Sound Waves & AI: Exploring the Connection

Grade Band: Middle School-High School	**Topic:** Physical Science

Brief Lesson Description:
Explore AI sound recognition by analyzing sound waves and designing AI systems.

Performance Expectation(s):

MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Specific Learning Outcomes:
Students will understand the properties of sound waves and how they can be manipulated using AI technology.
Students will conceptualize how AI can be used for sound recognition through hands-on activities and discussions.

Narrative / Background Information

Before beginning this lesson, students should have a basic understanding of artificial intelligence (AI) and sound waves. They should know that AI systems, like virtual assistants, can process and respond to various inputs, including audio commands. Familiarity with the concept that sound travels in waves, characterized by amplitude and frequency, will help students grasp how sound recognition systems work. Additionally, students should understand that AI is not always perfect and that various factors, such as background noise or unclear inputs, can affect its accuracy—concepts illustrated by the video "Alexa After Man Goes to Dentist." This prior knowledge will help students explore how sound is translated into data and why AI sound recognition may not always be reliable.

Science & Engineering Practices:

Obtaining, Evaluating, and Communicating Information
Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5)

Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (MS-PS4-3)

Disciplinary Core Ideas:

PS3.D: Energy in Chemical Processes and Everyday Life
Solar cells are human-made divides that likewise capture the sun's energy and produce electrical energy (HS-PS4-5)

PS4.A: Waves Properties
Information can be digitized (e.g. a picture stored as the values of an array of pixels): in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-5)

PS4.B: Electromagnetic Radiation
Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)

PS4.C: Information Technologies and Instrumentation
Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g. medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained on them. (HS-PS4-5)

Crosscutting Concepts:

Cause and Effect
Systems can be designed to cause a desired effect. (HS-PS4-5)

Structure and Function
Structures can be designed to serve particular functions. (MS-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering and Technology on Society and the Natural World
Modern civilization depends on major technological systems. (HS-PS4-5)

Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3)

Interdependence of Science, Engineering and Technology
Science and engineering compliment each other in the cycle known as research and development (R&D). (HS-PS4-5)

	Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)	**Connections to Nature of Science** **Science Is a Human Endeavor** Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)

Possible Preconceptions/Misconceptions:

Students may bring the following preconceptions/misconceptions to this topic:

1. AI is "perfect" and understands things like humans.
2. Sound waves are only related to music and visualizing waves is only helpful in musical applications.
3. Louder sounds always have a higher pitch.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Start the lesson by showing the video "Alexa After Man Goes to Dentist"

After the video, ask students to consider these questions ***"How do you think AI can recognize and process sound? Why was this not reliable in the video we just watched?"*** Have students write down their own thoughts and then discuss them with a partner. After partners have shared, have two sets of partners join together to make a group of 4 and share what their partner said.

Facilitate a class discussion about students' responses and their experiences with AI and sound.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Tell students that they will explore how sound waves are represented using a sound sensor (such as PocketLab Voyager) or a sound app (such as Sound Amplifier).

Provide each student group with a device to record sounds within a quiet area.

Have each group of students record a variety of sounds. These might include clapping, speaking, and music.

For each sound recording, have students record their observations of the sound wave patterns displayed on the visualization software on the Student Handout. Then have students complete the analysis questions on the handout.

Following the activity, discuss the following questions as a class:

What similarities and differences did you notice between the sound waves of different types of sounds (e.g., clapping, speaking, and music)? How do you think AI could analyze these waveforms to distinguish between various sounds or even recognize voices?

How do changes in amplitude and frequency relate to what we perceive as loudness and pitch in everyday life? How might AI use this information to improve technologies like speech recognition, music streaming, or virtual assistants?

Why do you think visualizing sound waves is important for fields such as music production, engineering, or healthcare (e.g., ultrasound technology)? How could AI enhance the analysis of sound waves in these industries to improve accuracy, efficiency, or innovation?

EXPLAIN:

Use the Slides "Sound Waves & AI: Exploring the Connection" to teach students about the connection between sound waves and AI. A Student Note Sheet is also provided for students to utilize during direct instruction.

ELABORATE: Applications and Extensions:

Students will use their learning from this lesson to create an AI Sound Recognition System. Group students in groups of 2-4 and provide each group with a Project Handout. Students will brainstorm possible AI sound recognition systems and then define the system including the types of sounds recognized, expected inputs and outputs. Students will prepare presentations to share their ideas with the class.

EVALUATE:
Formative Monitoring (Questioning / Discussion):
Formative Discussion prompts and student handouts in the explore, explain and elaborate sections can be used to check student understanding throughout the lesson.

Summative Assessment (Quiz / Project / Report):
Each group will present their AI Sound Recognition systems. Each presentation should explain how their system would analyze sound characteristics and the significance of the properties that they chose to focus on. Students should be assessed based on their creativity, understanding of sound properties, and clarity in their presentations.

Elaborate Further / Reflect: Enrichment:
Show students the video "7 Real World AI Audio Applications". After the video, have students consider how their systems compare to those presented in the video. Discuss what would happen if these systems (designed and described) were hacked. What could be the security implications for individuals? businesses? communities? governments? Have students research current security hacks that have occurred with Sound applications and propose ways to prevent these issues.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency Addressed: Responsible Decision Making

Objectives:
Students will explore the ethical implications of using AI to record and manipulate sound files.
Students will develop skills in empathy and responsible decision-making regarding technology use.

Start the lesson by asking students ***"What do you think the term "deep fake audio" means?"*** After getting student responses, provide students with the following definition

Deep fake Audio: a product of artificial intelligence used to create convincing speech sentences that sound like specific people saying things they did not say

Next, show students the video "This is not Morgan Freeman." Explain that this video is a deepfake made using AI. Then ask "What are your immediate thoughts and feelings about this technology?" and gather quick reactions.

Move students into groups of 3-4 and provide each group with an AI and Sound Scenario. In their groups, students should:

1) Identify the ethical issues present in their scenario
2) Discuss how different stakeholders might be affected (e.g., individuals recorded, the public, technology developers)
3) Each Group should then summarize their findings and share them briefly with the class.

After groups present, brainstorm a list of ethical principles related to technology use such as respect for privacy, informed consent, and accountability.

Ask students to write a quick reflection about the following prompts:
What did you learn about the ethical implications of AI and sound manipulation?
Why is it important to consider ethics when using technology?

Encourage students to share their reflections with a partner. Then briefly discuss how students can use these principles in their own daily lives.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Music: Students can use sound visualization software to analyze and compare sound waves from different instruments or musical pieces. They can present their findings on how the characteristics of sound waves differ across genres and discuss how AI could analyze or classify these sounds.

History: Students can research and present on a specific technology or invention related to sound, discussing its impact on society and how it has paved the way for modern AI sound recognition technologies. This could lead to a timeline project showcasing key developments in sound technology.

Language Arts and AI Ethics: Students can engage in a debate or write persuasive essays on the pros and cons of AI technology in sound recognition, focusing on issues such as privacy, consent, and the potential biases in AI algorithms. This allows students to critically analyze the implications of technology in society while enhancing their writing and speaking skills.

Materials Required for This Lesson/Activity	
Quantity	**Description**
1 per group	Sound sensor (such as Voyager Pocket Lab) or sound app (such as Sound Amplifier).
1 per group	Quiet area to record in

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