BHARATIYA VIDYA BHAVAN'S
SARDAR PATEL INSTITUTE OF TECHNOLOGY

AUTONOMOUS INSTITUTE AFFILIATED TO MUMBAI UNIVERSITY
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ACADEMIC YEAR 2024 - 2025
ELECTRONICS & TELECOMMUNICATION ENGINEERING DEPARTMENT
CLASS:TE and BE EXTC **Semester:VI and VIII**

Report on Innovative Teaching Learning Activity in Speech and Audio Processing

Activity Overview

The main objective of the Think-Pair-Share activity was to enhance students' understanding of the acoustical properties of the human ear, the frequency response of the auditory system, and the mechanisms through which the auditory system manages its dynamic range. This was achieved through collaborative problem-solving and discussion among students.

Preparation

Before the activity, students were provided with the following materials:

- A brief on the anatomical structure of the ear, focusing on the ear canal and eardrum.
- An introduction to the concepts of frequency response and neural spiking in the auditory system.
- Reading materials and lecture notes on the dynamic range of the human ear and auditory neurons.

Instructions were given to students to prepare for the Think-Pair-Share session by reviewing these materials and coming up with initial thoughts on the provided questions.

Execution

The activity was structured as follows:

1. **Think Phase (10 minutes)**: Students individually contemplated the provided questions:
    - How do the acoustical properties of the eardrum affect the frequency response of the overall system?
    - How do these properties affect neural spiking for a 100-Hz pure tone stimulus and for a 3-kHz stimulus?
    - How does the auditory system manage such a high dynamic range with such restricted elements?
2. **Pair Phase (20 minutes)**: Students paired up to discuss their thoughts and findings, comparing and contrasting their answers.
3. **Share Phase (30 minutes)**: Each pair shared their insights with the larger group. This phase also included a guided discussion facilitated by the instructor to highlight key points and address any misconceptions.

Content

The specific topics addressed included:

- **Acoustical Properties of the Eardrum**: The eardrum's role in transmitting sound waves from the ear canal to the middle ear, and how its inflexible nature influences the frequency response.
- **Frequency Response**: How different frequencies are affected by the ear canal's length and diameter, and how this relates to the resonance frequencies.
- **Neural Spiking**: The relationship between sound stimuli of different frequencies (100 Hz vs. 3 kHz) and the resulting neural activity.
- **Dynamic Range Management**: Mechanisms such as auditory filtering, compression, and the role of different types of auditory neurons in handling a wide dynamic range.

Student Interaction

During the Pair and Share phases, students engaged in active discussions, with several notable exchanges highlighting diverse perspectives. Some pairs brought up interesting analogies comparing the ear to mechanical systems, while others delved into the biological aspects of neural processing.

Observations

- **Challenges**: Some students struggled initially with the concept of frequency response and its dependency on the physical dimensions of the ear canal.
- **Successes**: The collaborative nature of the activity helped clarify these concepts, as students could learn from each other’s explanations and examples.

Feedback

Student feedback was generally positive, with many appreciating the interactive format of the activity. Some students suggested more time for the Think phase to better formulate their initial thoughts.

Results

The activity successfully met its objectives, with students demonstrating a better understanding of:

- The impact of the eardrum's acoustical properties on the ear's frequency response.
- How different frequencies affect neural spiking patterns.
- The mechanisms through which the auditory system manages its high dynamic range despite the limited dynamic range of individual neurons.

Detailed Explanation

1. **Acoustical Properties of the Eardrum and Frequency Response**:
    - The eardrum (tympanic membrane) serves as a barrier that vibrates in response to sound waves entering the ear canal. Its stiffness and mass, combined with the dimensions of the ear canal (3 cm length and 0.8 cm diameter), create a resonant frequency typically around 3-4 kHz. This is due to the quarter-wavelength resonance condition in a cylindrical tube closed at one end (the eardrum).

- The resonance frequency of the ear canal amplifies sounds in this frequency range, making it more sensitive to these frequencies. This is why humans are particularly sensitive to sounds around 3 kHz.

2. **Neural Spiking for Different Frequencies**:
    - For a 100-Hz pure tone, the sound wave will cause relatively slow and larger vibrations of the eardrum. These low-frequency sounds result in neural spikes that are less frequent but have larger intervals between them.
    - For a 3-kHz stimulus, the eardrum vibrates much faster due to the higher frequency. This results in a higher rate of neural spiking. Neurons in the auditory pathway, especially those in the cochlea, are tuned to respond selectively to different frequencies, allowing for precise encoding of high-frequency sounds.
3. **Dynamic Range Management**:
    - The auditory system uses several mechanisms to manage a dynamic range of approximately 100 dB, despite individual neurons having a dynamic range of only 20-30 dB:
        - **Auditory Filtering**: Different neurons are tuned to different frequency ranges and intensities, allowing for parallel processing of sounds across a wide dynamic range.
        - **Compression**: The cochlea applies a form of automatic gain control, compressing the range of sound intensities to fit within the limited dynamic range of neurons.
        - **Recruitment of Neurons**: As sound intensity increases, more neurons are recruited to fire, each responding to different aspects of the sound signal.

Outcome: Activity significantly enhanced students' understanding of the ear's acoustical properties, neural spiking mechanisms, and dynamic range management. Through collaborative discussions, they grasped how the ear canal and eardrum influence frequency response, differentiated neural spiking patterns for low and high frequencies, and explored how the auditory system handles a broad dynamic range. This interactive approach improved their critical thinking, problem-solving, communication, and collaboration skills, resulting in increased engagement and positive feedback.

Proofs attached: 1) Photographs

2) Activity feedback summary from Students

3) Sample report from Students

Think pair share(TPS) feedback

75 responses

Publish analytics

Have you aware about the flipped class learning before TPS activity?

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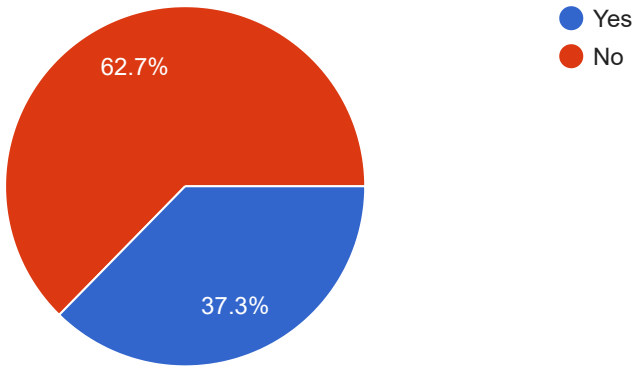
75 responses



How did you find the think-pair-share activity?

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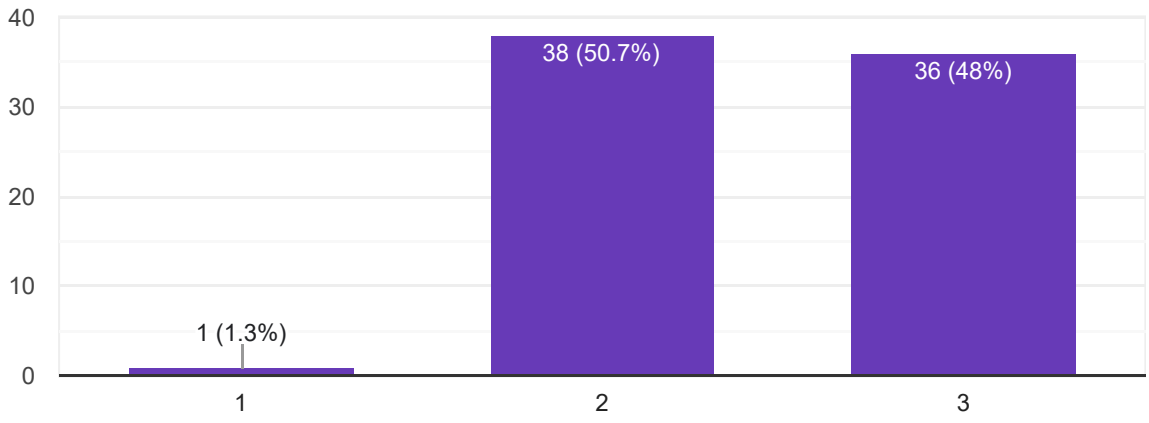

Did you find it easy to understand the instructions for the activity?

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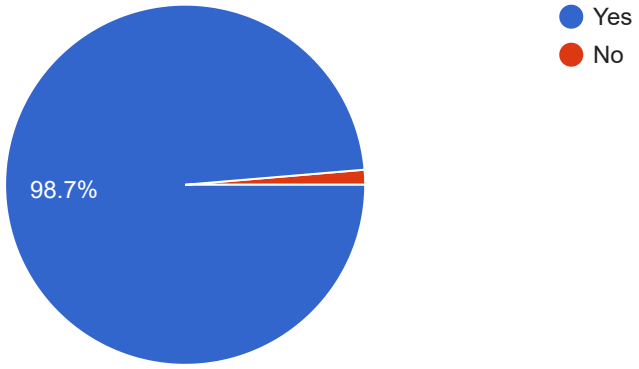

Did you feel engaged during the activity?

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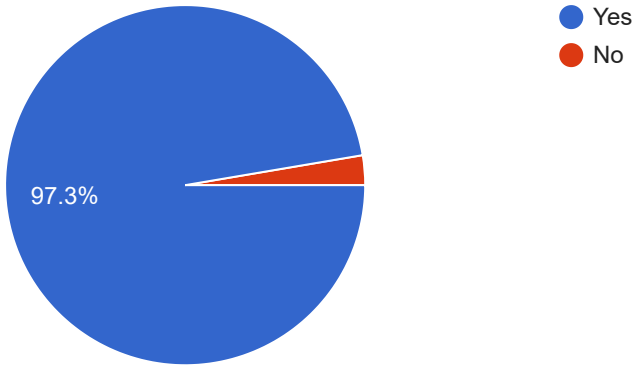

Did the activity help you understand the topic better?

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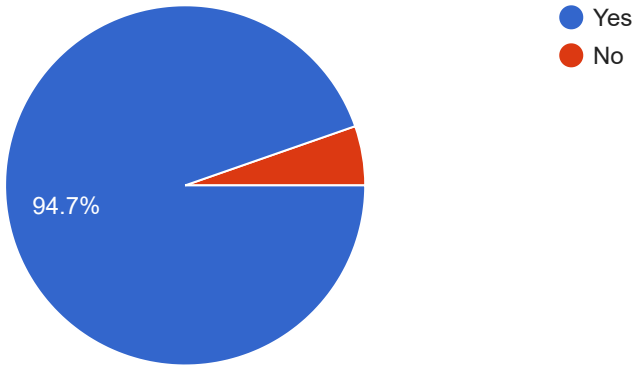

Did you feel comfortable sharing your thoughts with your partner?

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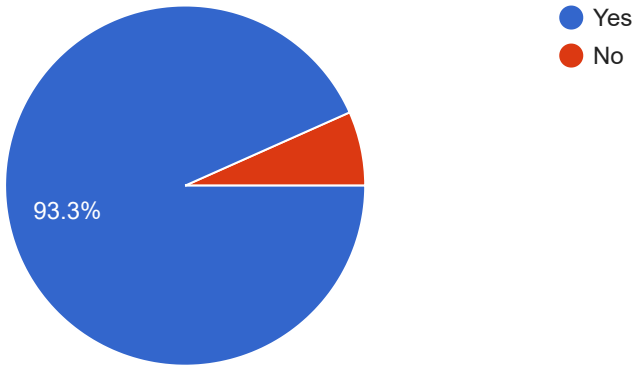

Do you think the think-pair-share activity helped you learn from your peers?

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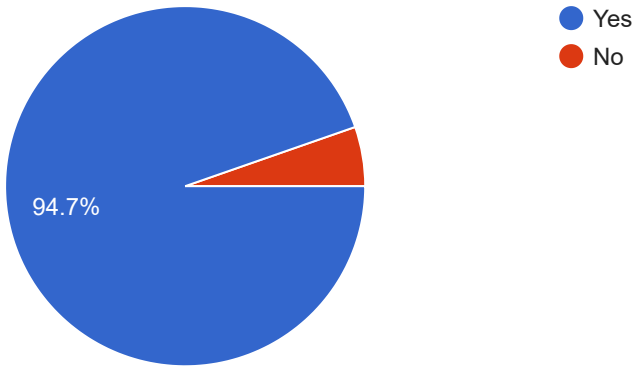

How would you rate the overall effectiveness of the think-pair-share activity?

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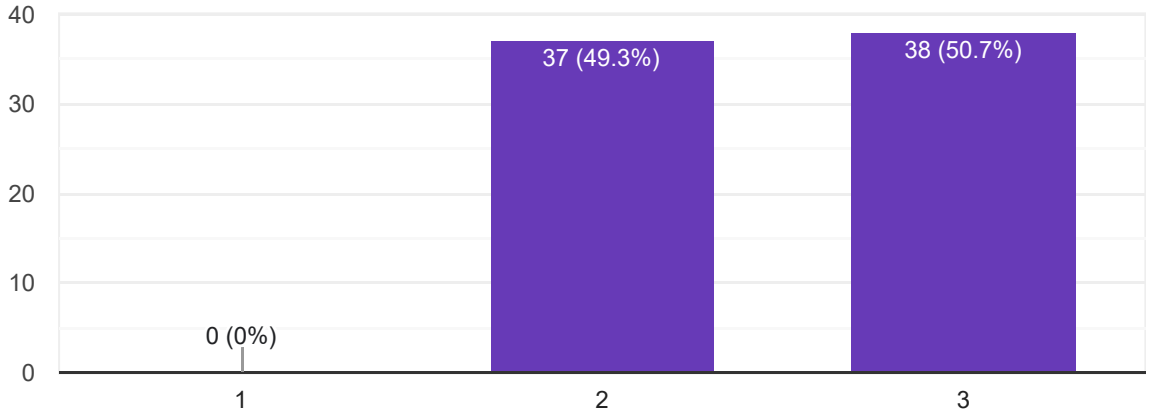

Were there any aspects of the activity that you found challenging?

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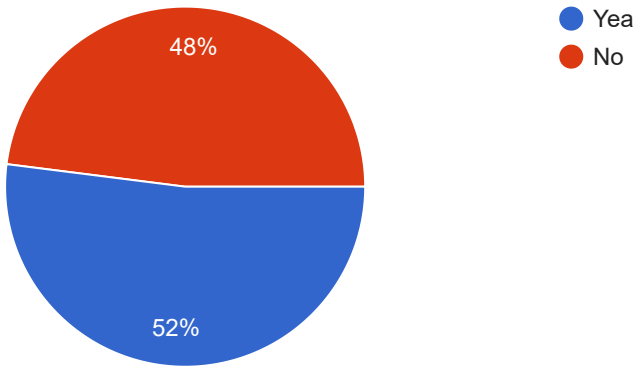

Do you have any suggestions for improving the think-pair-share activity in the future?

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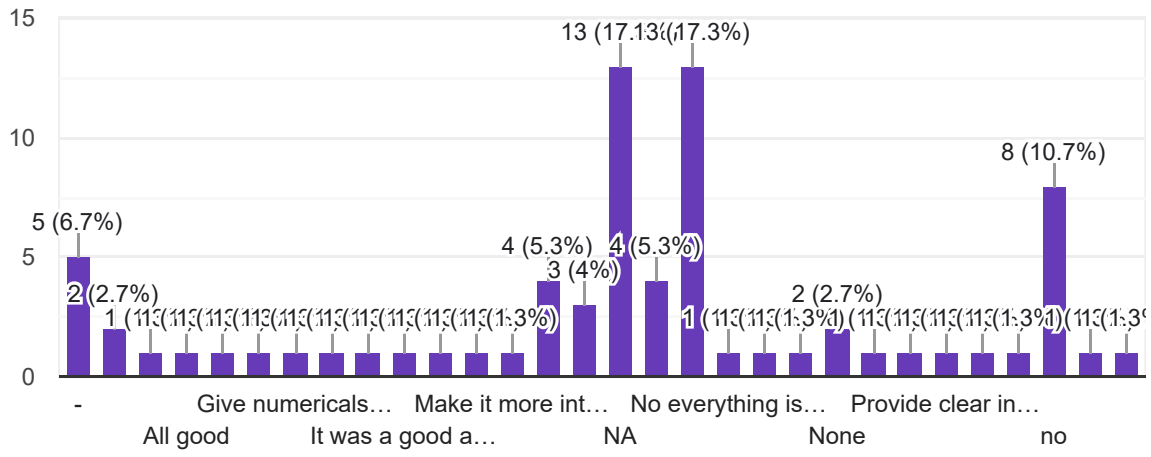

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Think Pair Share (TPS)

Student's name: Nishant Chandeliya Date: 14/03/24

Think-Pair-Share

Read the following question or problem:

Part1: Assume that the ear canal in a typical person is 3 cm long and of cylindrical shape with a diameter of 0.8 cm. Also, assume that the ear drum behaves like a solid, inflexible wall. Describe how the acoustical properties of the eardrum affect the frequency response of the overall system. How do these properties affect neural spiking for a 100-Hz pure tone stimulus and for a 3-kHz stimulus?

Ans: The eardrum's acoustical characteristics play a crucial role in shaping how we perceive sound frequencies. Its solid and inflexible nature acts as a resonator, emphasizing certain frequencies over others. Specifically, frequencies that align with the natural resonant frequencies of the ear canal are amplified, leading to a stronger perception of those frequencies. For instance, a 100-Hz pure tone stimulus would likely resonate strongly, enhancing its perception, while a 3-kHz stimulus might not resonate as effectively due to its higher frequency falling beyond the ear canal's resonance range. This resonance discrepancy influences neural activity by boosting signals at resonant frequencies, potentially resulting in a more pronounced neural response.

Part2: The dynamic range of a normal human ear is approximately 100 dB, but the measured dynamic range of many neurons is approximately 20-30 dB. How does the auditory system manage such a high dynamic range with such restricted elements?

Ans:

The human auditory system efficiently handles a wide range of sound intensities, approximately spanning 100 dB, despite its components, such as neurons, having a narrower dynamic range of 20-30 dB. This feat is achieved through sophisticated signal processing and neural encoding mechanisms. The auditory system showcases remarkable adaptability, capable of boosting faint signals while damping down excessively loud ones to safeguard the auditory nerve from harm. Key strategies include cochlear amplification, which is particularly effective at lower frequencies, and the auditory nerve's capacity to adjust its sensitivity to changes in loudness. Moreover, the brain plays a pivotal role in interpreting auditory signals by leveraging contextual cues and past experiences to discern between various sounds and perceive a broad spectrum of loudness levels.

Think

Individually, write down three thoughts you have about this question or problem:

1. The eardrum's acoustical properties significantly influence the frequency response of the auditory system, with certain frequencies being amplified more than others due to resonance.
2.The human auditory system's ability to manage a high dynamic range is a testament to its complexity and adaptability, with mechanisms for signal amplification and neural sensitivity adjustment playing key roles.

3.The brain's role in interpreting auditory signals, using context and previous experiences, is crucial for perceiving a wide range of loudness levels and distinguishing between different sounds.

Pair

During class discussions, debate your ideas with your partner. Put a check by any ideas, above, that your Partner also wrote down. Then, write down the concepts you had but your partner did not have

1.The eardrum's solid, inflexible nature allows for resonance, which can amplify certain frequencies more than others.

2.The auditory system's ability to manage a high dynamic range involves mechanisms for signal amplification and neural sensitivity adjustment.

3.The brain plays a crucial role in interpreting auditory signals, using context and previous experiences to perceive a wide range of loudness levels and distinguish between different sounds.

Share

Evaluate all of your thoughts and circle the one you think is most significant. Choose amongst yourself the one to present this idea with the whole class. As you listen to the concepts of the whole group, write down three more ideas you that captivated you.

1.The complexity and adaptability of the human auditory system in managing a high dynamic range.

2.The role of the brain in interpreting auditory signals, using context and previous experiences.

3.The mechanisms of signal amplification and neural sensitivity adjustment in the auditory system.