Amphibious Robotics and AI: Teaching a Turtle to Walk and Swim

Course challenge: Can students teach a turtle to recognise when it is on land, entering water, or fully submerged, and choose the right movement at the right time?

- Students collect and label sensor readings from the turtle.
- They use these examples to train an AI controller to select the turtle's movement.
- During a mission, the model classifies each new reading. The turtle uses its prediction to walk, pause during the transition, or swim.
- Programmed behaviours control the walking stroke, swimming stroke, and depth.
- Students investigate mistakes by comparing what the turtle sensed, what the model predicted, and how the turtle moved.

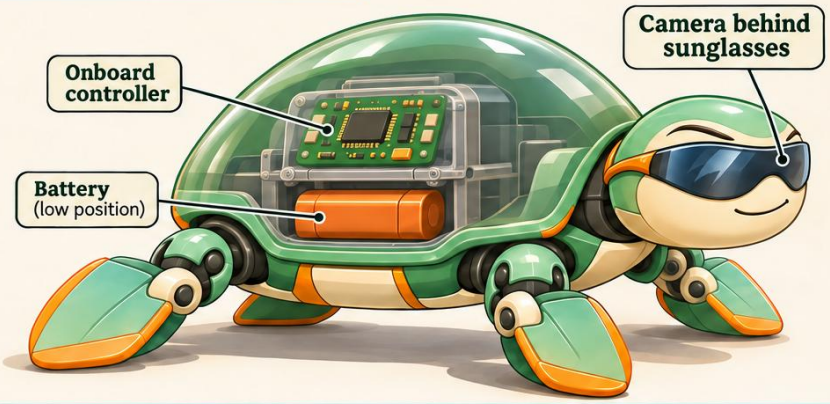
Suggested format: 12 sessions of 60–90 minutes for secondary-school students, working in teams of 3–4 and sharing a robotic turtle.



The classroom challenge

Can your team tell a splash from a dive? Film a trial, match the footage to the sensor readings, and explain the moment your turtle chooses to swim. Once underwater, track how closely it follows a target depth.

Inside the amphibious turtle





1 Flexible paddle feet
Articulated, wide paddles that walk on land and push water to swim.



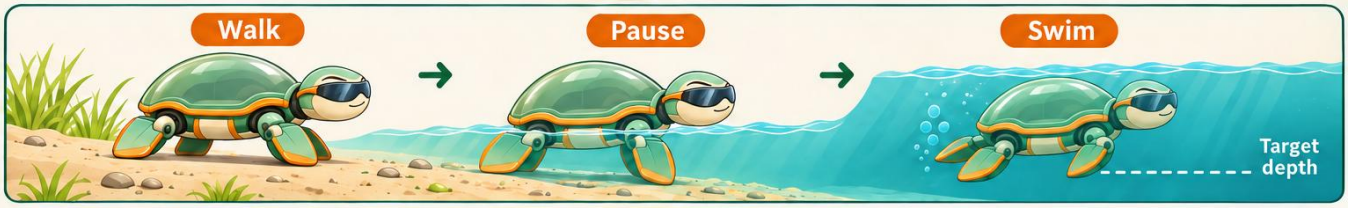
2 Water-contact pads
Water-sensing pads on the feet that detect when the turtle reaches the water.



3 Pressure sensor
Uses water pressure to estimate depth below the surface.



4 Onboard controller
Selects the gait and adjusts rear paddle angle to track the target depth.



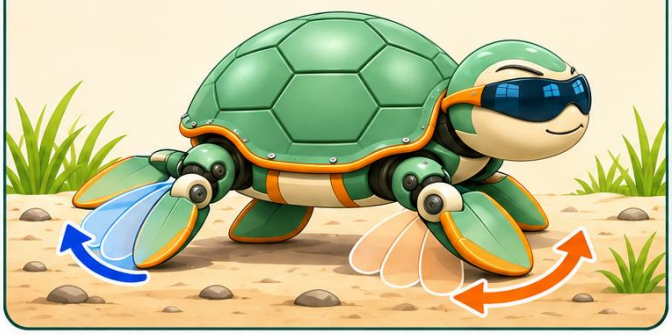


Contact + depth → Student-trained model → Walk / Pause / Swim

Measured depth → Depth controller → Rear paddle angle

Walk

Front: plant and push back.
Rear: staggered steps.



Swim

Front: sweep back, feather forward.
Rear: trail at a shallow angle.



Dive

Front: keep stroking.
Rear: tilt to lift the tail.



Hold depth

Front: steady strokes.
Rear: trim pitch to track depth.



COURSE OUTLINE

Twelve sessions with the turtle

Session	Learning focus	How students use the turtle
01	**Observe a turtle**	Compare animal footage with a robot trial. Sketch one limb through a complete stroke.
02	**Measure a walk**	Time three runs and use slow-motion video to identify grip, slip, and balance.
03	**Test buoyancy and trim**	Move a weight, then change flotation. Record how the shell tilts, rises, or sinks.
04	**Follow a target depth**	Graph depth during a swim. Measure how far the turtle overshoots as its rear paddles adjust its pitch.
05	**Write a baseline rule**	Test a hand-written switching rule on dry feet, splashes, and full immersion.
06	**Label a dataset**	Pair sensor readings with video. Label land, transition, and underwater samples, saving whole trials for testing.
07	**Train a decision tree**	Train a model on labelled examples. Trace one prediction from sensor input to movement choice.
08	**Investigate mistakes**	Replay a false swim command. Add examples of the difficult case and test the revised model.
09	**Run the model live**	Watch predictions with motors paused, then let the model select the turtle’s gait.
10	**Compare rule and AI**	Test both on the same unseen runs. Count false switches and measure delays.
11	**Predict swimming distance**	Measure distance at two stroke speeds. Use the data to choose a speed for a new target.
12	**Complete the mission**	Walk a marked route, lower the turtle into water, and swim through a target depth band.

What students take away

Each team presents a mission video, a graph comparing its AI with its original rule, and one design decision supported by evidence from the tank.