Using *Lesson Study* to Assess Student Thinking in Science

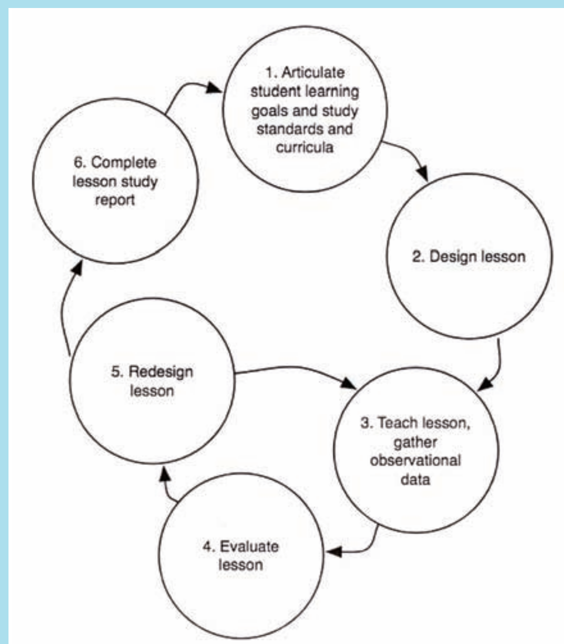
SUMMARY

Teachers examine fourth-grade students' understandings of magnetism through the use of science notebooks. Decisions about student learning outcomes, lesson design, and assessments are derived from the use of a Japanese lesson study approach. Lesson study leads the team through a process which includes a live research lesson with observers who gather extensive data on the lesson and outcomes. This forms a cycle of continuous improvement in all aspects of teaching.

Assessments are opportunities to study student thinking and analyze teaching practices to best develop students' ideas. Assessments, when tightly linked to standards and instructional design, provide information to evaluate:
(1) student learning,
(2) teaching practice,
(3) the effectiveness of curriculum materials, and
(4) the standards upon which the lesson is designed.

The purpose of this article is to describe our process for designing a formative assessment of fourth-grade students' ideas about magnetism through the use of science notebooks. The context for designing this assessment was the process of **Japanese lesson study** (Fernandez, 2002; Fernandez & Yoshida, 2004; Lewis, 2002; Lewis, Perry, & Hurd, 2004, 2009; Lewis, Perry, & Murata, 2006; Stigler & Hiebert, 1999). This process is outlined below.

Japanese lesson study process



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Lesson study begins as teachers work together to articulate goals for student learning. This begins with a broad, non-subject-specific goal that describes their students as learners. This broad goal can then be framed for a subject area, like science, then a unit, like magnetism, and finally a lesson. To complete this step, teachers study standards and curriculum to determine existing good ideas that use methods that align with their goals and help students learn. The team in this description is a group of two fourth-grade teachers, a special education teacher, and a science teacher educator.

In Step Two, the team writes a detailed plan to guide students' learning and specify what observers should look for when they attend the lesson. In this approach, observers are invited to view the lesson. Observers may be teachers and others who are invited. Examples of plans are available from sources such as Lewis and Hurd (2011).

Steps Three through Five occur as many times as the team decides are necessary or practical. Step Three begins with one educator from the team teaching the lesson to a class of students. The other members of the team attend this lesson and observe the students engaging in the task the group designed. This is called a "live research lesson" (Lewis, 2002).

Step Four occurs after the lesson implementation. The team meets as soon as possible to discuss the outcome. After this, they go to Step Five: redesigning the lesson based on the evidence of student thinking they gathered in Step Three and discussion they had in Step Four. The lesson can be retaught to a new group of students, repeating steps Three through Five.

For Step Six, teachers create a report that documents their learning. They can discuss what they know about students' ideas, what they know about teaching that particular lesson in that particular unit, and how their understandings relate to teaching generally and the goals and standards upon which the lesson was based (see Lewis, 2010).

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Step One: Articulate Student Learning Goals and Study Standards

During our lesson study, we worked with other teachers in our school to articulate our broad goal:

> ***We will create an engaging environment to teach students a core body of knowledge to become independent problem solvers and effective communicators.***

Thus, we needed to gather evidence in the live research lesson that students were engaged, learning core knowledge, problem-solving independently, and communicating with one another effectively, both orally and in writing.

After establishing our broad goal, we studied the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1994), the *National Science Education Standards* (National Academy of Sciences, 1996), and the *New York State Elementary Science Core Curriculum (Grades K-4)* to understand the indicators or outcomes of student learning for magnetism:

- Without touching them, a magnet pulls on all things made of iron and either pushes or pulls on other magnets (AAAS, 1994).
- Magnets attract and repel each other and certain kinds of other materials (NAS, 1996).
- Magnetism is a force that may attract or repel certain materials *(New York State Elementary Science Core Curriculum,* Standard 4, Key Idea 5, Performance Indicator 5.1).

These descriptions of what students should know about magnets are similar, but they are not identical. There are specifics within each one that informed our planning. For example, in the American Association for the Advancement of Science *Benchmarks for Science Literacy*, the effect of a magnetic force over a distance is stressed in the phrase "without touching." Also, they do not use the term "force"; instead they describe the force as a "push" or a "pull." This resource also distinguishes magnet-to-magnet interactions and magnet-to-iron-based object interactions. These distinctions are maintained in the *National Science Education Standards* as well, but not in the NYS *Elementary Science Core Curriculum.*

Step Two: Design Lesson

From our evaluation of these standards, outcomes, and performance indicators, we taught a series of lessons about magnets from the unit *Magnetism & Electricity* from the *Full Option Science System* (FOSS). FOSS was developed originally by the Lawrence Hall of Science at the University of California at Berkeley in

1993 and revised in 2001. (An overview of the unit can be found at *http://www.fossweb.com.*)

In the original unit, students were given magnets to investigate magnet interactions with objects in the classroom. Then, students would explore how the magnet interacted with a set of other items in the kit. The original lesson called for students to predict first by sorting these objects into two piles: one pile of objects that they predict magnets would attract and one that would not. Students were then asked to test the objects and re-sort them based on their tests. Teachers engaged students in a discussion of what they noticed. Students were then asked to construct an explanation for why a paper clip can stick to a nail that is already touching a magnet. In the original lesson, students were not asked to record their observations, only to generate an explanation of a phenomenon they might not have observed themselves.

We used many of the materials and strategies described above, but we decided to modify the original design by using *science notebook writing*. We think of science notebooks as tools to support students' thinking as they learn in science and as tools for assessment (Aschbacher & Alonzo, 2006; Gilbert & Kotelman, 2005; McQuitty, Dotger, & Khan, 2010; Ruiz-Primo, Li, Ayala, & Shavelson, 2004). Thus, we designed a notebook task in which students recorded this focus question:

What objects will stick to magnets?

We designed this question after studying the teacher's guide and discussing students' ideas from a previous lesson about magnets. We were also concerned that students were not recording their predictions or their observations. Therefore, we designed the notebook task asking students to record:

- their predictions about each object,
- the result of their test of that object with the magnet,
- a claim that identified a pattern in their data,
- support for their claim with evidence from their investigation,
- a conclusion in their notebook that began with the statement, "*Today I learned . . .*" and
- a reflection in their notebook to extend their ideas by beginning with the statement, *"I wonder what would happen if . . ."*

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F. Kevin Moquin uses a range of visual supports to enhance student learning.

The science notebooks informed our understanding of students' thinking and, as a result, our lesson design for the future.

We taught the lesson to two other groups of students before we arrived at the final design we report on here. During these lessons, we noticed that as students recorded their ideas, they changed their predictions as they realized they were incorrect. Even though each student was given only one magnet, students shared magnets so they could play with magnet-to-magnet interactions.

Some students were unfamiliar with the names of the 19 objects in the kit. Thus, we made additional changes to our lesson design. In the final lesson, the teacher identified each of the objects in the bag.

The live research lesson was co-taught by a general education and a special education teacher to a class of 23 fourth-graders. All students were Caucasian, ten were female, three had an Individualized Education Program (IEP), four received Academic Intervention Services (AIS), and six received free or reduced-price lunch. Based on the needs of our students, we designed the following accommodations *within* the lesson:

- A typed list of objects to streamline the prediction and data recording process,
- Verbal cueing for the task,
- Individual whiteboards to assist students with spelling new terms, and
- Peer-to-peer discussion of ideas before, during, and after writing.

Step Three: Teach Lesson, Gather Data

In addition to the two teachers working together to teach the lesson, additional adults observed the lesson to gather data: the authors of this paper, other teachers in the building, undergraduate teacher education students, and district administrators. We:

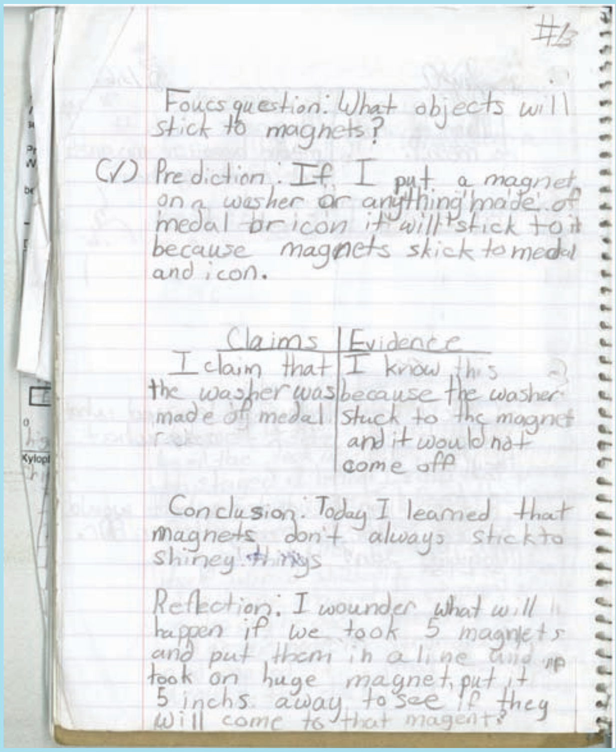
- gathered data regarding students' conversations with one another,
- described student use of materials,
- took photographs of student work and of their problem solving activities,
- videotaped the class, and
- collected students' science notebook entries.

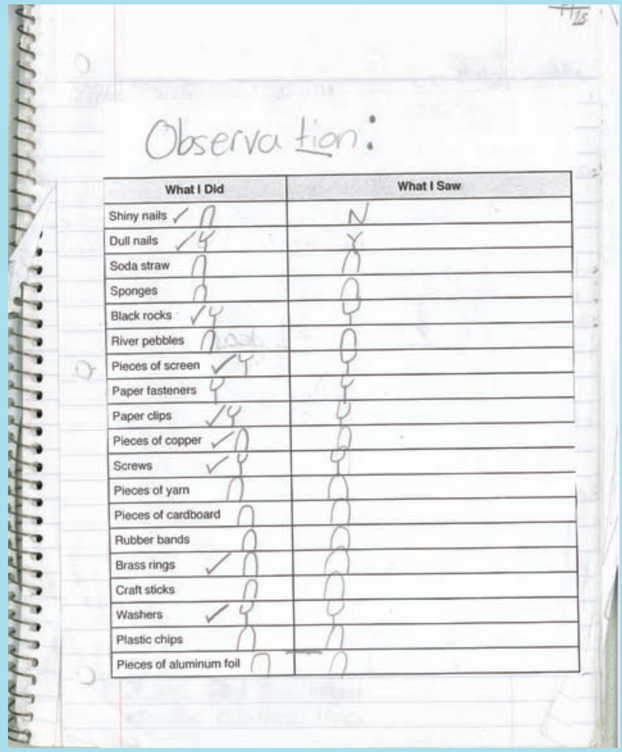
We will focus the remainder of our discussion on the science notebook and how that informed our understanding of students' thinking and, as a result, our lesson design for the future.

An excerpt of a science notebook is shown in Figure 1.

Figure 1

Excerpt of a Science Notebook





Science Notebook Writing and The Common Core Learning Standards

Science notebook writing provides an excellent opportunity to engage students in content area writing that aligns with the College and Career Readiness Anchor Standards for Writing in the *NYS P-12 Common Core Learning Standards for English Language Arts & Literacy:*

"Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence" (p. 18).

It is important to note, however, that the science notebook is not a final product. It is a process tool that should be used to give students an opportunity to think and develop over time. Therefore, spelling, terminology, and sentence construction need not be perfect within the science notebook — much as early drafts of many authors' work.

We imagine several ways students could use their science notebook as a tool to develop a product so they could share what they've learned with others. They could create a webpage, a class newsletter, or a school bulletin board to demonstrate their learning using scientific language and traditional writing conventions.

We studied the claims and evidence in the students' notebooks.

Step Four: Evaluate the Notebooks and the Lesson

Our goal was for students to articulate a *pattern* in their predictions. Their actual predictions presented us with insights into students' prior knowledge. Five examples of students' ideas are below. They illustrate the range of responses from the 23 students in the class.

Student 1: ***If I stick a magnet to a brass ring, it will stick because brass is heavy and brass may be gold.***

Student 2: ***If I took a washer and put a magnet on it, I think it will stick because from looking at it, it seems to be meadle (metal) to me.***

Student 3: ***If I had a magnet, I would stick it to the opshons (objects) that they gave me and I would use it on the black rock and the river rock to see if it stuck to both of them.***

Student 4: ***If I put two magnets together then they would either separate or stick together because one of the sides has something different than the other.***

Student 5: ***If I put a magnet on a different magnet then it would stick because the magnetic pulse would pull them together.***

These examples show that the students focused on a singular object to make their prediction. They did not discuss a pattern such as *magnets will not stick to plastics*. We also noticed that Student 3 incorporates the procedure of the investigation into her prediction. Students 4 and 5 discussed the relationship between magnets in their prediction. They offer two different reasons for why the phenomenon might occur.

When we studied the claims and evidence in the students' notebooks, we noticed their claims were specific to individual data points, rather than providing a general rule for the phenomenon. For example, students wrote:

- "I claim that the yarn does not stick because it is soft,"
- "I claim that the washer was made of metal," and
- "If you stick the side of a magnet to another side, they have resistance."

In each of these cases, students made a claim about one of the objects, rather than a claim about a pattern among them. For example, we expected students would say "Objects that do not contain metals will not stick to a magnet. I know this because the yarn, plastic chip, and cotton ball did not stick to the magnet. None of these objects contain metals."

Step Five: Redesign The Lesson

In debriefing the lesson, we studied the teacher guide again (i.e., *Magnetism & Electricity*, 2001). We noticed that in the original lesson, there was wisdom in two distinct practices we had modified. One was the wording of the question. Our question had been: ***What objects will stick to magnets?*** The manual suggested that the question to open the lesson should have been a statement of a problem that pointed toward identifying patterns:

"I'm wondering if there is something that is the same about all the objects that the magnet sticks to."

We hoped students would recognize this pattern when constructing their claims. While a case can be made for both approaches, we now think the original statement would have provided the level of support that was appropriate to our goals.

Another element of redesign was related to the materials. If we had the students create groups of objects by sorting instead of marking a pre-made list in their notebooks, they would have had a group of objects to study to generate their claims. This may have helped them see the pattern more effectively than trying to pick like objects from a list they could not sort.

Step Six: Complete Lesson Study Report

While a lesson study report would address all aspects of the lesson, we will focus here on what we learned about the science notebook as an assessment tool. We feel it was an effective component in our assessment plan for the following reasons:

1. The structure of the notebook task was open-ended enough that we could attribute students' writing to their own ideas, rather than to prompts that may be embedded in directed questions.

2. The structure of the notebook was flexible and therefore able to accommodate the variety of needs and the strategies preferred by our students.

3. The notebook and the associated lesson were well linked to the standards, allowing us to assess students' learning in a way that linked the standards to our practices and then to their ideas.

4. Observing students engage in the task, we learned that the structure of claims and evidence was difficult for them and have begun further inquiry into how to help students improve this portion of their scientific thinking and writing.

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Through our examination of student ideas using science notebooks and lesson study, we were able to study student outcome data that was directly linked to our instructional design. This linkage gives us important information about how to improve our teaching, for this lesson and for other science lessons we will teach in the future. By studying the notebooks, we were able to determine future goals for student writing, particularly for claims and evidence. Through the lesson study process, we experienced true collaboration with colleagues. We advocate the use of science notebooks and lesson study in classrooms and hope other teachers will publicly share their notebook designs and what they learn from their use.

Author Note

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