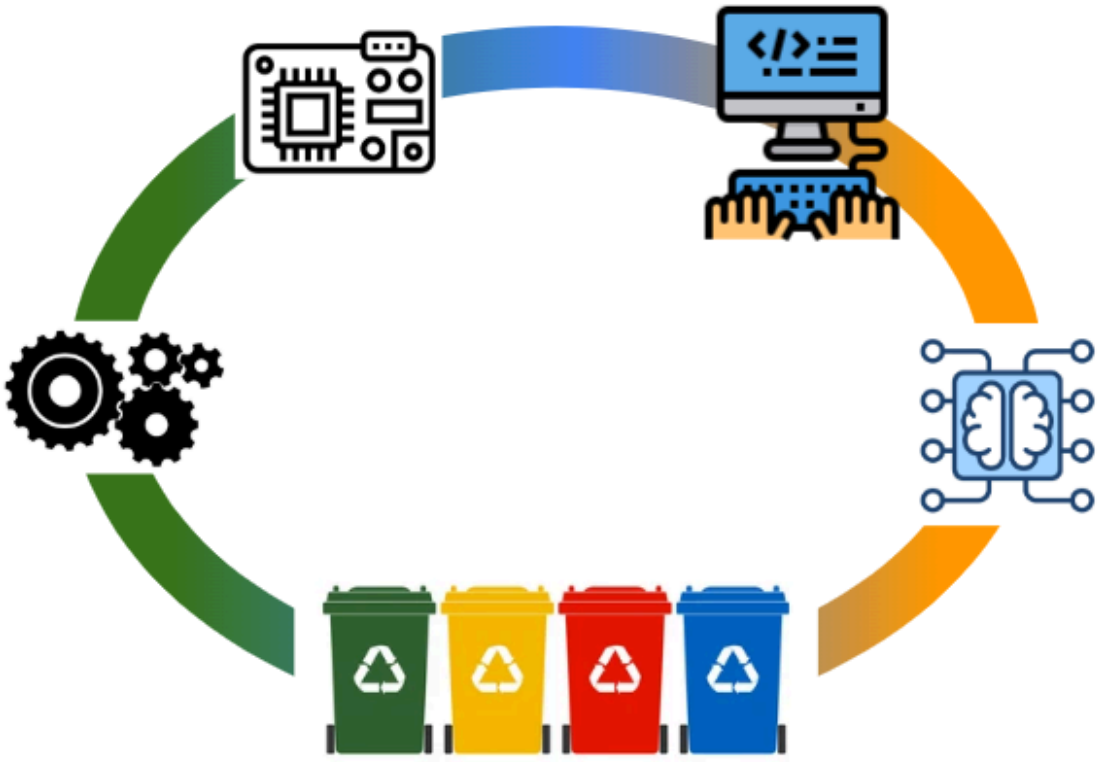
Smart Recycling System:
Building and AI-powered bin



Student booklet

Students in this group

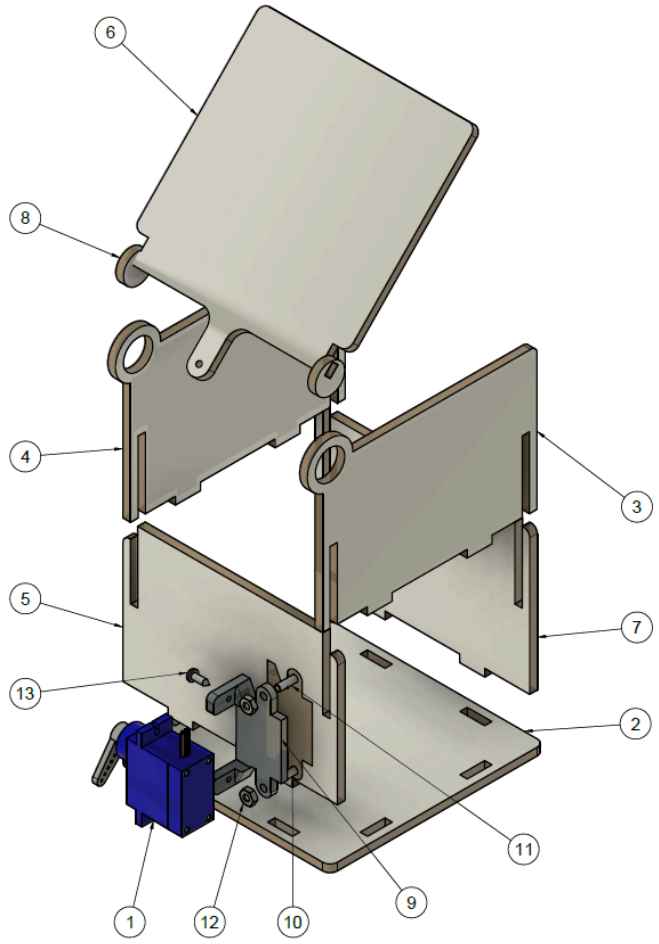
PROJECT: SMART RECYCLING SYSTEM

ASSEMBLING THE BIN AND CONNECTING ALL THE COMPONENTS

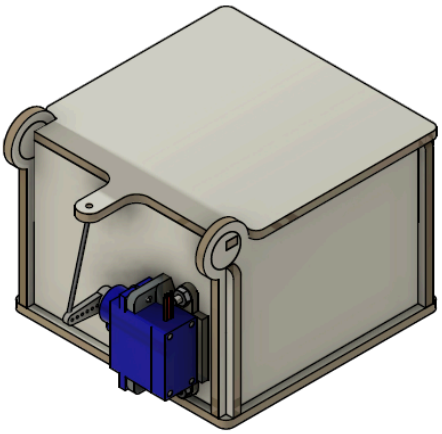
To assemble the whole system you will need the following materials.
Before starting, check that you have all the resources.

Materials	Tools
☐ Pieces to assemble the bin ☐ A servo motor with arm ☐ A servo bracket ☐ A paper clip/wire ☐ A micro:bit ☐ A Nezha expansion board ☐ Screws and nuts ☐ A laptop with camera ☐ USB lead to connect the micro:bit to the laptop	☐ Screwdriver ☐ Long nose pliers ☐ Side cutters

✏️ **TASK 1:** Follow the drawing to assemble the box and attach the servo motor at the back



Parts List			
Item	Qty	Part Number	Material
1	1	9g Micro Servo SG90	Plastic
2	1	Base	MDF Medium Density Fiberboard
3	1	Side	MDF Medium Density Fiberboard
4	1	Side (1)	MDF Medium Density Fiberboard
5	1	Back	MDF Medium Density Fiberboard
6	1	Lid	MDF Medium Density Fiberboard
7	1	Front	MDF Medium Density Fiberboard
8	2	Hinge	MDF Medium Density Fiberboard
9	1	Mini_Servo_Bracket	Plastic
10	1	DIN 7985 - M2.5x8-H H Steel 4.6 Plain	Steel 4.6, Plain
11	1	DIN 7985 - M2.5x10-H H Steel 4.6 Plain	Steel 4.6, Plain
12	2	DIN 934 - M2.5 x 0.45 Steel 6 Plain	Steel 6, Plain
13	2	DIN EN ISO 7049 - ST2.2 x 6.5 - C - H Steel 4.6 Plain	Steel 4.6, Plain



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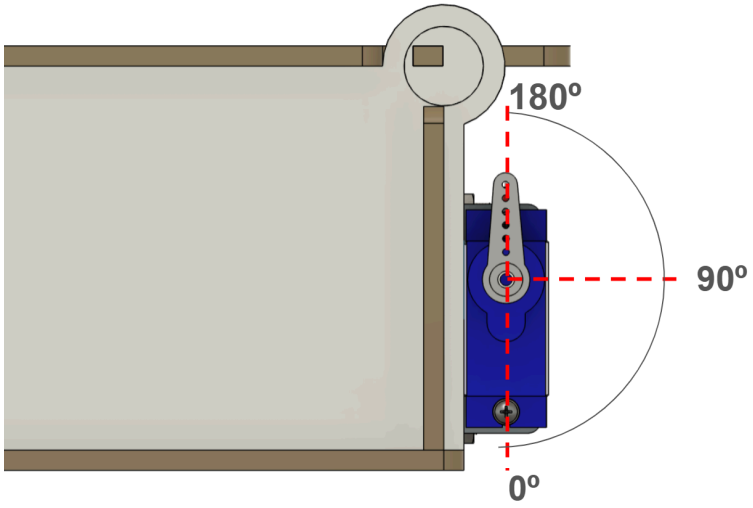
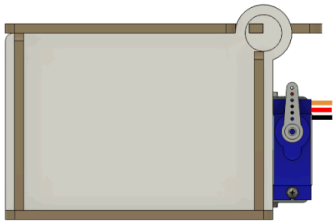
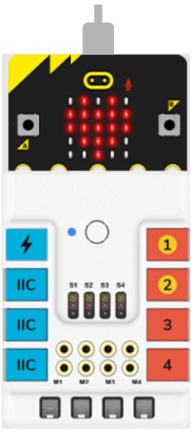
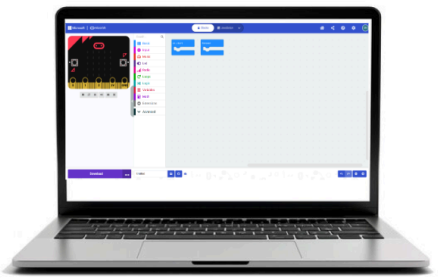
The **servo motor** can move from **0° to 180°**. Make sure the servo **arm** is positioned **vertically** and pointing up when the servo is **at 180°**. At 90°, the arm should be **horizontal**, and at **0°**, it should **point down**. This is important for setting the start and end positions correctly so the lid opens and closes properly.



✏️ **TASK 2:** Follow the teacher's instructions on how to connect the servo to the expansion board and draw the correct connections on the image below.







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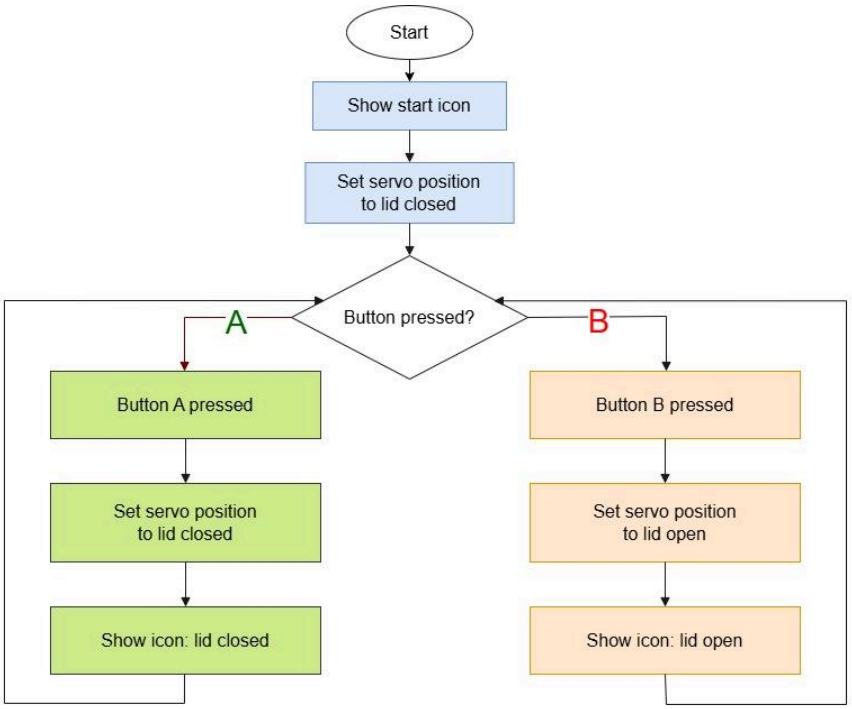
PROGRAMMING THE MANUAL OPENING OF THE BIN

You are going to create the code to open and close the lid of the bin using the buttons on the Micro:bit.
The following diagram is a flowchart showing the structure of the code



✏️ **TASK 3:** Based on the flowchart, complete the following explanation of what the code is doing:

On **start**:

- Show an _____.
- Set servo position to lid _____

On **button _____ pressed**:

- set _____ position to _____
- Show an _____ that represents _____

On **button _____ pressed**:

- Set _____to_____
- Show _____

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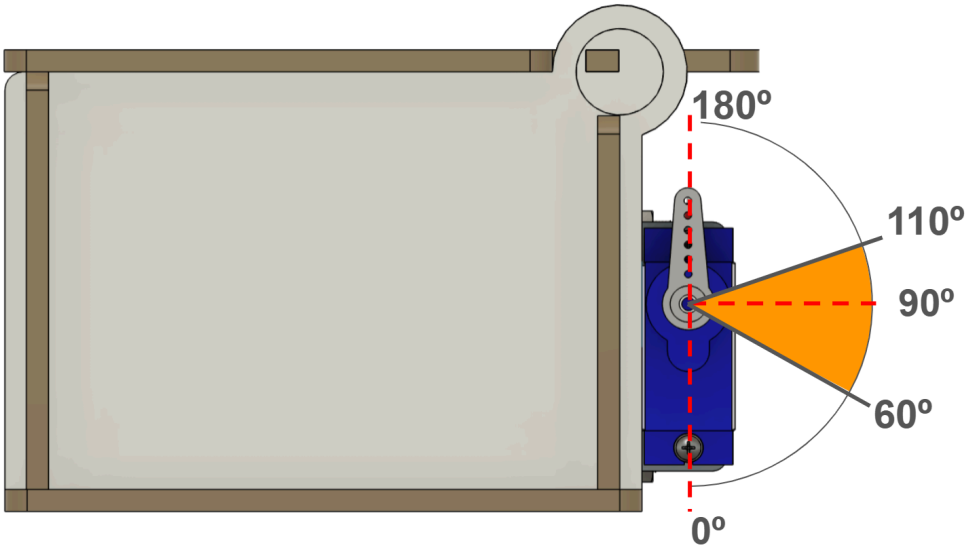
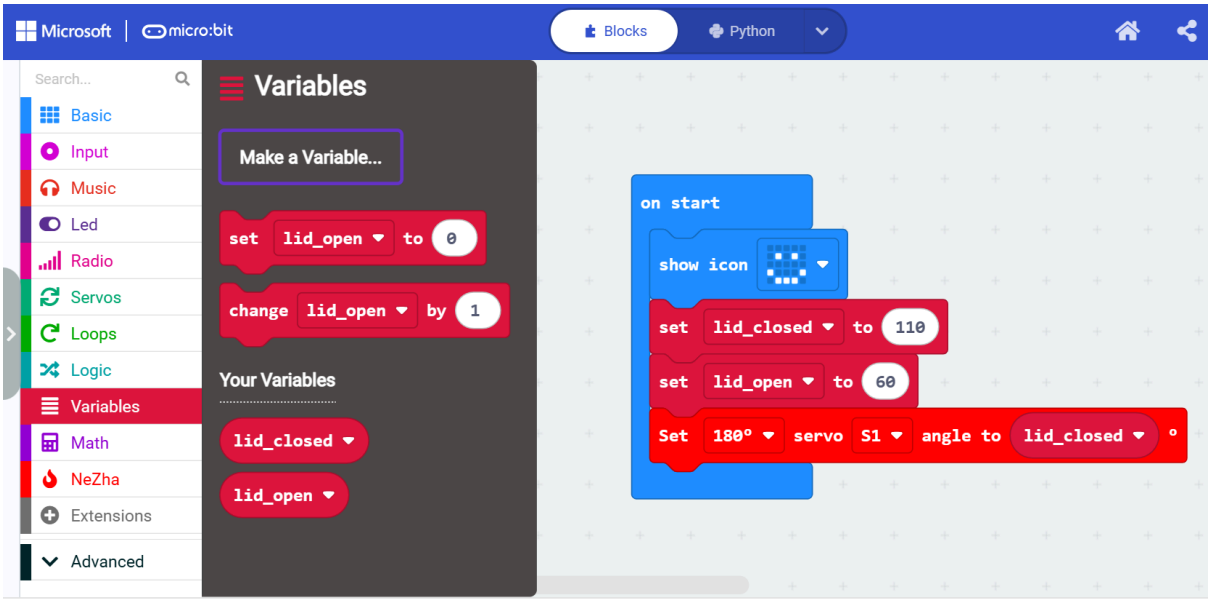
In MakeCode create two **variables**:

- *lid_open*
- *lid_closed*

For now assign the values shown. These are the positions of the servo in degrees.





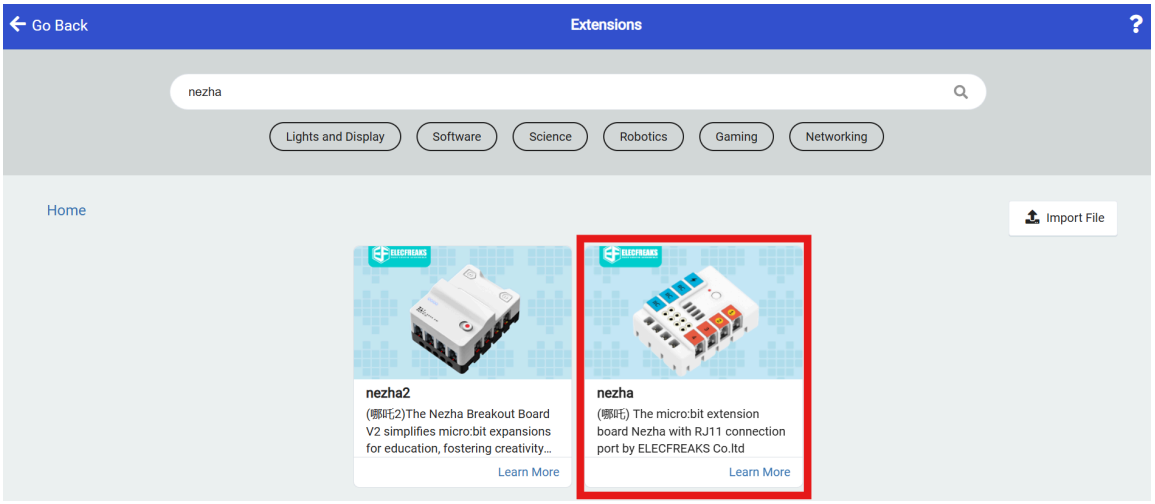
📖*A **variable** is a place where you can store and retrieve data. Variables have a **name, a type, and a value:***

- ***name** is how you'll refer to the variable*
- ***type** is the kind of data a variable can store (text, number, true/false)*
- ***value** is what's stored in the variable*

*Using variables has several **advantages**:*

> *1. The **code is easier to understand: lid_closed** and **lid_open** are much clearer than just writing numbers.*
>
> *2. The **code is easier to change:** You do not need to search through the whole program. Servo positions often need adjusting because the arm may be mounted differently each time. If the lid does not close properly, you only need to change: lid_closed = 110 to something like: lid_closed = 100*
>
> *3. It **reduces mistakes**: If the same number is written in many places, it is easy to forget to change one of them.*

To control the servo we are going to use the extension from the expansion board **Nezha**. Click on "**Extensions**" and type "nezha" in the search bar. Click on the correct extension board and the extension will be added to the toolbox. You now have specific blocks to control motors and servo motors connected to the Nezha expansion board.



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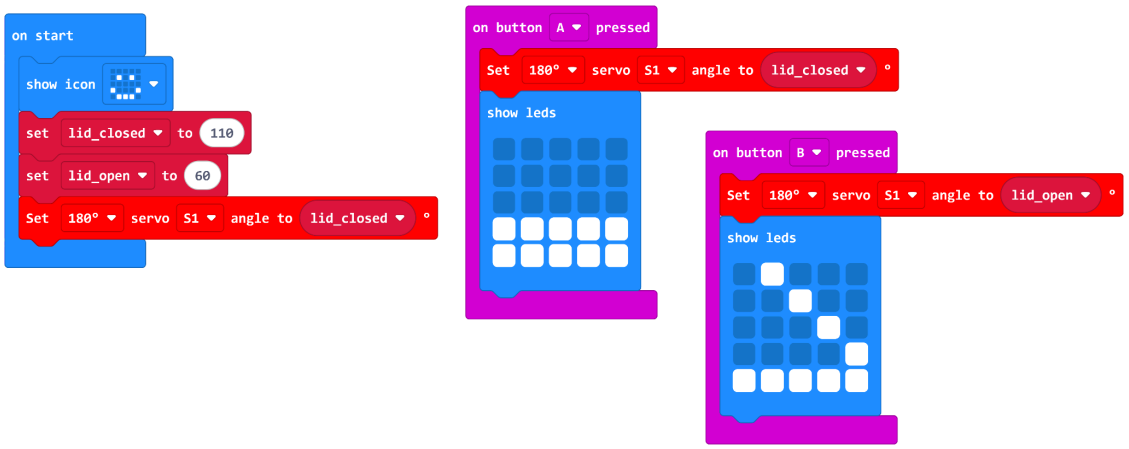
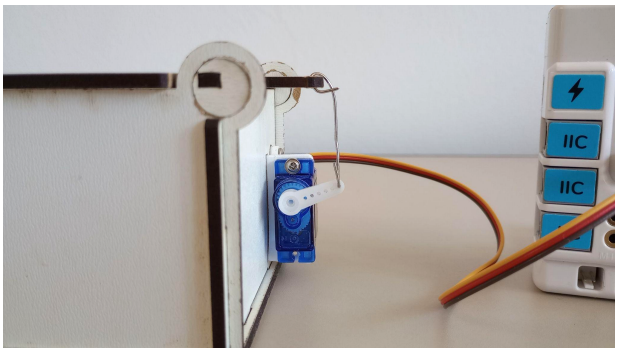
Complete the code adding the "**on button pressed**" as shown:

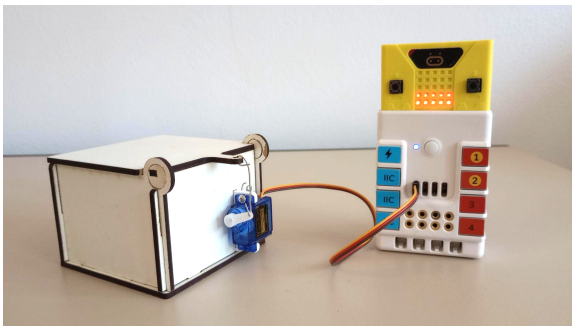


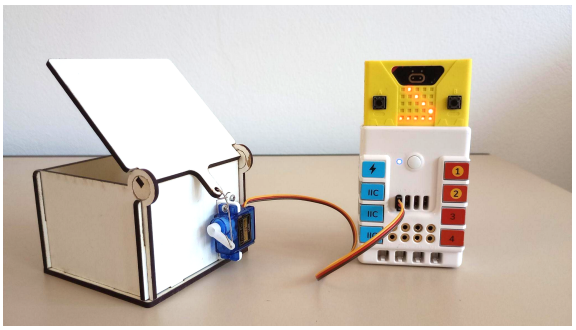
Download the code and test it.

With the servo at the 110 degrees position, add a linkage to connect the servo arm to the lid of the bin. This can be done by cutting and bending a paper clip or metal wire. Use side cutters and long nose pliers for this step.



Does the lid open and close properly? You may need to change the angles (value of the variables) if the lid does not open or close correctly.





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✏️**TASK 4:** Complete the following table with the final values you used in the code and the inputs and outputs used so far:

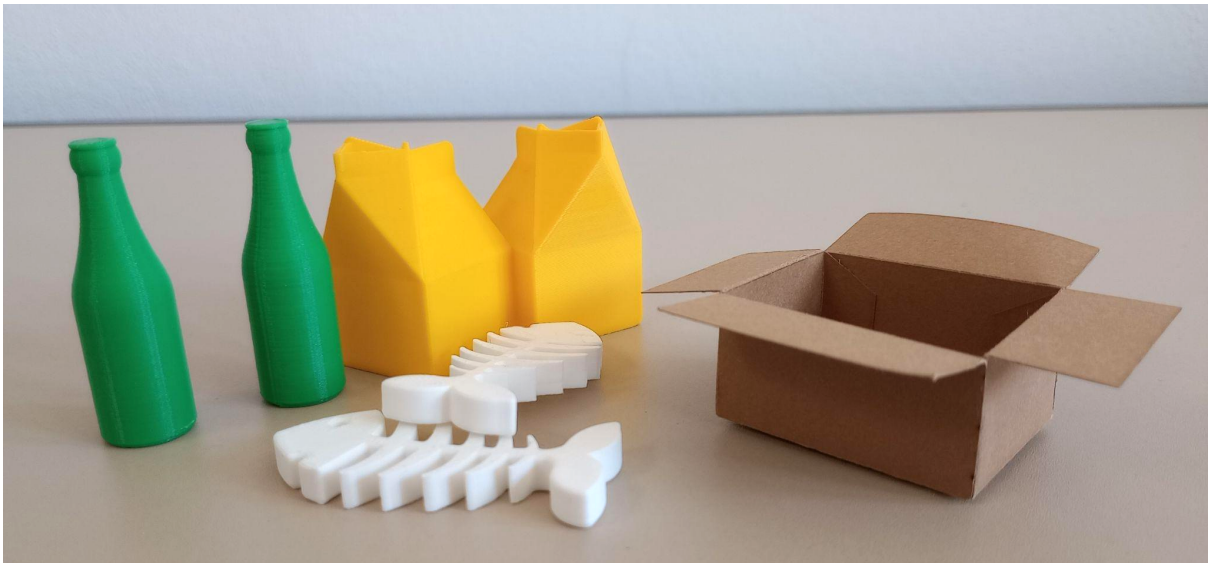
Variable name	Variable type	Variable Value

Inputs	Outputs

BBC bitesize: Electronic systems
https://www.bbc.co.uk/bitesize/guides/zhxqmsg/revision/1

TRAINING THE LEARNING MODEL

Your team will be assigned a type of recycling waste for your smart recycling system, e.g. glass, cardboard, organic waste, containers, etc.
You will need to train a learning model so it can recognise the different types of waste.



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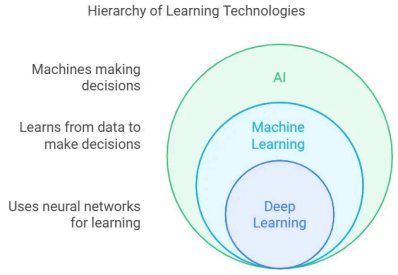
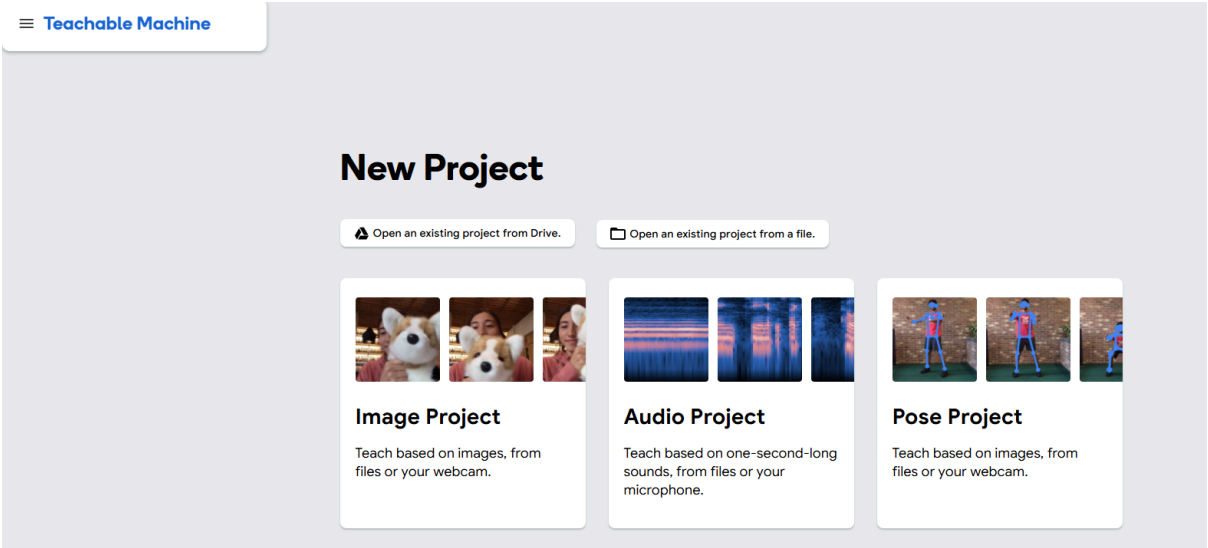


📖 *A **machine learning model** is a computer system that learns to recognise patterns from examples. In this project, the model learns from images of different types of waste so it can predict what item the camera is showing.*

***AI** is the broad field of making computers perform tasks that usually need human intelligence. Machine learning is a part of AI in which computers learn from data and examples.*

Source:https://medium.com/@tahirbalarabe2/what-is-machine-learning-artificial-intelligence-models-algorithm-and-learning-explained-ebce2e1ce00d

Go to the site **Teachable Machine** https://teachablemachine.withgoogle.com/ and start a new **Image Project**.
Teachable Machine is a web-based tool that lets you train simple machine learning models, such as image, sound, or pose classes, without needing to write code.



You will need to create a "**class**" for each category or item, plus one with only the background.
Name the classes with short, clear names **without spaces.**
For example, you may need to create the following classes:

no_item
cardboard
glass
containers
organic

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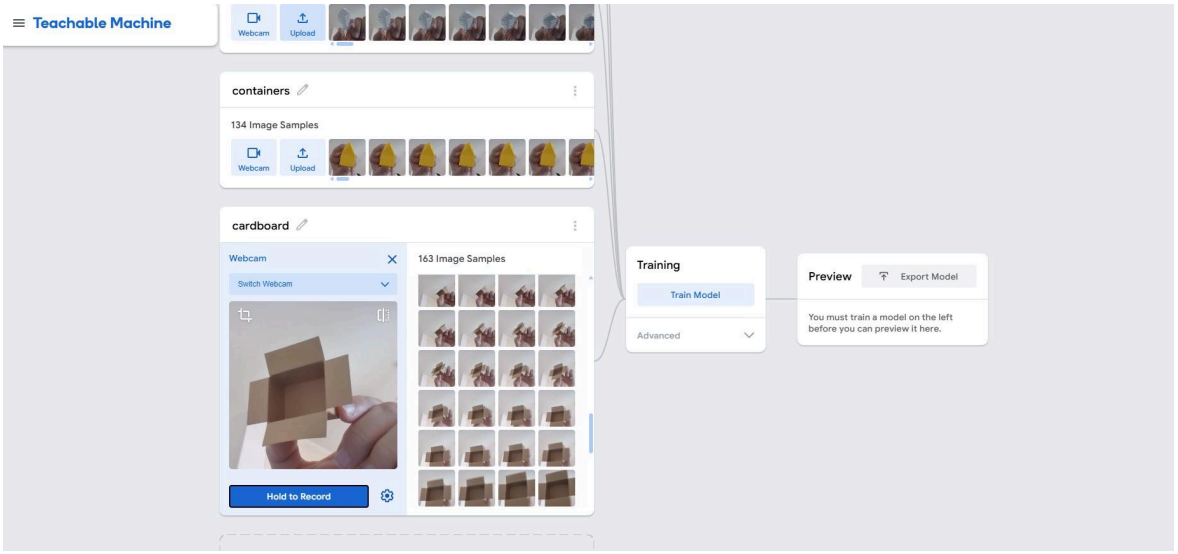
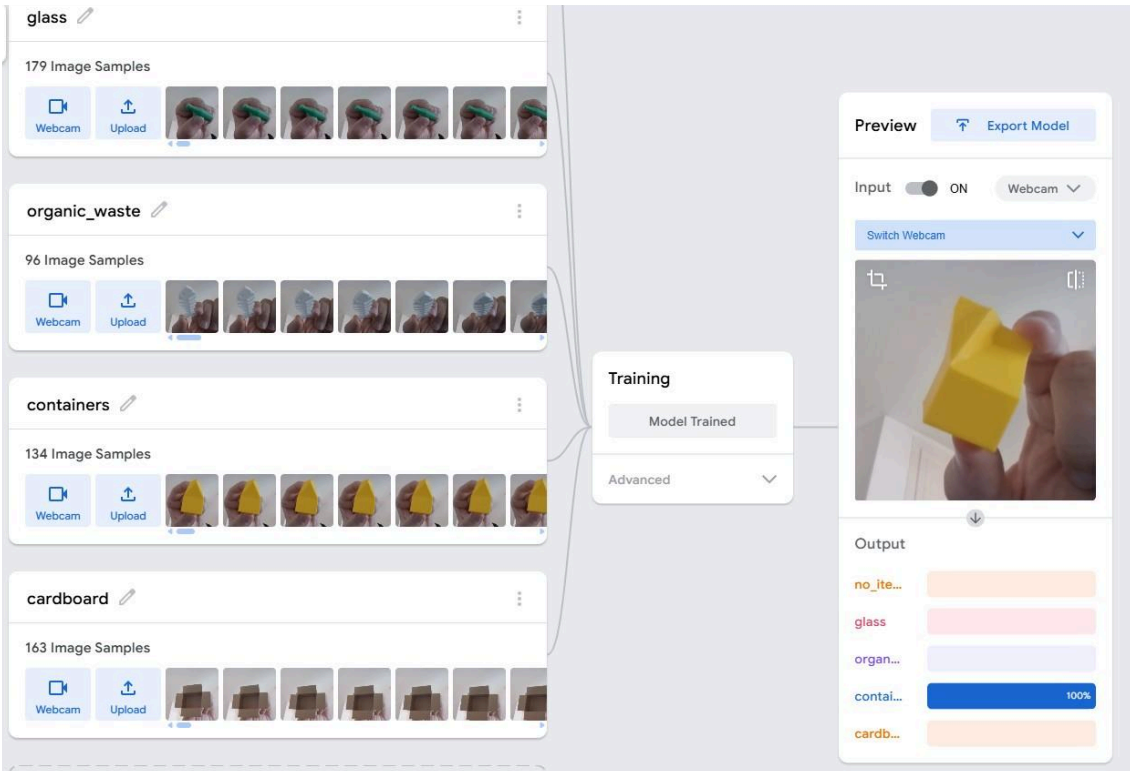


Gathering data: For each class, click on the webcam icon and record the correct item by placing it in front of the laptop's camera and move it around so different angles of the item are captured. Between 100 and 180 sample images per item should be enough for this project.

Train the model: once the model has enough data you can click on "Train Model". If you add or change data later, you will need to train the model again

Preview and test the model: after training the model you will see a preview window. Te.st every item by holding it towards the camera to check the accuracy of the model at predicting each item. If the model is not working well you may need to delete some of the classes, gather better data and train the model again.



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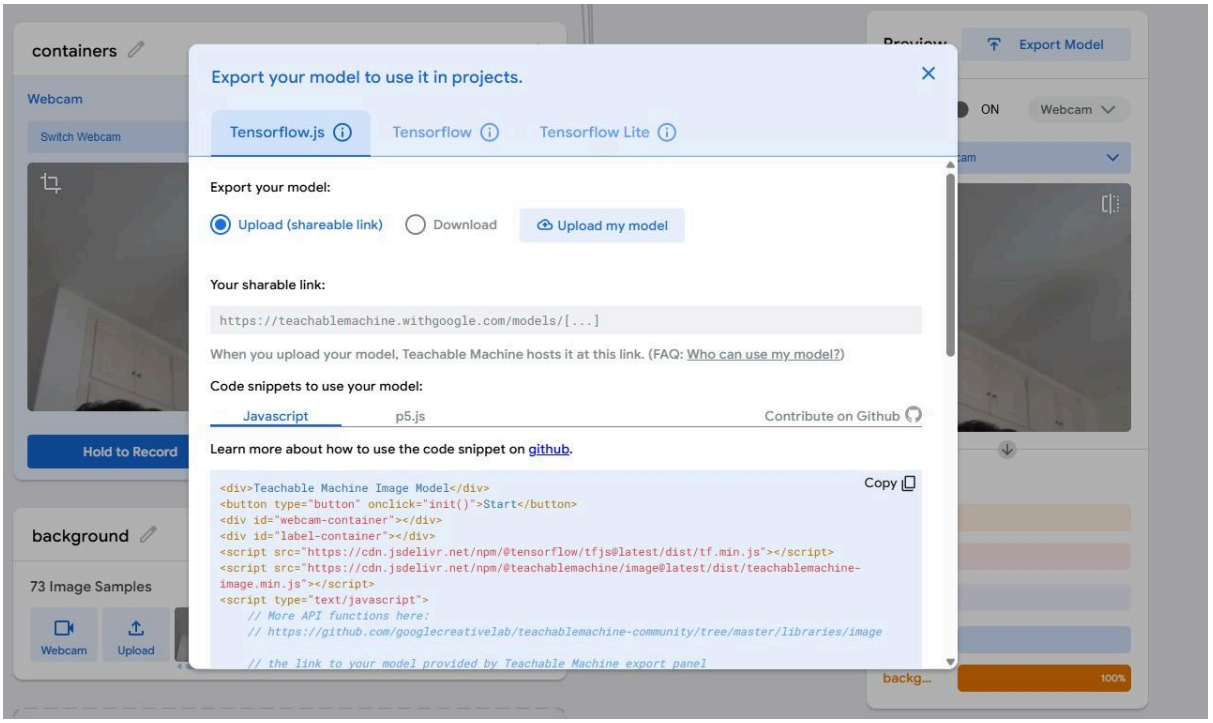
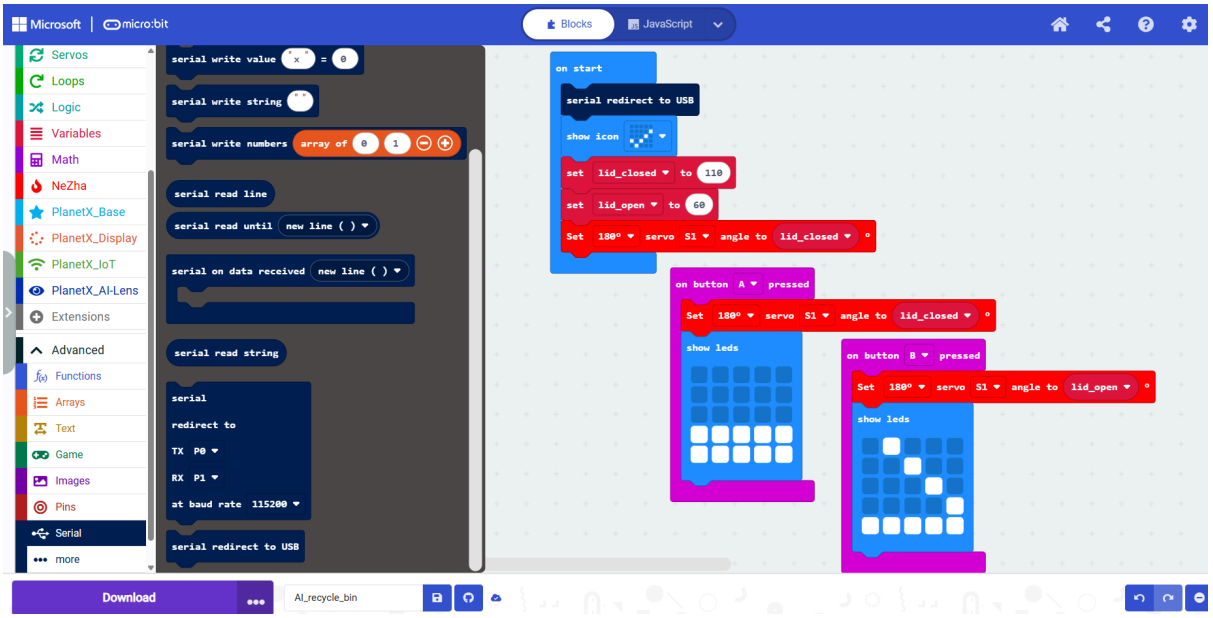
Export the model: when the model predicts each item correctly, go to **Export Model** → **Upload Model**. This generates a **shareable URL** for the model.



PROGRAMMING THE MICRO:BIT TO USE THE LEARNING MODEL

Starting from the previous code, we need to add a “serial redirect to USB” block inside “on start”. This directs the serial input and output to use the USB connection.



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Create a new variable called “**SerialData**”

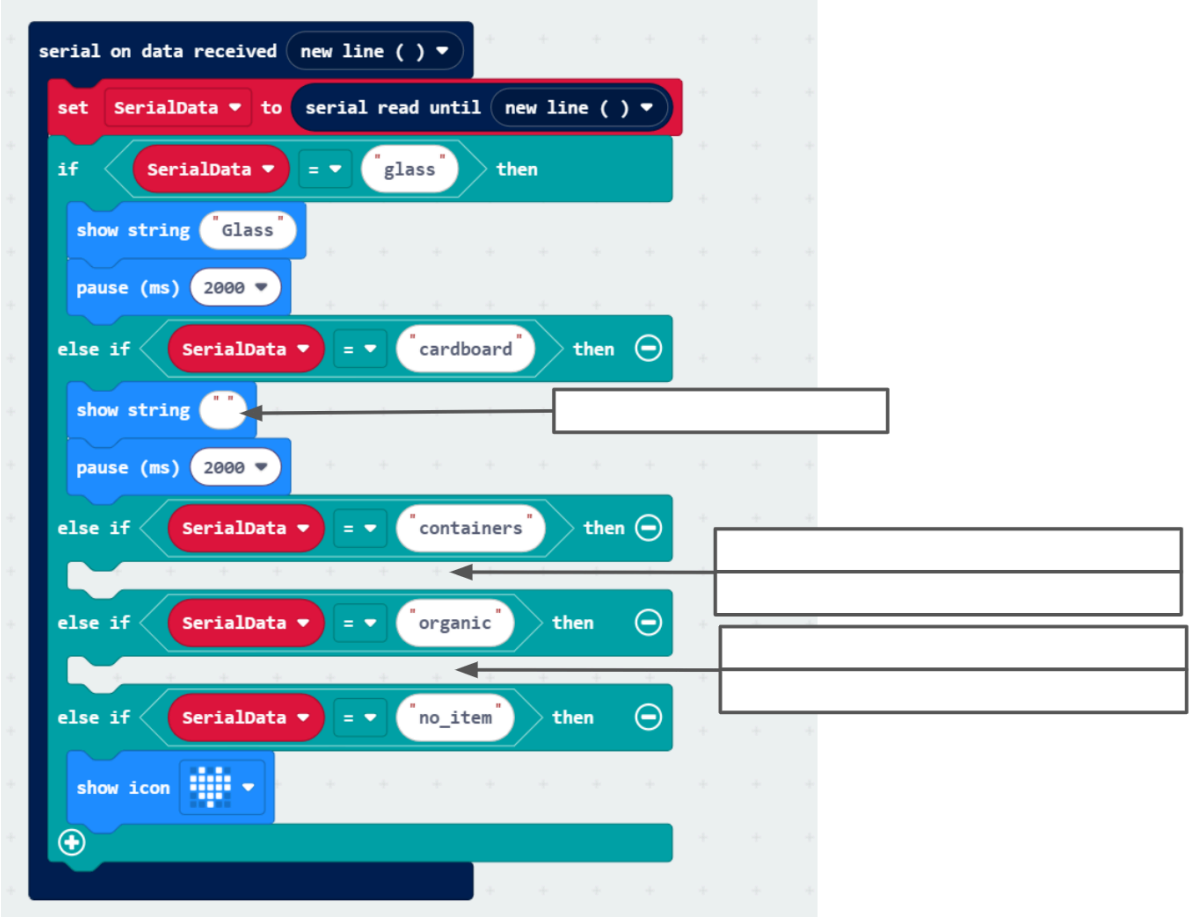
The following piece of coding is going to automate the bin depending on the data received from the learning model.

The micro:bit reads the text sent from the computer into the variable **SerialData**. It then checks which class label was received and provides feedback:

- "glass" → shows “glass”
- "cardboard" → shows “card/paper”
- "containers" → shows “containers”
- "organic" → shows “organic”
- "no_item" → shows an icon

The names used in the code need to be the same as the classes created in Teachable Machine.

✏️ **TASK 5:** This is part of the code you need to automate the system. Can you add the missing blocks?



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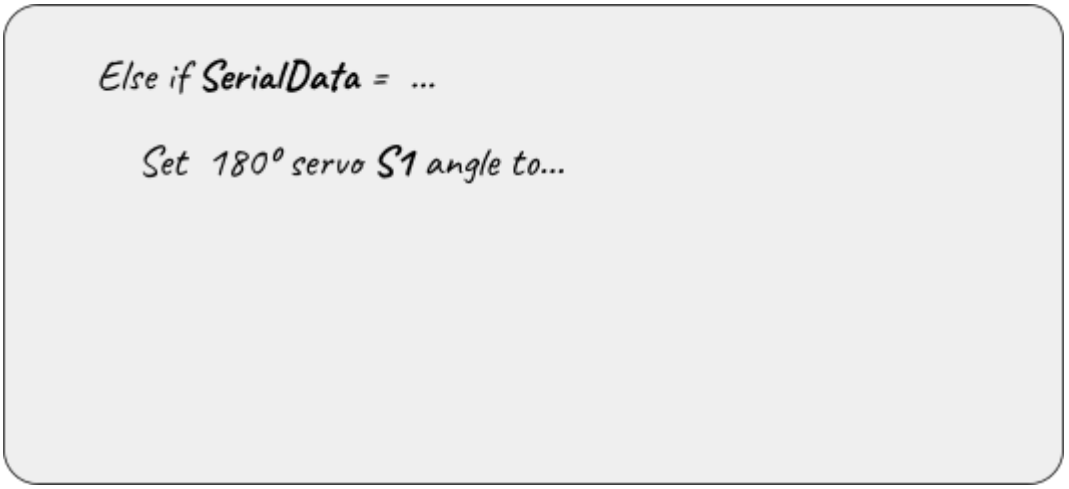
✏️**TASK 6:** Only the assigned recycling category should open the bin; the others should only display feedback.
We have been assigned the following category : _____

You need to add the code to open the lid under the correct conditional:

- opens the lid
- waits 5 seconds
- then closes it again

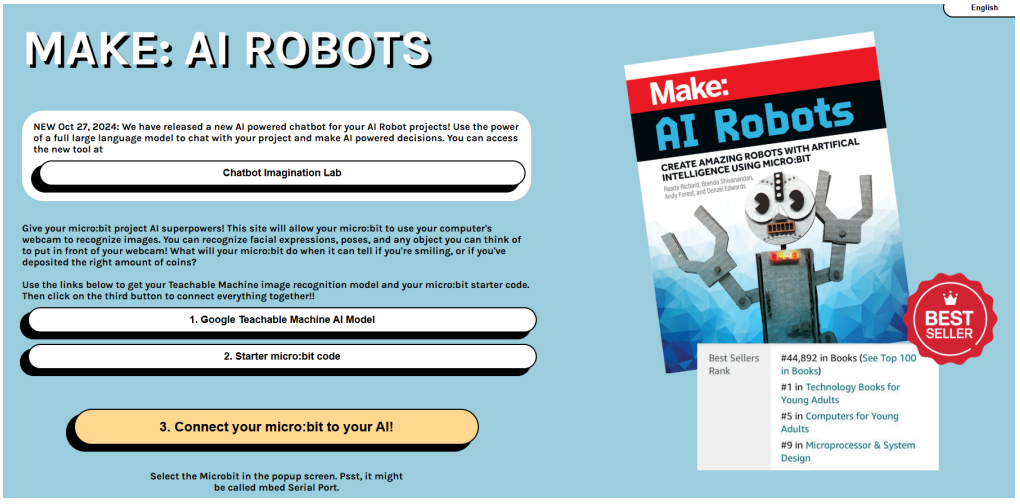
Write the blocks with the variables, pins you will be using to make the system work:



Implement the above code into your makecode project and download the code to the micro:bit.

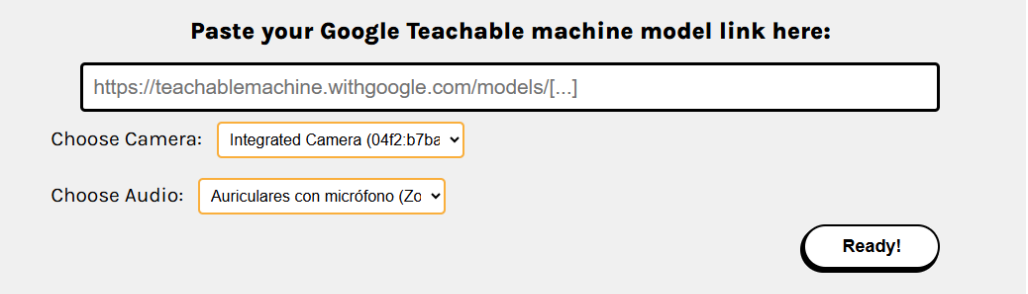
CONNECTING THE MICROBIT TO THE LEARNING MODEL

To connect the learning model created in **Teachable Machine** to the **Micro:bit** we need a third application: **MAKE: AI Robots** (https://makeairobots.com/)

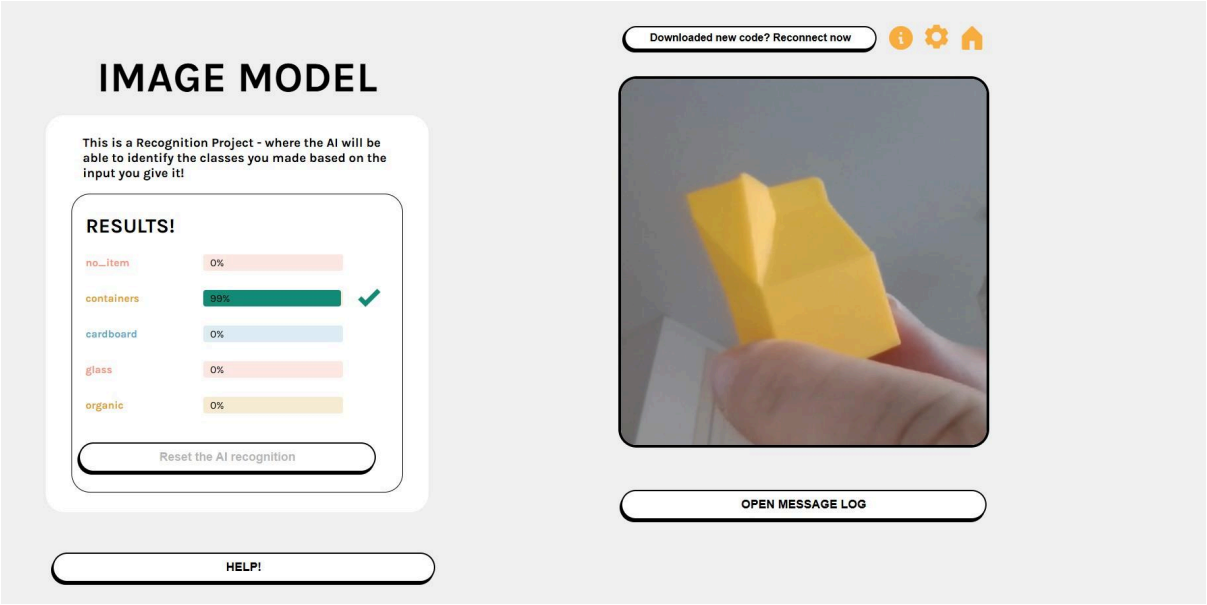


Make sure the Micro:bit is connected to the laptop with the USB cable.

Make sure the camera is not used by any other application.
Paste the **sharable link generated by Teachable Machine** into the box:



Now you should see the model you created. Show the items to the camera to check that the model works and that the micro:bit is receiving the data.



🛠️ Troubleshooting Guide

Problem	Possible cause	Solution
Lid does not move correctly	Servo angles are wrong or linkage is loose	Check linkage and adjust *lid_open* / *lid_closed* values
MakeCode does not pair with micro:bit	USB connection or board connection issue	Disconnect from Nezha, unplug USB, reconnect, and pair again
Correct item is not recognised	Poor training data or wrong class names	Improve images and check class names match the code
MAKE: AI Robots does not work	Camera or micro:bit still connected elsewhere	Close Teachable Machine and disconnect from MakeCode first

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✏️ **TASK 7:** Did the system work the first time? Explain what problems you had and how you solved them. Think about problems using the apps, wiring, coding, hardware, etc.

Some questions to think about	Words to use in your explanation	Some prompts to help you complete the task
What problem did you have? What do you think caused the problem? How did you fix it? Did the system work after the change?	**wiring, servo, variable, code, connection, class name, serial data, camera, model, test, error, solution, Learning model**	"At first, our system did not work properly. The main problem was _____. We checked _____ and realised that _____. We solved it by _____. After that, the system _____." "The lid did not open properly because..." "The servo angles were not correct, so..." "The micro:bit did not connect because..." "The model did not recognise the object because..." "The class names did not match the code, so..." "We fixed the problem by changing..." "After testing again, we found that..."

Your answer:

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✏️ **TASK 8:** Reflection questions:

1. Does this system actually reduce waste contamination?
2. Is recycling the best solution, or should we reduce and reuse first?
3. What are the limits of AI in solving environmental problems?

Your answer: