WHAT DETERMINES THE TUNE OF THE SINGING TUBE?

STUDENTS STUDY PROPERTIES OF SINGING TUBES AND EFFECT ON SOUND AND PITCH

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Church organs. (Photo Ana G. Blagotinšek)

STAMPEd

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SUITABLE FOR AGE(S)	SUBJECT(S)	KEY FOCUS
12 - 18 years	Physics	Designing investigations Conducting investigations

INTRODUCTION

This rich task is designed to introduce a simple inquiry with easily accessible hands-on materials. This task introduces students to the fundamentals of inquiry-based learning (IBL) through hands-on exploration of sound using hollow tubes. Through guided inquiry, students engage in observation, hypothesising, planning, and conducting a practical experimental activity (with a focus on controlling variables), thereby developing scientific thinking and inquiry skills. With small children (or beginner learners/teachers in IBL) in focus, the number of variables, constants and objects involved is limited. No measurements and/or calculations are required. The extension of designing a set of flutes and forming an orchestra to play a popular tune offers a challenge and motivation for further work, an opportunity for social bonding, or a simple, fun conclusion to the lesson.

Students are asked to observe and compare different tubes, noting both differences and similarities. They produce sounds by tapping the tubes on their palms and hypothesise which property of the tube influences the pitch of the sound. Guided enquiry then follows, focusing on a fair test by choosing variables and constants appropriately to find the answer.

The task also serves as an interdisciplinary bridge between science, physics, and music, suitable for a wide age range, from preschool to university level. Beyond science content, the task fosters social interaction, especially when used at the beginning of the school year to build group dynamics and cooperation among unfamiliar classmates.

TASK DESCRIPTION

Students are presented with a set of hollow tubes varying in length, diameter, material, colour, elasticity, and wall thickness. First, they observe and compare these tubes to identify similarities and differences. Then, by tapping the tubes against their palms, they explore the sounds produced and compare pitches. They are encouraged to hypothesise which property of the tube affects pitch.

This leads to the formulation of a guided inquiry question: "How does (chosen property) affect the pitch of the tube?" Students then design a fair test to investigate this hypothesis, selecting appropriate variables and constants. Working in small groups, students perform the experiment with a subset of tubes and report on their findings, highlighting how they controlled variables to ensure valid results.

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A musical extension allows students to participate in a simple classroom orchestra, with each student playing a note by tapping a tube when prompted by the teacher using a projected musical sheet.

TASK PREPARATION

The teacher should prepare sets of tubes with controlled variations in at least two properties (e.g., length, diameter, material) and create a basic guided worksheet or template for students to record their observations, hypotheses, and conclusions.

Materials needed:

Equipment Per Group:

- A set of approximately 10 tubes with (at least two different lengths, two different diameters, several different materials, e.g., plastic, metal, rubber)

Optional / Extension:

- Pre-cut musical tubes producing known tones, marked with coloured bands.
- Projected musical notation or visual sheet.
- Conductor's pointer (used by the teacher to direct the classroom orchestra).

TASK IMPLEMENTATION

Observation & Comparison

1. Students are presented with sets of tubes of different materials (e.g., colours, elasticity, lengths, diameters, thickness of tube walls) and asked to observe and compare them, thus identifying possible variables for later inquiries. They document similarities and differences, improving observational skills. The teacher guides discussion on possible variables (independent, dependent, and controlled).

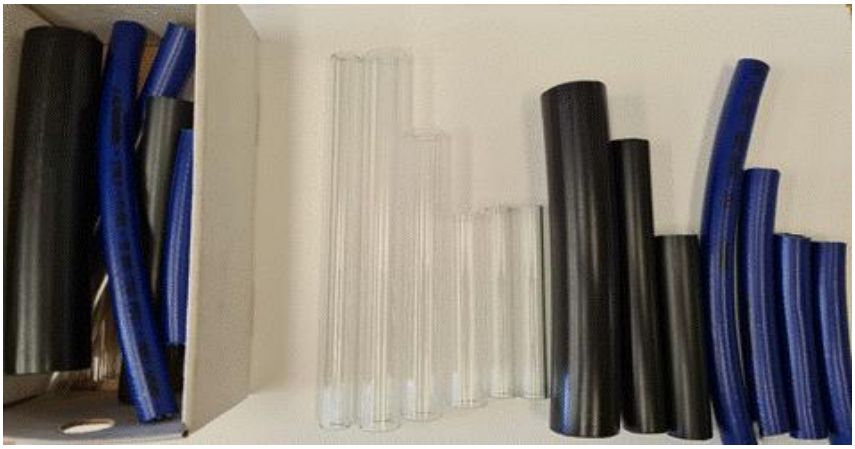


Figure: Set of tubes for the activity. (Photo Ana G. Blagotinšek)

Sound Production & Hypothesising

2. After observing and comparing objects (tubes), students are asked to produce a sound by tapping each tube on their palms and comparing them. This is a level more difficult for younger students, as the phenomenon is more demanding to compare than objects. Pitches are different enough even for untrained ears.

3. Interdependence between the properties of the tubes and the sounds they produce is suggested. Students are asked to hypothesise which property (difference among the tubes) of the tube determines the pitch and how they are related.

4. Inquiry questions are formed, transforming the hypothesis into a "How does ... (my chosen property) influence the pitch of the tube?" question.

Planning and Experimentation

5. Groups plan and conduct the inquiry but are limited to using only a pair (two) tubes from the set with appropriate properties, which reflect their chosen independent and dependent variable (and constants or controlled variables). They discuss and draw conclusions about how the tested property affects pitch.

Reporting

6. Reporting is done briefly, students stating their inquiry question, findings (answer to the inquiry question) based on experiments and how they ensured the fair testing, making results reliable.

Extension (Optional – Classroom Orchestra) - musical notation

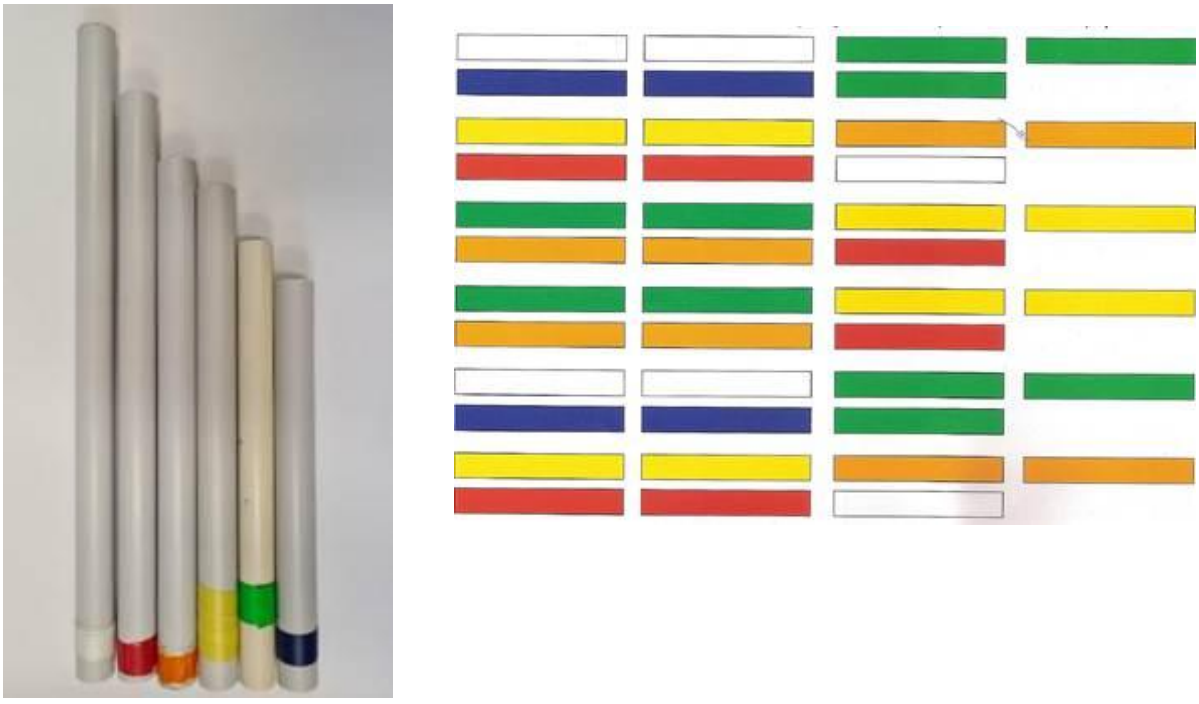
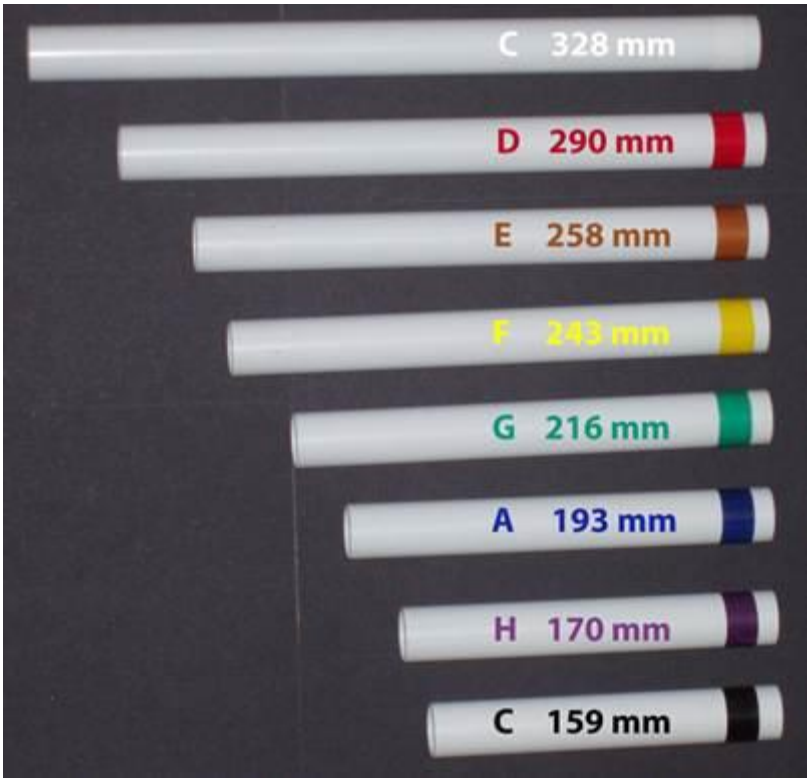


Figure: Musical notation and tubes required for playing Mozart tune (Rovšek & Razpet, 2006).

Tubes are cut to produce different frequencies (tones) and marked with coloured bands. They are randomly distributed among students – each student receives and "plays" one. All tones represented in the musical sheet should be available. The teacher (as conductor) projects the music sheet on the whiteboard and rhythmically points at the "notes" in the musical sheet; students tap their tube once when their colour is pointed out, producing a simple melody as a class.



Lengths of the tubes for basic music tones. Source: (Slovenian) House of Experiments.

https://www.he.si/slike/exp/palice.jpg (https://www.he.si/pojoce_palice)

KEY LEARNINGS

This task was tested by primary and kindergarten student teachers. The teachers found the task challenging enough even for them (especially fair testing and control of variables) and liked the interdisciplinarity of the task.

CONCLUSION

Singing tubes are short, fun activities that can be used specifically to develop inquiry-based learning skills and fair testing with younger students. For older students, there is additional content related to sound, oscillation, and waves. It also serves as a good example of an interdisciplinary approach, combining music and acoustics (Physics).

REFERENCES

- Halliday, D., Resnick, R., Walker, J. (2014). Fundamentals of Physics. Wiley.
- Rovšek, B., Razpet, N. (2006). Preprosta glasbila. Naravoslovna solnica, 10(3). Založba PEF: 21-27. In Sovenian.
- (Slovenian) House of experiments. https://www.he.si/pojoce_palice
- Wikipedia. https://en.wikipedia.org/wiki/Acoustic_resonance

APPENDIX

The context and additional information

Sound is a longitudinal wave phenomenon. When the sound propagates through the air (or any other matter), the molecules oscillate around the initial position along the direction of the propagation (and back) – hence the name longitudinal waves. Areas of compressed matter (with slightly heightened pressure) are formed, with areas of lower density (and pressure) in between, propagating through the air. The sound waves propagate through the air with a speed of v = 343 m/s (at 20 ^{0}C).

Sound from the singing tubes is produced by oscillations of the air column trapped in the tube. Oscillations propagate along the air column, forming waves which get reflected at the end of the tube (even if it is open) and propagate in the opposite direction. Waves travelling in opposite directions combine, sometimes forming standing waves that lead to a phenomenon called acoustic resonance (Halliday et al., 2014).

The pitch of the sound produced by hollow tubes depends on the length and shape of the tubes, as well as whether their ends are closed or open, and is similar to that of many musical instruments, such as flutes and organs.

Cylindrical tubes of length L with both ends opened resonate at frequencies f, approximately given by

$$f = \frac{nv}{2L},$$

Where n is a positive integer (1, 2, 3 … - resonance node) and v is the speed of the sound. In this approximation, only the length of the tube affects its pitch. More accurate description, however, considers that the pitch is also affected by the tube diameter, because at the open end, the waves are not reflected exactly at the end of the tube. Frequency f is hence given by

$$f = \frac{nv}{2(L + 0{,}6\,d)},$$

Where d is the diameter of the tube (Wiki).

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Worksheet: Singing tubes

Safety note: Do not blow into the tubes!

1. You have a set of different tubes at your disposal. Observe and compare them.
   - Write down the variables on the set of given tubes (properties by which the tubes differ).
   - Also write down the constants (properties according to which the tubes are the same).
   - If you tap the tubes on your palm, they make a sound. Try it. Compare the sounds of different tubes. Are they the same or different?

2. Make a hypothesis: Which characteristic of the tube determines the pitch of the sound emitted by the tube?

3. Test your hypothesis. Is your opinion correct? Find out with an inquiry. *My inquiry question is*:...

4. Make an inquiry plan to test your hypothesis with experiments.
   - Choose and write down the independent variable (what you will change during the inquiry):
   - Choose and write down the dependent variable (what you will observe, monitor, measure...):
   - List the constants (What will you not change between experiments to make the research fair?):
   - Choose a pair of tubes to test your hypothesis. Write down which two tubes you chose to try. Explain why you chose this pair of tubes.

5. Describe the experiment and interpret the results! What are your findings (answer to the inquiry question)?

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