavior for a few minutes.

- What do you notice about the compass?

1. Allow students to think quietly for a minute.
2. Ask them to discuss their thoughts with their partner. Give them time.
3. After they have had a few moments to practice expressing their ideas, bring the class together for a larger discussion so everyone can share. Give positive acknowledgement for any reasonable observations.

This three-step process for helping students prepare their thoughts in a safe environment is often called "Think-Pair-Share". It's a great way to help students build enough confidence to share ideas about unfamiliar concepts.

- What happens when you turn it very slowly?

Use the Think-Pair-Share strategy to help them express their ideas.

- What questions do you have about compasses?

These are **not** questions for you, the teacher, to answer! Students may attempt to answer each other's questions in discussion. Ask students if they might be able to answer an open question by doing a little experiment. With your guidance, allow them to design the experiment. Then have students do the experiment and discuss the results.

This takes time. Give it to them. Experiments suggested by students are generally more impactful than the experiment you planned.

This exercise may conclude with many questions left unanswered. That is to be expected. It indicates that students are engaged in thinking like scientists. Well done!

Give each group a magnet. As students get the magnet near the compass, they will notice it begin the move.

- Can the magnet make the compass move without touching it?
- What do you notice about the movement of the compass?

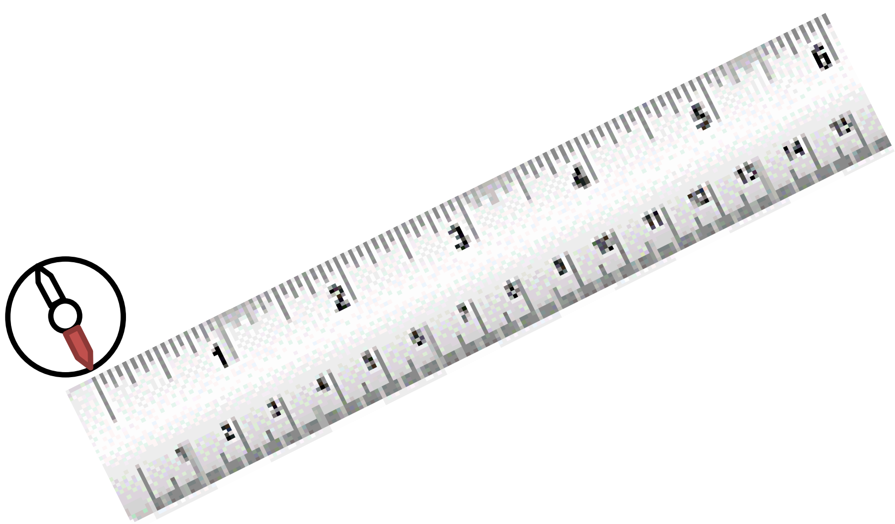
Use the Think-Pair-Share strategy to help them express their ideas.

- What questions do you have about how the magnet makes the compass move?

Allow them to discuss and experiment to answer their own questions.

Ask students to place their compasses flat on their desks and to keep their magnets at least a foot away, so the compass in not disturbed by the magnets.

Give each group a plastic ruler and a diagram that shows how to place the ruler with the "zero inches" mark aligned with the red pointer of the compass. Point out that their compass may be pointing in a direction different from the diagram, or from other compasses in the room. Rotating the diagram might help them see the alignment.



Move the ruler to match the compass. Not the other way around.

Take the magnet and very slowly bring it closer to the compass from the far end of the ruler.

- How close to the compass must you bring the magnet before the red pointer begins moving? Measure to the nearest ¼ inch.
- Does it matter which face of the magnet is approaching?
- What else do you notice?
- Try switching magnets with another group. Does this new magnet have a similar effect on your compass?

Use the Think-Pair-Share strategy to help them express their ideas.

Activity 2: Force and Motion

Objectives: In this activity, students will

- observe the motion that results from one magnet approaching another.
- identify the cause of the motion as a pushing force between magnets.
- predict the direction of the force as the line through the centers of the magnets.

Background Information:

Two magnets will place a force on each other that increases in strength as the distance between them is reduced. The force can be attractive or repulsive depending on which poles of the magnets are brought together. This force is invisible, but can be detected by the motions it produces.

Materials Needed for a class of 30:

- 30 magnets mounted on wooden discs as described in the previous activity.
- Print 15 Copies of the Student Card

Implementation:

In this activity, students will play two games. The first involves two magnets and the second introduces a third magnet. In their attempts to win the games, students will necessarily experience the relationships between the positions of the magnets and the strengths and directions of the forces.

Game 1: Sailboat Races

In this game, students race to push a magnet “sailboat” around a path as quickly as possible.

The push comes from another magnet, which is slid along the surface of the “lake” by hand. There are three essential rules:

1. Your fingers may only touch your pushing magnet, not the sailboat magnet.
2. Both magnets must stay flat on the paper at all times.
3. At least some part of the sailboat magnet must remain on the line that represents the race course.

Additional rules will be needed, but allow students to decide these rules as a class. You might write these rules on the board. They will need to determine start/stop line and what to do when the boat leaves the course, among other things. They may choose to do relay races in which each member of the group does one lap. If timers are available, students might compete by having the fastest time, rather than being first to the finish line.

After you feel that students have had enough time to experience the way magnets are moving in response to forces, it is time to list observations and questions. Keep the students focused on forces and motion, not the game rules.

- What did you notice about the motion of the sailboat magnet?

1. Allow students to think quietly for a minute.
2. Ask them to discuss their thoughts with their partner. Give them time.
3. After they have had a few moments to practice expressing their ideas, bring the class together for a larger discussion so everyone can share. Give positive acknowledgement for any reasonable observations.

This three-step process for helping students prepare their thoughts in a safe environment is often called "Think-Pair-Share". It's a great way to help students build enough confidence to share ideas about unfamiliar concepts.

- What did you notice about the forces between magnets?

This question is tricky. The forces are invisible! Students must infer the presence of the forces by feeling the push and pull while holding magnets and observing how things move in response to pushes and pulls. Use the Think-Pair-Share strategy to help them express their ideas.

- What questions do you have about the forces and motions of the magnets?

These are **not** questions for you, the teacher, to answer! Students may attempt to answer each other's questions in discussion. Ask students if they might be able to answer an open question by doing a little experiment. With your guidance, allow them to design the experiment. Then have students do the experiment and discuss the results. This takes time. Give it to them.

This exercise may conclude with many questions left unanswered. That is to be expected. It indicates that students are engaged in thinking like scientists. Well done!

Game 2: Magnetball World Championship

Magnetball is a game that students will get to invent and play. Two groups will compete against each other. They use sticks to push their magnet "players" around the field, trying to repel a magnet "ball" into the opposing goal. Each team gets one stick and one player magnet. A third magnet serves as the ball. Use a dry erase marker to put a dot on the ball, to distinguish it from the players.

The following rules are essential:

1. Players and the ball must remain flat on the table at all times.
2. Your stick may only touch your own player, not the ball, the other player, or the other stick.
3. You may not push your player so hard, that it actually touches the ball or the other player. Play with finesse, not strength.
4. If there are multiple students in a group, they must take turns using the stick.
5. Breaking these rules results in a penalty.

Additional rules will be needed, but allow students to decide these rules as a class. You might write these rules on the board. Students will need to determine scoring, time of play, penalties, and how to determine when the players on a team must switch roles (since only one has the stick).

After you feel that students have had enough time to experience the way magnets are moving in response to multiple forces, it is time to list observations and questions. Keep the students focused on forces and motion, not the game rules.

- What did you notice about the forces and motion of the ball magnet?

Use the Think-Pair-Share strategy to help them express their ideas. Focus on new ideas that were not apparent in the sailboat race. In this game, the ball was moving in response to <u>two</u> imposed forces. Each player magnet was responding to <u>three</u> forces (the ball, the other player magnet, and the stick).

- What questions do you have about the forces and motions of the magnets?

If you saved a list of questions from the Sailboat Races then that would be a good place to start. Ask students if they might be able to answer an open question by doing a little experiment. With your guidance, allow them to design the experiment. Then have students do the experiment and discuss the results. Perhaps students will be able to answer some questions or add new questions to the list.

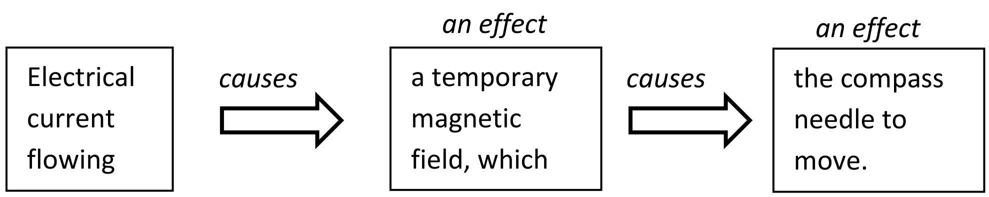
Activity 3: Questions of Cause and Effect

Objectives: In this activity, students will:

- Observe the motion of a compass needle in the presence of an electrical current.
- Identify and distinguish the cause and effect for this interaction.

Background Information:

Electrical current flowing through a wire (or anything else) creates around itself a magnetic field. In this way, an electrical current becomes a temporary magnet, as long as it continues to flow. A compass needle near this temporary magnet will move in response to the force. In terms of cause and effect, we could say:



Magnetic fields are invisible so students should not be expected to identify the creation of one as an effect. They can, however, link the initial cause “electricity flowing” with the final effect “the compass needle moves”.

Materials Needed for a class of 30:

- 15 D-cell batteries
- Aluminum foil, cut into strips of roughly 1” wide and 12” long
- 15 compasses (as described in activity 1)
- Print 15 copies of the Student Card

Implementation:

Form students into groups of two and give each group a compass and a long strip of aluminum foil.

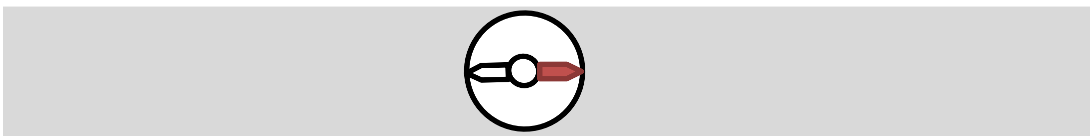
- Is the aluminum foil magnetic? Explain.

4. Allow students to think quietly for a moment.
5. Ask them to discuss their thoughts with their partner. Give them time to experiment.
6. After they have had a few moments to explore, bring the class together for a larger discussion so everyone can share. Give positive acknowledgement for any reasonable observations.

This three-step process for helping students prepare their thoughts in a safe environment is often called “Think-Pair-Share”. It’s a great way to help students build enough confidence to share ideas about unfamiliar concepts.

Give each group a battery. Tell them that electricity will flow from one end of the battery to the other if it can find a path.

Ask students to place the strip of foil flat on the desk, underneath the compass so that its length is aligned with the compass needle as shown in the diagram.



Now they may bend the ends of the foil strip up to touch each end of the battery as shown on their Student Card. This creates the path (a circuit) through which electricity can flow.

- What do you notice about the compass needle when the foil touches the battery ends?

Use the Think-Pair-Share strategy to help them express their observations.

Tell students to hold the compass about ¼ inch above the foil.

- Does the compass needle still move when it is not in contact with the foil?

Let them try. Magnetic fields do not have to be in physical contact to push and pull each other with a force.

- What might be causing the compass needle to move when you connect the battery to the foil?

Do not expect students to give a correct scientific explanation of this. Rather, help them focus on words like *cause* and *effect* to help them distinguish between the two.

Effect: what you notice happening

Cause: what made it happen

- What questions do you have about what’s happening?

These are **not** questions for you, the teacher, to answer! Students may attempt to answer each other’s questions in discussion. Ask students if they might be able to answer an open question by doing a little experiment. With your guidance, allow them to design the experiment. Then have students do the experiment and discuss the results. This takes time. Give it to them.

This exercise may conclude with many questions left unanswered. That is to be expected. It indicates that students are engaged in thinking like scientists. Well done!

Activity 4: Lifting with Magnetic Force

Objectives: In this activity, students will:

- build an electromagnet.
- define an objective way to measure the performance of their electromagnets.

Background Information:

Any wire carrying an electrical current behaves as a temporary magnet. Coiling that wire around a metal nail or bolt strengthens the magnetism. In this activity, students will make a magnet strong enough to lift metal objects including staples and small paperclips.

Magnets of this type are called electromagnets as they rely on an electrical current to function. Electromagnets are the primary components of electrical motors and generators that have been driving modern technology for over a hundred years.

Materials Needed for a class of 30:

- 15 batteries (as described in previous activity)
- 15 nails or bolts (2 to 4 inches long, thicker is better)
- 30 feet of 24-gage insulated electrical wire (Cut into segments of 24" and use scissors, wire cutters, or wire strippers to remove about ¼" of insulation from each end of the wire segment.)
- Print 15 copies of the Student Card

Implementation:

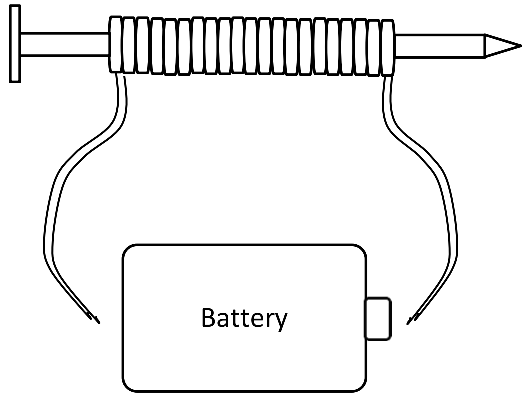
Show students a video of an electromagnet being used to move scrap metal. Here are two from YouTube:

> https://www.youtube.com/watch?v=nvyL5s6hLjk or
> https://www.youtube.com/watch?v=2nY2i_L68jA

Lead a class discussion about what they saw.

- How does this crane lift the metal?
- How is this magnet different from the ones we have used?
- What type of magnets can be turned off and on?

Form students into groups of two or three and give each group a battery, a nail, and 24" of wire with the insulation stripped from both ends. Show them the diagram on their Student Cards and allow them to try building the electromagnet.



One or two pieces of masking tape might be helpful for keeping the wire coiled. When they think they have it, give students a small paperclip and a few loose staples to see if their magnets can pick them up.

Challenge them to move their scrap metal from one place to another without touching the metal with their fingers. They will have to turn their magnet off to drop whatever metal they lift.

- If we held a contest to see who built the best crane, how would we decide which was best?

Students will naturally suggest counting how many staples can be lifted at once. That's a good start. Remind them that the scrap yard needs to move metal from one pile to another as quickly as possible. Guide the class toward adopting a set of simple rules for judging which crane is best.

Hold a brief competition. Encourage students to keep experimenting with their designs to get better performance from their cranes. Have them share with the class any notable improvements they are able to make.

Two groups might band together to link their wires together to make a bigger coil. Using more battery power improves the magnet, but don't go beyond 6 volts, as the wires and battery will become too hot.