COURSE „I dig STE(A)M“

Module: STEM

Learner profile (practitioner - P, youth worker - YW or mentor - M): P

Lesson number: 8 - The secret of mysterious box

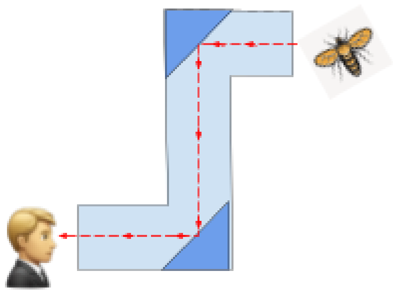
Introduction section of the Lesson

Periscopes have largely become toys today, but during World War I, they saved many lives by allowing soldiers to look out from trenches without exposing their heads. Nowadays, there are still a few practical applications for periscopes. For example, they are used in nuclear reactors to observe reactions, are essential in submarines for peeking above the water's surface, and are sometimes used in the defense industry, such as in armored vehicles and targeting systems. Periscopes also play a role in scientific research, such as in astronomy and physics, for studying the movement of light. In medicine, instruments like the endoscope operate on the principle of a periscope, enabling doctors to view the inside of the human body.

Background

What is a Periscope?

A periscope is an optical instrument that allows observation over obstacles (such as beyond an edge or around a corner). A typical periscope consists of a tube, lenses and/or mirrors, and viewing openings. The simplest periscope can be made by placing two mirrors inside a tube or narrow box so that they are positioned at the same angle relative to each other. By applying the law of reflection, it is possible to create a device that allows you to see around corners.



According to the law of reflection, objects can be observed at a 90-degree angle (from the side) if a mirror is placed at a 45-degree angle relative to the observer. In this setup, a light ray strikes the mirror at a 45-degree angle and reflects off the surface at the same 45-degree angle. The sum of the angle of incidence and the angle of reflection equals 90 degrees.

If two such systems are connected in sequence, a periscope can be constructed. The first 45-degree mirror redirects the light ray 90 degrees to the side, while the second 45-degree mirror aligns the light rays back in the same direction as the viewing angle.

The human eye perceives light rays reflected from various objects. Since the surfaces of objects have different properties, they appear to us in various ways (shiny, dull, different colors, etc.). Without light reflecting from a surface, the human eye would not see anything. Therefore, it is essential that the observed object is always illuminated.

Time investmen: 135 min

What will you learn:

After completing the project, the participant:

- Understands what a periscope is and how it works.
- Knows the principles of light reflection and how mirrors direct light rays.
- Is aware of the fields and situations where periscopes are used.
- Plans and constructs a functional periscope-like device and optimizes its design using appropriate materials and tools.
- Works responsibly with materials and tools, adhering to safety guidelines.
- Applies geometric knowledge to position mirrors at the correct angle (45°) to ensure proper light reflection.
- Can test the functionality of the constructed device and make necessary improvements.
- Understands the practical value of science and technology in everyday life.
- Develops creativity and problem-solving skills by experimenting with how design influences functionality.

Methodology used in the Lesson- Pedagogical Approaches and Methods:

Inquiry-based learning: Before starting the construction of the device, the problem is introduced, and a discussion is initiated around the question: *"How can we see past obstacles without revealing ourselves?"* This encourages participants to explore and experiment with potential practical solutions to the problem.

Collaborative Learning: Participants are divided into small groups (2–3 members) where they can collaboratively plan, build, and test their solutions. This approach develops teamwork skills and promotes shared responsibility. Each group can assign different roles (e.g., designer, builder, tester) to ensure active participation by all members.

Active Learning: Through hands-on activities, participants measure, cut, assemble, and test their device themselves.

Experimental Learning: Participants experiment with how different angles, mirror sizes, and distances affect the functionality of the periscope. This fosters scientific thinking and helps them understand the principles of light and mirrors.

Discussion and Analysis: At the end of the session, participants are encouraged to answer reflective questions, such as:

- What worked well?
- What challenges did you face, and how did you solve them?
- How did the laws of light reflection help in constructing the device?

Feedback: Participants present their creations during the practical activity and reflect on what they learned and experienced throughout the process.

Lesson content:

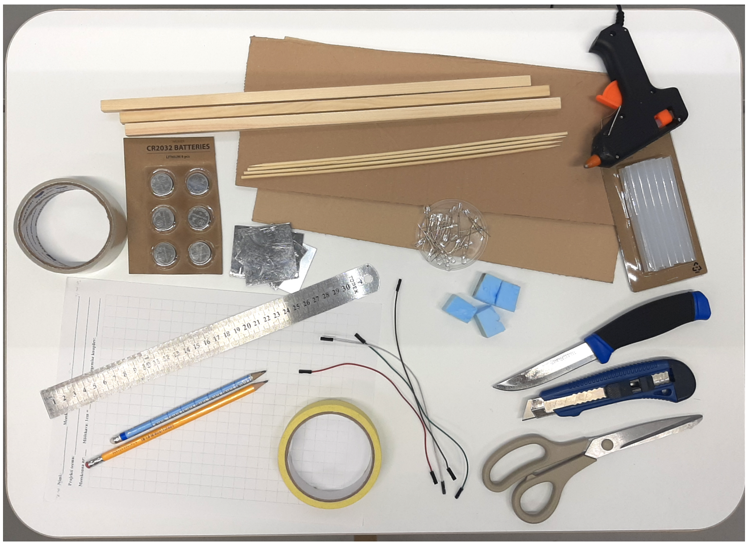
Project goal is to craft a device that enables participants to:

- see the contents of a mystery box from a distance of 70 cm.
- determine how many different objects are hidden inside the mystery box.

This project combines practical construction, the application of optical principles, and problem-solving to achieve a functional solution.

Materials Required for the Project:

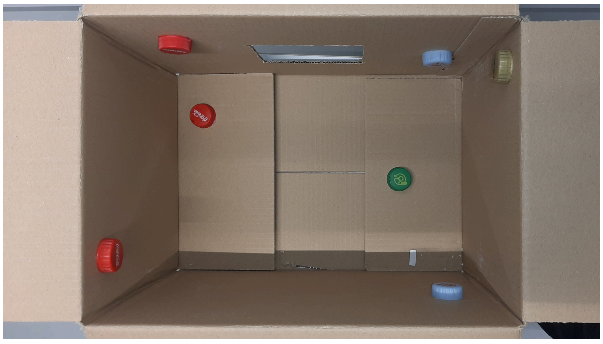
- Mirrors (3 pieces)
- Skewer stick
- Cardboard sheet
- Foam cube
- Battery
- LED bulb
- Wires (if needed)
- Hot glue gun and glue sticks
- Pencil
- Scissors and knifes
- Ruler
- Paper tape
- Duct tape
- Square wooden
- dowe



These materials provide the necessary components for constructing a functional device while encouraging hands-on learning and creativity.

Preparation

- **Distribute materials:**
  - Hand out the materials to the participants.
  - Ensure that the mirrors are clean and, if they are covered with a protective film, instruct participants to remove the film for better results.
- **Set up the test area:**
  - Prepare a cardboard box as the "mystery box" and hide objects inside (e.g., bottle caps or small insect models).
  - Position the box in the test area with its opening facing away from the participants.



- **Mark observation distance:**
  - Measure 70 cm from the box opening and mark a line using tape.
  - Clearly instruct participants that they must not cross this line while observing the box's contents.

Activity plan:

1. Introduction:

- **Familiarize with materials, equipment and tools:** Introduce the materials, devices, and tools participants will use in the project. For example, demonstrate how to connect an LED bulb to a battery to make it light up.
- **Safety Guidelines:** Review safety rules when working with sharp tools, such as scissors, knives, and the hot glue gun. Emphasize the importance of careful handling to ensure safety.
- **Introduction to periscopes:**
  - Present background information on periscopes and their working principle.
  - Facilitate a discussion around the question: *"How can we see past obstacles without revealing ourselves?"* This will help participants think critically about how to approach the project.
    Guiding questions and hints (if needed):
    - *Which materials can we use to observe areas around a corner?*
    - *How does a dentist see all sides of your teeth?*

        - *What shape do the periscopes on submarines have for observing above the water?*
        - *How should you place the mirrors to ensure the reflection in one mirror is visible in the other?*
        - *What can we use to improve visibility in the dark?*
- **Mini research project (optional):**
    - Allow participants to conduct a brief research project using a computer and internet search engines.
    - Participants can look for additional information about periscopes, light reflection, or similar devices and present their findings in a short presentation.

This structured introduction will set the stage for participants to explore the project while building knowledge and skills related to optical principles and problem-solving.

2. Tasks

Objective: Participants must build an observation device from the provided materials that allows them to view the contents of a mystery box from a distance of 70 cm.

Rules:

- First session:
    - No one is allowed to enter the observation zone. This time is dedicated to designing and constructing the device.
    - During this period, participants will plan and assemble their observation devices.
- Second session:
    - Participants (or teams) can test their devices in the observation area.
    - The mystery box cannot be approached closer than 70 cm.
    - Only one participant is allowed in the observation area at a time.
    - Each participant can remain in the observation zone for a maximum of 30 seconds.

These rules ensure that participants stay focused on the task and work collaboratively while adhering to the parameters of the challenge.

3. Development device design

- **Provide materials for sketching:**
    - Distribute graph paper and drawing tools to participants, allowing them to sketch their design for the observation device before beginning construction. This step helps participants visualize their ideas and consider potential practical solutions to the problem.
- **Individual design proposals:**

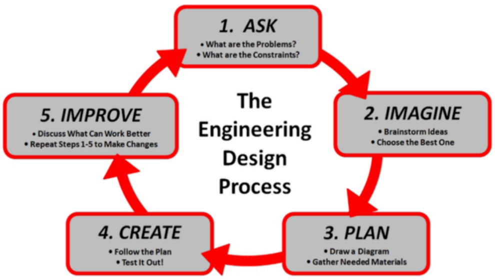
    - If working in groups, each participant presents their individual design concept. This encourages everyone to contribute their ideas and provides a variety of perspectives.
- **Group discussion and collaborative design:**
    - During the discussion, the group will merge the best aspects of each design to create a final collaborative design plan. This ensures that the group arrives at a shared solution that incorporates different ideas while considering the practical aspects of construction. For presentation can be used the digital tool SketchUp https://www.sketchup.com/en

4. Device Construction

Using Provided Materials. Participants will use the given materials purposefully to construct their observation device based on the design plan they have created. They will follow their sketches and plans, ensuring they adhere to the measurements and specifications needed for the device to function correctly.

5. Testing the Result and Adjusting the Design

- **Test the device:** Once the device is assembled, participants will test it in the observation zone. They will check if it allows them to see the contents of the mystery box from the required 70 cm distance and assess whether the reflections work as expected.



- **Identify issues:** During testing, participants should identify any problems or areas where the device doesn't perform as intended (e.g., poor visibility, misaligned mirrors, unstable structure, etc.).
  Based on the test results, participants will make necessary adjustments to their device's design. This could involve repositioning the mirrors, adjusting angles, reinforcing components, or rethinking the use of materials.
- **Continuous development:**
  Participants will test, modify, and retest the device multiple times. This ensures the final product is fully functional and meets the challenge requirements. The process encourages problem-solving and refining ideas until the desired outcome is achieved.

6. Device presentation and determining the best solution

Announcing completion:

- A participant or team signals that their observation device is complete and ready for testing. They are then granted permission to enter the competition area.

Testing Procedure:

- The participant or team enters the observation area with the mystery box in place. The box is surrounded by a 70 cm restricted zone, which they are not allowed to cross with their eyes while observing the contents.

Answering the Mystery:

- Each team or participant will attempt to answer the mystery by determining the number of objects inside the box based on what they can see with their device.
- The response is written down on paper, and it will not be immediately revealed.

Incorrect Answers:

- If the answer is incorrect, the solving process continues, and the right to answer moves to other participants or teams.

Winning the Challenge:

- After all answers are collected, the correct responses will be identified. If no team gives the correct answer, the competition continues in subsequent rounds until a correct answer is provided.

7. Discussion and feedback

After the competition, gather participants to discuss their experiences. Ask them to reflect on the challenges they faced during the project and the testing phase. Some guiding questions for the discussion could be:

- What difficulties did you encounter while building the device?
- Did you have to make any unexpected changes to your design during the testing phase?
- What worked well, and what didn't go as planned?
- What new skills or knowledge did you gain from this project?

Evaluation and completetion:

- **Theoretical understanding:**
  - Can the participant explain the principles of light reflection?
  - Does the participant understand how a periscope works?

    Questions such as:

    "Why must the mirrors be at a 45° angle?"

    "How does the angle of light reflection affect the functioning of the periscope?"
- **Design and construction:** Is the observation device built properly and creatively?
- **Functionality**:
  - Does the periscope allow viewing around obstacles?

    Testing the completed device:
    - Does the periscope display objects clearly?
    - Are the mirrors positioned correctly?
  - Was the participant able to solve any problems that arose during the construction process?
- **Collaboration skills**
  - Did the participant contribute actively to the group activities?
  - Were tasks divided fairly among the group members?
  - Did the group members communicate with each other and solve problems together?
  - Self and peer evaluation: "What was my contribution to the group work?"
- **Problem-solving and creativity**
  - Has the participant shown independent thinking and creativity?
  - The participant's ability to adapt and improve the design to find solutions to problems that arose during the project work will be considered.
- **Reflective discussion and analysis**
  - Criterion: Participants are able to analyze their actions after the project is completed, express what they learned, and suggest ways to improve their solution in the future.
  - Assessment: Participants may be asked to provide oral or written reflections, where they analyze their learning experience and relate it to the project objectives.