Co-funded by the
Erasmus+ Programme
of the European Union

VISION TUBE

Co-funded by
the European Union

The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the European Union.

Erasmus+

General information
Title of the activity
Vision Tube
Subject
Physics, Biology
Keywords
inquiry-based learning, reflection of everyday life concepts, interactive and motivational
Learning outcomes
Teacher learning outcomes: ● Will be able to assess student's everyday life concepts ● Will be able to explain basic concept of optic (emission, absorption, reflection of light) ● Will be able to develop students understanding of the nature of science ● Will be able to explain functionality of our eyes and a photo sensor (advanced & additional sequence; Step 5)
Student learning outcomes: ● Will be able to integrate their everyday life concepts in the laws of physics ● Will be able to differentiate between self-luminous and light-reflecting objects ● Will be able to reproduce the definition of emission, absorption, reflection ● Will be able to explain the role of colour and brightness in the process of reflection ● Will be able to recognize, why we see the colours greyish under low lighting conditions ● Will be able to explain the process of vision ● Will understand, that the mean of observation will affect the findings (advanced & additional sequence)
Transversal skills
Reflective thinking, Reasoned decision-making, Flexibility and adaptability
Number of participants and target age group
Number of participants: 1 to 25; Age: starting from 12, depending on the depth of content
Duration
60 to 90 min
Short activity description
To give excess to the experience of total darkness, is the core idea of the Vision Tube. We are lacking this experience in our everyday life. That's why we get the impression that non-self-luminous objects at least send out a tiny bit of light by themselves in dark situations. The Vision Tube allows us to gain the specific experience that non-self-luminous objects are not visible in total darkness and depend on light they can reflect to be seen. It is possible for the students to control the illuminance of the vision tube and to examine the path of light. E.g.: If the tiny hole of the vision tube faces the surface of a table, we can only get a visual impression as light is getting emitted by a light source, which gets reflected by the table to then enter the vision tube where the light gets reflected at the crossbar or other surfaces to our eyes. Now the light source, the surface of the table (colour) or the entrance to the Vision

Tube can be analysed precisely to prove the concepts of emission, reflection and absorption (the Sender-Receiver-Concept.

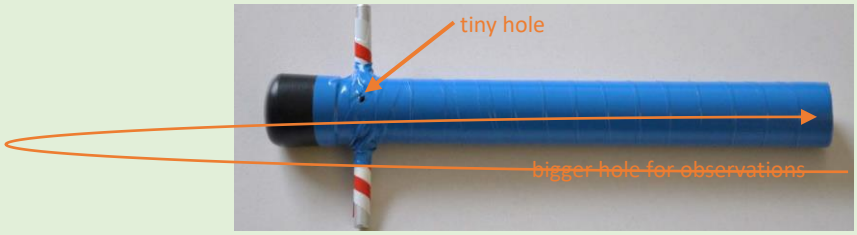
Preparation

Materials

List of materials (Vision Tube made out of plumbing material:)

- Plumbing Tube 20-30 cm, ⌀ 3-5 cm
- Plumbing Tube end cap same ⌀
- Crossbar - Stick 12-15 cm, ⌀ 0,8-1 cm
- Driller with matching ⌀ of the stick
- Insulating tape with two colours of high contrast
- Gaffer Tape / any other non-transparent tape
- Thin driller / any other device to make a hole of about 1-2 mm

Technical backline:
Construction of the vision tube is possible in many varieties. The one presented is quick to build, more or less cheap and the material is easy to get in any hardware store. By using upcycling material it's even cheaper. However, it is very important that the material of the tube is thick enough and assembled the way that **there is no light entering the tube except through the tiny hole**! The materials on the list are referring to a version using plumbing material, the one shown in the picture used upcycling material.



Additional preparation instruction:
The sun, strong and parallel light, is by far the best source of light. On a cloudy day or at night, old school light bulbs (filament lamps) are to be preferred, as LED or other energy saving lamps produce diffuse light only.

Announcement

Announcement for teacher trainings:
Get to know an easy to build and low-budget hands-on-experiment which gives the opportunity of precise observation, inquiry-based learning and reflection of everyday life concepts. With the exploration of the path of light, emission-reflection-absorption and the experience of total darkness through the Vision Tube one can focus on the teaching of scientific facts and the development of students's nature of science knowledge at the same time.

Announcement for students:
Are you keen to find out what happens in total darkness? Is it really possible for colours to turn into grey under low light conditions? What do you need to see things? Find your own answers to all of these questions with the Vision Tube.

Hook

Are you keen to find out what happens in total darkness? Is it really possible for colours to turn into grey under low light conditions? What do you need to see things? Find your own answers to all of these questions with the Vision Tube.

Activity type/strategy					
Lower order thinking			Higher order thinking		
Knowing / remembering	**Comprehending / understanding**	**Applying**	**Analyzing**	**Synthesizing / evaluating**	**Creating**
● Lecture ● Video ● Illustrations ● Examples ● Visuals	● Questions ● Discussion ● Review ● Test ● Reports ● Exercises	● Practice ● Demonstrations ● Presentations ● Projects ● Role play ● Micro-teach	● Problem solving ● Case Studies ● Critical Incidents ● Discussion ● Questioning ● Test	● Projects ● Problem solving ● Case studies ● Plan development ● Constructing ● Simulation	● Simulations ● Critiques ● Complex case study ● Design/ development ● Product generation ● Producing
Hands-On-Experiment, Inquiry based learning					

Delivery sequence			
Epidemiological suitability			
Is the activity suitable for execution in stricter epidemiological restrictions?			
☐ Yes ☐ No ☒ Partly As with every hands-on-experiment in a group there is the question of disinfection and social distance needs to be ensured. It would be quite a huge challenge to let the kids make the Vision Tube on their own (at home, or in school, so that every kid has their own tube) as it was already a challenge with teachers to get the tube impermeable to light, which is the key of the whole experiment.			
Is the activity suitable for execution in an online setting?			
☐ Yes ☒ No ☐ Partly An online setting will lead to a more teacher centred setting (with videos / pictures of the Vision Tube) and will cause quite some impact to the inquiry based learning approach. It would mean to develeop a different concept and need quite some work.			
Can the activity be sequenced? I. e. divided into smaller parts which could function as standalone parts which could maybe even be integrated into other activities.			
☐ Yes ☒ No ☐ Partly			
Step 1			
Step type/strategy:	Experimentation	**Step duration** (minutes):	15
Step title: (if applicable)	Guided exploration		

Subaims: What teaching aims are you fulfilling with this part of the sequence?	Every experiment has a certain goal and needs to be undertaken within the control and manipulation of a specific variable.

Step by step description:

The core of this sequence is to facilitate the student to the following experience. Make sure they know how to make the observation, where the tiny hole is, how to place it and how to look into the tube and what is at the core of our interest. The Main goal is to observe the inside of the vision tube under different light conditions. One way to make sure students know how to conduct the experiment correctly is a step-by-step instruction (a supporting worksheet for further editing and translation is attached).
However, there are many ways to make sure students make the following observations. Feel free to adapt.

Students should observe:

- The more light enters the tube, the better the crossbar inside the tube is visible
- Even stray light from a non-self-luminous object will send light into the tube
- If there is no light entering at all, the crossbar inside the tube is invisible
- The colours at the centre of the crossbar are shining brighter, colours at the edge are more greyish due to the amount of light hitting the surface
- At low illumination all colours seem to turn into grey. However: the white/bright surface is much brighter than the coloured/dark
- With strong and directed illumination (e.g. parallel light beams of the sun) the inside surface of the tube appears in the same colour of surface the light shines on. E.g. the sun hits a red surface only, the surface inside the tube gets a red shading

Tips & tricks Make sure the students can observe what is to be observed, but don't show or explain the result of the observation!

Interpretation & analysis (for teachers)	How are your students dealing with experimental set up? Are they aware of the need to control and manipulate given variables?
Interpretation & analysis (for students)	See step 3-4

Step 2

Step type/strategy:	Collecting data	**Step duration** (minutes):	10
Step title: (if applicable)	Sharpen and grasp observation		
Subaims:	Train your students to use scientific language!		

What teaching aims are you fulfilling with this part of the sequence?	
Step by step description:	
The main point of this step is to make sure the observations of step one have been carried out properly and the observation went well. Moreover, your students should learn to state an observation in clear and distinct language for scientific purposes. To achieve this goal there are concrete questions placed after the observations instructions in the attached worksheet. Once again, there are many ways to make sure your students describe the observations accurately. Feel free to adapt the concept of the worksheet. However, focus in this sequence on the following steps: ● Depending on the lab-skills of your students, they can work on their own, in small groups, or more teacher focused set up ● Help them to find a precise wording of the observations ● Make sure they can discuss their opinion before they are confronted with the “perfect” scientifically correct wording ● Double check if their observation is based on good exploration vs. everyday life concepts **Tips & tricks:** Train their scientific language as much as possible. Make them feel that their everyday life language is not wrong but can be misunderstood for scientific purposes!	
Interpretation & analysis (for students)	See step 3-4

Step 3			
Step type/strategy:	Develop first conclusions	**Step duration** (minutes):	20
Step title: (if applicable)	Reflection and interpretation of data		
Subaims: What teaching aims are you fulfilling with this part of the sequence?	Train your students to analyse, conclude, reflect and interpret their observation		
Step by step description:			
To gain some first interpretation we chose the Method of Socratic Questions. These questions first connect to the observation in the experiment and second try to focus on important differentiations of scientific concepts, differentiations which often are absent in our everyday life language. Try to explore their opinions and conclusions, make them rethink their			

everyday life concepts and not focus on the perfect explanation yet. This will be done at the next step anyway. However, you could choose a different method due to the lab experience, the NOS knowledge and the content level of your students, as well due to your personal preference.

Your students should be able to explain …

- that the amount of light entering the tube affects the visibility of its inside
- the difference of "shining by itself" and "shining through reflection of light"
- difference between dark and bright surfaces
- the source for an visual impression
- the difference between surfaces of different colours in terms the reflection/absorption of light

Tips & tricks: Try to connect the explanations to the experience with the Vision Tube; if some explanations contradict science, try to falsify them with the Vision Tube or other empirical based examples.

Interpretation & analysis (for students)	See step by step description & step 4

Step 4

Step type/strategy:	Abstraction	**Step duration** (minutes):	15
Step title: (if applicable)	Finding of principles and definition of scientific terms		
Subaims: What teaching aims are you fulfilling with this part of the sequence?	Digging deeper into nature of science		

Step by step description:

At this step the focus is on the definition of basic terms in the field of optics and their fundamental laws. Based on the experience on the Vision Tube, the specification of observation and its interpretation, the students are likely to come up with the definition and principles by "themselves". However, a guided inquiry or the structured Socratic Questions of the worksheet will help!

The outcome of this Sequence should focus on

- The ***path of light***, from the source, over the different objects to the eyes.
- Defining the terms ***self-luminous*** and ***light-reflecting*** objects by stating examples from the experiment and everyday life.
- The definition of the essential terms: ***emission, absorption and reflection of light***
- The ***role of colour and brightness*** in the process of reflection, to be precise reemission & absorption

- Does the ***eyesight depend on an active beam*** sent out from the eyes, scanning all the visible objects or is it more likely that our ***eyes are passive and need to receive light*** from all visible objects? => ***Sender-Receiver Concept***

Tips & tricks: It can be a challenge to let the student come up with satisfying definitions and principles. However, this is at the core of transversal skills. With some training and patience, they are able to achieve well.

Step 5			
Step type/strategy:	Methodological discourse	**Step duration** (minutes):	30
Step title: (if applicable)	The photo sensor vs. eyesight		

Step by step description:

For high school or advanced students, this could be an option to dig even deeper into the nature of science. However, this is some additional sequence you can add but it is strongly connected to the observational skills and experience of step 1 to 4.

The main point of this sequence is to show that the mean of observation has some impact on your result and science is based on a very complex network of different conclusions.

Electromagnetic waves are huge in range, impact and importance. What we see is a tiny bit of it. However, our eyesight is one of our main sources to our understanding of the world and nature. What are the limits of knowledge, when we have only access to information determined by our physical constitution? The invention of the telescope and microscope had a huge impact on science. But can we rely on external objects? Aren't they some sort of black box, do we really know what they measure? What about a theory proved one million times like the Newtonian laws, are they to be taken for granted?

When we observe through our eyes, we have access to the information which is accessible to the two different kinds of receptor cells of our retina. The type in charge of the colours (cone cells, three different photoreceptor cells for colour) are less light sensitive than the one in charge of the perception of brightness (rod cells, low-light photoreceptor). On the other side, the photosensor of a camera is only referring to three different colours and within a wider spectrum of the electromagnetic field. Moreover, it has much more technical options through different sizes of lenses, exposure time etc.

The aim of this sequence is to sensitize the students to the impact of the mean of observation due to our scientific results and conclusions. It is based on the comparison of two different research groups with contradicting answers to the same question: Can the colours disappear in the dark? Both research groups tested the vision tube under the condition of stray light (only a little amount of light gets indirect through the tiny hole). Group A, *the Survey*, states that 94 % of the interviewees stated that the colours of the cross bar are appearing in different shades of grey only. Research Group B, *the Photograph*, states: after getting the

right settings (low shutter speed etc) the picture shows the colours of the cross bar very clear, only in lower intensity then outside of the vision tube.

The pupils are then given two sets of explanations of contradictory statements per group of researchers (worksheet attached). The explanations consider logical but science contradicting everyday life concepts,
as well. Moreover, statements in respect to the nature of science and the appropriate scientific explanations at their level of understanding. First, they should discuss the statements in small groups, and try to find out which research group states the true explanation.

The clue is, that both research groups are stating a true, better to say scientifically widely accepted statement. The different outcome is due to different means of observation and the combination of both outcomes is getting us closer to the laws of science.

Tips&tricks: This is a very tricky but high potential learning sequence. Feel free to adapt this idea due to your needs. Lower the challenge by sharing more information or make a teacher centred key lesson out of it.

Wrap up & sequence interpretation
Evaluation/assesment
The assessment lies within the different steps, as the activity focuses on continuous reflection and interpretation of the made observations.

Additional attachements:

- *Can the colours disappear in the dark?* handout

Can the colours disappear in the dark?

There have been quite some contradicting observations in the past. Some people mentioned that there are no colours in the dark, only different shades of grey. So, two groups of researchers set out to answer the question. However, they come to contradicting results as well. To prove their point, they stated arguments in correlation of their observations.

1. Go through the stated arguments and discuss in groups of three which research group states the valid result. [7-10 min]
2. After that we will have a fishbowl discussion where you can argue for the research group of your choice.

Important: both research groups tested the vision tube ***under the condition of stray light*** (only little amount of light gets indirect through the tiny hole)

Research Group A – The Survey

The survey asked 100 people to look into the vision tube under the condition of stray light. **Outcome: 94 % stated that the colours of the cross bar are appearing in different shades of grey.** Their conclusions and arguments to explain this outcome are:

a) The colours turn into grey, as there is no more light getting inside the vision tube.

b) Our retina works differently under different light conditions.

c) As you can't proof 100% what is happening inside the camera (black box), the most reliable instrument of research is the human being.

Research Group B – The Photograph

A photo had been taken under the very same conditions, only stray light gets into the vision tube. **Outcome: After getting the right settings (low shutter speed) the picture shows the colours very clear, only in lower intensity than outside of the vision tube.** Their conclusions and arguments are:

a) A photographic camera is a more reliable instrument of research than the eyes of humans.

b) The sensor, which generates the picture of the digital camera, works the same under different light conditions.

c) The different light conditions have no influence on the process of a picture taken.

Please analyse the arguments carefully and discuss which research group proved the correct outcome

Erasmus+