

Building a sound scale

FizziQ Junior has been developed by the start-up Trapeze.digital in partnership with the Fondation La main à la pâte. It has been designed for use on tablets by K4-K8 pupils and facilitates the implementation of experimental activities in science and mathematics, based on the Inquiry Based Science Education pedagogy. The app allows students to access the tablet's sensors to carry out experimental measurements and to document their work in an experiment notebook. It is free and without any requirement to register.

This document was originally created in French by la Fondation La main à la pâte as a user guide for FizziQ Junior. It has been translated and amended by Trapèze.digital. Thank you to Pauline Bacle for creating the original document and Ikya Kondapolu for subsequent amendments. The present document is published under the following Creative Commons license: Attribution + Non-commercial + Share Alike.



Warning: as the application is under constant development, some features and/or the appearance of some pages may change. This guide corresponds to version 1.0.108.

Introduction

Themes Covered	Sound, measurements
Summary and Objectives	The students are reappropriating the concept of sound intensity level by placing sounds from their daily lives on a noise scale. They make hypotheses about the relative position of familiar sounds and use a measurement tool (the FizziQ Junior application, available on tablets) to confirm or refute them.
Disciplines Involved	Science and Technology
Duration	1 h à 1 h 15

This sequence belongs to the project "What is noise?" which aims to raise students' awareness of their sound environment and the consequences noise can have on their health. Noise is approached from a scientific perspective, focusing on a measurable quantity, namely the concept of sound intensity (or volume), as it is often the origin of sounds perceived as nuisances and sound pollution.

However, it is important to note that, on the one hand, the concept of noise, compared to sound, is not always well defined in everyday language, and on the other hand, this distinction is not exclusively linked to the intensity of a sound:

- The term "sound" (or "acoustic phenomenon") refers to the auditory sensation caused by an acoustic wave that propagates to our ear. In other words, it is a physical and objectifiable signal perceived by our sense of hearing.
- The term "noise" is based on perception: it is an auditory sensation considered undesirable, often with a negative connotation, because the sound is not harmonious (as opposed to music), and is unpleasant or annoying.

This concept is therefore subjective: an acoustic phenomenon may seem pleasant to some and unpleasant to others, particularly when it disturbs listening to the environment or communication.

In everyday language, the terms "noise" and "sound" are often confused, and the Larousse dictionary describes noise as follows: "1. Ensemble of sounds produced by more or less irregular vibrations; any phenomenon perceptible by hearing."

In general, sounds that do not make sense as speech or music are considered noise, even if their perception is not necessarily unpleasant. For example, someone may say that "the sound of falling rain is pleasant", while a sound may be described as unbearable.

Given this usage and assuming that in this project, we will only address the aspect of noise (in the sense of "undesirable sound") related to the intensity of sound level, we will use the terms "noise" and "sound" to refer to "any phenomenon perceptible by hearing" from now on.

Getting Started

This resource uses the FizziQ Junior digital tool, an application developed by Trapeze.digital in partnership with the La main à la pâte Foundation, and available for free on tablets.

This application allows students to write an experiment notebook, organize it into different stages, and add photos, text, drawings, etc. It also allows the use of tools and access to instruments for measuring physical quantities. For more information: <https://www.fizziq.org/fizziquniormain>.

The project includes three sequences that can be conducted independently:

- Sequence 1: Sound level: from impression to measurement
- Sequence 2: Building a sound scale
- Sequence 3: Challenge: Less noise for the neighbors!

We encourage the teacher to create their own progression adapted to their students and the available time. However, we recommend conducting the "Sound Level: From Impression to Measurement" sequence first to introduce concepts related to sound volume and allow students to familiarize themselves with the FizziQ Junior digital tool. The following sequences then help consolidate students' knowledge of sound level and measurement.

In this resource, scientific explanations are provided to help students appropriate the sequence.

Activity : Placing everyday sounds on a sound level scale

Overall objectives: Verify a hypothesis based on one's senses using a measuring tool; place common noises on a risk scale for hearing; understand that beyond a certain threshold, loud noises present a danger to hearing.

Summary	
Disciplines	Science and Technology, Mathematics
Overview and Modalities	The teacher asks students to list sounds from their environment and classify them from the least to the loudest, highlighting the subjectivity of perceived sound level by the ear (Phase 1). They then propose to construct a scale based on measurements and discuss with the students how to proceed to ensure that the scale accurately represents the differences in sound level (Phase 2). They conduct objective measurements using a digital tool (here, the FizziQ Junior application on a tablet) (Phase 3). They share their measurements to finalize the scale and discuss different elements, particularly the thresholds that mark a danger to hearing, and add a conclusion to their experimental notebook.
Duration	1 h

Material

Paper, pens, scissors, rulers, tape.

- For each group of students:
 - A simplified sound level scale (document in the appendix);
 - (optional) about fifteen image cards depicting different sounds from school or elsewhere: a calm discussion, children shouting, cars on the street, a car horn, a nightclub, a pedestrian street in the city center, a department store, a bedroom, an alarm clock, a concert hall...;
 - A tablet with the FizziQ Junior application;
 - The FizziQ Junior user guide in the appendix.

Takeaway Message :

- We can classify everyday sounds from the least to the most intense by placing them on a graduated scale, using sound level measurement.
- On the scale, there are thresholds beyond which sounds pose risks to our hearing and can become painful.

Preparation of the material beforehand

- Make sure that each tablet is charged and that the FizziQ Junior application is installed.
- On each tablet, you can also check that the application has the necessary permissions to access the microphone, by going to the settings. For Android, in the "Applications" tab, select FizziQ Junior, then check that the microphone is in the "Authorized" list. If not, click on "Microphone" in the "Not authorized" list and select "Allow only if the app is in use".
- To prevent the tablet from going into sleep mode too quickly when giving instructions, you can choose a relatively long sleep time (several minutes). You need to strike a balance between quick sleep (which prolongs battery life) and the fact that the "screen going off" will be a source of distraction, and sometimes frustration, for students, especially when giving instructions. For Android, you can change this element in "Settings" > "Display" > "Sleep".

Pedagogical note :

The study of the characteristics of a sound signal is not directly part of the science curriculum for the cycle 3, but the concept of sound level can be related to nuances in music. Nuances indicate the intensity of sounds, i.e., the sound volume of notes. This activity can also be conducted in parallel with work on the functioning of the ear and the dangers associated with noise pollution. The work proposed in this activity can also serve as a basis for creating with students a tool for managing noise in the classroom (see extensions).

Lesson

Building a sound scale - What is noise

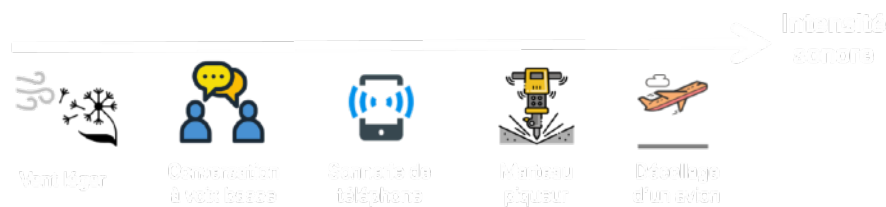
If the first sequence of the project has not been carried out in class, we recommend planning a session beforehand focused purely on the discovery and handling of the FizziQ Junior tool. The time dedicated to its handling may vary depending on the class level, for example, if students are already used to using the tablet and/or the application. However, we recommend keeping at least 15 minutes for the students to re-appropriate the tool and, for example, to create and personalize their experiment notebook.

This can also be an opportunity for the teacher to give instructions for using the tablet: only one student presses the tablet at a time, do not remove the tablet case, stay in the FizziQ Junior application...

For more information, please refer to Phase 3 of the activity "Sound Level: From Impression to Measurement."

Phase 1: Estimate an order for everyday noises (20 min)

The teacher explains to the students the objective of the activity: "In this session, we will seek to become more aware of the intensity (volume) of the sounds that surround us."



The teacher then asks the students to list ten common noises from everyday life, which he or she can write on the board. Alternatively, he or she can distribute image cards representing various situations: a conversation between two people, the classroom, the playground, the cafeteria, a library, a forest walk, a gymnasium, traffic, a construction site, a departing plane, etc.

The teacher then divides the students into groups of three or four and asks them to sort these situations according to the associated sound, using a simplified scale (document 1 in the appendix), in two steps:

1. First, place them in four categories: light noises, moderate noises, loud noises, and dangerous noises.
2. Second, for each category, rank them in ascending order of sound level, from the least intense noise to the most intense.

Pedagogical Note :

This phase can also be done directly on the FizziQ Junior application, using the prepared activity available in the appendix as a QR code (version requiring a Wifi connection). Students can download this pre-filled notebook (see note below). In the "Hypotheses" step, they can then modify the drawing corresponding to the simplified scale and add the elements of the pre-established sound list in each box. For example:

Building a sound scale - What is noise



Pedagogical Note : How to open an "Activity" in FizziQ Junior using a QR code?

- Open FizziQ Junior and click on the "Student" tab on the home screen.
- In the "Student" menu, select "I start an activity" and then "I download an activity."
- The window that opens allows you to scan the QR code of the activity: when the activity is recognized, the message "Activity detected!" appears.
- Click "Start this activity" to open the associated notebook.



The teacher then takes some time to share the students' estimations: the teacher asks them to compare their rankings and they realize that they may be different. The teacher can then emphasize the subjectivity of sound level: noise doesn't bother everyone in the same way. However, above a certain threshold, it becomes a nuisance for everyone. They also point out the approximate nature of the rankings made:

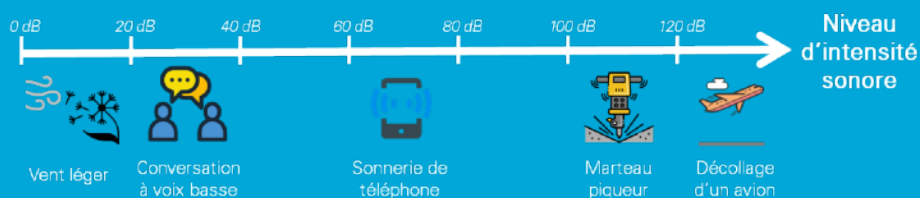
- It is impossible to obtain a purely objective order based solely on what our ears perceive, and even less so on the memory of our impressions: images or words only indirectly and imprecisely reflect the intensity of sounds.
- By simply classifying sounds into categories or in ascending order, one cannot express the relative differences between several sounds: how to translate if the difference in sound intensity is much greater between two sounds compared to two others?

These two points emphasize the need to make a numerical measurement to characterize the sound level, but also to build a graduated scale on which students can place different sounds to compare and visualize their differences in sound level objectively and precisely.

The teacher then introduces the tool of FizziQ Junior, which allows measuring sound level (like a sound meter): the application gives a measurement in decibels of the sound that the sensor perceives. In the next phase, the students will use this tool to make measurements corresponding to some of the established situations.

Scientific Note

- The intensity level of sounds is expressed in decibels (dB).
- Between the minimum and maximum amplitude of a sound signal audible to humans, there is a factor of 1 million. If we compare values between these two extremes, it would be like comparing weights ranging from 1 g to 1 t, or distances varying from 1 mm to 1 km: such a difference is difficult to represent on a linear scale. This is why a logarithmic scale is used, which stretches small values and compresses large ones.
- A scale ranging from 0 dB (threshold of human hearing) to generally 120 dB (upper limit of usual noises in our environment and threshold of pain) is commonly used.



- Since the decibel scale is logarithmic, doubling the sound intensity does not correspond to a doubling of the decibel measurement: a sound that is twice as loud in terms of sound intensity corresponds to a difference of 3 dB (i.e., $60 \text{ dB} + 60 \text{ dB} = 63 \text{ dB}$) and a sound that is 10 times louder corresponds to an increase of 10 dB ($10 \times 60 \text{ dB} = 70 \text{ dB}$).

Variant: If the first sequence of this project has been previously conducted with the class, the concept of sound level expressed in decibels would have already been addressed. Depending on the level of the class and the students' mastery of this concept, the teacher can use this time to question them about the work done in the previous session: do they remember the tool they used to measure the sound level and why it was necessary? What is the unit in which this measurement is expressed? How does the measurement value change as the sound gets louder? However, it is interesting to let the students make a first ranking of the different sounds without the measurement tool, even if they have already understood that it will necessarily be biased.

If the concept of decibels is understood, the students can also make a quantitative estimation (in decibels) of the intensity of the different represented sounds, relying on references given by the teacher (for example, road traffic at 85 dB, a rock concert at 110 dB, a taking-off airplane at 120 dB...).

The next phase will allow them to confront their perception and estimations with objective measured data, and to reinforce their understanding of the subjective nature of their impression of the sound level.

Building a sound scale - What is noise

Phase 2 : Building a graduated scale (30 min)

The teacher then proposes to the students to construct a noise scale for the class and to measure the sounds listed in the previous phase (or a portion of them).

The teacher makes them think about a work approach that allows for the completion of this activity by asking them: what are the necessary elements to draw the scale and to easily place the measurements? Do we already know values that we can place?

At the end of the discussion, the students will have understood that they need to:

- Draw a scale using graduations with a constant interval (for example every 5 or 10 dB, depending on the size of the scale);
- Indicate on this scale the values of the graduations between two reference limits: 0 dB for the threshold of audibility and 120 dB for the threshold of pain;
- Measure the different sounds, then place them on the drawn scale.

The scale can then be constructed (by the students or the teacher beforehand) on a large format to be displayed in the class at the end of the activity, so that the students keep a record and acquire new references regarding the level and the noise nuisances. Depending on the level of the class, the construction of the scale can be done collectively.

The teacher can give each group a sheet on which he has drawn two horizontal lines to form a timeline: the students can then grade this timeline, assigning each group a given interval. For example, the first group will place the graduations between 0 and 20 dB, every 5 dB. The second group will take care of the graduations between 20 and 40 dB.

At the end of this construction phase, the different sheets are placed one after the other to form the complete timeline, and the students can place the above-mentioned marks

Pedagogical Note :


This construction work allows students to reinvest the notion of fractions, for example, to place the graduations with a constant interval, they will need to divide the total width of the sheet by the interval between two graduations.

Phase 3 : Measurements (25 min)


The students use the FizziQ Junior app to make measurements of the different sounds chosen by the teacher in consultation with the class.

Pedagogical Note : How to access the "Sound Volume" in FizziQ Junior?



1. Open FizziQ Junior and select the "Student" tab on the home page.
2. Create or Open a Notebook
3. Click on  to access the toolbox, then click on « measurements».



4. Select « sound volume » the measurement will be displayed and can be saved in the notebook using the button .

Each group can then be in charge of measuring one or more sounds, depending on the available tablets and how the teacher decides to organize the session.

At this stage, it is interesting to discuss with students about the measurement: will all tablets give the same value for the same sound? What are the parameters that can vary the measurement (distance from the sound source, day of measurement, presence or absence of other background noises...)?

Scientific Note :

- Sound is a wave that corresponds to a mechanical vibration of matter (such as air) in which it propagates in all directions: the sound "occupies" an increasingly large sphere as one moves away from the source. The sound intensity thus depends on the distance from the source: the farther away one is, the less intense the sound level will be. More precisely, by doubling the distance between the sound source and the device that detects it (the tablet's microphone, the ear...), the level will be attenuated by 6 dB.
- The FizziQ Junior app uses the sensors present in the tablet to obtain measurements of physical quantities: here, the app uses the microphone to "hear" the sound and deduce its characteristics.
- Since the sound intensity level depends on the distance from the source, the position of the tablet's microphone relative to the source will have an impact on the measured level. To optimize the measurement, it is preferable to orient the microphone towards the sound source when possible.
- Because of all the surrounding noises, distance, and also because each tablet has its own microphone, the measurement may differ from one group to another (i.e., from one tablet to another).

Pedagogical Note :

It may be interesting to propose to several groups to measure the same sound (or even to repeat the measurement several days in a row) and to explain to them that we will calculate an average: all measured values are "around" this average value. The calculation of an average is a tool widely used in science to take into account possible slight variations inherent in the measurement instrument characteristics, for example.

The teacher can take some time at the beginning of this phase to demonstrate (or remind) how to take measurements with the application, and then the students carry out the measurements. Note that measuring some sounds that they want to add to the timeline will need to be done at specific times: the school bell, the playground during recess, the gym during a sports class, the cafeteria during mealtime, etc.

In the classroom, during silent reading time	around 35 dB
In the classroom, during individual work	around 40 dB
In the classroom, during a lesson given by the teacher	around 60 dB
Four classes walking up the stairs	around 70 dB
The cafeteria	around 70 dB

A whispering voice	around 30 dB
In the library	around 40 dB
Traffic Noise	around 85 dB
Playground noise	between 80 and 100 dB
A construction site	around 100 dB

A glass breaking in the cafeteria: children's reaction	around 90 dB
The school bell ringing in the hallway	Around 100 dB

A rock concert	around 110 dB
An airplane taking off	around 120 dB

On the left, examples of measurements taken at Doudeauville School. On the right, estimates of the sound levels in several situations.

Conclusion (15 min)

In the whole class, each group presents the results of the measurements they have taken. The teacher discusses with them the position of the measured values: for a given sound, is it better to indicate one of the measurements taken by one of the groups, the average of all the measurements for the same sound, or perhaps a range (for example, between 50 and 60 dB for the sound level measured during individual work in the classroom)? Once a representation mode is chosen and the timeline is completed, the teacher can add other reference points such as the danger threshold (estimated at 90 dB) to draw the students' attention to the dangers and harmfulness of certain noises to the hearing.



Example of a scale built by the CE1/CE2 class of Alexandra Fernandes (Doudeauville school, Paris).

Finally, the teacher discusses with the class what they should remember from this activity and proposes a conclusion that the students can add to their experiment notebook, directly in FizziQ Junior: "Thanks to measuring the sound level with a scientific instrument, we were able to classify everyday sounds from the weakest to the strongest, placing them on a graduated scale. On this scale, there are thresholds beyond which sounds present risks to our ears and can become painful."

Further steps

- The construction of this scale can continue throughout the year as opportunities arise to measure new situations (such as during a class outing).
- Additionally, measuring the sound level of the class can be a tool for managing noise, by defining zones separated by thresholds and coloring them with a color code, according to the level of discomfort associated with the sound level.

For example:

Upto 60 dB : You work in silence.

Between 60 and 70 dB : The volume is suitable.

Between 70 and 80 dB : Caution! It becomes difficult to work with this noise

Above 80 dB : There is too much noise: it is impossible to work.

If the class is restless, the teacher can use the tablet to show students the value of the sound level and ask them to place this value on the scale: is the noise level located in a zone of the scale that allows them to work properly?

- To go further on the issue of the dangers associated with noise, the teacher could discuss the damage that prolonged exposure to too loud sound can cause to our auditory system. They could also address the issue of exposure time, especially by taking the example of the school bell, which is generally above the danger threshold (around 100 dB during class tests, for example), but which is emitted for a short time: the louder a sound, the shorter the exposure time should be. This information on the tolerated exposure time could also enrich the sound level scale built by the students.
- You can also gather any questions they may have about the links between noise and health and use them as a starting point for a letter to a doctor or ENT specialist, for example.
- Following a discussion on the risks of exposure to too high a sound level, the teacher can encourage a discussion on the ways that students know to protect themselves from noise. Some may have attended concerts with earplugs or noise-canceling headphones, or seen workers on construction sites wearing them, for example. Some establishments may also have undergone soundproofing work. This discussion will be an excellent transition to the third sequence of this project, namely the challenge "Less noise for the neighbors!" (coming soon).

Crédits

Illustrations on pages 4 and 6: created by Pauline Bacle for the La main à la pâte Foundation using royalty-free icons from Reshot (<https://www.reshot.com>).

Images on pages 5, 8, 10, 12, and 13: screenshots from the FizziQ Junior application (Trapeze.digital).

Annexures

Document : A simplified scale to fill in (phase 1)

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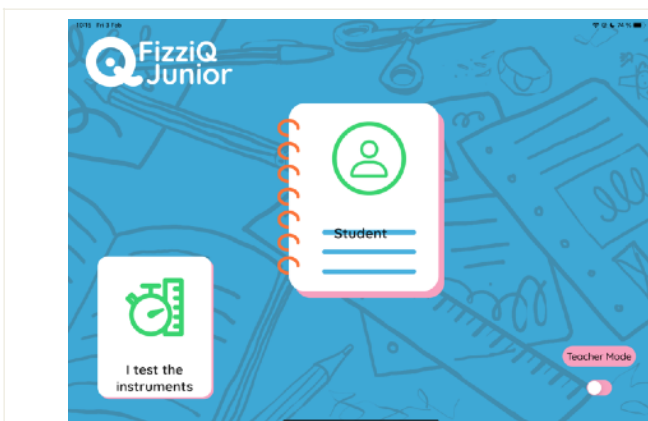
Danger
Threshold

Pain
Threshold

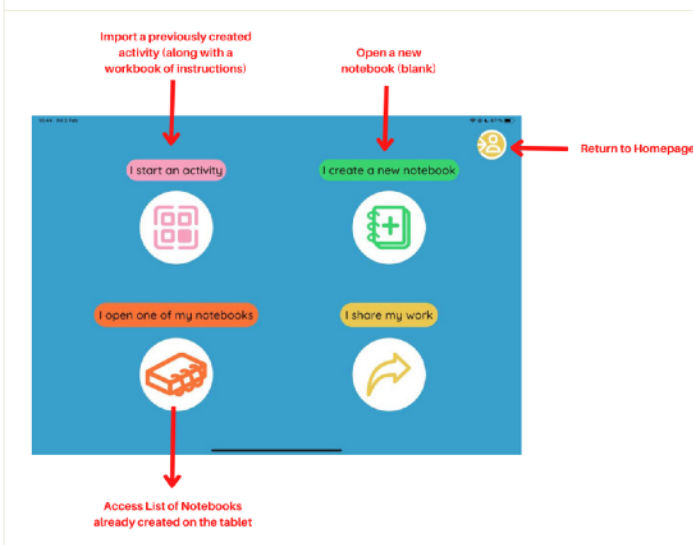
Low noises : CALM	Moderate Noises : LIVELY	Very loud noises : TIRESOME, UNPLEASANT	Very loud noises : DANGEROUS
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Guidance for Students (if needed)

This step-by-step guidance can be distributed to students to save time if they are stuck, unfamiliar or uncomfortable with the application, and to help them draw conclusions and respond to the challenge.

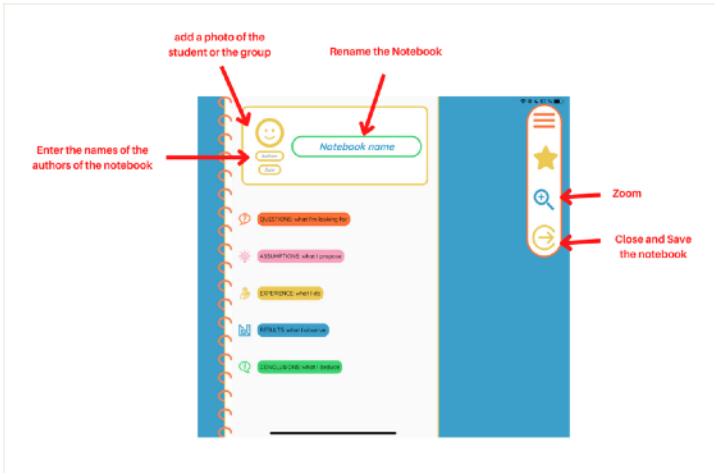


1. Open FizziQ Junior and click on the "Student" tab on the home screen.



In the "Student" menu, select one of the tabs to open :

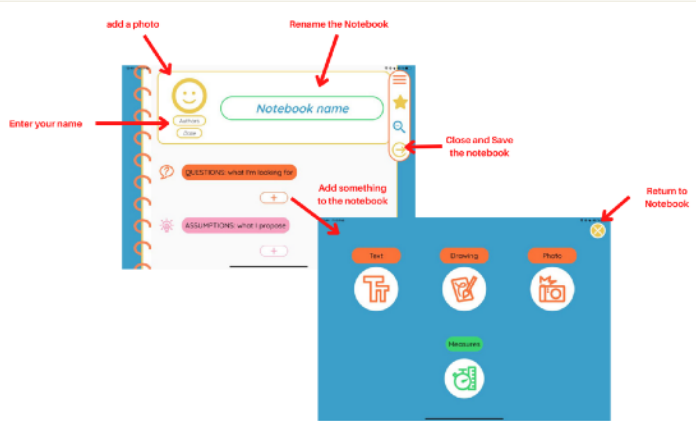
1. a new (blank) notebook;
2. a notebook from the list of notebooks previously created on this tablet;
3. or a notebook prepared by the teacher (i.e. an "Activity", see below)



3. The notebook is open: you can personalize it and fill it with your measurements and observations.

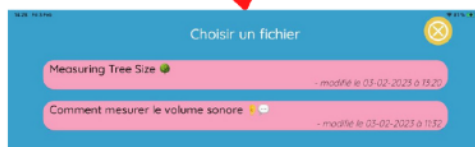
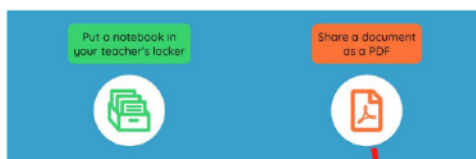
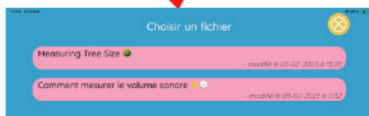
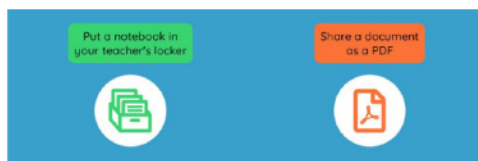


4. You can also delete a notebook from the list of notebooks stored in the tablet by clicking on the notebook and dragging the card towards the left side.



- **Access the list of tools and measuring instruments**
- To add a card to the notebook, click on the button **+** in a given section: the window that appears gives access to the toolbox.
- Please note that the corresponding map will be added to the selected section.

How to Share the Experiment book with the Teacher ?




1. In the "Student" menu, click on "I share my work". Two options are offered:

- "Put in your teacher's locker";
- "Create a document to share" (in PDF format).

2. By clicking on "Put in your teacher's locker", you have access to the list of notebooks saved on the tablet:

- select the notebook you want to share;
- confirm that you want to place it in the "teacher's locker";
- the insert of the notebook that has been placed in the locker turns red (which means "Pending correction", see below).

3. By clicking on "Create a document to share", you have access to the list of notebooks saved on the tablet: select the notebook you want to export in PDF format.

When the PDF file is created, simply press the button  and use the sending method of your choice (Drive, AirDrop, mail, etc.)

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This resource was produced with the support of CGI and the Fondation Sciences Éducation Solidarité



Education Resilience in Europe

Supported by:



Education Resilience in Europe is funded by the Grant Agreement signed on 21 September 2022 with Cisco Foundation and supported in promotional activities by Scientix 4 (Grant agreement N. 101 000063). The content of this document is the sole responsibility of the organizer, and it does not represent the opinion of the European Commission (EC), and the EC is not responsible for any use that might be made of information contained.



Date of Publication

February 2023