CODING GALAXY
CITY X

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Smart Agriculture

# Gardening Robot

## TEACHING PLAN

Ver. 1.0.1

HOUR OF CODE

TEACHING PLAN

# Gardening Robot

## Lesson Overview

In this lesson, learners will learn about a smart watering system through teaching, discussions, unplugged activities and a learning app. Learners will explore the factors affecting plant growth and understand real-world needs for a smart watering system. The components and design of the system will be introduced and learners will work through programming a simple controller.

**Audience**
Aged 10+

**Class size**
8–40 students

**Duration**
60 minutes

**Key concepts**

System, controller, conditionals, sensor

**Learning objectives**

By participating in this lesson, learners will:

- Identify the plant growth factors;
- Understand the need for watering systems;
- Understand the use of soil moisture sensors;
- Design a watering system;
- Identify the inputs and outputs of a watering system controller;
- Write conditional programs;
- Plot time series graphs.

**Lesson flow**

| | |
|---|---|
| **1. Introduction** | 10 mins |
| a. Growing a plant<br>b. Watering timing | |
| **2. Class activities** | 20 mins |
| a. Smart watering in Barcelona<br>b. Smart watering system and control | |
| **3. Self-directed learning** | 25 mins |
| a. Learning app | |
| **4. Wrap-up** | 5 mins |
| a. Reflection<br>b. Certificate presentation | |

# Teaching Guide

## Materials, resources and preparation

1. Review the *Hour of Code Educator Guide* and *Best Practices from Successful Educators* to plan your Hour of Code event.
2. Register your Hour of Code event and promote it with some fun posters.
3. Make sure to download the learning app in advance to the mobile devices that will be used (available for both Android or iOS smartphones and tablets). Also make sure those devices are fully charged.
4. Review the lesson and the resources first. Prepare the materials for the lesson: worksheets to hand out to the students.
5. Try out the quest in the learning app yourself. It contains a summary of the lesson topic materials and games to further and test your knowledge.
6. Each student who completes the lesson should receive a certificate. Print one for everyone in advance to make this easier at the end of your Hour of Code.

## Terminology

| | |
|---|---|
| **System** | A set of connected things that work together to do something. A system has inputs going into it and outputs coming out from it. Each part in the system has its inputs and outputs connected to other parts in the system. |
| **Input and output** | An input is something that goes into a system or a part, while an output is something that comes out from a system or a part. An input to a part may be an output from another part. |
| **Controller** | The part in a control system that computes what to do in order to regulate the system. The input to the controller may be sensor signals (e.g. a thermometer) and manually set target values (e.g. keep the room warm). The output from the controller is a signal for the actuator to do something to the system (e.g. turning on the heater if the temperature is too low). |
| **Sensor** | A device that measures a physical quantity from its environment and converts it into a signal which can be read by another device. For example, a thermometer has a temperature sensor that detects the temperature, and electronics to convert the signal and display the value for us to see. |
| **Conditional** | A statement or structure containing a condition and actions that are only performed if the condition is met. |

# Lesson plan

## 1a Introduction: Growing a plant

5 mins | Worksheet p.1

**Motivation of topic with growing a plant.**

The teacher may ask students whether they have experience in growing a plant. Invite students to share their experience, including the procedures, how to take care of plants, and the plant growth process.

Complete Worksheet Part 1.

Discuss the factors affecting plant growth. Proper temperature, water, nutrients, and sunlight are important factors. To provide the best environment for plant growth, we should take care to control these factors.

This exercise aims to raise interest in growing plants, and deliver a basic understanding of it, bridging to our main topic about watering plants.

## 1b Introduction: Watering timing

5 mins | Worksheet p.1

**Understand the need for watering and a smart watering system.**

Plants mostly absorb water through the roots, so we can examine the water content in the soil to determine if they need watering. Let's have a look at a soil moisture graph.

Complete Worksheet Part 2.

**1. Reading the soil moisture graph.**

Guide students to read the soil moisture graph on the worksheet. The graph shows how the soil moisture changes with time. The soil is wetter higher up the graph and drier lower down the graph, and time progresses from left to right.

Ask students: *Why are there variations in the soil moisture level?* It is affected by weather. For example, when it rains, the soil becomes wet, whereas sunny days dry up the soil.

Guide students to identify events on the graph, for example, high peaks are probably after rain, and troughs are probably after a period of dry weather.

**2. Watering the plants when needed.**

Ask students: *When should we water the plants manually?* We should water the plants when the soil is dry, and stop watering if the soil is wet. We probably don't want to water the same amount everyday, as some days are dry and some are wet. Rainy days may already provide enough water for the plants so we should not water them.

Ask students to mark when we should water the plants on the graph.

To wrap up and lead into the topic of smart watering systems, elicit students to think: "*If we cannot constantly tend to and water the plants when needed, are there any ways to help us?*"; "*Can you think of ways to apply technology to solve the watering problem?*"

## 2a Class activity: Smart watering in Barcelona

5 mins | Worksheet p.2

**Read about smart watering in Barcelona.**

Complete Worksheet Part 3.

Read with students an excerpt from a news article on the smart watering system in Barcelona.

With the excerpt, guide students to appreciate smart watering systems, including their advantages, challenges and operations. Smart watering systems save effort and water by automatically monitoring the soil and watering the plants. Some challenges include the cost and maintenance of the underground components, which may be damaged by nature or pests.

Optionally allow students to research on real-world applications and news about smart watering or irrigation.

## 2b Class activity: Smart watering system and control

15 mins | Worksheet p.3

**Putting together a smart watering system.**

Look at Worksheet Part 4.

**1. The soil moisture sensor.**

Ask students: *If we want to design a smart watering system, what information does it need to determine when to water the plants?* Remind students of the soil moisture graph. We measure the water content in the soil with a soil moisture sensor.

Optional information: The soil moisture sensor measures the dielectric permittivity of the soil, which is determined by the water content of the soil. The sensor averages the measurement over the length of the sensor.

**2. Components in the watering system.**

Guide students to design a smart watering system. Think about: *What components are there?* And *what external resources are needed?*

Elicit answers from the students and introduce the components: A soil moisture sensor to measure the water content in the soil; A sprinkler to water the plants; A controller to determine when to turn on the sprinkler.

For external resources, all the components need electricity to run, and the sprinkler needs water.

**3. The controller.**

Explain that to control the soil moisture level, the controller is programmed to respond to different soil moisture measurements from the sensor and tell the sprinkler to turn on and off accordingly.

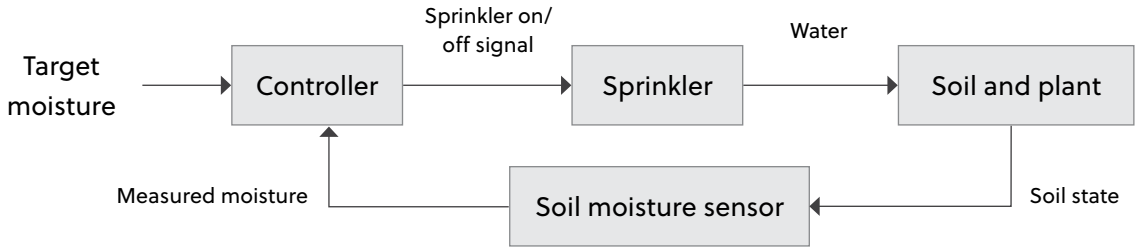
Explain the concepts of input and output: The soil moisture measurement is the input to the controller and the signal to turn the sprinkler on or off is the output of the controller. Each component has inputs and outputs. Ask students to think about the inputs and outputs for the other components. The components should connect so that their inputs and outputs match, and so we can draw a diagram to represent the whole system.

**4. The control system.**

Explain how the system works: The components form a control system for the soil and plant. We can specify the target range of soil moisture in the controller, so it can calculate if the current soil moisture is too low or too high. We want to turn on the sprinkler if the soil moisture is too low, and turn off the sprinkler if the soil moisture is too high.

Draw a diagram of the system in the worksheet.

In a block diagram, we draw the components as blocks, and the things that pass from one block to another as arrows (outputs from one block and inputs to the next block).




## 3 Self-directed learning: Learning app

25 mins

Log in to the learning app and complete the Quest "Gardening Robot".

Each mission in the quest will provide some short reading materials to summarize the main points of the topic. Then students will then take a quiz, which prompts them to recall or look up the knowledge, and to think about questions that test their understanding.

The teacher can go through the first mission to review together with the students while familiarizing with the app. **Mission 1** concerns the factors for plant growth and the need for a smart watering system.

**Missions 2** and **3** are about the smart watering control system, the soil moisture sensor, and inputs and outputs for the controller.

**Mission 4** requires students to code a controller program using a block programming interface. Here, multiple conditionals are used to turn the sprinkler on or off, and a loop is used to keep the program monitor the soil moisture continuously.

In a "while" loop, the code inside the loop is repeated as long as the "while" condition is true. At each iteration of the loop, we record the current time and the soil moisture data from the sensor, and plot a graph of the record history.

In a conditional structure, we first specify the condition to check for ("if ..."), and if the condition is satisfied, the subsequent code is run ("then ..."). We check if the moisture is lower than a threshold value, we will run the "turn on" function in the sprinkler program; and if the moisture is higher than another threshold, we will run "turn off" in the sprinkler program.

The teacher should observe and help individual students if they have problems. Afterwards, the teacher can ask students to reflect on what they have learnt through the app.

## 4 Wrap-up

5 mins

Discuss with students to reflect on the lesson:

1. What are the benefits of a smart watering system?
2. What is a system and how can we apply a controller to improve it?
   A system is a set of connected components. A controller can observe what is happening with the help of a sensor, and calculate what to do accordingly to regulate the process in the system.
3. How can we apply the concepts and ideas from the smart watering system to control the other factors for growing plants, or to other problems in daily life?
   For example: controlling the temperature for growing plants; an automatic food dispenser to feed pets.

To wrap up the lesson, let students reflect on the problems they encountered in order to better understand their learning process and motivate them to learn.

Celebrate and hand out certificates to students.

**Beyond one hour**

This lesson is part of a curriculum about smart city with concepts and applications of technology including artificial intelligence (AI), blockchain, big data and the Internet of Things (IoT):

Learn more about the Coding Galaxy: City X curriculum.