# AI & SUSTAINABILITY IN VET EDUCATION

**Name of the Author/s:** Politeknika Txorierri

**Title of WP:** WP3 – AI-SAVES@ProjectHub

**Activity Reference:** AI Waste Classifier – LED-Based Material Recognition

**Logo:**

POLITEKNIKA TXORIERRI

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

# Table of Contents

1. **Project Title:** 4
2. **Project Category:** 4
3. **Project Description:** 4
4. **Keywords:** 4
5. **Target Audience:** 4
6. **Project Objectives:** 5
7. **Project Timeline:** 5
8. **Resources Provided:** 6
9. **Tools and Technologies Used:** 6
10. **Step-by-Step Implementation Plan:** 7
1. **Phase A – Data collection & model training** 7
11. **Evaluation Criteria:** 7
12. **Languages Available:** 8
13. **Contributors:** 8
14. **Feedback and Continuous Improvement:** 8

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

1. **Project Title:**

AI Waste Classifier – LED-Based Material Recognition for Sustainable Education

2. **Project Category:**

Artificial Intelligence • Computer Vision • Sustainability

3. **Project Description:**

This project introduces a simplified AI system that detects and classifies different recyclable materials using a Raspberry Pi camera and a lightweight TensorFlow Lite model.

The system identifies common materials—paper, plastic, and metal—and activates a corresponding LED to visually indicate the detected category while continuously displaying the live camera feed and the recognized material on screen.

- Green LED → Paper
- Yellow LED → Plastic
- Red LED → Metal

Students train their own AI model using Teachable Machine by capturing real-world images of waste materials and exporting it in TensorFlow Lite format for edge inference.

The project emphasizes sustainability awareness, AI implementation, and hands-on experimentation without requiring any robotic movement or complex wiring.

4. **Keywords:**

AI, Raspberry Pi, Computer Vision, TensorFlow Lite, Teachable Machine, LEDs, Recycling, Sustainability

5. **Target Audience:**

Vocational students (2nd-year) and educators interested in AI, environmental sustainability, and IoT fundamentals.

Ideal for students with limited robotics experience who wish to understand how AI can promote ecological responsibility.

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

6. **Project Objectives:**

- Learn to train a simple image classification model with Teachable Machine.
- Understand how to deploy and run AI models on Raspberry Pi.
- Map visual recognition results to physical outputs (LED indicators).
- Foster awareness about recycling and environmental sustainability.
- Encourage critical thinking and experimentation with accessible technology.

7. **Project Timeline:**

| Task | Estimated Hours | Description |
|---|---|---|
| Introduction & project overview | 1 hour | Define goals and explain the link between AI and recycling |
| Dataset collection | 2 hours | Capture 40–50 photos per class (paper, plastic, metal) |
| Model training in Teachable Machine | 2 hours | Train, test, and export TensorFlow Lite model |
| Raspberry Pi hardware setup | 3 hours | Configure Python environment and GPIO |
| LED wiring and testing | 2 hours | Connect LEDs and verify manual control via script |

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

| Task | Estimated Hours | Description |
|---|---|---|
| AI model integration | 4 hours | Load model, run inference, and activate LEDs accordingly |
| Testing & calibration | 3 hours | Adjust thresholds and verify detection accuracy |
| Final documentation & presentation | 3 hours | Report findings and prepare sustainability reflection |
| **Total** | **20 hours** | |

8. **Resources Provided:**

- Example Python scripts (classify_led.py, camera_test.py)
- Preformatted requirements.txt for dependency installation
- README.md with wiring guide and step-by-step execution
- Report template and grading rubric
- Example labels.txt structure for TensorFlow Lite model

9. **Tools and Technologies Used:**

- Hardware: Raspberry Pi 4/5, Raspberry Pi Camera V2/V3 (or USB camera), 3 LEDs with resistors (220–330 Ω), breadboard, jumper wires.
- Software: Python 3, OpenCV real-time visualization window (cv2.imshow) for continuous video display and text overlay with classification results, TensorFlow Lite Runtime, RPi. GPIO, Teachable Machine.
- Tools: Thonny IDE / VS Code, GitHub (optional), basic electronic toolkit.

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

**10. Step-by-Step Implementation Plan:**

1. **Phase A – Data collection & model training**
   a) Gather real images of paper, plastic, and metal waste.
   b) Upload to **Teachable Machine** (Image Project).
   c) Train and test until classification accuracy ≥ 80%.
   d) Export TensorFlow Lite model and save as model/waste_model.tflite.
   e) Create a corresponding labels.txt file (one class per line).

2. **Phase B – Hardware setup**

   a) Connect the 3 LEDs to Raspberry Pi GPIO pins (16, 19, 26) with resistors.
   b) Verify connections with a simple Python script to turn each LED on/off.
   c) Connect the camera and test video feed using camera_test.py.

3. **Phase C – AI integration**

   a) Install required libraries from requirements.txt.
   b) Load and run inference using classify_led.py.
   c) Continuously display the live camera feed using OpenCV (cv2.imshow).
   d) Overlay on-screen text showing the detected material in real time.
   e) Assign each predicted material to a specific LED colour (Red = Metal, Green = Paper, Yellow = Plastic).
   f) Add a brief delay or smoothing logic to ensure stable LED transitions.

4. **Phase D – Testing & validation**

   a) Test the model with new objects and mixed lighting conditions.
   b) Measure recognition speed and accuracy.
   c) Record a demo video showcasing the system's behaviour.
   d) Discuss environmental implications and areas for improvement.

**11. Evaluation Criteria:**

- **Model Training (25%):** Quality and diversity of captured dataset.
- **Hardware Setup (20%):** Correct wiring and safe circuit design.
- **AI Integration (30%):** Functional inference and LED response accuracy. Includes functional real-time visualization with clear on-screen classification labels.
- **Creativity & Presentation (15%):** Clear explanation and sustainable focus.

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

- **Team Collaboration (10%):** Shared roles, documentation, and reflection.

**12. Languages Available:**

English

**13. Contributors:**

- **Miren Arrien (Project Lead)** – Lead educator responsible for project development and coordination.
- **Enaitz Elejalde (Technical Expert)** – Hardware testing and wiring verification.
- **Aitor Rey (Technical Expert)** – Python programming and debugging.
- **Jokin Goioaga (Technical Expert)** – Computer vision and AI deployment.

**14. Feedback and Continuous Improvement:**

- Short progress reviews will be conducted after each phase (training, wiring, and testing).
- Final feedback will include a discussion on environmental impact and model performance.
- Students will propose improvements such as additional material categories, integration with an LCD screen, or sound feedback for accessibility.
- Documentation of lessons learned will contribute to future AI & Sustainability modules, fostering iterative improvement and responsible innovation.
- Future improvements could include integrating additional material categories or enhancing the graphical interface (e.g., showing detection confidence or bounding boxes).

Co-funded by the European Union

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.