ACTIVITY 5

WHERE DOES COLOR COME FROM?

EXPERIMENT OBJECTIVES AND CONTENT

The goal of this activity is to initiate students into the concept of light radiation by studying color. By experimenting with refraction and reflection, students discover that objects' colors are a result of our ability to perceive different wavelengths of visible light.

ESSENTIAL KNOWLEDGE

Energy:
- Transmission of energy: light radiation (reflection, refraction)

Techniques and instrumentation:
- Use of tools
- Design and manufacture of devices

Appropriate language:
- Terminology related to an understanding of the material world
- Conventions and types of representations specific to the concept studied: drawings, sketches

SUGGESTED MATERIALS

Scientific equipment:
- Magnifying glasses
- Glass prisms
- Table of the electromagnetic spectrum

Perishable non-scientific materials:
- Water

Household materials:
- Flashlights, pedestal lamp
- Mirrors
- Plastic tubs
- Spray bottles
- Clear glass and plastic drinking glasses
- Kit for making soap bubbles
- String

School supplies:
- Pencils, colored pencils
- Scissors, rulers, adhesive tape
- White cardboard
- Precision knives

School equipment:
- Window (optional)

CONTEXT: SITUATIONAL PROBLEM OR RESEARCH QUESTION

While watching a documentary on TV about animals, you learn that not all animals can perceive color. For instance, horses and cows only see in black and white. So you wonder where color comes from.

SUGGESTED PREPARATORY ACTIVITIES (INTRODUCTION)

The teacher asks the students to look around the classroom and pick out objects that have color (e.g., a blue book, red shoes, a purple box, a green plant) and asks questions such as "How are colors useful?" (They help us recognize objects, to select fruit that is ripe, to tell if an element on the stove is very hot or not, etc.). The teacher then turns off the lights and closes the window blinds. What happens? We can hardly see, and in the dim light, we can distinguish the shape of objects, but colors seem less vibrant. The teacher then turns the lights back on and initiates a discussion: Could light have something to do with the perception of color?

INITIAL IDEAS AND HYPOTHESES

Here are a few examples of hypotheses the students might formulate based on their initial ideas:

Example 1
I predict that I can make the colors that compose light appear by using water and a mirror. I predict this because I once saw my big brother do it and I know that mirrors reflect images and colors.

Example 2
I predict that I can see the colors that compose light by using a prism. I predict this because we have a crystal chandelier at my house and when sunlight shines on it, colorful reflections appear on the walls.

Example 3
I predict that light can be broken down into seven colors in the presence of water. I predict this because I think the colors of the rainbow that appear after a rain storm are the colors that compose light.

Example 4
I predict that the colors that compose light will appear on the surface of a soap bubble. I predict this because when I do the dishes with my brother, we have noticed that the soap bubbles have colorful spots on them.

WORK PLAN AND EXPERIMENTATION

Here are a few examples of experiments the students can carry out to verify their hypotheses:

Example A
The students place a mirror in a glass half full of water. They lean the mirror against a ruler placed across the mouth of the glass. They decide on an angle for the mirror and affix the ruler to the glass with adhesive tape. Part of the mirror must be submerged. The students then shine a flashlight onto the submerged part of the mirror. By playing with the angles, they can capture light reflected from the mirror on a piece of white cardboard.

Note: To better control the light, the orientation of the mirror and light source must be changed slowly, since a very small change can make a difference.

RECORD ALL YOUR IDEAS AND OBSERVATIONS IN YOUR EXPERIMENT WORKBOOK.

FOR BEST RESULTS, THE LIGHT SOURCE SHOULD BE SMALL AND CONCENTRATED (E.G., SMALL FLASHLIGHT).

Example B
The students break white light into its component colors using a triangular prism. They place the prism in front of a sunny window and place a piece of cardboard so that the colors refracted by the prism are projected onto it. They do the same experiment using a flashlight to see if the same colors appear.

Example C
The students place a little water in a glass drinking glass and hold it firmly with their fingers in such a way as not to block the light coming through the side of the glass. They raise the glass in front of a light source such as a table lamp without a lamp shade or a flashlight so that the light shines through the glass. By placing a piece of white cardboard on the other side of the glass, opposite the light source, the students observe a spectrum of light appear. As they move the light source or the cardboard, they will also observe that the intensity of the colors varies according to the distances between the elements. They may also try changing the amount of water in the glass or the angle at which the glass is inclined.

Note: The experiment can also be done with a large glass vase or using containers with different shapes.

Example D
The students try to reproduce a rainbow by using a spray bottle to spray droplets of water in front of a light source. They can experiment with different types of sprayers and light sources. They may even decide to conduct the experiment outside.

Example E
The students make soap bubbles with a soap bubble kit in order to break light down into its component colors. They try to grasp why colors appear on the surface of the bubbles by varying the intensity of the light source. As the light refracts off the surface of the bubble, its speed changes according to the angle of refraction, breaking the light down into its component colors and thereby creating small rainbows that undulate as water moves over the surface of the bubble.

Note: It is also possible to do an experiment on the addition of colors by using flashlights and pieces of yellow, blue, red and green cellophane.

EXPERIMENTAL FACTORS

To ensure scientific rigor, the students should evaluate the experimental factors that might influence the experimental results.

- Angle of inclination of mirror and of water container
- Strength of flashlight
- Intensity of natural light
- Size and quantity of water droplets
- Orientation of light source
- Position of water stream with respect to light source
- Type of prism

DISCUSSION: SUGGESTED INTEGRATION ACTIVITIES (CONSOLIDATION)

The teacher has the students bring the results of all the teams together by having them present their discoveries to the rest of the class and proposing an explanation for the physical phenomena observed. Where appropriate, the teacher takes the opportunity to reinforce or make clear the concepts of reflection and refraction of light. They can end the discussion by introducing the students to the electromagnetic spectrum in order to make them understand that the visible light that lets us perceive color is only a small part of the electromagnetic spectrum.

SUGGESTED ACTIVITIES FOR APPLYING KNOWLEDGE (APPLICATION)

To consolidate the students' learning, the teacher suggests that the students design a "color wheel." They use the colors of the rainbow to make the "color" white. The students cut a circle out of a piece of white cardboard and divide it into seven sections, which they color with the seven colors of the spectrum of visible light. By piercing the centre of the resulting disc with a pencil or piece of thread and spinning it very quickly, the disk will appear white. The teacher could also have the students design a kaleidoscope, which will give them another angle with which to explore the concepts of light and color.

SCIENTIFIC CONCEPTUAL CONTENT

Light

Light is a form of energy made up of electric and magnetic elements. It is emitted naturally by any hot object, such as the element of a stove, a fire, the Sun or the element of an incandescent light bulb. Light travels in a straight line (which is proved by the way shadows are formed) unless it is reflected by a surface—in other words, when it "bounces" off a surface the way a ball bounces off a wall. The smallest unit of light is the photon.

Light is made up of a number of colors, or wavelengths, which make up a portion of the electromagnetic spectrum. In addition to visible light, the electromagnetic spectrum is made up of many other wavelengths that cannot be perceived by the human eye: gamma rays, x rays, ultraviolet rays, infrared rays, microwaves and radio waves.

Light can travel through a vacuum or through a medium (liquid, solid or gas), and its speed varies depending on the resistance it encounters. Hence, the speed of light is about 300,000 kilometers per second in space but about three times slower in water.

Reflection

This phenomenon occurs when light comes into contact with a barrier between two media, for example between air (a gaseous medium) and an object (solid medium). Energy is reflected at the surface of the body and does not pass through, it bounces off. A red apple appears red because only the red wavelength of visible light is reflected by the apple's surface.

Refraction

This phenomenon occurs when the trajectory of a light wave is changed as it passes through a medium different from the one it has come from. Light behaves differently depending on the medium through which it travels. Doing experiments with this phenomenon is easy by using water (liquid medium) or a prism (solid medium).

The colors of visible light

The colors of the visible spectrum are those of the rainbow: red, orange, yellow, green, blue, indigo, and violet. When the colors are added together (superimposed), the light becomes white. They are also called chromatic or spectral colors.

Achromatic colors

These are the shades of grey, black and white.

Pigments

Pigments are substances that absorb certain wavelengths of visible light and reflect others depending on their composition. The color of objects and of the environment is the result of the presence of pigments.

Perception of colors by the eye

Human beings perceive color because of receptors on the eye's retina called cones. When light enters the eye, the cones react to different wavelengths and transmit nervous signals to the brain. There are three types of cone: red cones, which perceive the colors red, orange and yellow; green cones, which perceive the colors green and sky blue; and blue cones, which perceive the colors blue and violet.

CULTURAL REFERENCES

Scientific discoveries

The first scientific explanation of light was by a scholar named Alhazen (965-1038). He proved that light does not come from the eyes, contrary to popular belief at the time, but rather that it is produced by light sources such as the Sun and fire. It was not until 1621 that Willebrord Snell (1580-1626) discovered the law of refraction. Then in 1665, Isaac Newton (1642-1727), by way of experiments with glass prisms, proved that white light is composed of different colors of light. In 1926, Gilbert Newton Lewis (1875-1946) gave the name "photon" to the small units of light energy discovered by Albert Einstein (1879-1955) in 1905.

FOR MORE CULTURAL REFERENCES, VISIT THE ÉCLAIRS DE SCIENCES WEBSITE:

www.eclairsdesciences.qc.ca

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PROCESS OF ACTIVE DISCOVERY

GENERAL LEARNING PROCESS IN SCIENCE AND TECHNOLOGY (IN ELEMENTARY SCHOOL)

Context related to everyday life

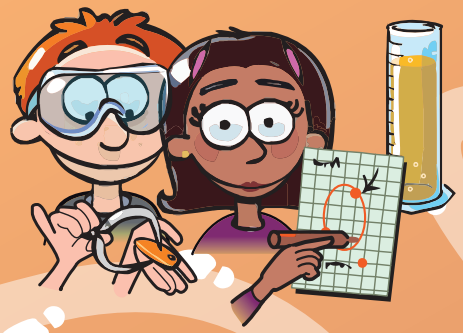
- **Situation problem** or
- **Discovery question** or
- **Need to be fulfilled**
- **Question related to the operation of an object** (how does it work?)

Initial ideas and hypothesis

My initial ideas:
- I share my own ideas.

My hypothesis:
- I predict that... I think that because…
- I imagine my prototype.
- I think it works like this…

Planning and carrying out



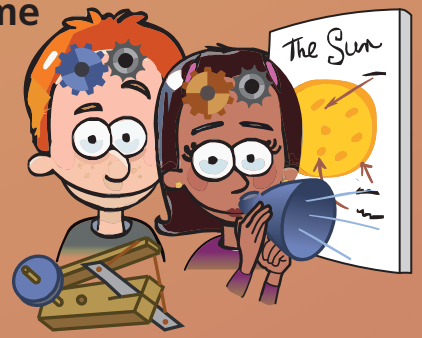
My equipment:
- I observe and handle the equipment.
- How could this equipment be useful to me?
- I choose my equipment and my materials.

Carrying out my process:
- What will the steps be?
- What precautions should I take?

My actions:
- I carry out the steps of my protocol.
- I note or draw what I observe, what I do and what I discover.

My results:
- What is my answer to the problem, question or need?

Outcome



My outcome:
- Do my results confirm my hypothesis or not?
- Are my results similar to those of the other teams?
- Can the other teams' results help me to find answers to my problem, my question or my initial need?
- What could I communicate concerning my discoveries?

New question?

What I learned:
- What do I retain from this activity?
- What could I communicate concerning my results or my discoveries?

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