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Sound : the study of differentiating pitch and volume with preschoolers

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Using random sampling from a classroom of 20 students, I chose six participants between the ages of four and five. As prekindergarten children experimented with sound, I probed understanding of two of the main concepts in the existing module: volume and pitch. Results indicate productive questions about amplitude can be a successful starting point for inquiry into loud and soft sounds. Later such pitch vocabulary as *high* or *low* could be added – perhaps introduced when talking about music in Expressive Arts time – thus integrating science concepts into other areas of the curriculum. Through the use of productive questioning, this study provided an opportunity for preschool students to participate in a physical knowledge learning activity. This study provides a current review of literature that supports the use of inquiry-based play as a means for laying the foundation for early STEM development.

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I designed an exploratory study for adapting an early elementary physics of sound science module to use in preschool. The purpose of the study was to observe and collect data regarding the use of an inquiry-based physical knowledge activity, implemented in a play-based preschool setting, and how this knowledge could assist in advancing Science, Technology, Engineering, and Mathematics (STEM) education in early childhood. Using random sampling from a classroom of 20 students, I chose six participants between the ages of four and five. As prekindergarten children experimented with sound, I probed understanding of two of the main concepts in the existing module, volume and pitch. Results indicate productive questions about amplitude can be a successful starting point for inquiry into loud and soft sounds. Later such pitch vocabulary as high or low could be added, perhaps introduced when talking about music in expressive arts time, thus integrating science concepts into other areas of the curriculum. Through the use of productive questioning, this study provided an opportunity for preschool students to participate in a physical knowledge learning activity. This study provides a current review of literature that supports the use of inquiry-based play as a means for laying the foundation for early STEM development.

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Introduction

The study of differentiating volume and pitch with preschoolers was developed as I was completing my internship with the Regents' Center for Early Developmental Education (RCEDE). As a research assistant, I was asked to complete multiple tasks including preparing materials for training modules focused on math and physical science that the RCEDE had developed. Through my assignments, I learned a great deal about implementing physical science learning centers in early childhood classrooms. One in particular captured my attention. I found that the Physics of Sound module lacked documentation regarding implementation in preschool settings. Much of the research and documentation came from first and second grade classrooms. I developed this study because I wanted to provide more documentation for the Physics of Sound module. My purpose was to observe and collect data regarding the use of an inquiry-based physical science activity, implemented in a play-based preschool setting, and how this knowledge could assist in advancing Science, Technology, Engineering, and Mathematics (STEM) education in early childhood.

According to the Center for Early Education in Science, Technology, Engineering, and Mathematics (CEESTEM, 2015) STEM education should start early, and when done well, takes advantage of children's natural curiosity to lay a foundation for later STEM learning. Children are interested in the physical world around them, and they are interested in creating sound, so why not use these interests to our advantage. Early childhood educators can take advantage of children's natural curiosity about sound to start early development in STEM and begin creating little scientists.

Purpose

The purpose of this study is to show how inquiry-based play that is developmentally appropriate and geared toward developing physical knowledge can lay the foundation for early STEM development. Early childhood educators have the opportunity to engage young children in meaningful and developmentally appropriate play-based STEM activities. In doing so, we are laying the foundation for children to become future engineers, mathematicians, and scientists. This study uses productive questioning in an inquiry-based play setting to observe what children already know, and what they can discriminate in regard to the volume and pitch of sounds.

Research Questions

The project is designed to answer the following questions:

1. What do preschool children already know, and what can they discriminate, in regard to the volume and pitch of sounds?

2. How can early childhood educators use inquiry-based play, focused on developing physical knowledge, to lay the foundation for early STEM development?

Review of Literature

Why Physics of Sound?

Much of the current research related to young children's knowledge and understanding of the concepts related to sound is focused on the K-2 population. The lack of research regarding preschool children's abilities concerning sound is what influenced me to explore this research project. The Physics of Sound is simply one avenue to explore with students when looking for a topic that piques student interest, promotes inquiry-based play, and lays the foundation for STEM development. The development of sound concepts typically comes over time and with experience. When children come to us with low knowledge of pitch and amplitude, do we assume they are not capable? When children propose the wrong idea, educators must appreciate and believe that with adequate opportunities for experimentation and reflection, children will construct the correct logic. A child's construction of logic takes more time than memorizing the teacher's logic, but it is a more solid achievement (DeVries et al. 2002)

One way teachers can promote STEM development is by simply verbalizing, as they observe the children working, that they are using their senses and working as scientists to promote exploration (Ashbrook, 2013). The teacher's job is to adjust the learning experience to support the children's curiosity (National Science Teachers Association, 2014). In order to do this, teachers capitalize on children's interest and focus their observations by posing occasional questions and comments that foster problem solving (Chalufour & Worth, 2004; Zan & Geiken, 2010). Implementation of a Physics of Sound learning center provides an opportunity for teachers to engage students based on their interests.

This research is important for children, who will benefit from being engaged in an activity that involves scientific inquiry and experimentation. Students gain knowledge from hands-on experiences, and have an opportunity to practice their reasoning skills. When early childhood educators detach from inquiry-based play, they are failing to challenge children to figure out solutions to new problems and develop new ways of thinking.

Benefits to the early childhood education field include adding evidence about using productive questioning in an inquiry-based play setting to observe what children already know, and what they can discriminate in regard to the volume and pitch of sounds. By having this knowledge, the early childhood education field will have an idea as to what level of instruction is appropriate for preschool aged children in a physics of sound learning center. Another benefit to the field is focusing on the importance of inquiry-based play during physical science activities.

Pitch and Amplitude

In order to have sound, three things are needed: something that vibrates (such as a struck tuning fork or a plucked rubber band); a medium to carry the vibrations (air or water); and something to receive, detect, and interpret the vibrations (an ear, a brain) (DeVries et al. 2002). According to Robertson & Diskin (2003) vibrations produce sound. With little to no vibration, there is little to no sound produced. The changing size of the vibrations is known as the amplitude (the loudness). When the vibrations are large the sound is loud. When a child plucks a rubber band hard, the vibrations are large and the sound is loud. When a child plucks a rubber band softly, the vibrations are small and the sound is soft. Frequency, also known as pitch, involves the speed of the vibrations. The faster the vibrations move, the higher the pitch. The slower the vibrations move, the lower the pitch.

Using Inquiry-based Play to Promote STEM Development

High quality inquiry-based play activities that are intriguing to children and promote STEM development provide opportunities for children to experiment and make new mental relationships. In order for a teacher to determine whether an activity provides opportunities for children to experiment and make new relationships, what happens must be producible, immediate, observable, and variable (Kamii & DeVries, 1993). If an activity is producible, the child can produce "what happens" with his or her own actions (not just watch a teacher do it). When an activity is immediate, the "what happened" must occur as soon as the child acts on the object. An observable activity is one in which the child is able to perceive something happen with his or her senses. Teachers can add variables to create an inquiry-based activity that promotes STEM development by providing opportunity for the child to vary his or her actions to produce and observe variations in the object's reactions (CEESTEM, 2015).

Planning for Physical Knowledge STEM Activities in Preschool

Early childhood educators who begin to think of themselves as science teachers are able to stimulate children's thinking throughout the day (Moomaw, 2013). Prior to implementation, teachers should explore the materials. This gives educators an opportunity to reflect, try out, and become confident with developing and implementing physical knowledge activities in an inquiry-based setting (Mong & Ertmer, 2013).

Teachers must remember to start simple. Teachers could use large group time to introduce a sample of the materials that will be available during the STEM activities. This allows the teacher to spark interest and model appropriate interaction with the materials. Teachers must be prepared to provide language and social models to students who lack STEM learning center experiences. A peer model, or adult model, provides comfort and guidance while promoting social and relationship skill building to students (DeVries & Sales, 2011; Donegan-Ritter, 2015; Zan & Geiken, 2010).

Teachers can prepare themselves by having high quality productive questions ready to use as children take part in the STEM activity. This preparation will ensure that the teachers are ready to pose productive attention focusing and prediction questions to encourage children's thinking (DeVries & Sales, 2011). A simple question such as, "What happened when you…" can focus children's attention. Children who are stimulated in the early years by insightful questions like this become immersed in scientific inquiry (Moomaw, 2013). Finally, teachers must plan to be flexible. STEM activities are supposed to be open-ended, hands-on activities. Teachers implementing physical knowledge STEM activities will be prepared to observe children and follow their interests (DeVries & Sales, 2011; Donegan-Ritter, 2015; Zan & Geiken, 2010).

Methodology

This study was designed to provide insight into what preschool children already know, and what can they discriminate, in regard to the volume and pitch of sounds. The study also focused on how early childhood educators can use inquiry-based play to lay the foundation for early STEM development. The current literature has primarily used child interviews, field notes, transcriptions, video recordings, and data analysis as methods. The site selection was due to location, flexibility, and the center's support. Using a random sampling from a classroom of 20 students, I chose six participants between the ages of four and five. The participants consisted of two girls and four boys.

Before I introduced the materials to the students, I visited the classroom on three occasions the week prior to data collection. I introduced all of the participants to the cameras and the person operating the camera. I asked each participant's permission before I turned on the camera. I used a wooden box in the interview process that had wooden pegs, holes drilled through the wooden pegs, and rubber bands stretched across the length of the box and tied to the pegs (see Figure C). The box served as a resonator so the students could clearly hear the sound the rubber bands were producing.

I introduced the research materials over a period of six days. Each student was interviewed three times on three different days. Ideally, the students were to be interviewed on three consecutive days, although that was not possible for some students due to illness, school cancellations, and the weekend. The three-day interview process was designed so that day one questions focused on amplitude, day two questions focused on pitch, and the final day focused on integrating the two concepts (see Figure B for a list of interview questions).

Data Collection and Analysis

As I interacted with the children using the materials videotaping was in progress. Videotaping took place for eighteen sessions over a period of six days. The videotaping allowed for capturing a wide variety of variables that were considered during the data analysis. The video footage from a combination of the two cameras captured the body language, verbal, and non-verbal communication between the children and the researcher. The cameras also captured the children's interactions with the experimentation box. I created a data findings sheet to condense the transcriptions and analyze the data. The components of the data findings sheet came from observations I made as I was collecting data and transcribing. Keeping the purpose of this study in mind, I created the data findings chart so I could compare the children's answers and knowledge, as well as analyze the results.

Findings and Discussion

Are four-five year olds able to report the difference between loud and soft?

In the interview, the participants were asked to tell whether a rubber band sounded loud or soft. They were asked to use the wooden experimentation box with rubber bands to demonstrate how to make loud and soft noises with the rubber bands. The participants were given an opportunity to explain what they were doing in order to create loud and soft sounds. Each participant was able to successfully report the difference between loud and soft sounds, either through demonstration or explanation. An additional observation I made was that, of the six children, only one child was able to tell me that a rubber band can be both loud and soft.

Can four-five year old children differentiate between high and low pitch?

Through a variety of productive questions and hands-on exploration of the wooden experimentation box, participants were given opportunity to demonstrate their understanding of pitch. As I analyzed the data collected through the interviewing process, I found that all six participants were unable to consistently name a rubber band's pitch. Each participant was able to tell me that the rubber bands sounded different, although they were unable to correctly use the terminology "high" and "low." On day two of the interview process, each participant was asked "What do you notice when you pluck a thick rubber band and then a thin rubber band?" I asked this question twice during the interview process on day two. I was looking for the children to demonstrate the understanding that thicker rubber bands produce lower sounds, when compared to thin rubber bands. I found that five of the six participants told me the thickest rubber bands pitch was high, and then later in the interview labeled the same rubber bands pitch as being low. This inconsistency showed me that the participants did not truly understand the difference between high and low pitch. Due to the fact that the participants were all able to tell me that the rubber bands sounded different, I have reason to believe that the four-five year old participants had not yet developed the terminology necessary to communicate the difference in pitch however the children were certainly aware of the different pitches.

Can four-five year olds differentiate between pitch and volume?

My study shows that half of the participants demonstrated an emerging understanding of the difference between volume and pitch. Three of the six participants either answered pitch to a volume question, or volume to a pitch question. The following is taken from the transcripts to show a conversation between one of the participants, (M) and the researcher (me). This conversation comes from day three of the interview process. I had asked the student questions regarding both amplitude and pitch in previous sessions. Refer to Figure C for a diagram of the experimentation box, and an explanation of the numbering system used in this conversation:

> Me: "What did you do to make this rubber band produce a loud sound?" (points to rubber band number 3)
> M: (pulls rubber band number 3 up very high and releases, then looks at R)
> Me: "What did you do?"
> M: (pulls rubber band number 3 up high) "I lift it up so high and I let it down and it makes a low sound. It is only a low sound, not a high sound."
> Me: (points to rubber band number 3) "This one is low, or loud, or what did you say?"
> M: "It is low."

This conversation was interesting to me, as the student was able to physically show me that pulling a rubber band up high and releasing it will make a louder sound than gently strumming the rubber band. When the student was asked to verbally explain her answer, she spoke about pitch rather than volume. This conversation, along with other statements, led me to believe that the participant could produce a loud sound, and she was developing her ability to express her understanding the difference between the volume and the pitch of the sounds the rubber bands were creating.

As I worked on completing the data findings chart, I came to realize that there were many noticeable similarities in the responses and actions from the children. One action that I observed was that many participants would pull a rubber band up high and report that the sound was high. Below are examples taken from the transcripts to show conversations between one of the participants, (P) and the researcher (me). These conversations come from day three of the interview process. I had asked the student questions regarding volume and pitch in previous sessions.

> Me: "Do you remember playing with this box before?"
> P: (nods)
> Me: "It has been a few days. What do you remember?"

P: "Doing that." (plucks all rubber bands)
Me: "Do you remember what the rubber bands sound like?"
P: "High!" (plucking rubber band number 3 by pulling up high and releasing)

Me: "Listen to these sounds." (plucks rubber bands 3 and 4, then points to rubber band number 3) "Is this rubber band high or low?"
P: (plucks rubber band number 3 by creating a very loud sound) "High!"

Based on the research cited in the review of literature, I know that pulling a rubber band up high creates large sound waves which creates a loud sound. When participants would pull the rubber band up high and report that a high sound was created, I came to the conclusion that they were referring to the proximity of the rubber band in space as opposed to the sound being produced. This was one of the first instances that gave me evidence that the children do not differentiate between volume and pitch.

Conclusions and Implications

This research project can assist early childhood educators in determining a developmentally appropriate way to introduce a physics of sound learning center in their classroom. This project shows the potential that preschool children may have when it comes to studying the physics of sound. Early childhood educators need to be aware of the abilities as well as the possibilities for their children. A physical science STEM activity, focused on sound, could be introduced by exploring loud and soft sounds. The experience could expand as time progresses by adding additional variables for the children to explore. Educators can change variables (ie. using tuning forks or a guitar instead of rubber bands) to continue to explore and expand the experience into various aspects of sound.

Teachers should feel confident that a Physics of Sound learning center is appropriate for children younger than the primary grade children for which such science curriculum typically has been developed. Productive questions about amplitude are likely to provide a successful starting point for inquiry into loud and soft sounds. Later such pitch vocabulary as high or low could be added, perhaps introduced when talking about music in expressive arts, thus integrating science concepts into other areas of the curriculum. In future research children could be observed as they engage in STEM learning throughout different aspects of the early childhood classroom; this could include various learning centers, outdoor play, free play, as well as structured and unstructured activities.

I think it would be interesting to complete a similar interview process with four-five year old students, while implementing a physics of sound learning center in their classroom over a period of time. A post-test interview could be added to analyze the changes in responses. I feel this interview process would be worth the time to test because the students may very well demonstrate progression between the pre- and post-interviews if they were exposed to a physics of sound learning center in their classroom. The data findings could potentially bring insight into the abilities of young children when working with physics of sound.

This study points to the benefits of inquiry-based processing in early childhood settings as a means for laying the foundation for future STEM development. However, the study has certain limitations and the results should not be overgeneralized. This was a small study conducted in only one district, which means the results may not be typical across other schools in other areas. Finally, this study was conducted at the same time of day for each interview process. It was designed to take a sample of the children's knowledge of pitch and volume. It is possible that the representation may have changed depending on the time of day the interview process took place.

Through this research project, I have learned a great deal not only about the abilities four-five year old children have when exploring the physics of sound, but also about the research process. Through this process, I have been able to implement the procedures necessary to conduct a successful research project. I have learned from my mistakes in this project, and I feel that I am better prepared to carry out another research project in the future. My abilities as a principal investigator will increase with experience, and I am grateful to have been given the opportunity to learn so much through this experience.

Connecting a Physics of Sound learning center to Teaching Strategies GOLD and Iowa Early Learning Standards (Teaching Strategies, Inc. 2010 and 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.	• 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.	• 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.	• explore and investigate ways to make something happen. • repeat skills and experiences to build competence and support the exploration of new ideas.

Appendix

Figure B – Sample of Interview Questions

Day 1 Questions

- Can you find a way to make these rubber bands produce sound?
- What have you noticed about these rubber bands?
- How did you make this rubber band produce a loud sound?
- I wonder, which rubber band makes the quietest sound?

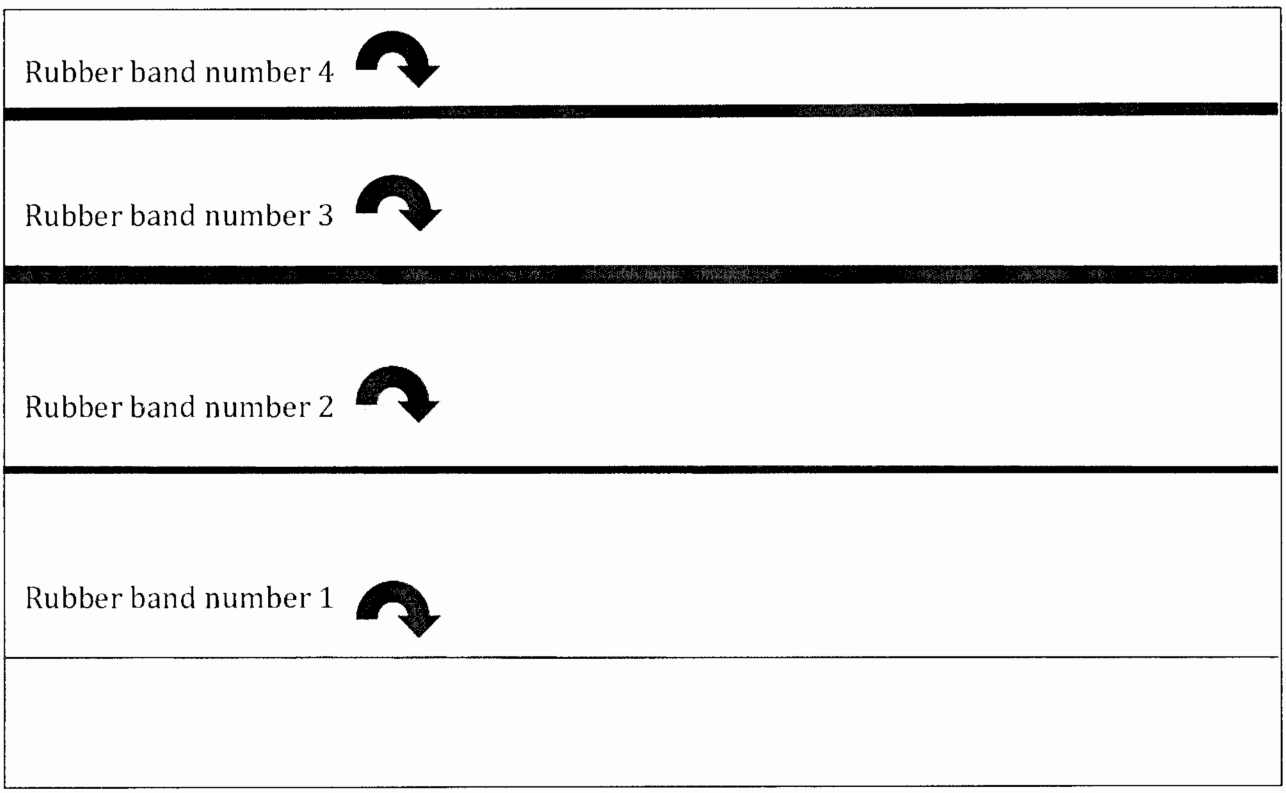
Day 2 Questions

- How do these two rubber bands look the same? How do they look different?
- What do you notice when you pluck a thick rubber band and then a thin rubber band?
- Can you show me which rubber band makes the lowest sound?
- Can you tell me if this rubber band makes a high pitch sound or a low pitch sound?

Day 3 Questions

- What did you do to make this rubber band produce a loud sound?
- What would happen if you were to pluck this rubber band softly?
- What would happen if you were to pluck the thickest rubber band?

Figure C- Birdseye View of Wooden Experimentation Box (note: thickness of the line reflects thickness of rubber band)



References

Ashbrook, P. (2013). The STEM of inquiry. *Science and Children, 51*(2), 30.

Center for Early Education in Science, Technology, Engineering, and Mathematics. (2015). Retrieved from http://www.uni.edu/ceestem/

Chalufour, I., & Worth, K. (2004). *Building structures with young children.* St. Paul, MN: Redleaf Press.

DeVries, R., & Sales, C. (2011). *Ramps and pathways: A constructivist approach to physics with young children.* Washington, DC: National Association for the Education of Young Children.

DeVries, R., Zan, B., Hildebrandt, C., Edmiaston, R., & Sales, C. (2002). *Developing constructivist early childhood curriculum: Practical principles and activities*. New York: Teachers College Press.

Donegan-Ritter, M. (2015). STEM for all children: Preschool teachers supporting engagement of children with special needs in physical science learning centers. *Young Exceptional Children.* Retrieved from yec.sagepub.com

Heroman, C., Burts, D. C., Berke, K., & Bickart, T. S. (2010). *Teaching strategies GOLD: Objectives for development & learning*. MD: Teaching Strategies.

Iowa Early Learning Standards. (2012). Preschool early learning standards. Retrieved from: http://www.state.ia.us/earlychildhood/files/early_learning_standarda/IELS_2013.pdf

Kamii, C., & DeVries, R. (1993). *Physical knowledge in preschool education: Implications of Piaget's theory*. New York: Teachers College Press.

Mong, C. J., & Ertmer, P. A. (2013). Addressing STEM education needs: The case for adopting a PBL approach. *Educational Technology, 53*(3), 12-21.

Moomaw, S. (2013). *Teaching STEM in the early years: Activities for integrating science, technology, engineering, and mathematics.* St. Paul, MN: Redleaf Press.

National Science Teachers Association. (2014). *NSTA position statement: Early childhood science education.* Retrieved from: http://www.nsta.org/about/positions/earlychildhood.aspx

Robertson, W.C., & Diskin. B. (2003). *Sound: Stop faking It! Finally understanding science so you can teach it.* Virginia: NSTA Press.

Zan, B., & Geiken, R. (2010). Ramps and pathways: Developmentally appropriate, intellectually rigorous, and fun physical science. *Young Children, 65,* 12-17.