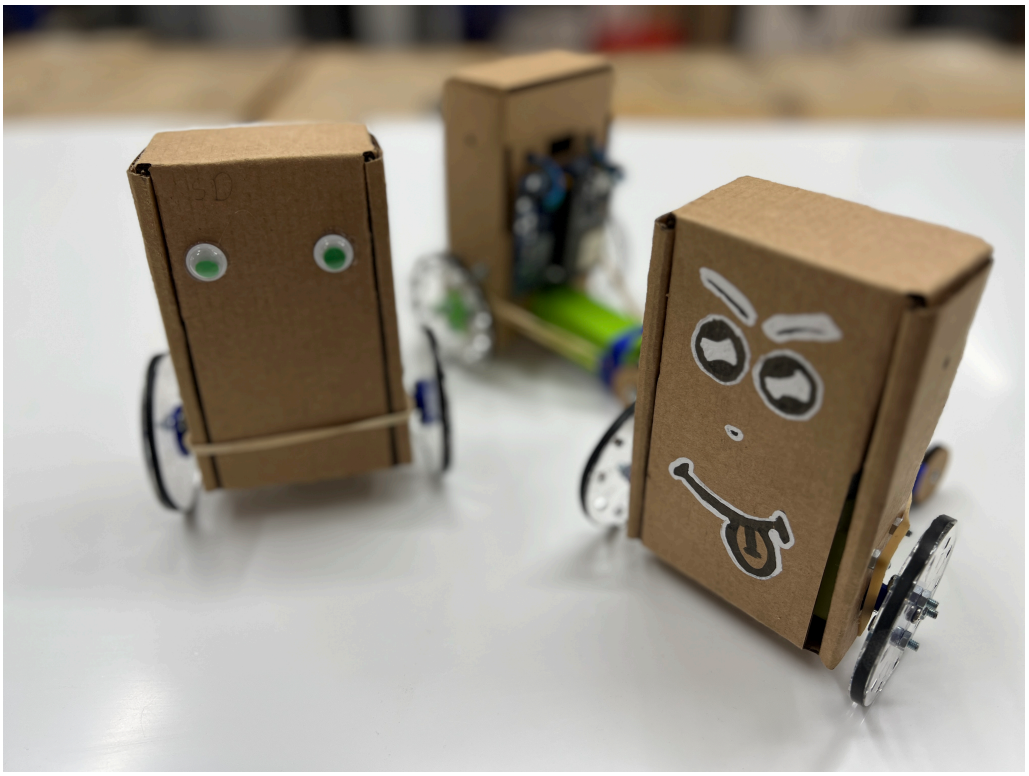
Cardboard Bots: Robotics



Distinctive Objects

Lesson 1:	Topic: Introduction to project and robotics

Learning Objectives: Following the lesson pupils should be able to:

- **Define what a robot is.**
- **Explain how engineers apply robotics to solve real-world problems**

Resources:
Example of robot

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science

Starter Activity: What IS a robot?	**Learning Objective:** Define what a robot is.

Task: Pupils to look at the images and discuss which product is a robot and why

Discussion from this starter should lead into the difference between something which is **AUTONOMOUS** an has some method of **MOVEMENT.**

Key questions:
Does a robot have to look as we expect? – Eg. Wall-E/ robots in i-Robot - is this what we imagine as a robot?
How does the robotic arm differ from our expectation of a robot? No face, no body
The Sky Box can act autonomously – Why isn't it a robot (movement)

Starter Activity 2:	**Learning Objective:** Define what a robot is.

Get pupils to read through definition of robot and ask them to simplify what it means.

Expected Pupil notes: Pupils to write and agree a definition for a robot that they all understand and note down in workbooks.

Key point to definition: A robot is:

- Autonomous in operation (therefore why a remote-controlled car is not a robot)
- Reprogrammable and therefore multifunctional (can fulfill several tasks)
- Can move (this movement can be material, parts, tools, or specialised devices)

Teacher content: Introduce the Boston Robotics Atlas/ASIMO robot videos to the pupils:

Please highlight:
The amount of money being invested into robotics worldwide is in the billions of dollars.

Asimo is a research robot made by Honda – the video shows Asimo running (both feet off the ground) emphasize how difficult this is to create, consider how long it takes a child to learn to walk/run and jump. Use the Boston Robotics videos (such as the Parkour one) to emphasize the ongoing progression of research and development.

Consideration of what areas robots are used and why.

Learning Objective:

Explain how engineers apply robotics to solve real-world problems

Possible Teaching Activities/Learning Methods

Pupils discuss in what areas robots might be used instead of humans.

Eg, Repetitive tasks such as placing components, emphasise that video is in real time and consider how long it would take a human to do it.

Ask them why a robot is better suited – what do we not need for robots that humans need?
Food, Heat and Light, Rest, Pay, Time off, holidays, reasonable working hours.

Give them 5 minutes to add to the mind map with other areas:

E.g., Hazardous situations – Space exploration, bomb disposal, nuclear/chemical clean-up/ paint spraying
High precision tasks – Surgery (Da Vinci Robot), handling of ICs
Dull/repetitive work – production lines, assembling,

Pupils to add to their mind map and include areas discussed, show videos of pick and place machines or car manufacture.

How do robots know what's going on around them and how do they affect their environment.

Learning Objective:

- Explain how engineers apply robotics to solve real-world problems

Pupils discuss what they think, in a computerised system, a sensor/input is.

Consider our 5 human senses, what are they? What would we know of our environment if they were removed? This is the same as us removing the keyboard and mouse from a computer; it would have no information about the outside world.

Example definition: 'A sensor is a component that takes information about the outside world and sends it into the computerised system'.

Examples of sensors: Microphone (sound sensor), light sensor, Touch sensor (button), humidity sensor, pressure sensor

Pupils discuss what they think, in a computerised system, a device/Output is.

Consider what we use to affect the outside world. Eg. If we had no way of moving or speaking, how could we ever make it known what we are thinking? Suppose someone slapped you, how do you respond? – Say 'ouch'? slap them back? Walk away? If we were a machine all of these would be us using an output.

Example definition: 'An output is a component that is controlled by the processor and causes changes in the physical world, something we can experience'.

Example of Devices: Speaker, buzzer, LED, Lamp, Motor, heater etc

Phase 4: Review

Review the learning from the session.

Suggested activity: Pupils play 'pass the question' You as teacher ask the first question, pupils need to answer, formulate their OWN question based on the lesson and ask it to another student. Questions such as – 'Is a microphone an Input or Output?'

Lesson 2:	Topic: Form follows function

Learning Objectives: Following the lesson pupils should be able to:

- **Understand why the aesthetics of a product are generally driven by the physical constraints of components/ functional aspects.**
- **Design their robot to be both aesthetically interesting yet still highly functional.**

Resources:
Examples of robots for analysis
Key component sheet

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: Form follows functions vs function following form	**Learning Objective:** Function driven Aesthetics

Opening discussion: Collect two images of different cars (Ideally the Concept and Actual), why do the pupils think the final design looks so different to the original?

Points to derive: Engineers must fit engine, suspension components and fit requirements of the customer (e.g., being able to get kids in and out of the car easily)

Starter Activity: Pupils consider the images - Aesthetics vs function – what problems can they see arising from the product in use?
Discussion from this starter should lead into a discussion about form.

Key questions:
Is the way something looks more important than the way it works?

Main Activity 1: Key Considerations	**Learning Objective:** Define what a robot is.

Show pupils the robots and explain what the different parts do. in groups of 4 – Ask them to identify the things they will need to consider when producing their own design.

Expected Pupil notes: Pupils to write what the agreed key aspects to consider are in their workbooks.

Key points to derive:

- Wheels must be lower than the body.
- Battery Box needs to be held securely.
- Rear wheel needs to be at the back and balanced.
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Teacher content: Introduce the robot components.

Please highlight:
The size of the battery box, how batteries are changed and the location of the USB Sockets/battery snap connector.
The potential of including microswitches – explain how these work in the robot.
The motors – show size and emphasize hole that is needed for back of the robot.
The size of the circuit board.

Main Activity 2: Designs for the robot

Learning Objective:

Design their robot to be both aesthetically interesting yet still highly functional.

Possible Teaching Activities/Learning Methods

Pupils produce 2 quick designs for their robots considering the points discussed in the last section.

Try to emphasize to the pupils that we are looking for designs that are interesting and exciting, but which are also practically effective. Even if using our 3D Print it is useful for students to design these pieces to see if they can consider practical constraints.

Teacher content: Designing the Robot

Discuss the designs with the pupils. Ensure they are considering the aspects discussed in the previous key considerations discussion.

Main Activity 3: Finalising the Design

Learning Objective:

- **Design their robot to be both aesthetically interesting yet still highly functional.**

In pairs - Pupils are to discuss their designs

Ask pupils to look at each other's designs and consider whether they are interesting and fulfil the requirements.

Refining the design: Once the pupils have discussed their ideas and written a review of each other's work, should now transfer their chosen idea to a full drawing of the design, consider colour.

Teacher Task: Refining the design.

discuss the designs with the pupils. Check key aspects such as suitable clearance for wheels, any holes do not damage the structure of the wheels & a suitable distance away from the edge of the acrylic, battery box suitably supported.

Phase 4: Review

Ask Pupils to review each other's designs looking for issues.

Lesson 3:

Topic: Manufacture Step: Soldering

Learning Objectives: Following the lesson pupils should:

- **Understand the steps necessary to solder effectively and apply principles to solder robot circuit board.**

Resources:

Distinctive Objects' Robot Board and components
Pre-made boards with errors (poor soldering, bridges, dry joints)

Opportunities for Assessment (Formative and Summative Assessment)

Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: Poor Soldering	**Learning Objective:** Analysis and Fault Finding

Starter Activity: Each pair of pupils is given a circuit board with faults – Students should examine the boards to see if they can identify the problems.

Discussion from this starter should lead into a discussion of common soldering faults and how they occur.

Key Aspects to identify.

- Dry Joint – wire moves in solder joint when 'wiggled'. Visual hole round component leg
- Joined Tracks – 2 or more of the IC holder's legs are joined.
- Stray Wires – Wires from motors etc. are too long and touching each other/ other tracks on the board.

Starter activity feedback: PRACTICAL DEMONSTRATION: Please show pupils correct soldering techniques:

Key Aspects to identify.

- Heating tracks and components equally
- Use of SILs to stabilise ESP32 etc.

Main Activity 1: Acrylic – Soldering	**Learning Objective:** Understand how to join electronic components to a PCB successfully

Teacher content:

Demonstration: Show pupils the correct way to solder - Soldering iron onto pad and component leg to pre-heat, solder introduced once hot.

Expected Pupil notes: Pupils to write the key terminology onto their workbooks and procedures of use.

Key points to derive:

PCB (Printed Circuit Board)

- PCBs are commonly a form of composite (glass reinforced fibre) with a conductive copper layer on top.
- Solder is an Alloy of different metals, designed to melt at low temperatures and conductive (tin is often the most substantial metal)
- For solder to work effective it needs to be put onto a pre-heated area as this allows it to flow easily.
- When soldering we start with the lowest profile components first to reduce the chance of them falling out.
- Commercial PCBs are commonly come with a coloured coating called solder resist; this is there to prevent solder flowing from one pad to another.

Student Activities/Learning Methods

Students to solder main circuit board.

Teacher content: Designing the Robot

Please circulate the room and discuss the designs and progress with the pupils. Ensure they are considering the aspects discussed in the previous key considerations discussion.

Review

Possible Teaching Activities/Learning Methods

Teacher to Introduce Target Setting:
Explain that they will be setting challenging targets each lesson which are then reviewed by a work partner.

Student Activity:
Pupils should fill in their own review of how well they have worked in the session.

Lesson 4:	Topic: Manufacture Step 4&5

Learning Objectives: Following the lesson pupils should:

- **Understand how wires are structured and methods necessary to ensure safe function.**

Resources:
ESP32 Robot boards and components
Motors and connecting wires (also cable ties to hold wires to body)

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: Recap from last lesson	**Learning Objective:** Understand how wires are structured and methods necessary to ensure safe function.

Teacher Task: Ask pupils to come up with as many technical terms and facts they can think of in relation to last week's learning.

Pupil Task: Once starter is discussed they should set their targets for session.

Main Activity 1: Manufacturing 2 - Adding wires to motors	**Learning Objective:** **Understand how metal rods and bars are marked out, cut and shaped in a school environment.**

Teacher content: Conductive wires and short circuits

Demonstration: Demonstration – Adding wires to motors.
Teacher to show how to strip the connecting wires and solder to the motor. Note that this can be made easier by temporarily removing the plastic strip at the back (this must go back on as it holds the motor to the gearbox)

Key points to derive/ for notes:

- Wires are covered by a plastic insulation to prevent conduction if they touch other metals/conductors.
- Only strip 5-10mm of wire so that it reduces the chance of wires touching the metal part of the motor.
- Wires come in solid core and stranded wires. With thin stranded wires it is wise to twist the strands together before soldering so that no stray wires can conduct accidently
- If we join two points which should not be joined with solder or a wire this can lead to a short circuit which can prevent the circuit functioning and can cause components to heat up and fail.

Main Activity 2: Students working on circuit boards and motors.	**Learning Objective:** **Understand how internal threads are shaped and be able to apply knowledge**

Teacher content: Supporting practical work.

Review

Possible Teaching Activities/Learning Methods: Discussion - Pass the question.
Teacher starts by asking 1 question based on learning from lesson. Student answers question then poses another question to another pupil.

Note: *Teacher needs to ensure that questions are spread round the group rather than individuals being asked more than once.*

Student Activity: Student Work partners fill in review section of student workbook:
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Lesson 5:	**Topic: Constructing the body**

Learning Objectives: Following the lesson pupils should:

- **Understand in what ways cardboard is an amazing material.**
- Understand how wires are structured and methods necessary to ensure safe function.

Resources:
Cardboard nets for robot main body
ESP32 Robot boards and components

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: Recap from last lesson	**Learning Objective:** Understand how wires are structured and methods necessary to ensure safe function.

Teacher Task: Ask pupils to come up with as many technical terms and facts they can think of in relation to last week's learning.

Pupil Task: Once starter is discussed they should set their targets for session.

Main Activity 1: manufacturing 2 - Adding wires to motors	**Learning Objective:** • **Understand in what ways cardboard is an amazing material**

Teacher content: Folding the Main body.

Demonstration: Folding the body
Teacher to show how to fold the body of the robot. Discuss the advantages of using card over other materials such as acrylic.

Key points to derive/ for notes:
- Corrugated cardboard is lightweight and has a high strength to weight ratio.
- It is easy to cut and shape.
- It is recyclable.
- The corrugations add structural strength while still allowing the card to be light.
- Industrially cardboard is shaped using processes called Die Cutting and Die folding.

Main Activity 2: Students working on circuit boards, motors and body.	Learning Objective: Understand in what ways cardboard is an amazing material.

Teacher content: Supporting practical work.

Review

Possible Teaching Activities/Learning Methods: Discussion - Pass the question.
Teacher starts by asking 1 question based on learning from lesson. Student answers question then poses another question to another pupil.

Note: *Teacher needs to ensure that questions are spread round the group rather than individuals being asked more than once.*

Student Activity: Student Work partners fill in review section of student workbook:
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Lesson 6: Topic: Manufacture Step

Learning Objectives: Following the lesson pupils should:

- **Understand the advantages of CADCAM and be able to give examples.**
- **Have a basic knowledge of 2D CAD systems – Techsoft 2D Design/ Onshape/ AutoCAD (whatever school uses).**
- **Be able to apply their CAD learning to produce their own wheel designs**

Resources:
Example of Wheels
2D Design or equivalent running on teacher's machine for demonstration

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: What is the advantage of designing and making using computers	Learning Objective: • Understand the advantages of CADCAM and be able to give examples

Teacher Task: Teacher asks pupils what the acronyms CAD and CAM stand for. Pupils asked to discuss in pairs/threes what they think the advantage of designing and making on computers might be.

Pupil Task: Discussion and challenge of others thinking *(Teacher controlled as necessary)*

Key points to derive:
- CAD – Computer Aided Design CAM – Computer Aided Manufacture
- Speed and Accuracy – Can achieve accuracy into fractions of a mm.
- Repeatability – Items can be cut numerous times with same level of accuracy and quality.
- Ability to send information to other parts of the world/ other stakeholders.
- Can be altered quickly and easily if design needs modification.

Main Activity 1: Using Techsoft 2D Design	Learning Objective: • Have a basic knowledge of 2D CAD systems – Techsoft 2D Design

Teacher content: Introduce pupils to 2D Design.

Demonstrate import of wheel template
Demonstrate use of basic tools including lines/ shapes/ fills/ cutting line segments
Demonstrate duplication tools.

Key points to derive:

- Need to leave outline and inner profile untouched.
- Need for there to be material holding the outer edge of the wheel together.
- Need to consider thin sections in the design.

Expected Pupil notes: Pupils to write the key terminology onto their workbooks and procedures of use. This can go on the back of one of the other sheets.

Main Activity 2: Student Independent Working on 2D Design	Learning Objective: Be able to apply their CAD learning to produce their own wheel designs

Teacher content: Practical Session

In this session teacher and technician should be supporting pupils independent learning.

Key points:

- Use mistakes and Questions as an opportunity to develop learning- DO NOT just correct without explaining what was wrong.
- Assist and advise as necessary throughout the session.

Review
Possible Teaching Activities/Learning Methods: Pass the Question Pupils and teacher play pass the question based on learning from the session.

Lesson 7&8	Topic: Manufacture

Learning Objectives: Following the lesson pupils should:

- **Completion of Practical assignments**

Resources:
Access to laser cutter
All components/boxes etc.

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Main Activity 1: Completing their design and manufacture	**Learning Objective:** •

Teacher role: Support completion of robots

- In these sessions the objective is for the students to complete/be nearly complete in their physical design

Expected Pupil notes: Target Setting

Lesson 9

Topic: Programmable Systems

Learning Objectives: Following the lesson pupils should:

- **Understand that many products are controlled by programmable systems.**
- **Understand how to connect the PictoBlox and how to check basic operation.**
- **Understand the key elements of programming Arduino.**
- **Understand how Outputs are defined and used.**

Resources:
Laptops charged.
Example of Code and working robot.
pictoblox software running on teacher's machine and on Laptops.

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: What products can be programmed?	**Learning Objective:** • **Understand that many products are controlled by programmable systems.**

Teacher Task: Teacher asks pupils to discuss what products or systems are controlled by programmable systems.

Pupil Task: Discussion and challenge of others thinking (*Teacher controlled as necessary)*

Key points to derive:

- Programmable systems can be changed and updated as necessary (E.g., PlayStation/ iPhones etc.) meaning features can be extended and improvements made.
- Programmable systems can be cheaper to maintain due to entire circuit boards needing to be replaced if issues arise.
- Examples: Phones, tablets, Traffic control systems etc.

Main Activity 1: Using Pictoblox environment	Learning Objective: • Understand how to connect the ESP32 and how to check basic operation

Teacher content: Introduce pupils to Arduino interface.

Demonstrate how to change board to ESP32.
Demonstrate how to set the COM port in the software.
Demonstrate opening, verifying and downloading motor tests.

Key points to derive:

- Need to wait for Serial to USB driver to install.
- Under Board – Set to ESP32
- Open guidance file (this shows how the motor driver works) and get them to try the first motor.
- Challenge them to change the motor to the other one and test, then how to programme both to come on at the same time.

Main Activity 1: Completion of all Manufacturing Steps	Learning Objective: Apply all manufacturing principles discussed in previous sessions

Teacher content: Practical Session, finishing physical item and programming.

In this session teacher should be supporting pupils independent learning.

Key points:

- Use mistakes and Questions as an opportunity to develop learning- DO NOT just correct without explaining what was wrong.
- Assist and advise as necessary throughout the session.

Expected Pupil notes: Pupils to write the key terminology onto their workbooks and procedures of use. This can go on the back of one of the other sheets. Pupils will also need to note down which of their pins is attached to which input/output.

Lesson 10:	Topic: Consolidation of previous learning and completion of task

Learning Objectives: Following the lesson pupils should:

- **Apply all manufacturing principles discussed in previous sessions**

Resources:
Access to programming guidance
Arduino, Robot Shields and components
Cardboard Bodies

Opportunities for Assessment (Formative and Summative Assessment)
Q&A feedback
Observation of discussion – teacher intervention
Assessment of workbooks

Cross Curricular Opportunities: Science/ Mathematics

Starter Activity: Intro to If/Else statements in Pictoblox	Learning Objective: Reinforcement of previous lesson's learning and objectives

Teacher Task: Teacher demonstrates how If and ELSE is used to control events based on the dabble instructions being received across the Bluetooth connection.

Pupil Task:

- Once starter is discussed they should set challenging targets i

Main Activity 1: Completion of all Manufacturing Steps	Learning Objective: Apply all manufacturing principles discussed in previous sessions

Teacher content: Practical Session

In this session teacher should be supporting pupils independent learning.

Key points:

- Use mistakes and Questions as an opportunity to develop learning- DO NOT just correct without explaining what was wrong.
- Assist and advise as necessary throughout the session.

Review

Possible Teaching Activities/Learning Methods: Examination of others work.

Teacher asks all pupils to lay out their work on demo table and asks them to examine where they are up to.

Student Activity: Student Work partners fill in review section of student workbook:

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