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I. Initial Plans

NGSS Standard Addressed:

- **HS-PS4:** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Student Friendly Standards:

- **I can explain how musical instruments work.**
- **I can explain how sound acts differently in different substances.**

Crosscutting Concepts:

- **Cause and effect:** How does changing one part of the wave (wavelength or frequency) change other parts or behaviors of the wave?
- **Systems and system models**: How can we model the types of waves talked about as well as the types of mediums discussed? How can we model the mathematics behind wave production?

Science and Engineering Practices:

- **Using mathematics and computational thinking:** How can we model waves with mathematics?
- **Obtaining, evaluating, and communicating information:** How can we predict or prove mathematical relationships between waves by getting data from the lab?

Day 1: Eliciting ideas about sound

- **Summary:** Students will be shown different sized drums and 2 different sized clarinets. They will be asked to predict how the sounds will be the same and different between the different drums and clarinets and to draw how they think the sound is produced and travels. Students will connect to realizations about instruments, and will begin to develop ideas about wavelength and frequency.

Phase 1: Engaging with a problem/Questions

- Students will be asked during the bellwork question that shows a drum, a flute, and a guitar[1] and asked to describe how they sound, and to compare and contrast the sounds made by each. Then two clarinets (E-flat and B-flat) will be shown along with a set of marching quads (4 different sized drums). The question will be asked for students: **Predict how the sounds produced by each clarinet and each set of drums will be similar and different.** Then, after predictions are discussed briefly, the instruments will be demonstrated, and then students will be asked to: **Explain what you heard and how this fits with your prediction, and then draw how the sound was made and travels.** The results will be discussed, and ultimately revisited (if there is not enough time in the 3 day sequence, this could be done on day 4).

Phase 2: Data or observations / Evidence.

- **Students will take qualitative data on whiteboards in groups of 4.** For the bellwork, the students will answer on their own sheets, discuss with a partner briefly, and then share out with the whole group. For the clarinet and drum demonstrations the students will work with their normal lab groups of 4 on large whiteboards. Each student will have a different color marker. Evidence will be shared with the whole group at the end of the class.

Phase 3: Finding and explaining patterns / Explanation.

- **Students will connect to previous experience**, which will generally be that bigger instruments sound lower. This will be emphasized by playing both clarinets simultaneously with the same fingering and noticing the difference in pitch, then one player adjusting until the notes come out identical. Students will have the opportunity to see two examples and begin to think about WHY sound works this way with their drawings. All groups will discuss their drawings with guidance from the instructor prior to the end of the hour. **This idea will further be cemented day 2 with further examples in the lab and day 3 with the actual instruction of how instruments work and the mathematics behind it.**

Phase 4: Alternate Explanations.

- Students will discuss individual ideas in their groups and then discuss with guidance from the instructor during the hour. **Guiding questions will be critical for low level learners.** Many students will probably understand that sound is made through vibrations and that they travel through the instrument, but will not be able to explain WHY the pitches differ or how the sound travels to the listener.

Phase 5: Communicate and Justify.

- Students will communicate in individual groups and then as a whole class. A consensus among the drawings and explanations will be reached. Students will be expected to think deeply and really explain "why do you think that" about how the sounds are produced, why they are the same or different, and how the sound travels. Emphasis will be placed by the instructor (through indirect guidance) on the length/size of the instrument and the change in pitch. The relationship between frequency and wavelength (which will be previously touched on in the introduction to waves) will begin to take shape.

[1] See video on sound

Day 2: Sound lab

- **Summary:** Students will cement their ideas on the size of an instrument and its relationship to wavelength, frequency, and pitch by the manufacture of straw kazoos. Students will begin to unravel the ideas of different media and their relationships to sound by listening to sounds created by listening through solids versus air. The lab will be completed, and then discussed.

Phase 1: Engaging with a problem/Questions

- While the general question or problem will be the same, students will be presented with smaller questions that fit the overarching thematic material of the unit. In particular, while the first day focused on the relationships of wavelength, frequency, pitch, and wave speed, the lab will also include more of the work with different media.

Phase 2: Data or observations / Evidence

- **For the lab students will take qualitative data.** The lab will consist of three parts. The first will have the students explore how sound moves through a metal grate versus the air and then how tapping a pencil on a table sounds different when their ears are pressed against it. The second and third part will cement the ideas of the day before, where students will experience the difference in pitch (frequency) when the length of a ruler and a kazoo changes. Students will make qualitative observations on their lab sheets (which can be used to help study for assessments down the road). The lab (see attached) allows students to explore without directly prompting a correct or incorrect response.

Phase 3: Finding and explaining patterns / Explanation.

. **Students will connect to experience from the day before and draw on new examples to make patterns on how sound travels.** In particular, students will see a drastic change in sound as the medium changes and look to explain why by discussing in small groups and with the whole class at the end of the hour. Students will build and solidify size of instrument and pitch relationships from the day before through active discussion and review of the previous day's work.

Phase 4: Alternate Explanations.

- Students will first be able to communicate and explain things to their lab groups before breaking off into full group discussions. **Guiding questions will be critical for low level learners.**

Phase 5: Communicate and Justify.

- While individual and full group discussions are important to "unpack" the lab work and provide students to discuss and confirm/change thoughts, this lab will be collected by the teacher and glanced at for evidence of solid thought. The results of this lab are very important as any misconceptions left after the lab has been completed could become too permanent to be changed (especially since these students are very concrete thinkers).

Day 3: Putting the pieces together

- **Summary:** Students will have 1 more opportunity to experience the effects of changing the size of a tubular instrument and how it affects the wavelength, frequency, pitch, and speed of the wave. Students will reflect on their previous thoughts on sound and make adjustments to their models.

Sequence of events for day 3

1. Students will do their daily bellwork question which will involve a demonstration of several "boom-whacker" tubes. Students will be asked to make predictions based on the previous days and compare and contrast the sounds they make.

2. Using the labs and activities, students will revise and discuss their models from day 1. This will transition into the student-led guided notes for the unit. Also issues from the previous day's lab will be addressed.

3. Students will be given an exit ticket using "plickers" to ensure core ideas are firmly cemented.

Assessments during my unit:

Day 1: Students will be assessed based on the quality of their discussion and the work put into their diagrams. At this point there is not a lot of "core knowledge" to be assessed; rather it is an exploratory day.

Day 2: Students will be assessed based on questions asked by the instructor during the lab, after the lab, and when participating in unpacking the lab after it is complete. The labs will be collected, looked over, returned the next day, and large scale issues will be addressed.

Day 3: Students will first be assessed on their analysis of the "boom-whacker tubes" at this point students should be able to formulate correct predictions on how the sounds are the same and how different length tubes will produce different pitches (and why). Students will be also assessed based on how they have re-evaluated their first day drawings and explanations. After further discussion about how the waves travel through the air, students could be asked to revise a third time. Finally, at the end of the third day students will answer a series of impromptu learning check questions using "plickers" which will gauge their understanding of the material.

Final formative assessment on sound, mediums, and work with the equation (and math) would be done at a later date. Students in this class (most of which struggle with mathematics) will need a few solid days on the wave speed equation.

Differentiation during my unit:

The use of visible thinking practices and small group and large group sharing will provide a canvas for natural differentiation amongst the students.

Students will complete labs in groups based on the seating chart (mixed ability).