MODULE IV

Lesson Plan 2

Summary

Title	
Wireless lighting system	
Duration	110 minutes
Age range	10-14

Abstract

Currently, it is estimated that around 750 million people worldwide do not have access to electricity. Although this value has been halved in the last 20 years, there are still regions that lack connection to the power supply grid or cannot acquire systems to generate it, such as a photovoltaic panel. This makes it difficult to ensure lighting in enclosed spaces, such as homes or schools, among others. Therefore, it is important to search for accessible alternatives that allow the use of solar radiation to provide lighting in environments without access to the power grid, as well as in areas where it is available to save energy or increase efficiency. This lesson addresses the development of a wireless lighting system, which will be tested in an experimental phase involving the measurement and monitoring of indoor lighting using an Arduino device.

Learning results

Aim of the project / Learning objectives

- Understand the importance of giving materials a second life.
- Design a system that allows lighting spaces where electrical energy is not available.
- Verify and compare the results through an experimental phase.

Transversal objectives

- Understand the relevance of the role of science in solving real-world problems.
- Internalise the importance of reusing materials in everyday life.
- Raise awareness among students about the needs of vulnerable communities in various parts of the world.

Sustainable Development Goals Connection

This topic is aligned with SDG 7 “Ensure access to affordable, reliable, sustainable, and modern energy” –Goal 7.1: By 2030, ensure universal access to affordable, reliable, and modern energy services.

Implementation

Facilitation

- Ensure that all necessary resources for the activity are available before the class begins.
- The use of gloves must be ensured whenever working with scissors and pliers.
- Keep in mind that, as a result of manual work, both the students and the classroom may get dirty.
- The teacher must supervise the activity involving using scissors to puncture the model.
- Create an appropriate environment for working.
- Coordinate the students in a way that keeps them motivated and engaged.

Resources / Materials needed

To carry out the activity, the following materials are needed:

- Sheets of paper.
- Pencil.
- Ruler.
- Compass.
- Paper scissors.
- Corrugated galvanised sheet (30 cm x 30 cm).
- Hammer.
- Chisel.
- Curved-tip metal cutting scissors.
- Cut-resistant gloves.
- Pliers.
- Sandpaper.
- Hot glue gun.
- The cardboard box is approximately 60 cm tall, with a width and length of 20 cm x 20 cm.
- Arduino UNO with USB cable.
- Computer equipped with Arduino IDE software.
- Photoresistor and a 10 kΩ, 0.25 W resistor.
- Electronic circuit prototyping board and wires.

Ideas to continue

Look around your environment for places where the developed prototype could be used. These places may have access to electricity, but using the prototype could lead to a reduction in consumption: workshops, garages, etc.

On the other hand, the experimental phase involves measuring the voltage in the LDR in digital units. Although this measurement gives an idea of the presence of more or less lighting, it does not provide a value in the International System's units. It could be interesting to continue the experimental phase by making the necessary modifications to the code so that the lighting measurement is done in International System units.

Source / Classroom materials and preparation

Introduction to the concept of “litre of light”:
https://www.youtube.com/watch?v=o-Fpsw_yYPg
A detailed explanation of how to create the model:
https://www.youtube.com/watch?v=i5YQ4t5apPM
Wiring and Arduino LDR programming:
https://www.youtube.com/watch?v=4ibf6wHOIok&t=234s

Topic outline

Time	Step-by-step instructions
10 min	Pre-activity: Watch the video introducing the concept of "Liter of Light." Based on this context, students are encouraged to reflect on the lack of access to electricity that affects the daily lives of millions of people and how science can contribute to improving their living conditions through a sustainable and ecological solution.
15 min	An activity is proposed where students form groups of three to acquire bottles that have not yet been given a second use. To do this, they can visit the canteen, inspect the vicinity of the school, or even check recycling bins. This section emphasises the importance of giving a second life to materials that would otherwise be discarded, potentially contributing to environmental pollution in some cases.
5 min	Once a bottle is available, draw two circles of different sizes on a sheet of paper using a compass. The first circle (Circle 1) should have the same diameter as the bottle, which can be measured using a ruler. The second circle (Circle 2) should have a diameter of 2 cm smaller. Figure 4.2.1 of the Annex shows an example of how the template should look. Use scissors to cut out both templates.
5 min	Place the template of Circle 1 on a galvanised sheet at the highest point of a ridge. Using a pencil, trace the outline of Template 1, and then place the template of Circle 2 concentrically and trace its outline, as shown in Figure 4.2.2 of the Annex.
5 min	Make three cuts along the outline of the smaller circle with the help of a chisel and hammer, as shown in Figure 4.2.3.
5 min	From the notch made in the previous step, use the curved-tip metal cutting scissors to cut along the outline of Circle 2 (Figure 4.2.4).
5 min	With the help of the metal cutting scissors, make a series of cuts along the galvanised metal sheet-like teeth that will be used to grip the bottle. The length of the cuts should reach Circle 1, as shown in Figure 4.2.5.
5 min	Use pliers to bend each of the teeth about 45 degrees towards the protruding part of the ridge on the metal sheet, as shown in Figure 4.2.6.
5 min	Sand the part of the bottle that divides it into 1/3 and 2/3 using sandpaper, as shown in Figure 4.2.7. This will allow for glue to be applied in the later steps, ensuring proper adhesion.

Time	Step-by-step instructions
10 min	Apply the silicone to the sanded area and insert the bottle into the hole in the metal sheet with the teeth facing upward (Figure 4.2.8). Using your finger and a little soap, seal the bottle-to-metal sheet joint, doing the same on both sides of the joint (Figure 4.2.9).
5 min	Fill the bottle. Seal the cap with silicone to prevent leaks or evaporation. Once the cap is in place, add a layer of silicone to protect against cracks (Figure 4.2.10).
5 min	Cut the top part of the cardboard box, which is 60 cm high and has a section of 20 cm x 20 cm. For the experimental phase, a light measurement circuit and an Arduino will be placed at the bottom of the box. Therefore, making a small incision at the bottom of the box is a good idea to allow a USB cable to pass through. The areas to cut with scissors are shown in Figure 4.2.11.
15 min	Build the circuit shown in Figure 4.2.12. It integrates an LDR to measure brightness, a 10k resistor to create a voltage divider, a prototype board with wires, and an Arduino UNO.
5 min	In the Arduino IDE software, copy and run the code shown in Figure 4.2.13. This code is used to measure the voltage received by the analog input of the Arduino, which is connected to the LDR voltage divider. In the experimental phase, you will observe that the higher the light level, the higher the voltage measured due to the decrease in the ohmic value of the LDR. Verify that the voltage values, in digital units, are received through the PC's serial port.
5 min	To conduct the experimental phase (Figure 4.2.14), place the cardboard box in an outdoor area. Put the Arduino and measurement circuit inside and record the values received by the PC in three scenarios: ● The cardboard box is uncovered. ● The cardboard box has a lighting system. ● The cardboard box is covered with any opaque object.
5 min	Discuss the need for this type of lighting system and the importance it can have.

Formative evaluation

Classroom Observations:

- Description: Teachers observe the students while they carry out the activities.

- Objective: To assess the students' level of understanding and their ability to apply the knowledge acquired in a practical activity.

The following evaluation is proposed:

Criteria	Excellent (5)	Very Good (4)	Good (3)	Adequate (2)	Insufficient (1)
Concept understanding	Demonstrates a full and thorough understanding of the activity, explaining clearly and accurately.	Shows a good understanding, with some advanced ideas or applied examples.	Understands basic concepts, with generally correct explanations.	Has a basic understanding but needs clarification on several points.	Shows little understanding of concepts, with significant errors.
Practical skills	Performs prototype construction accurately and creatively, with attention to detail and without errors.	Completes the task accurately, making minimal errors that do not affect performance.	Completes most of the steps correctly, with some minor errors.	Completes assembly with significant errors but is still functional.	Presents considerable difficulties, with an end product that does not meet basic requirements.
Teamwork	Collaborates exceptionally, leading, motivating, and actively helping others.	Collaborates effectively, contributing consistently and supporting colleagues.	Participates appropriately, with useful contributions and general cooperation.	Participates on a limited basis, with occasional contributions and need for guidance.	Minimal or negative participation, with little or no contribution to the team.
Active Participation	Participates actively in all activities and discussions, showing enthusiasm and curiosity.	Participates regularly, with interest and commitment evident in most activities.	Participates adequately, although with less enthusiasm or frequency.	Participates only when asked, showing little interest or commitment.	Participates rarely or not at all, showing obvious disinterest in the activity.
Reflection and evaluation	Offers in-depth and critical reflections, clearly identifying lessons learned and areas for improvement.	Provides detailed reflections, with some critical ideas and suggestions for improvement.	Reflects on the process and outcomes with a general understanding.	Reflects superficially, with few clear ideas for improvement.	Does not provide meaningful reflections or shows a lack of understanding of the process and outcomes.

Table 4.2.1 Evaluation table

Feedback

Net Promoter Score (NPS) is a widely used tool to measure customer loyalty and satisfaction or student satisfaction in an educational context. It measures the likelihood that students will recommend the subject or course to others. Below is an explanation of how to analyse and apply NPS:

Development of the NPS Question:

- Main question: "On a scale from 0 to 10, how likely are you to recommend this subject to other students?"
- Follow-up questions: "Why did you select that score?" and "How can we improve this subject?"

Collecting Responses:

- Digital surveys: Use online tools like Google Forms, SurveyMonkey, or Typeform to gather student responses.
- Paper surveys: At the end of the lesson, distribute paper questionnaires for students to complete. The Annex provides a template for collecting responses with paper surveys.
- Interactive applications: Use interactive applications like Quizziz, Mentimeter, or Kahoot! to gather responses in real time.

Classifying Responses:

- **Promoters (Score 9-10):** Very satisfied students who are likely to recommend the subject.
- **Passives (Score 7-8):** Satisfied students, but not enthusiastic; they could easily change their minds.
- **Detractors (Score 0-6):** Unsatisfied students with a low likelihood of recommending the subject; they might provide constructive criticism.

NPS Calculation:

- Formula: NPS = % of promoters - % of detractors.
- Interpretation of the score: NPS ranges from -100 to +100. A positive score (above 0) is generally good, and a score above 50 is excellent.

Analysing and Using Feedback:

- Review comments to understand the reasons behind the scores.
- Identify patterns and specific areas for improvement among detractors and passives.
- Use positive feedback from promoters to reinforce the strengths of the subject.

Annexes

In this Annex, the Figures representing the development of the proposed activity are shown.

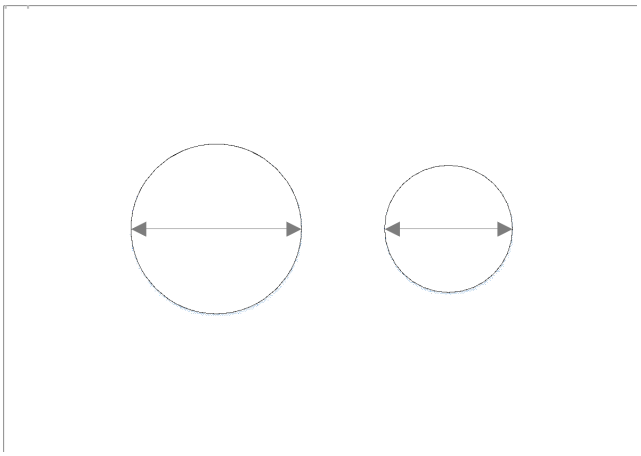


Figure 4.2.1 Example of creating templates for Circles 1 and 2



Figure 4.2.2 Drawing of Templates 1 and 2 on the galvanised sheet. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg



Figure 4.2.3 Making three small cuts along a small arc of Circle 2. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg



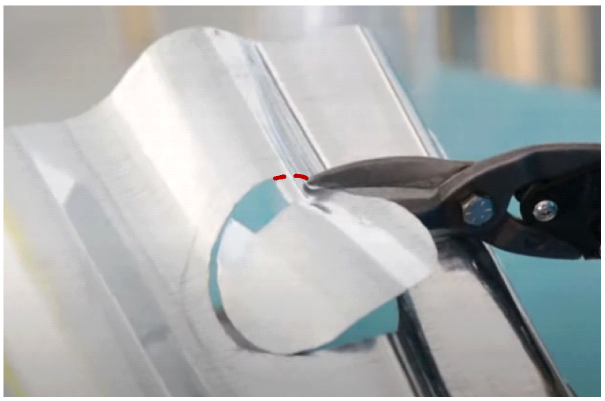


Figure 4.2.4 Cutting along the template drawn for Circle 2. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg



Figure 4.2.5 Cutting the "teeth". Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg



Figure 4.2.6 Bending the "teeth" 45 degrees. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg

https://www.youtube.com/watch?v=o-Fpsw_yYPg





Figure 4.2.8 Applying silicone and placing the bottle. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg



Figure 4.2.9 Sealing the bottle-to-metal sheet joint. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg



Figure 4.2.10 Sealing the bottle-to-metal sheet joint. Link: https://www.youtube.com/watch?v=o-Fpsw_yYPg

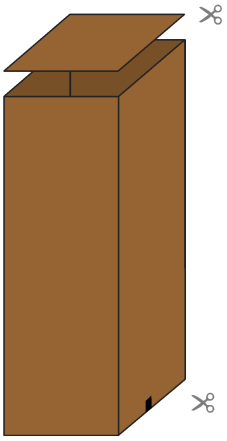


Figure 4.2.11 Removing the top of the cardboard box and making a hole for the USB cable.

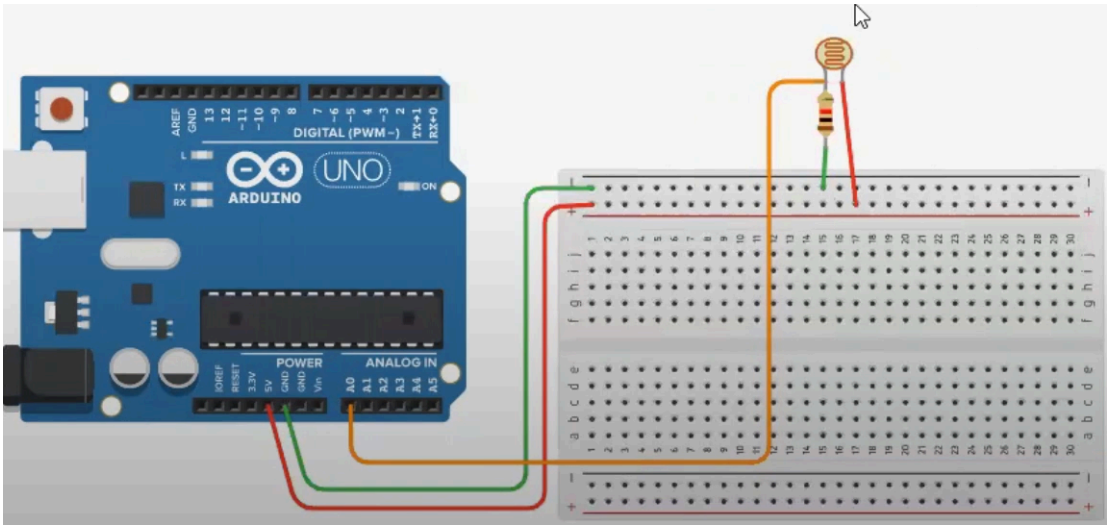


Figure 4.2.12 LDR-Resistor connection with Arduino. Link:
https://www.youtube.com/watch?v=4ibf6wHOIok&t=234s

```
int sensorValue = 0;
void setup()
{
pinMode(A0, INPUT);
Serial.begin(9600);
}
void loop()
{
sensorValue = analogRead(A0);
Serial.println(sensorValue);
delay(100);
}
```

Figure 4.2.13 Code for reading the analog input connected to the LDR. Link:
https://www.youtube.com/watch?v=4ibf6wHOIok&t=234s

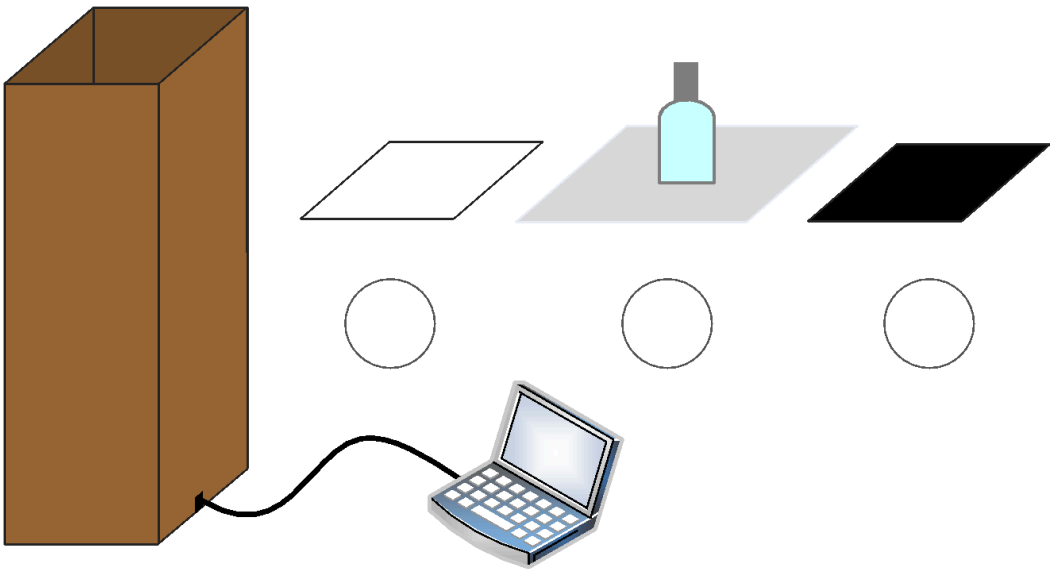


Figure 4.2.14 Setup for the experimental phase

QUESTIONNAIRE TO GATHER FEEDBACK ON THE SUBJECT

On a scale from 0 to 10, how likely are you to recommend this subject to other students?

0	1	2	3	4	5	6	7	8	9	10

Not likely at all Extremely likely

Why did you choose that score?

How could this subject be improved?