Sound Program of Study Reasoning Assessment: Explanations

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This document is a supplement to the answer key for the Sound Reasoning Assessment. For each question, there is typically a statement identifying the science concepts that are targeted, and it is followed by an explanation of how those concepts apply to the situation represented in the question. The correct response is identified, indicating how it follows from understanding the science concepts and applying them to the context of the question, and further information may be given about what an incorrect response can reveal about a student s understanding.

Question 1, 2, and 3:
Interpretation of the graphics at the beginning of these questions is key to responding accurately to Question 4, which is about designing an investigation in which all variables are controlled with the exception of the one of interest.
Question 1: The variable of interest here is the size of the bottle. The drawings are intending to show the bottles as being of the same size, but in our own work we have noticed that there can be a bit of an optical illusion with our brain interpreting these as being of differing size.
Questions 2 and 3: The variables of interest here are the relative amounts of water and air. The amounts of each material in a bottle is related, but students may not see it that way. The bottles depicted have different amounts of each material.

Question 4:
This question addresses the design of an investigation, and seeks to reveal whether students understand the scientific norm of investigating via experimentation (i.e., controlling all variables but one, also know more colloquially as conducting a "fair test"). The question provides the information that Marissa sought to investigate how changing the amount of air in a bottle might change its pitch. Scientifically, that means that only the amount of air should differ between the bottles, and not anything else. The bottle sets represent different ways that the amount of air could be changed, but only one represents the correct choice for a scientific experiment. Although answer choices (a) and (c) have different amounts of air from the other bottles in their set, they also have a different size of bottle from the others. Results comparing the sounds from each of these sets mean that differences in pitch could be from the amount of air in the bottle or the size of the bottle. Answer choice (b) is correct because only the amount of water (and hence, the amount of air) differs among the bottles. Further investigation would actually reveal that the height of the bottle is the critical factor (the pitch of the empty bottles in (a) and (b) would produce the same pitch, but higher than either of the other bottles, and the empty bottle in (c) would produce the highest pitch. This type of context and this type of comparison is a major feature of the Big Book text, so it should be familiar to children following the program of study.

Question 5:
This question is also about the design of an investigation, and seeks to reveal whether students can choose the best materials to compare for the study of sound in this new context: comparing the rate of vibration to the length of the vibrating material. This context is one that the students will be familiar with after completing the program of study, but prior to it may interpret this question in a different way. Prior to any instruction, students who know about the importance of a fair test may think that (b) is the correct answer because it shows that the rulers are the same, and controlling variables in an important part of conducting a fair test. Answer choice (c) may be chosen by children who focus on the need to have a difference between the rulers because the rulers look like they are different in maximal ways (indeed, both length and width are different).

The correct response, (a), is the only answer choice that shows only one variable changed, and it is the variable of interest: length.

Question 6:
This question concerns the interpretation of data. It requires students to know how to interpret the vibration pattern on an oscilloscope, as well as being able to compare vibration patterns. The vibration patterns shown do not differ in amplitude but they do differ in. Differences in frequency are related to pitch, with a higher frequency vibration being a higher pitch. That makes answer choice (a) the correct response. If students incorrectly associate amplitude differences with differences in pitch, they may chose answer choice (b). Answer choice (c) might be selected if students did not associate vibration with pitch or if they thought the lack of any scale for the pictures prevented one from interpreting pitch. However, since the pictures provide information to compare, and the two pictures appear to be in the same time span (we should have shown a timeframe below the pictures), it is reasonable to conclude that picture **A** shows a higher pitch than picture **B**.

Questions 7 and 8:
These questions are about conducting an investigation in which sand on a drum is used to provide information about the vibration of the head of the drum (which is not easily observed by itself) when struck by a drumstick. *Question 7* concerns making an observation, and (in the case of this assessment item) correctly interpreting a graphical representation. Even though the sand grains do not all reach the same height in response to the drum head being struck, there is a discernible difference in each case (approximately a1 cm bounce in response to the smallest stick, a 2 cm bounce from the medium size stick, and a 3 to 3 1/2 cm bounce in response to the largest stick. Thus, the largest drumstick causes the sand to bounce the highest, and answer choice (c) is the correct response.
Question 8 asks for a determination of the knowledge claim that could be made from the observations of the sand grains. Since the sand grains were used to tell about the vibration of the head of the drum, that is what the claim should be about. Answer choice (b), then, is the best response. Answer choice (a) is a correct characterization of what occurred when the drum was struck, but there are no data reporting loudness, so this is not an appropriate claim to make from the information provided in the question. Answer choice (c) may be chosen by those students who confuse the circumstances resulting in differences in pitch compared to loudness; i.e., the frequency of a vibration versus its amplitude (height).

Question 9:
This question attempts to ascertain students' knowledge about conventions for organizing and representing data. Although there are many ways to organize data, particular choices are more powerful than others. For example, displays of data in a graph facilitate estimating the quantities of a variable that lie between the values at which it was measured. Scientists seek to represent data in graphical ways because they are more powerful in illustrating relationships. Thus, the best representation of data for illustrating a claim is answer choice (a). Students may prefer answer choice (b) because it is the most similar to the actual collection of data. However, as a representation, it requires the most effort from those viewing the data to interpret what they mean. The expectation is that when data are presented to others, they are presented in a form that makes it easy for others to interpret them. The representation shown in (c) is a fine way to

represent the data, and considering the claim in Question 8, it would be sufficient. However, it is still not the preferred representation because it does not provide as much information about the data for inferential purposes (i.e., for speculating about quantities that were not measured but which could be inferred from the graph), compared to a display of the data as a graph.

Question 10:

Scientists invent tools to measure quantities. Our sense organs, though they provide comparative information for us, are not accurate instruments for measuring. For example, our sense of touch does not tell us about the temperature of an object but the extent to which it conducts heat from our body (transferred by our touch) to the object and/or the environment. Our ears can discern pitches and differences in pitch, but only over a particular range. If the birds are making sounds at frequencies above our range of hearing, we would not know it. Thus, answer choice, (a) is not the best response. A tape recorder is a useful device for recording sounds. The employment of this tool would be useful in capturing the initial observation of the bird sounds so that they could be analyzed at a later time. An oscilloscope is a device that can convert sound input into a waveform. The waveforms represent vibrations over a particular period of time, and that information can be used to determine the pitch. Thus, answer choice (b) is the best response to this question.