Although most elementary students have had experiences with magnets, they generally have misconceptions about magnetism (Driver et al. 1994; Burgoon, Heddle, and Duran 2010). For example, students may think magnets can attract all metals or that larger magnets are stronger than smaller magnets. Students often confuse magnets with magnetic materials and may say things “stick to magnets” but not consider repulsion.

Driver et al. (1994) recommends using everyday experiences and focusing on the uses of magnets to help students gain greater insight into how magnets work. However, the everyday uses of magnets typically examined in the classroom (e.g., motors, electromagnets) are not developmentally appropriate for students in primary grades. Young children have difficulty understanding concepts they cannot see, even when the lesson is hands-on (Olson 2008). When content is too abstract, students have no choice but to memorize key facts and consequently never mentally engage with the concepts. Therefore, this article provides a series of developmentally appropriate experiences and discussions, which concretely scaffold students between grades 2–4 toward accurate ideas of magnetism.
Figure 1.
Materials provided to students during the mystery box activity.

- Cork
- Piece of copper
- Rubber band
- Nut and bolt
- Straw
- Piece of aluminum foil
- Paper clip
- Pennies, nickels, dimes
- Sponge
- Piece of wax paper
- Marble
- Key ring
- Nail (steel)
- Nail (aluminum)
- Domino (ceramic works better than wood or plastic)

Our Process
Part of effective science planning involves carefully scaffolding students toward more complex ideas. We intentionally sequenced the activities in this article to add complexity as the unit progresses. The mystery box and the magnet hunt involve interactions between a magnet and metal. We advance to using two magnets to teach about poles, and finally to comparing the magnetic force among many magnets. We start with a visual and concrete activity and move toward more difficult concepts as the activities progress. Each step along the process adds a layer of understanding. The National Science Education Standards (NRC 1996) for grades K–4 indicate students should deeply understand that magnets attract and repel each other and certain kinds of other materials. Furthermore, A Framework for K–12 Science Education states that students should know that magnets push and pull as well as understand magnetic poles (NRC 2011). However, if students are not carefully scaffolded through these concrete activities, the aforementioned misconceptions may inhibit meaningful engagement with the concept.

The Mystery Box
What types of objects are attracted to magnets? We begin our investigations by using a modified version of the mystery box activity found in the Electricity and Magnetism Full Option Science System kit (Lawrence Hall of Science 2005). Prior to the activity, we tape magnets to the inside of boxes. Each pair of students is given a sealed “mystery box” (with a magnet affixed) and a number of objects to use as they explore the box (Figure 1).

When students have their materials, we ask, “Using these objects, how could you determine what is inside this box without opening it?” Students often answer, “Poke the box with the objects!” or “You could rub the objects on..."
the box.” We tell students to try those ideas, but clarify that they may not damage the box. Once students begin investigating, they quickly conclude a magnet is present because some of the objects “stick” to the box. We then ask the whole class, “How could you use your objects to figure out where the magnet is located in the box?” In our experience, students try each of the objects to find the magnets’ locations and categorize the objects based on their magnetic properties. If students do not begin to categorize, we ask the whole class, “How could we keep track of which objects help you find the magnet and which ones do not?” Students often say, “Put them into piles.” Students then categorize their objects into two piles: objects that “stick” to the box and objects that do not.

After students complete their categorizations, we ask the whole class, “I noticed you only used materials from one of your piles to find the magnet. Why didn’t you use materials from the other pile, such as the sponge?” Students quickly respond, “Only the metal things stick.” We explore this idea by asking, “What do you notice about all of the objects that stick to the box?” Students conclude, “They are all made of metal!” We use students’ ideas to deepen their knowledge by asking, “If objects have to be metal to stick to the magnet, then why doesn’t the aluminum nail or the coins stick to the magnet?” Students will often qualify their response by saying, “Only certain types of metals are magnetic.” By purposefully guiding students to categorize their objects and then explain their categories, students begin to become dissatisfied with the notions that (1) many different types of materials are attracted to magnets, and (2) all metals are attracted to magnets.

### Magnetic Objects Classroom Hunt

This is an assessment and extension of: “What objects are attracted to magnets?” Students interpret classroom activities through the lens of their prior experiences. As a result, one activity is not enough to adequately challenge students’ misconceptions. Therefore, we extend the mystery box activity to a “magnetic hunt” to formatively assess how well students understand that only certain metals are magnetic. We begin by asking “What types of objects can we test to see whether they are attracted to a magnet?” and “How can we keep track of which objects are magnetic and which ones are not?”

Through questioning, we guide students to create a chart as a class (see NSTA Connection). Students are then divided into groups of two, given a disc magnet, and asked to explore the classroom to seek out objects that attract to magnets. As with any activity involving magnets, the teacher needs to make clear to the students that putting the magnets near anything electronic is dangerous and shouldn’t be done. Because the magnet hunt has students roaming around to find magnetic objects, this safety consideration is of extreme importance. Once the safety issues have been addressed, students record the names of objects they want to explore, their predictions, and the actual results.
Predictions can be a powerful formative assessment tool for teachers when students have substantial background information with the phenomena. If students do not have adequate knowledge to make logical predictions based on evidence, students often end up just guessing. Because students have numerous prior experiences with magnets, their predictions help us establish their level of understanding. In addition, students become invested in the activity because they want to check whether their predictions are right. Some of the predictions we heard from students during the activity were, “Let’s go try the doorknob first. Metal will definitely work” and “That is made of cloth. Don’t even try that one.”

Once the hunt is concluded, students create a common list on the board (this will vary from classroom to classroom). We use student ideas from the chart to help them think critically about magnets. We ask:

- What are some things you thought would be magnetic that weren’t?
- Why did you think those things might be magnetic?
- What do you notice is similar between the magnet hunt activity and the mystery boxes?
- What can we conclude about magnets and metals?

After students deeply understand that only certain kinds of metals are magnetic, we help them apply knowledge by asking, “What do you think would happen if we tried a rock with a magnet?” Students protest by saying, “A rock won’t work! It isn’t made of metal!” However, we continue this demonstration and try a magnet and lodestone (a naturally magnetized piece of the mineral magnetite). Students are often amazed by the magnetic rock. Building on students’ curiosity we then ask, “If this rock is attracted to a magnet, what do you think has to be a part of the rock?” Students realize that lodestone contains the same types of metal as the other objects they have used. We ask students to brainstorm by asking, “What other objects can you think of that don’t look like...
they have magnetic metals in them, but you know are magnetic?” Students often come up with the classroom whiteboard and a refrigerator. This application activity deepens students’ understanding to include the idea that not all magnetic materials have the same appearance, but they are all made out of certain types of metals.

By using both the mystery box and magnet hunt we encourage students to mentally wrestle with the idea that all metals are not attracted to magnets. This knowledge serves as the foundation for helping students more deeply understand other aspects of magnetism.

**Toy Trains and Cars**

Next we explore the question, “How do two magnets interact with each other?” To teach students the concept that magnets have north and south poles, we use toy trains or matchbox cars with magnets attached by tape (see Figure 2, p. 64). Students are given the challenge in groups of two to move one train or car without touching it. During the activity, we walk around the room and pose questions such as, “What do you notice happens when you put the train cars close to each other?” Students often say, “The trains get pulled together.” We then might ask, “If you wanted the trains to get pushed away from each other, what could you do?”

After students have had time to investigate, we ask the whole class, “How did you get your train to move because you couldn’t touch it?” Students say, “We had to flip one around so it would push away the other one.” We would then ask, “If you didn’t flip one around, what happened?” Students would say, “The two would stick together.” “What do you notice about how magnets interact with each other? Students often say, “Magnets have two sides.” Once students realize attraction and repulsion are due to the sides of the magnets, we introduce the terms “north” and “south” poles.

We give students three different magnets: a bar magnet, a horseshoe magnet, and a disc magnet. Each magnet is labeled “N” and “S” so students can see all magnets have two poles, even if the shape and size is different. We challenge students to think deeper about north and south poles by asking, “What do you have to do to get your magnets to attract each other?” Students say, “You have to put the north side by the south side.” We then ask, “If that is the case, how would you get the magnets to push each other away?” Students reply, “You put the same sides together.”

To formatively assess students’ understanding of north and south poles, we ask students to write a prediction and draw a picture of what they think will happen when disc magnets are placed on a pencil or wooden dowel (Figure 3, p. 65). Students usually write, “They will all stack up.” We ensure the magnets are all placed on the pencil with north side facing up. We then ask students to make another prediction and drawing for the following question: “What do you think would happen if we flipped one of the magnets in the middle of the stack?” Students will usually write, “They won’t touch anymore.” or “They will still stack.” After the demonstration, we ask students, “Why do you think it hovered?” Students will say, “When you flip the magnet, the north side is by another north side.” We then scaffold back to the toy trains and cars by asking, “How is this activity similar to what we did with the train and toy cars?” Students respond, “When the trains and cars stick to each other, north touches south. When they push away, the north is by the north or the south is by the south.”

**Magnet Strength**

How does the size of the magnet compare to the strength of the magnet? This next investigation is intended to challenge students’ common misconception that the bigger the magnet, the stronger the magnetic force (Etheredge and Rudnitsky 2003). During this investigation, students use various sizes and shapes of magnets (disc magnet, bar magnets—small and large, magnetic wand, horseshoe magnets—small and large, magnetic marbles) to predict and test the magnetic strength of each magnet by using paper clip chains (Figure 4, p. 65). Students immediately predict the largest magnet would be the strongest. In pre-
paring for this experience, we ensure the strongest magnet is not the largest. In our magnet collection, the disc magnet was one of the strongest. Because the disc magnet was one of the smallest in the collection, students often become dissatisfied with their original prediction.

After a short display of the magnet options, students are challenged, in groups of two, to find the strongest magnet in the bunch. We start the challenge by asking, “How could we use the paper clip chain method to determine the strength of each magnet?” Students will suggest adding paper clips one at a time until the chain fails. We then ask, “Why should we use the same size of paper clips?” Students often say we need to be able to compare between magnets. After students are finished, we guide them to create a bar graph of the length of the paper clip chain for each magnet which have been arranged on the graph from smallest to largest. Creating a group bar graph allows all students to view the trend and easily see the problems with their initial ideas. We ask students, “How does this graph look differently than you predicted?” Students will initially predict the graph would be a slow incline, but in reality it has mountains and valleys. We ask, “What do you think this means about the strength of magnets?” Students usually conclude bigger magnets are not always the strongest.

Scaffolding Is Key

Although these activities set the stage for student learning, the actions of the teacher determine how much learning actually occurs. Effective teachers ask intellectually engaging questions that help students see problems in their thinking and scaffold students toward the desired conceptual understanding (Clough 2007).

Effective questioning also helps the teacher diagnose student understanding. We use the questions described in these activities to formatively assess students’ understanding of magnetism. By assessing students during the activity, we can make adjustments on the spot to maximize student learning.

Teachers often go too far with magnetism by including abstract concepts such as motors, electromagnets, or Earth’s magnetic field. Including these types of activities is understandable considering they are commonly included in textbooks and other curricular materials. However, when developmentally inappropriate activities and examples are included, students often get confused and lose site of the big ideas and important concepts of the magnetism unit (Olson 2008). Additionally, by using abstract activities, less time is available to scaffold student thinking through appropriate experiences. If elementary teachers are to successfully help students confront misconceptions, activities should be limited to concepts that are visible, can be scaffolded effectively, and are developmentally appropriate for students in the primary grades. The activities included in this article use everyday objects and teacher questioning to help students make sense of magnetism in a meaningful way.

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References


Connecting to the Standards

This article relates to the following National Science Education Standards (NRC 1996):

**Content Standards**

**Grades K –4**

**Standard A: Science as Inquiry**

- Abilities necessary to do scientific inquiry

**Standard B: Physical Science**

- Light, heat, electricity, and magnetism


**NSTA Connection**

For a class chart for the magnet hunt, visit [www.nsta.org/SC1210](http://www.nsta.org/SC1210).