

**Creating a Classroom of Young Scientists:
How to Support First-Graders' Scientific Reasoning
Through Inquiry Science**

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Claims

1. Primary students learn scientific concepts with deeper, conceptual understanding when offered a variety of ways to share their scientific reasoning (i.e. student “labs”, modified science talks, student journals, KLEW chart, electronic drawings, creating an iMovie, and free exploration with materials prior to investigations).
2. Using tools such as journals and electronic drawings on KidPix provide students the opportunity to share, draw, and reflect on their findings while also all serving as an assessment tool for the teacher.
3. When students’ understandings are not always accurate, the teacher must find ways to structure lessons to help them come to a more precise understanding.
4. Lessons formulated from student wonderings increase student participation and engagement.
5. Appropriate teacher questioning during student explorations helps students more clearly state their evidence-based explanations.
6. Providing primary students with the materials used during an investigation as they discuss their learnings increases their ability to make strong, evidence-based claims which connect the investigation to the sharing (“show me”, not just “tell me”).
7. Referring to students as “scientists” and supporting their investigations with appropriate, “scientific tools” can increase engagement, excitement, and interest during inquiry-based investigations as well as the confidence to share/reason scientifically.

Classroom Context

In my first grade classroom, there are 17 students; 9 females and 8 males. Based on classroom observations and student's background, the following categories have been established to more accurately describe the students:

- ❑ *Gifted or Talented:* There are no students in the classroom who are gifted or talented. However, four students (2 males and 2 females) receive math enrichment for thirty minutes each Monday.
- ❑ *Need Emotional Support:* There is one student who utilizes our school guidance counselor as an outlet for emotional support. The other student, a female, is also new to Lemont this year. Her parents have recently divorced and she is making the transition to a single-parent situation in a new school and new community setting. Earlier in the year, this student would have emotional breakdowns where she could not focus on her schoolwork and would be visibly upset. Her meetings with the school counselor and adjustment to the new setting have improved in the past few months. She is able to complete assignments and is a classroom leader.
- ❑ *ADD/ADHD:* One student, a male, has been diagnosed with ADHD. He is currently on medication for this, which he takes at lunchtime each day. Since he is medicated, his symptoms are minimal, and he is a cooperative and enthusiastic learner. When it is time for him to take his next dose, his behavior begins changing, and it is hard for the student to stay focused on academic tasks.
- ❑ *Learning Disabled:* There are no learning disabled students in this classroom.
- ❑ *Reading Level:* Out of the 17 students in this class, seven students are at or above the first grade reading level. Out of the remaining 10 students, seven students are close to grade level, and three are below the first grade level.
- ❑ *High Achievers/Social Leaders*—There are four students (2 males and 2 females) who are high achieving, social leaders in the classroom. Without fail, these students are highly cooperative and contribute a great deal to the classroom dynamics.
- ❑ *Non-conformists/Behavior Challenge*—There is one student who displays off-task behavior fairly consistently within the classroom. He often shares that he will not want to complete a given task and has a hard time staying focused. His work habits make it difficult for him to complete his work within reasonable time.

Project Background

As I began teaching science in the fall during the *Magnets* units with my students, I was inspired by the scientific reasoning abilities of my students when provided inquiry-based opportunities. When considering possible inquiry project ideas to implement, I reflected on the successes of my students during their magnet explorations. Through the magnet investigations, I began to recognize the potential of my students' abilities to reason scientifically as I listened to their wonderings once they had collected evidence. At this time, I began to think about the possibility of structuring a unit based on student wonderings that would not only address the unit concepts, but follow a more meaningful sequence for the students. Upon entering the *Light & Sound* primary science unit, a unit that offers many opportunities for concepts to be addressed through inquiry, I was able to use the process from our SCIED methods course to effectively restructure and implement an inquiry-based unit within my own classroom.

Using the successes from my magnets lessons with my students, I wanted to continue teaching science as inquiry with the light and sound concepts in a way that would gauge how inquiry science can increase students' abilities to reason scientifically. In 1996, the *National Science Education Standards* were developed, suggesting that "students should be engaged in an *inquiry approach* to science that basically parallels the procedures scientists use and the attitudes they display in doing science" (Carin and Bass 15). For my inquiry, creating a classroom of scientists who could collect evidence through inquiry-based explanations and be given opportunities to share their learnings and wonderings scientifically was the ultimate objective. I realized that—although my students were only in first grade—they surely had the potential to be "scientists", within reason. After completing concept research on both light and sound, locating resources discussing the significance of teaching science as inquiry at the primary level, and identifying the unit concepts and state standards, I was able to begin brainstorming possible inquiry-based investigations to provide my students. Over the next two months, I would be able to identify student wonderings, formulate lessons that addressed concepts of the unit in an inquiry-based manner, and allow students to use materials which would enhance their ability to share and discuss their scientific learnings through a process of evidence-based explanations in various contexts.

Article Abstract

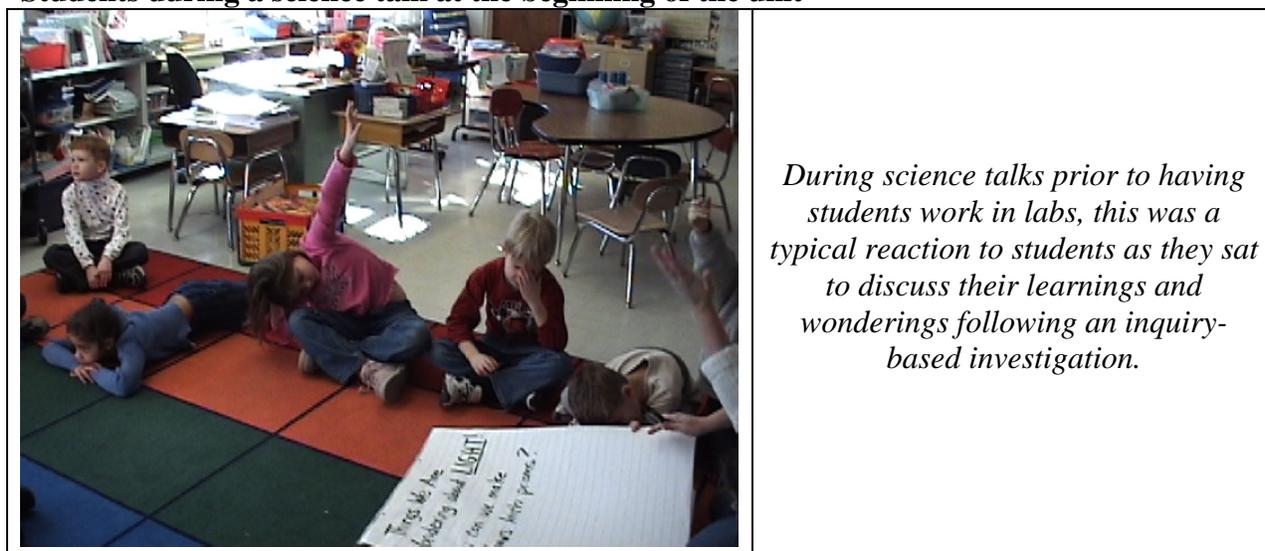
Is it possible for first-graders to think and act like scientists using appropriate materials through inquiry-based investigations? This article takes a look at a unit on light and how students' scientific reasoning was supported through specifically targeting their questions, theories, and misconceptions.

Creating a Classroom of Young Scientists: A Framework for Supporting Primary Students' Scientific Reasoning Through an Inquiry-Based Unit on Light

Imagine a classroom of six and seven year-olds using materials like prisms, light probes, flashlights, laser pointers, mirrors, and even a power drill. Is it possible for young students to use these materials effectively in inquiry-based investigations to begin thinking like a scientist?

As a beginning teacher, it was a personal goal to create opportunities for my students to be engaged in and excited about science during activities that supported their scientific reasoning. In my light lessons, as my first graders attempted to sit and discuss their wonderings and findings following each investigation, it was clear that they were not sharing the depth of discussions I had heard during the exploration period of the lesson. In fact, after reviewing videotapes of my lessons, students were clearly inattentive, disengaged, and seemingly disconnected from what had been shared and discussed during the investigations they were involved in earlier (Figure 1). To address this issue, I wondered how I could truly engage my students in discussions about their learnings and evidence in a more involved manner. As I introduced my students to the *Light & Sound* primary science unit, it was imperative that I found a means for students to share their findings and wonderings in a variety of ways.

Figure 1.
Students during a science talk at the beginning of the unit



As I began considering ways to facilitate my students' thinking, the focus of the unit shifted to the children—what were the students' questions, preconceptions, and understandings and how could I capitalize on these to reframe the unit? The following quote from Karen Gallas in Talking Their Way Into Science: Hearing Children's Questions and Theories, Responding with Curricula (1995) best summarizes my purpose:

“When we begin to think of curricula as emerging from children’s questions and employ both directed and unobtrusive strategies of instruction, the science curriculum moves more natural into the communal life of the classroom. It becomes part of a process of building a community of scientists whose laboratory is the classroom and whose interests, questions, and theories emerge from the inside-out, not the outside in.” (101)

Let There Be Light!

As I researched the best approaches to take in getting my students to think like scientists, I found a framework from *Organizing Wonder: Making Inquiry Science Work At the Elementary School Level* (Hall, 29). In this framework, the steps for organizing an inquiry science unit were presented. However, I felt it necessary to make my own modifications that suited the needs of my classroom more appropriately (Table 1).

TABLE 1
A Framework for Organizing an Inquiry Science Unit

Step One: Establish strong background knowledge of the concepts to be explored.
Step Two: Search for activities with potential for inquiry investigation that also support the concepts of the unit and address district and state standards.
Step Three: Locate student wonderings through group science talks and free exploration with materials.
Step Four: Transform children’s ideas and wonderings into questions to investigate.
Step Five: Begin to reshape suggested unit activities into inquiry-based explorations and introduce these to students.
Step Six: Modify the sequence of activities (as necessary) based on student wonderings following each inquiry investigation.
Step Seven: Provide students with various opportunities to discuss their conclusions by making claims based on evidence.

Making It Happen!

Step One: Before I could access my students’ knowledge about light, I needed to research the concept on my own. It was crucial that I understood the basic concepts of light before I could help my students understand it. In order to do this, I researched websites, children’s literature, and adult-level material on light in order to gain a broad knowledge base before considering which activities would work best with my students. I experimented with materials such as flashlights, prisms, bubbles, aquariums filled with water, mirrors, and laser pointers. I always knew that prisms made rainbows, for example, but never realized the reasoning behind what was happening; it was breaking white light into the colors of the spectrum. As I challenged myself to think about *how* these objects supported the light concepts within the unit, I realized that I could now challenge my students to make scientific claims and support them with evidence to do the same.

Step Two: To get started, I went to Penn State’s library to collect books about light as well as locate suggested activities to implement. I returned with an armload of books, finding information about light in several literary resources. It was obvious that I had more than enough

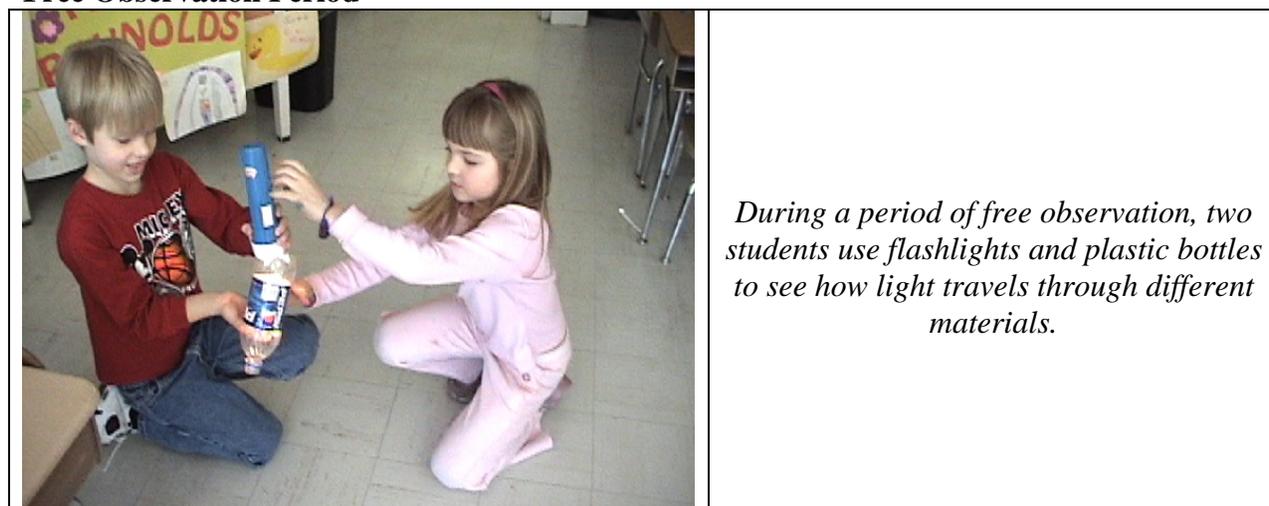
resources to address all unit concepts, and enough to save myself a trip to the gym for an entire week. After locating appropriate activities to share with my students, it was necessary for me to try each of these out, finding which would work best while also supporting the concepts. In the *Light & Sound* primary science unit, there were six concepts to address, and an incredible amount of activities to support them all (Table 2).

TABLE 2
Concepts from the *Light & Sound* Primary Science Unit

Concept I: Eyes are organs which receive light.
Concept II: Light comes from many sources (distinguish between natural/artificial light; explore how the amount of light affects what we see).
Concept III: White light is made of a spectrum of colors.
Concept IV: Light travels in a straight line.
Concept V: Shadows can be made with three things: a light source, an object to block the light, and a surface on which a shadow will appear.
Concept VI: When light strikes an object, it is reflected, absorbed, or it passes through.

Step Three: Before students could begin to express their wonderings about light, I wanted to provide them with the opportunity to have materials in their hands that might arouse their natural curiosity. As Harlen (1985) suggests, “A short period of free observation...with the materials is a most effective way of stimulating children to raise questions, to wonder about things” (32). I set up three stations in my classroom that included bubbles, prisms, sunlight, flashlights, a variety of materials (transparent, opaque, and translucent), and a box of objects from the classroom. With these materials, students were encouraged to think about how light interacted with various materials (Figure 2) and begin to formulate wonderings about to eventually record on our KLEW chart, a variation of the KWL chart (things we think we Know, what we are Learning, our Evidence that supports our Learnings, and our Wonderings).

Figure 2.
Free Observation Period



During a period of free observation, two students use flashlights and plastic bottles to see how light travels through different materials.

Will*: “How it (a prism) makes a rainbow is that light reflects off of it and it makes a rainbow because there’s colors around the room.”

Miss Reynolds: “Wow! Now you used a word I hadn’t heard before. What word did you use?”

Will: “Reflect?”

Miss Reynolds: “Yeah, now what does *reflect* mean?”

Will: “It means it bounces off the thing and it goes, like, somewhere else. And it goes in the opposite direction.”

Miss Reynolds: “Now, does light reflect off everything? Does it bounce off everything?”

* Student’s names have been changed.

After students had an opportunity to explore with materials and discuss their observations, we added their wonderings to our KLEW chart (Figure 3).

Figure 3.
The Wonderings on our KLEW Chart

	<p><i>Throughout inquiry-based investigations on the concept of light, students had the opportunity to explore with materials, collect evidence, and share wonderings as seen on the KLEW chart.</i></p>
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Step Four: Following their exploration with these materials, the students were brought back as a whole group. At this time, we generated a list of what students were wondering. From this list, I was able to create a potential sequence of inquiry-based investigations that would support students’ wonderings, address concepts of the unit as well as standards, and provide opportunities for my students to think like scientists about light. As the students worked through several investigations about light concepts, I found that the list of student wonderings expanded, calling for modifications in my original sequence of activities. The students’ wonderings increased as they were provided with more opportunities to try new explorations. For instance, as part of an investigation in which students sorted objects according to whether or not light could pass through them, one student noticed the beam of light. Another student asked, “What is a beam?” and the first student asked if we could actually see the beam of light while holding a flashlight and using baby powder to make the beam visible. I was excited to see the students

engaged in the investigations they were presented with and, upon giving students the appropriate materials, I encouraged them to pursue these questions.

Step Five: Now that I had a more sound understanding of what sparked my students' interests, it was much easier for me to begin thinking of a sequence of lessons on light that would be meaningful. As I worked through an appropriate sequence of inquiry-based investigations, my goal was to formulate opportunities that allowed students to learn while also teaching one another. Based on the students' wonderings, the questions about light and color were the most frequent and it seemed like a logical place to begin. It was clear that the students had some misconceptions about light from the wonderings they shared, but to me that meant that I needed to provide them the appropriate investigations to explore their own wonderings and erase their misconceptions. I was not concerned with students having the right answers immediately; instead, I wanted them to have meaningful ways to explore what captivated them most. From Harlen in Primary Science: Taking the Plunge, "*We must begin to look for a right answer which the children can give with confidence, which depends on their own observations: a right answer which originates from their experiences.*" (14)

Step Six: "*We also assign a new value to children's questions by giving them a place of importance in the curriculum.*" (Gallas, 100) As I continued planning lessons about light for my students, I found that the direction and content was constantly changing. Initially, I had planned a sequence of light lessons to span a four-week period, carefully deriving the lessons from the students' wonderings.

At the beginning of each investigation, the students were given a question to focus on as they began to collect evidence. Going into the *Light & Sound* unit, I knew exactly what concepts I needed to address. For instance, one of the unit concepts was that when light strikes an object, it either reflects, absorbs, or passes through. In order to begin exploring this concept, the "scientists" of my room were given a basket of various objects—pattern blocks, transparency paper, tissues—and were to sort these with their group according to what the light does when it shines on them.

In past science units, students had worked in small group stations to answer the question given at the beginning of an investigation. Although the science talk following their evidence collecting was not effective in maintaining the students' engagement and attention, I felt it would be meaningful for students if they became "scientists" and the stations became their "labs". Students were given time to investigate the question with the appropriate materials and gather evidence. Following the investigation period, the students would share their learnings with supported evidence from their own lab, using the materials as a way to show their findings. My classroom soon came together as a community of young scientists as the class moved from lab to lab, listening to the claims and evidence from their fellow scientists (Figure 4).

Figure 4.
Lab Walk Setting



Brian*: “To make a shadow, you have to use light, a thing, and something to hold it on. We did it by going through things.”

Miss Reynolds: “So show us what you mean when you say what it takes to make a shadow.”

Tyler: “You have to use something that light can’t go through.”

Miss Reynolds: “Ok, let’s let him show. If we shine the light in different places, what happens to the shadow?”

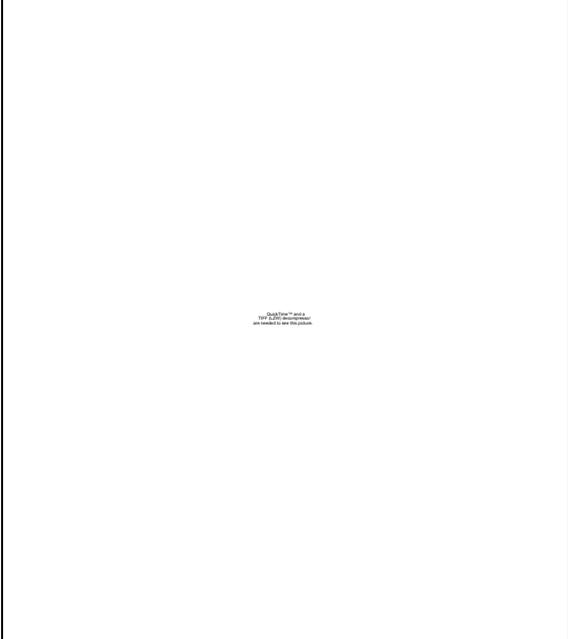
Tyler: “If we shine the light far away from it, it turns littler, and if you shine it real close it gets bigger.”

Following the first lab walk setting, students were going to follow a similar format in future investigations. The structure of these investigations was essentially the same; students were given a question to investigate, made predictions, and went to their labs to collect evidence:

Miss Reynolds: “Last time, you had to sort all those objects you had and you needed your flashlight to do that. Now today, you’re going to do something similar. You’re going to use another sorting mat, but I’m going to tell you what piles you’re going to make. Today, you’re going to sort by things you can see through and you can’t see through. But because you’re going to have two piles of things this time, you’re going to have to think about what groups of objects are going to make shadows. Susan* pointed this out to us and was working at her station when she showed me which of her objects could make a shadow. Think about it for a second before we go to our labs. If you separated your objects by what you can see through and what you can’t see through, which do you think might make shadows? (Students predict before entering their labs.)

Throughout the light investigations of our unit, it seemed as though the structure of each lesson became increasingly student-centered. After my scientists shared at their labs, their claims and evidence were recorded as a part of the KLEW chart (Figure 5). Providing students with activities that allowed them the freedom to structure their findings in meaningful ways ultimately influenced their ability to reason scientifically.

Figure 5.
The Learnings and Evidence of Our KLEW Chart

	<p><i>After hearing students share at their labs, their learnings and evidence on the KLEW chart . As the unit went on, the KLEW chart was revisited at the beginning of future investigations to remind students of what they had previously discovered.</i></p>
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Step Seven:

As I began brainstorming ways to wrap up the concepts of light my students and I had explored in five weeks, it seemed that having the students create their own news report about their understandings would not only reinforce the major concepts, but would allow students ownership of the project (Figure 6). During the five weeks we explored light, my students used a variety of tools to allow them to share their explanations and support them with evidence—student journals, lab walks, and a KLEW chart (Figure 7). At this point, it was time to do something different, but something that allowed students the opportunity to use all the materials from the light lessons and also reflect on their scientific claims over the course of the unit.

Before creating our newscast, I used our KLEW chart to review all the Learnings we had discovered in the past few weeks. Students chose a partner to “report” with and a Learning they would explain with evidence during the taping. I placed all the materials we had used over the past five weeks on a table, such as prisms, bubbles, and light boxes, for instance. While the students were working on their newscast presentation, I was a little nervous that this would turn chaotic. However, after viewing the final taping, I felt such a sense of pride in my students; it was not because of their ability to perform on camera, but their ability to present their findings, support them with evidence, and continue to find new conceptions with their materials was absolutely impressive.

Figure 6.
The Culminating Newscast by the Scientists of Room 12



In this classroom, everyone is a teacher; everyone is a student.

By the close of the unit, my students had reached a level of scientific reasoning and understanding I never imagined possible within my first grade classroom. I had the opportunity to sit back and watch students take a question, collect evidence with the provided materials, and share and discuss their findings with one another as if they were truly scientists. Not only were they all learning from one another through these discussions, but they had taught one another how to converse scientifically in a meaningful context.

Using their questions, their theories, and their misconceptions, I found that, through inquiry, I was able to help children reconstruct their initial ideas by providing them with new opportunities to explore and discover what puzzles them most. In addition to allowing my students new, meaningful ways to address their wonderings, these “scientists” began to take ownership of their learning and contribute to the scientific community within their own classroom.

Figure 7.
Student’s Evidence-Based Explanation through KidPix

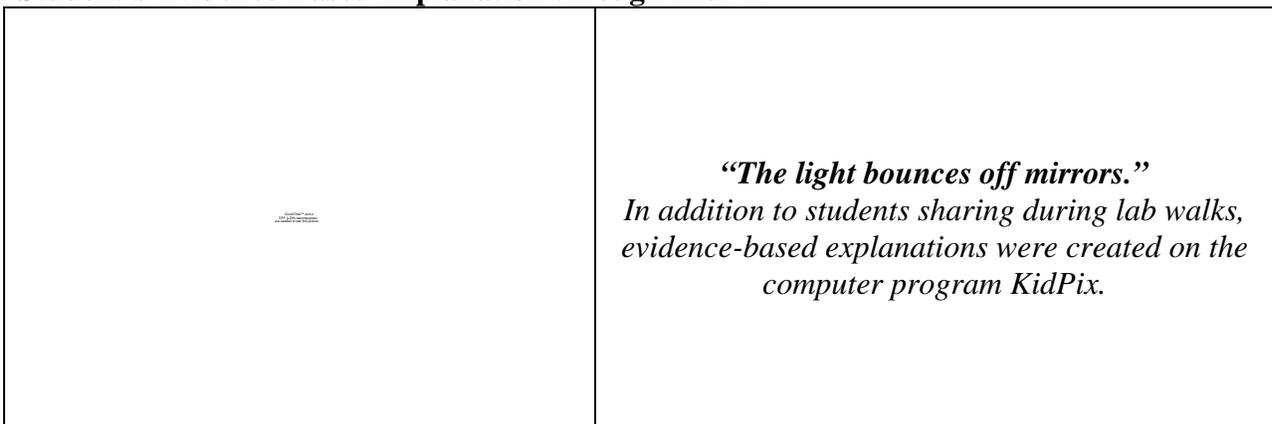


Table 3
Connecting to the Standards

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In addition to the concepts of the *Light & Sound* unit, 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
- Understanding about scientific inquiry

Standard B: Physical Science Standards

- Properties of objects and materials
- Position and motion of objects
- Light, heat, electricity, and magnetism

Standard E: Science and Technology Standards

- Abilities to distinguish between natural objects and objects made by humans
- Abilities of technological design
- Understanding about science and technology

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