

**TABLE 1: Structure of the Curriculum [Xu, 2020]**

**Goal:** Design a smart greenhouse with a microcontroller and sensors to collect data and answer a relevant research question

Table 1 is very useful for teachers in planning their lessons and implementation. It is a very useful guide that contains learning goals, activities and suggested topics for reading. We suggest that, teachers use this table as a lesson plan.

Day	Topic	Goals	Learning Activities	CS/Tech	Reading Materials
1	Course Overview	<ul style="list-style-type: none"><li>• Learn the science of smart, automated greenhouses.</li><li>• Understand microcontrollers, Python, and import statements.</li></ul>	<ul style="list-style-type: none"><li>• Introduce students to real-world greenhouses.</li><li>• Conduct interactive coding in Python</li></ul>	<ul style="list-style-type: none"><li>• Use Python to perform basic arithmetic operations on the microcontroller.</li></ul>	How do greenhouses work?
2	Light and Plant Growth	<ul style="list-style-type: none"><li>• Understand how colors of light affects plant growth.</li><li>• Program the LED strip to mimic professional grow lights.</li></ul>	<ul style="list-style-type: none"><li>• Watch a video on photosynthesis.</li><li>• Understand the light spectrum.</li><li>• Program the LED strip.</li></ul>	<ul style="list-style-type: none"><li>• Create instances of objects.</li><li>• Use functions (methods) to modify states of objects and passing function arguments (Parameterization)</li><li>• Use lists (data structures) to control colors of light.</li></ul>	Can plants “see” light?
3	Light and Plant Growth	<ul style="list-style-type: none"><li>• Understand how intensity of light affects plant growth and the relationship between light intensity and distance to light source/color.</li><li>• Program the digital light sensor to measure light intensity in lux.</li></ul>	<ul style="list-style-type: none"><li>• Use the light sensor to measure light intensity from the LED strip.</li><li>• Hypothesize the nature of the relationship between distance to the light source and light intensity.</li><li>• Graph the light sensor readings at different distances to test the hypothesis and understand the relationship.</li></ul>	<ul style="list-style-type: none"><li>• Continue using functions (methods) with return values to read light intensity values in lux.</li><li>• Use loops to measure data at specific intervals.</li></ul>	Light intensity and duration impact on plant growth

Day	Topic	Goals	Learning Activities	CS/Tech	Reading Materials
4	Temperature/ Humidity and Plant Growth	<ul style="list-style-type: none"> <li>Understand how change of temperature affects (relative) humidity (think as a system).</li> <li>Program temperature and humidity sensors to measure these two values.</li> </ul>	<ul style="list-style-type: none"> <li>Watch a video on how temperature/humidity affect the photosynthesis/respiration.</li> <li>Learn to collect data and automatically transmit data to other devices.</li> </ul>	<ul style="list-style-type: none"> <li>Understand how data is communicated between networked devices.</li> </ul>	Temperature/ humidity and plant growth
5	Treasure Hunt With Live Data Visualizations	<ul style="list-style-type: none"> <li>Make scientific hypotheses and use scientific reasoning with empirical data.</li> </ul>	<ul style="list-style-type: none"> <li>Game: Treasure hunt. Select groups of students to hide temperature/humidity sensors somewhere in the classroom for others to locate using live data visualizations.</li> </ul>	<ul style="list-style-type: none"> <li>Read real-time data visualization and make scientific arguments.</li> </ul>	N/A
6	Manipulation of Temperature/ Humidity in Greenhouses	<ul style="list-style-type: none"> <li>Design an experiment to test hypotheses.</li> <li>Use actuators (servos, relays, and fans) and “if” statements to achieve automation.</li> </ul>	<ul style="list-style-type: none"> <li>Come up with a scientific hypothesis on how variables (temperature, humidity, light intensity, etc.) affect plant growth. Design a smart greenhouse that can manipulate these variables and collect data that helps support the hypothesis.</li> </ul>	<ul style="list-style-type: none"> <li>Use if conditionals to achieve automation using sensor data and actuators.</li> </ul>	N/A
7	Design and Build the Greenhouse	Students continue to design and build a smart greenhouse that could help them support their hypotheses or answer research questions that they came up with in Lesson 6.			