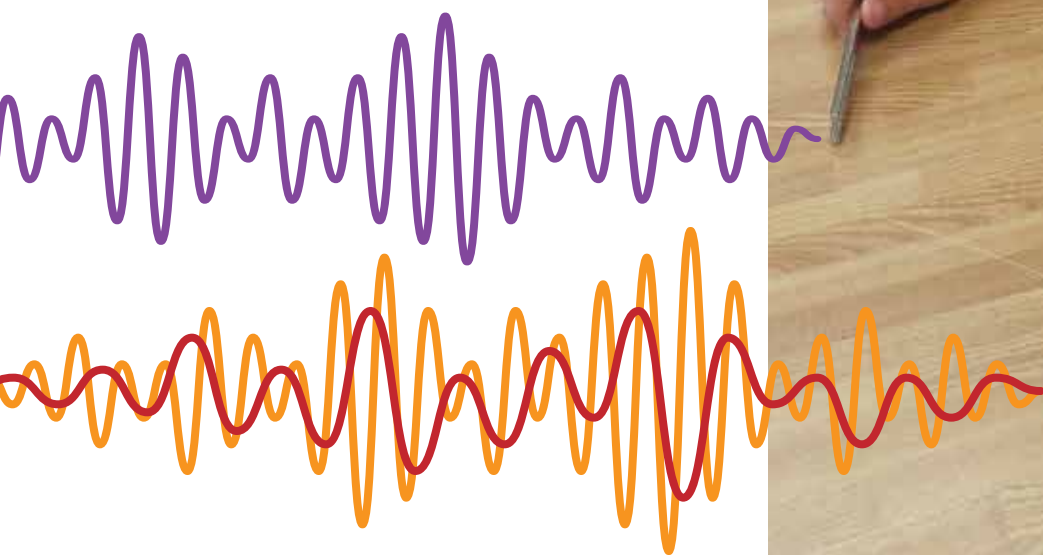


The Physics of Sound

Using a learning center to
promote STEM development
in early childhood

By Jennifer Miller



Asking Productive Questions

I implemented the learning center with my three- to five-year-old students in an integrated morning class (nine students; four on IEPs) and an integrated afternoon class (10 students; four on IEPs). I began by reading *Sound: Loud, Soft, High and Low* (Rosinsky 2002) at large-group time, then introduced our *experimentation box*, a wooden box with four rubber bands varying in thickness stretched across the top. Students wear goggles to protect their eyes when working with rubber bands.



I prepared productive questions to spark student interest. These questions create an opportunity for students to independently inquire, process, and solve problems. In-

FIGURE 1.

Productive questions when introducing the learning center.

Can you find a way to make these rubber bands produce sound?

Possible student responses:

- Student strums rubber bands.
- Student lifts a rubber band very high and releases.
- "I use my finger to move it [rubber band]."

What have you noticed about these rubber bands?

Possible student responses:

- (pointing to rubber bands) "This one is small, this one is bigger, this one is kinda big, this one is the biggest!"
- "They all look different."

How did you make this rubber band produce a loud sound?

Possible student responses:

- "I bring it up high and kinda let go slowly."
- "I pull it up like this, and let it go."

Which rubber band makes the quietest sound?

Possible student responses:

- "This one [pointing to rubber band] because it is bigger than the other one."
- "This one, [pointing to rubber band] it makes a soft noise."

How do these two rubber bands look the same? How do they look different?

Possible student responses:

- "They all have the same color"
- "They are pretty close. This one is bigger, and this one is smaller."

stead of making a simple statement such as, "Look at my rubber bands," I focused students' attention by asking, "What do you notice about these rubber bands?" and "Can you make these rubber bands produce sound?" (Figure 1).

Investigating Sound

Students were given the option to explore the physics of sound center for the next six weeks. Students were developing various communication, language, cognitive, science, and mathematical skills as they studied the materials, all while collaborating with their peers, classroom teachers, and paraprofessionals. I used questioning and observations to determine the need for new materials. After the introduction of rubber bands, I put tuning forks, sponges, and tongue depressors into the experimentation area. I also incorporated balloons containing various materials (such as cotton balls and beans), which students used to create and investigate with sound. After being used in these activities, the tuning forks may never have accurate pitch, so be sure to supply your own tuning forks for the sole purpose of this learning center.

Because of the possibility of latex allergies, I purchased latex-free balloons. Some of the materials, such as balloons and rubber bands, pose a choking hazard and require close adult monitoring to ensure safety. I created a rules chart with visual cues such as "no mouth," "listening ears," "my turn," "your turn," and "quiet voices."



I posed productive questions to keep the students actively engaged in planning and carrying out their investigations (see sample questions in Figure 2, p. 37).



PHOTOS COURTESY OF THE AUTHOR

A student explores sounds produced using a tuning fork on different pieces of furniture in the classroom.

Physics of Sound Learning Center

Materials

Before introducing materials, explore them yourself. When we play with materials before introducing them to students, we are able to anticipate learning opportunities and potential problems (Zan and Geiken 2010). Playing with the various materials (tuning forks, sponges, balloons, tongue depressors, rubber bands, and so on) gives teachers an opportunity to think of potential questions they may ask students. It also gives teachers a chance to test the materials for safety concerns, which can be helpful when discussing rules with students before introducing new material. Use large-group time to introduce a sample of the materials that will be available during the STEM activities. This sparks interest and models appropriate interaction with the materials.

Be ready to add and remove materials based on student interest, engagement, questions, and investigations. Materials to have available include tuning forks and a variety of items for students to strike the tuning forks against. Different blocks (foam blocks, cardboard blocks, wooden blocks)

and sponges are a great way to start investigating the various sounds produced, all while using a tuning fork! Other materials to have available are rubber bands, wood and metal objects, balloons (a pump comes in handy), and various materials to insert into the balloons (e.g., rice, beans, beads, and cotton balls) to create balloon maracas that produce different sounds.

Children also compare how the materials feel with the sounds they produce. For example, squishy items such as cotton balls make quiet sounds, and hard items such as beans make loud sounds. These materials also offer many opportunities to integrate mathematics, such as counting, comparisons, weight, and measurement. You can also include items to help the sounds resonate (any item that allows the sounds to amplify, such as a hollow box, cup, or juice carton with a hole cut out). The resonating materials allow students to explore and investigate the movement of sound waves. For instance, if students pluck a rubber band against the side of a cup, they are going to hear a loud slap sound because sound waves are unable to travel. If students pluck a rubber band suspended along the top of a cup, the sounds are different.

TABLE 1.

Connecting a Physics of Sound learning center to Teaching Strategies GOLD and Iowa Early Learning Standards (Heroman et al. 2010, IELS 2012):

Teaching Strategies GOLD	IELS	Connections to Classroom Activity Students will:
Objective 24: Uses Scientific Inquiry Skills Objective 28: Uses Tools and Other Technology to Perform Tasks	Standard 12.4: Children observe, describe, and predict the world around them. Standard 12.5: Children plan and carry out investigations to answer questions and test solutions to problems.	<ul style="list-style-type: none"> • make close observations. • use data from observations to describe the world, including cause-and-effect relationships and predictions. • use scientific tools to extend the senses and aid understanding.
Objective 11a: Attends and Engages	Standard 9.2: Children purposefully choose and persist in experiences and play.	<ul style="list-style-type: none"> • persist in and complete both adult-directed and child-initiated experiences of increasing difficulty. • choose to participate in play and learning experiences. • sustain work on age-appropriate tasks.
Objective 11d: Shows Curiosity and Motivation	Standard 9.1: Children express curiosity, interest, and initiative in exploring the environment, engaging in experiences, and learning new skills.	<ul style="list-style-type: none"> • explore and investigate ways to make something happen. • repeat skills and experiences to build competence and support the exploration of new ideas.

The learning center should include books related to sound, paper, pencils, and clipboards for students to record their data. Teachers can model using the books and recording materials. Students will likely attempt to write and draw their observations, just as the teacher is doing. This is a great way to provide students opportunity to show an appreciation for books, explore fiction and non-fiction text, and write to convey meaning.

I also created communication boards for students with specific needs. Figure 3 (p. 38) shows an example of a communication board that was created for a student that responded positively to visual cues versus verbal directions. I would use the communication board to assist the student in initiating requests (for example, asking

Here a student is comparing the sounds he hears when he strikes the tuning fork against a sponge, when he strikes the tuning fork on the top of the table, and when he strikes the tuning fork on the side of the table.



FIGURE 2.

Productive questions to use in the learning center.

What did you do to make this rubber band produce a loud sound?

Student response may be: *"I lift it up so high."*

What would happen if you were to softly pluck this rubber band?

Student response may be: *"It goes quiet."*

What would happen if you were to pluck the thickest rubber band?

Student response may be: *"It makes a funny noise."*

How does this balloon sound different from this one?

Student response may be: *"This one is loud, and this one doesn't make a sound."*

What different sounds do you hear when you strike the tuning fork on the table? On the sponge?

Student response may be: *"Watch! On the table it sounds like a bell. On the sponge it doesn't work!"*

How does the experimentation box feel different when you pluck this rubber band, and this one?

Student response may be: *"This noise is louder [pointing to rubber band]."*

What do you notice when you pluck a thick rubber band and then a thin rubber band?

Student response may be: *"This one [pointing to thin rubber band] kinda tickles. It's kinda going really quick!"*

Can you show me which rubber band makes the lowest sound?

Student response may be: *Plucking / strumming all rubber bands, pointing to the thickest rubber band, and saying, "That one."*

How does the tongue depressor sound different when you strike it hard? Soft?

Student response may be: *"I can be very gentle. See? You can't hear it!"*

Can you show me how to make this rubber band produce a quiet sound?

Student response may be: *Pluck rubber band with one finger and say, "I just pull it up and let go carefully."*

Can you show me how to make this rubber band produce a loud sound?

Student response may be: *"I just pulled it up very high!"*

What will happen when you strike this tuning fork on this sponge?

Student response may be: *"I think that would be funny!"*

Can you make this balloon produce a quiet sound?

Student response may be: *Shaking balloon slowly, and whispering, "It's very soft."*

for rubber bands). I also referred to the communication board when using my productive questions. The student was able to discuss the loud and soft sounds and attend to conversations with multiple exchanges when he had the visual communication board as a support. The communication boards were used to enhance learning, language, comprehension, and communication throughout the implementation of the center.

Student Reactions

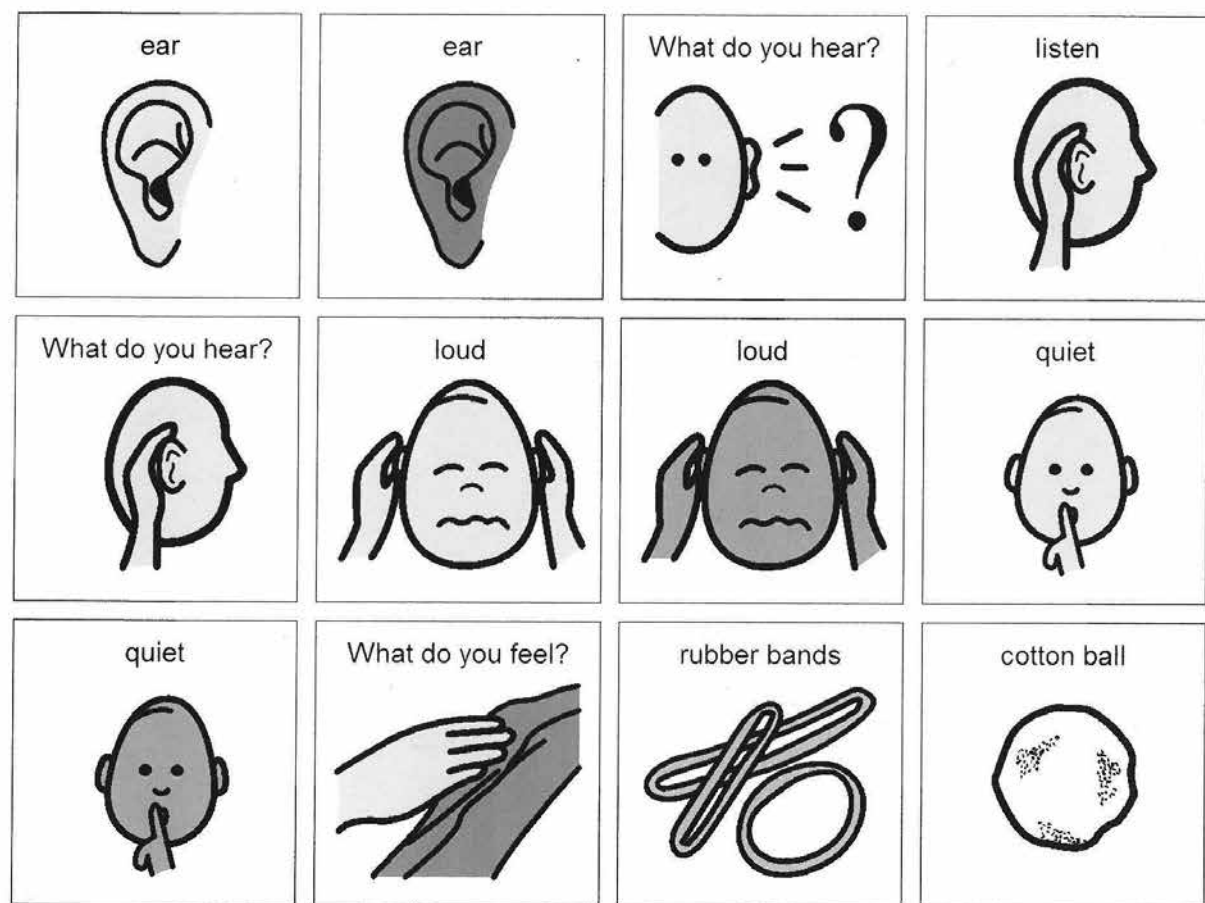
Students were persistent and engaged. It was rewarding to see the excitement on their faces as they collaborated

This student made the softest possible sound with the tuning fork before moving it to his ear to hear it. "It sounds like a ringing bell."



FIGURE 3.

Communication board used to enhance learning, language, comprehension, and communication throughout the implementation of the center.



with peers and staff members and when they reported how they had created sound. Many students wanted to demonstrate their findings by showing their work to their peers. One student reported that the sounds he created with the tuning fork in the sound center could also be created in the reading and writing center! When I prompted the student by saying, “Tell me more,” he proceeded to go to the sound center and get a tuning fork. He struck the tuning fork against the metal base of the chair and then went to the reading and writing center and struck the tuning fork on the metal base of another chair, saying, “See, same sound!” Students would experiment with the tuning forks all over the classroom and create lists indicating the best surfaces that create sound.

I was able to build on and encourage students’ inquiry process by including some of the items from our physics of sound center into other areas of the classroom. For example, I placed a bin of disposable cups and rubber bands in the math manipulatives center. I wrote uppercase and lowercase letters on tongue depressors and placed them in the reading and writing center. I chose letters in the students’ first names to stimulate interest while providing opportunity to practice alphabet knowledge. I also placed sponges and tuning forks in the blocks center. The children enjoyed using the tuning forks as the whistle when using the trains in the blocks center. Students were able to use their recall skills and apply their knowledge of the movement of energy through sound waves even after the physics of sound center had been removed. The students were using the problem-solving and inquiry skills being developed in the sound center and applying it in other learning centers throughout the classroom.

Assessment

Ongoing assessment ensures the learning center will continue to grow along with student interest, engagement, inquiry, and findings. I used videos, photographs, anecdotal notes, Teaching Strategies GOLD, Iowa Early Learning Standards, and classroom observations throughout the entire six-week time period. Referring to the Teaching Strategies GOLD objectives provided me with a continuum of development. I could use the objectives, benchmarks, examples, and expected age-range abilities to scaffold learning and continuously challenge students on an individual basis. A chart showing the alignment between Teaching Strategies GOLD and the Iowa Early Learning Standards (Table 1, p. 36) outlines the standards and objectives a physics of sound learning center will foster in both science and cognitive development. A preassessment was done during the first large-group lesson, in which I introduced some new materials, read a book related to sound, and kept notes of the students’ reactions, thoughts, ideas,



A student discovers multiple ways to use tongue depressors to create sounds.

and questions. I used a system of checklists (see NSTA Connection), on-the-spot documentation, and other forms of classroom observations as formative and summative assessment. Using the data collected throughout the implementation of the sound center allowed me to make informed instructional decisions. When students were no longer demonstrating the persistence, engagement, and inventiveness that I had once observed, I knew it was time to change the variables.

Reflection

Learning centers not only foster scientific inquiry and problem-solving skills but also persistence, inventiveness, communication, collaboration, literacy, mathematics, and science skills. I once implemented this learning center in a self-contained three- to five-year-old preschool program for children with moderate to severe disabilities, including hearing loss, Autism spectrum disorder, and intellectual disabilities. I will never forget the look on the face of a child with hearing impairments when he could see and

feel the sounds. He could see the tuning fork vibrating when he struck certain surfaces, and he could feel the vibrations that were creating the movement of energy. That was when I knew this learning center has the potential for endless possibilities. ■

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Resources

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Pfeffer, W. 1999. *Sounds all around*. New York: HarperCollins.

Rosinsky, N. 2002. *Sound: Loud, soft, high, and low*. Minneapolis, MN: Picture Window Books.

NSTA Connection
 Download assessment checklists at www.nsta.org/SC1612.

Connecting to the Next Generation Science Standards (NGSS Lead States 2013):

1-PS4 Waves and Their Applications in Technologies for Information Transfer	
www.nextgenerationscience.org/1ps4-waves-applications-technologies-information-transfer	
The materials/lessons/activities outlined in this article are intended for use in PreK classrooms. Science experiences in PreK by their nature are foundational and relate to early elements in learning progressions that facilitate later learning in K–12 classrooms. As the NGSS performance expectations are for K–12, we have not included specific performance expectations but have identified the disciplinary core ideas and other elements that are addressed to show the link between these foundational experiences and students’ later learning.	
	Connections to Classroom Activity <i>Students:</i>
Science and Engineering Practices	
Planning and Carrying Out Investigations Constructing Explanations and Designing Solutions	<ul style="list-style-type: none"> collaboratively observe and collect, describe, and interpret data to answer the following questions: <ul style="list-style-type: none"> What makes sound? How do we make loud sounds? Soft sounds? What is the difference between loud sounds and low sounds?
Disciplinary Core Idea	
1-PS4.A: Wave Properties <ul style="list-style-type: none"> Sound can make matter vibrate, and vibrating matter can make sound. 	<ul style="list-style-type: none"> observe and investigate different ways to produce sounds.
Crosscutting Concept	
Cause and Effect	<ul style="list-style-type: none"> design and carry out simple tests in order to gather evidence. use and respond to productive questioning.