Hands-on-Remote

Teaching Module

Sound

All materials and contact details can be found on the project websites as well as in the Erasmus+ project profile:

https://sites.google.com/campus.ul.pt/hands-on-remote-language/home
https://erasmus-plus.ec.europa.eu/projects/search/details/2020-1-DE02-KA226-VET-008295

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Disclaimer

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1 Introduction

General aims

This module allows students to:

- Build different type of musical instruments, explain how the instruments produce and transmit sound, as well as understand the sounds attributes;
- Measure the sound level in different stations of their homes or school;
- Measure the rate of reduction of the sound intensity of a model to conclude that some materials are more sound-insulating than others;
- Build a microphone with everyday materials;
- Develop 'hands-on' work even under pandemic conditions;
- Use online simulations or other APP to promote collaborative learning.

In addition, students have the opportunity to develop many inquiry skills, such as: formulate hypothesis; plan an investigation; carry out your investigation and record the data; organize and analyze data collected; test the hypothesis; and draw conclusions. This module can enrich students' scientific and digital literacies.

Didactic rationale

Sound is a phenomenon of our everyday life and is a typical standard topic of physics. The exploration of this module is guided by big ideas (e.g., related with sound properties and sound effects). In order to explore these big ideas, we intend to use situations related to real life (e.g., microphones, audiogram etc.) which typically are of interest for learners. Moreover, we use Inquiry-Based Science Education (IBSE) as the pedagogical approach. Thus, students will be engaged in several sciences and engineering practices: asking questions and solving problems, developing models, constructing explanations, and designing solutions, using different sources of information, collecting and processing information/data, and obtaining and communicating results. In the module, we also aim to enable hands-on practice in a variety of classroom settings and offer students to learn taking into account their needs.

Community feeling

During the implementation of this module, students will work in group. For that, in order to foster students' interaction, teachers can use tools such as ZOOM, Google Meet and Skype, providing synchronous learning contexts (e.g., group work in different rooms). Team-work in remote set-tings works better with groups of 3–4 students where each one is responsible for specific tasks/roles.

At the same time, teachers can use synchronous moments to provide oral feedback and to help students to overcome their difficulties. Teachers can also use these tools to pay attention to students' conceptions regarding sound (some examples from the literature: sound is a material unit of a substance, sound pushes the air molecules in the direction of its propagation, sound moves be-cause the air pushes it, sound moves like an invisible liquid). During the four activities, it is also possible to use padlet to introduce the activity and also to ask introductory questions in order to detect and discuss students' alternative conceptions. Teachers can also use other tools where students can discuss in chats or discussion forums, such as Moodle platform or Google Docs. For example, students can share their hypotheses, investigation plans, data collected, findings and conclusions using a forum in Moodle or for example in a Google Docs.

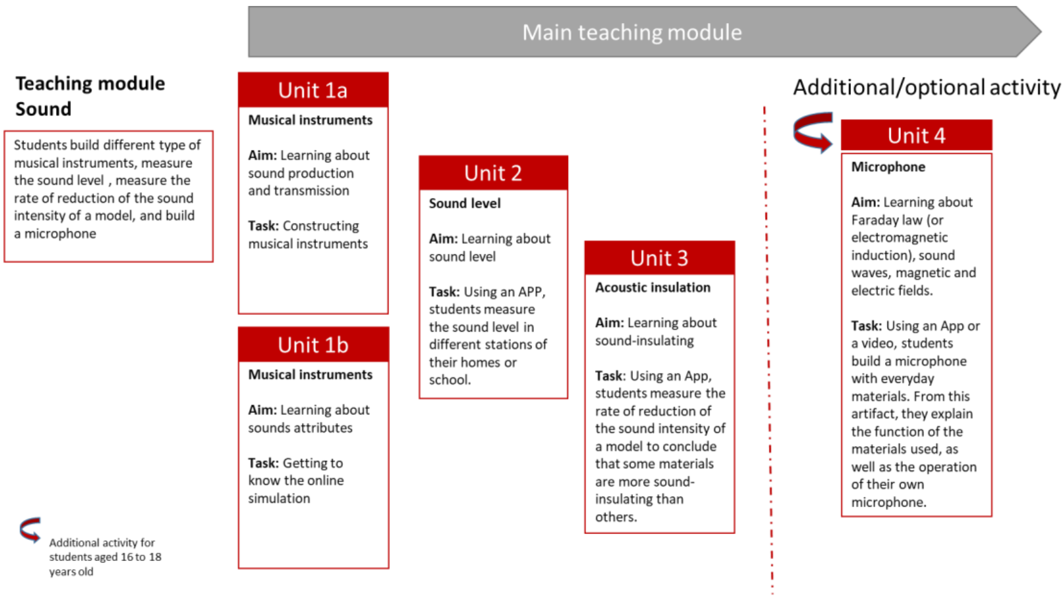
Short summary

Sounds' module includes four activities, entitled: Musical instruments, Sound level, Acoustic insulation and Microphones. 'Musical instruments' is a hands-on activity. During the activity, students construct their musical instruments with everyday materials, and they study the sound waves associated with their instruments. Then, students open a 'Sound Waves' simulator and using a 'Listen from a single source', recreate sounds and associate a musical instrument constructed. In the activity 'Sound level', students are invited to measure the sound level in different stations of their homes or school. So, students should define different measurement stations in different locations at home or school, and use their cell phones/tablet with the application that allows them to take measurements. During the activity, 'acoustic insulation', students must solve the following problem:' What will the two brothers do to soundproof the bedroom wall to reduce the noise produced at the festival?' For that, using an App, students measure the rate of reduction of the sound intensity of a model to conclude that some materials are more sound-insulating than others. Finally, in the activity 'Microphones', students build a microphone. Before that, students can visualize a video about the microphones and their construction using simple materials.

Curriculum fits

This module is recommended for 8th to 9th grade students (age 13-15 years old) and its expected duration is 12 hours in total. The teacher can select the activities to be developed by the students.

Overview of the module sequence



2 Learning sequence

2.1 Unit 1 - Musical Instruments

Students' task

1. Construct your musical instrument with everyday materials.

2. Study the sound waves associated with your instruments. Open the 'Sound Waves' simulator. Using the 'Listen from a single source', recreate the sounds in the table and associate a musical instrument. Don't forget to check the 'Turn on audio' box.

https://phet.colorado.edu/pt/simulation/sound

Sound	**Musical instrument**	**Explain how you used the simulator to recreate the sound**	**Draw a representation that appears in the simulator**
Case A: High and loud			
Case B: Low and soft			
Case C: High and loud			
Case D: Low and soft			

3. Represent in graphic form each of the representations drawn in the previous question.

Teachers' guide

Aims: Using daily life materials, students build different type of musical instruments and explain how the instruments produce and transmit sound. In addition, this activity allows that students associate: the terms HIGH and LOW to an attribute of the sound called pitch and the terms STRONG and WEAK to an attribute of the sound called intensity; the pitch to the frequency of a sound wave and the intensity to the amplitude of a sound wave; high pitch sound with high frequency sound wave; low pitch sound with a low frequency sound wave; loud sounds with high amplitude sound wave, and soft sounds with low amplitude sound wave.

Topics addressed: categories of musical instruments, sound production, sound transmission, sound attributes (pitch and intensity) and sound waves.

Duration: Two lessons (2 x 90 minutes) and independent work of students at home

Solution

Question 1

Materials: Daily life materials (such as, spoons, cups, shoe boxes, yogurt cups, paint cans, etc).

Design criteria: as a class, students build different categories of instruments (string, percussion and wind instruments) and the instruments must be able to make at least two different sounds (high and low).

Question 2

The simulator allows exploring the attributes of sound – pitch and intensity. Java simulations run on most PC, Mac, and Linux systems. Students use the simulator at home, varying the frequency or amplitude of a sound wave represented in the simulator, in terms of pressure variation. Then, they associate the sounds produced by the simulator to the musical instruments built. For each musical instrument, students must fill in the table (see example of students' answer – Figure 1). In the table, students explain how they reproduce the sounds (by varying the amplitude, frequency or both) and make the representation that appears in the simulator for each sound.

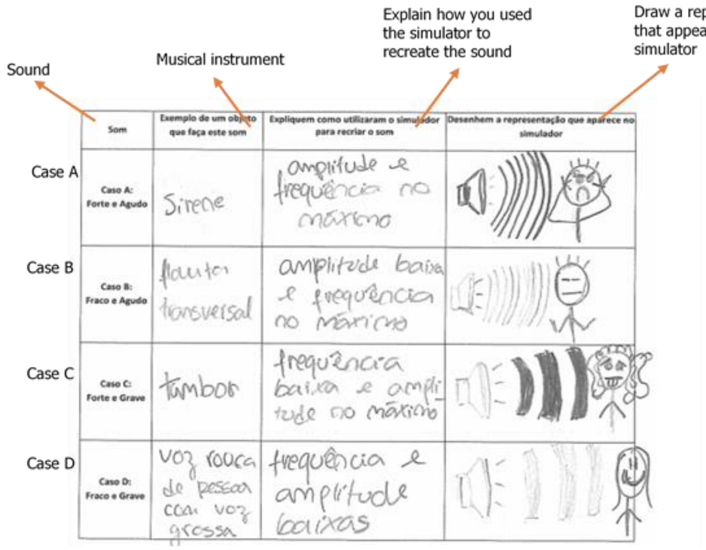


Figure 1 - Example of students' answer

Question 3

The students represent graphically (sinusoidal representation) the sounds they reproduced in the simulator (see example of students' answer figure 2), associating the characteristics of the sound wave - amplitude and frequency - to the sound intensity and pitch.

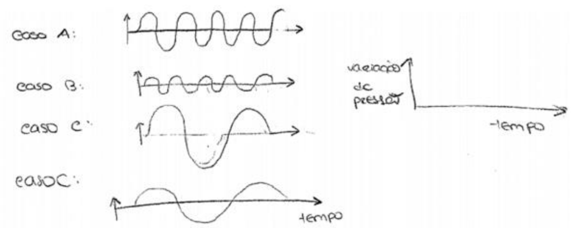


Figure 2 - Example of students' answer

2.2 Unit 2 – Sound level

Students' task

1. At home or at school identify stations of interest (classrooms, kitchen, etc.) and predict the expected sound levels in the different sources.

2. Using an App, measure the sound levels in the different stations identified and collect data for your mobile phone.

3. Register your data in a table.

Source/station	Sound level (dB)	Time

4. Discuss the data collection, i.e., what the data means. Does the data support your predictions? Did you repeat the measurement? Why? How many times?

5. Make conclusions.

Teachers' guide

Aims: Using an APP, students measure the sound level in different stations of their homes or school.

Topics addressed: sound level

Duration: Two lessons (2 x 90 minutes) and independent work of students at home or group work at school.

Material: Each student/group needs a smartphone or tablet with a noise monitoring app (e.g., Sound Meter - Noise Meter).

Question 1

Students select at home or school various stations to measure the sound level. Students should take in account how and where the measurements must be done. Students should define different measurement stations in different locations at home or school, and use their cell phones/tablet with the application that allows them to take measurements (Sound Meter - Noise Meter).

Questions 2 and 3

The students use the App (Sound Meter - Noise Meter) to measure the sound level. They must take into consideration:

I. When the app opens, it starts to measure the sound level, but students need to calibrate the values;

II. Students must click start to begin recording the measurements. For each station of interest identified, students must collect data at least 5 minutes. After that, they stop and register the average value.

Question 4

After data collection, teachers discuss with students the following questions: - How long did you measure the sound level in each source of interest identified? (At least 5 minutes to gather useful data.) - Did you repeat the measurement? Why? How many times?

Question 5

Students must compare the values obtained in each of the stations and find justifications for the differences found. They can also conclude that the sound level is a scale that relates the intensity of a given sound to the intensity of the weakest sound that we can hear. The sound level can be measured with a sound level meter.

2.3 Unit 3 - Acoustic insulation

Students' task

In several European capitals, an electronic music festival has been taking place for some years now. This festival takes place, for the first time this year, in Lisbon. Smith and Nicole live near the festival place. This year, they will do an interrail, which starts at dawn, on one of the days of the festival. So they have to get up very early. In advance, they planned to sleep, the day before they left, at their grandparents' house, to sleep without noise. However, the two brothers read on the internet how they could acoustically insulate one of the walls of their room, so they wouldn't have to leave their house the day before the interrail. What will the two brothers do to soundproof the bedroom wall to reduce the noise produced at the festival?

1. Formulate a hypothesis that allow you to answer the question.

2. Plan an investigation by which you can test your hypothesis (describe in detail all the steps, including study variables). Use a model.

3. Carry out your investigation and record the data.

4. Organize and analyze data collected.

5. Test the hypothesis by determining the sound intensity reduction rate of the model.

6. Compare the sound intensity reduction rate of the model obtained by all groups. Make a conclusion about the best soundproof material.

Teachers' guide

Aims: Using an App, students measure the rate of reduction of the sound intensity of a model to conclude that some materials are more sound-insulating than others.

Topics addressed: sound level, acoustic insulating materials, noise reduction or noise pollution.

Duration: Two lessons (2 x 90 min.) and independent work of students at home or group work at school.

Material: Each student/group needs a smartphone or tablet with a noise monitoring App (e.g., Sound Meter - Noise Meter), a sound source that can be a smartphone, a small cardboard box (e.g., shoebox), everyday sound insulating materials (e.g., cardboard, egg cartons, Styrofoam, bubble wrap, sponge, etc.)

Question 1

The hypothesis formulated depends on the material selected. Students need to select the sound-proofing material to be used in the investigation. Groups can select different soundproofing materials.

Question 2

Students' must plan an investigation by which they can test their hypotheses. Students' design a "room" – model- like a shoebox to soundproof (each group could choose a shoebox with a different dimension and/or materials). The shoebox dimension variable must be controlled, as well as the distance from the sound source to the model boundary (isolated wall). If not, this situation should be discussed when comparing sound intensity reduction rates for different insulating materials.

Question 3

Test the model: (i) place a mobile phone to emit a sound with the same intensity (ii) measure the volume of the model (optional); (iii) place the phone – sound source – inside the model; (iv) measure the distance from the sound source to the model's internal boundary (optional); (v) collect data using an App to measure the sound intensity value of the sound source, under the same test conditions, without insulating material.

Collect data using an App to measure the sound level from outside of the model. Control the distance variable from the model's border to the mobile phone's microphone, located on the outside. Register 10 readings.

Question 4 and 5

Use the average value of the 10 readings to determine the rate of sound intensity reduction (sound intensity value inside of the model - sound intensity value outside of the model) / (sound intensity value inside of the model) X 100).

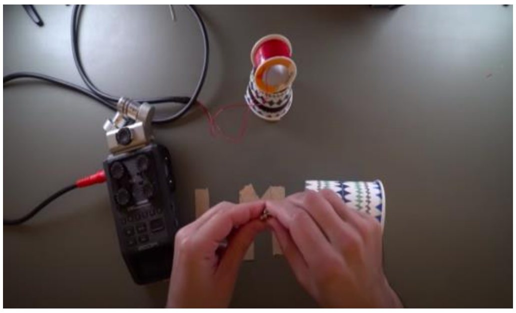
Question 6

The conclusion of the best acoustic insulator within all groups requires controlling the variables described in question 4.

2.4 Unit 4 - Microphone

Students' task

The microphones have the purpose of transforming sound waves into electrical signals (by electromagnetic induction). These electrical signals, which have the pattern of sound waves, are used in amplifiers, recorders, telephones, hearing aids, radio broadcasting, TV, among others. There are several types of microphones and some can even be constructed with simple materials, such as what is exemplified in the following video:



https://www.youtube.com/watch?v=1hU6wrR2J24

1.Using the App or the video, select materials and build your own microphone.

2.Explain the function of all selected materials.

3.Explain how your own microphone works.

4.Write changes to your microphone to improve its effectiveness.

5.Explain how electricity is produced in a hydroelectric plant based on what you learned in the previous questions.

Teachers' guide

Aims: Using an App or a video, students build a microphone with everyday materials. From this artifact, they explain the function of the materials used, as well as the operation of their own microphone.

Topics addressed: Faraday law (or electromagnetic induction), sound waves, magnetic and electric fields.

Duration: Two lessons (2 x 90 min.) and independent work of students at home or group work at school.

Material: Each student/group needs:

– A paper or plastic cup

- A thin electrical conductor wire

- An empty packaging of tape or adhesive (empty roll)

- Pliers that cut the electrical conductor wire

- A pocket knife or scissors to pierce the empty roll

- Insulating tape

- A magnet

- A cotton thread

Question 1, 2 and 3

Students build a microphone and describe the function of the materials used:

- The base of the paper cup – membrane – vibrates due to the propagation of sound waves created by the student's vocal cords.

- The vibration of the membrane transmits a pattern of sound waves to the cotton thread.

- This pattern propagates through the cotton thread causing the magnet to vibrate inside the coil (the electrically conducting wire wound in turns in the empty sticky tape package consists of a coil).

- The movement of the magnet inside the coil produces an alternating magnetic field (which changes direction in time). The microphone takes advantage of this phenomenon. The variation of the magnetic field (which follows the pattern of vibration of sound waves) creates an electric field in the electrical conductor wire.

Question 4

There are many possibilities to improve the effectiveness of the students' microphone. For example, if the bottom of the paper cup is replaced by a plastic of one balloon, it is possible to improve the transmission of sound waves to the cotton thread and to the magnet.

Question 5

In a hydroelectric plant, the transformation of the potential energy of water into kinetic energy causes the movement of large magnets inside the coils, creating an alternating magnetic field, which, in turn, creates an electric field in the electrical conductor wires of the coil. The electrical energy is transferred by electrical cables to the electrical grid.

Students' assessment

With this module, students can develop many skills, such as planning investigations and working collaboratively. Proposed assessment methods include teacher observation, student artefacts and peer- and self-assessment.

Skill: Plan investigation

Emerging	Developing	Consolidating	Extending
The research designs is not related to the hypothesis/questions or contains serious mistakes. There is problems with the experimental procedure.	The research design is incorrectly constructed based on the hypothesis/questions. Some steps of the experiment are described but some crucial details are omitted.	The research design is reasonably constructed based on the hypothesis; the experiment gives an answer to the research question. The steps of the experiment are described.	The research design is appropriately constructed based on the hypothesis; the experiment gives a complete answer to the research question. The individual steps of the experiment are described accurately.

Attitudes: Work collaboratively

Emerging	Developing	Consolidating	Extending
Observe and accept the proposals of colleagues, but does not make any suggestions. Only accept what colleagues are doing (due to difficulties in interpersonal relationships).	Participate in the structuring of the group's work, but contribute only with one or two suggestions (due to difficulties in interpersonal relationships).	Participate in the structuring of the group's work and contribute with positive suggestions for a productive dynamic in the group.	Participate in the structuring of the group's work and contribute significantly to a productive dynamic in the group, creating positive personal interactions

(www.sails-project.eu)

All materials are available at

https://erasmus-plus.ec.europa.eu/projects/search/details/2020-1-DE02-KA226-VET-008295

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