4. OPTIMIZE WATER MOVEMENT IN A GREENHOUSE

Project Overview

Students use an EcoChamber and a //control.Node along with all Greenhouse inputs (temperature, humidity, brightness, soil moisture) and outputs (USB Fan, USB Pump, Grow Light) to investigate ways humidity can be manipulated in a Greenhouse and write a program to identify an ideal plant choice based on Greenhouse sensor measurements.

Time Requirements

Teacher Preparation: 10 minutes

Student Project: 2 or more 45 minute class periods

Goals

- Use temperature and humidity data to optimize Greenhouse program design.
- Use lists or arrays to simplify computational tasks in a program.

Materials and Equipment

- Data collection system
- //control.Node
- Grow Light with included cables and USB power adapter
- Greenhouse Sensor
- Greenhouse Sensor Module with cable and stopper
- Soil moisture probe
- USB Fan
- Power Output Module with cable
- EcoChamber with lid and stoppers
- Small cup or beaker half-filled with tap water
- Plant pot, ~4" x ~4", filled with soil
- Sponge, 2" x 2" square
- Plastic caps from water or soft drink bottles (3)
- Zip-seal plastic bag, quart-size

Teacher Tips

- For best results, fully charge wireless devices before starting the investigation.
- For long-term investigations, it is recommended to connect the //control.Node to continuous USB power.
- For Blockly help, enter code-related search terms in PASCO's online Blockly reference guide at **help.pasco.com/sparkvue**. The guide is also accessible from the **Help** option in SPARKvue's main menu while data collection is stopped.
- For helpful Greenhouse videos, visit PASCO's Greenhouse Sense and Control Kit video library (**click here** or scan the QR code).
- This investigation requires background knowledge of Blockly variables, loops, functions, accessing Greenhouse Sensor measurements, operating the Power Output Module, creating numeric and text outputs, working with the USB fan, and creating data displays. To establish prior knowledge, consider having students complete the coding investigations titled *Program a Sunny Day for Plants*, *Code a Cooling Breeze for a Greenhouse*, and *Program Perfectly Timed Rain* before performing this investigation.
- This investigation will require 2 days for most students to complete. Parts 1 and 2 are to be completed on Day 1 and the remainder of the investigation is to be completed on Day 2. To maximize hands-on time, have students complete Part 3, step 21 before starting the investigation.
- Have nearly dry potting soil available for students (or other soil as desired); students will need a data point for "dry" soil. Make sure the soil is not so dried out that it fails to retain added water, and not so moist that it would not be suitable for plants that prefer mostly dry soil.

- Students will work with a live plant in the fifth lab investigation in the Greenhouse series titled *Program a Greenhouse Sense and Control System*. If you plan on completing that investigation, review Appendix A to make sure the listed plants are available in your area. Revise the list if necessary. Remind students to save their SPARKvue file and set aside their pots with "perfectly" moistened soil for use in the final investigation.
- A few weeks before starting this investigation, ask students to bring plastic bottle caps to class until you have collected 3 similar-height caps for each student group.
- Optional: Use the Greenhouse Sensor to further explore the relationship between temperature and humidity in a larger system like the classroom or outdoors. Connect observations of annual and perennial plant life cycles to daily weather conditions and yearly climate patterns. Include soil moisture measurements to see how land moisture levels change with atmospheric conditions.

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Don't allow exposed electronic boards to contact a metallic or conductive surface.
- Keep water away from sensor boxes, electrical plugs, and exposed electronic boards.

CAUTION:

- *Don't look directly at the LEDs.*
- *Don't touch the LEDs.*

Prototype

Part 2: Investigate Humidity and Temperature (Day 1)

Table 1. Temperature and Relative Humidity Performance Over One Minute under Different Conditions

Condition	Starting Temperature (°C)	Ending Temperature (°C)	Temperature Change (°C)	Starting Relative Humidity (%)	Ending Relative Humidity (%)	Relative Humidity Change (%)
Control	22.9	22.9	0	51.4	51.5	0.1
Fan	22.9	22.9	0	51.5	49.3	-2.2
Fan + sponge	22.9	22.9	0	49.6	53.6	4.0
Fan + water	22.9	22.8	-0.1	50.2	54.5	4.3

16. Review the results in Table 1. Share your conclusions for each greenhouse condition in the spaces provided; your conclusions will help you balance soil moisture control with optimal greenhouse air temperature when you are ready to add a plant to your Greenhouse.

    a. What happened to temperature and relative humidity when nothing was changed either inside or outside the Greenhouse (control condition)? Explain the result.

    Temperature and relative humidity were stable. No changes were introduced to either the system or its surroundings, so you would not expect either measurement to change.

    b. What happened to temperature and relative humidity when the fan blew air into the Greenhouse? Explain the result.

    Turning the fan on reduced relative humidity but temperature remained stable. Increased air circulation from the fan moved drier air into the chamber.

    c. What happened to temperature and relative humidity when water vapor is drawn into the Greenhouse through the fan? Explain the result.

    Relative humidity increased due to water vapor moving into the chamber but temperature remained stable.

    d. What happened to temperature and relative humidity when standing water was added to the chamber with the fan running? Explain the result.

    Relative humidity increased and temperature showed a small decrease. Since the water was evaporating from *inside* the chamber instead of *outside* the chamber, chamber air temperature dropped when the water absorbed energy from it to change from a liquid state to a vapor. The evaporated water removes heat when it leaves the chamber.

Part 3: Use Lists in a Program (Day 2)

Table 2. Criteria for Indoor Temperature, Humidity, and Light Conditions

Measurement	High	Medium	Low
Temperature	Above 75 °F	Between 63 and 75 °F	Below 63 °F
Humidity	Above 55 %	Between 42 and 55%	Below 42 %
Brightness	Above 42 %	Between 28 and 42%	Below 28 %
Your measurements:	*Temperature = medium, humidity = high, light = low*		

20. Switch to the data display and test the code. Working code will display Status A, B, C, or D in the Status **Digits** display; revise code if necessary. Describe how the *for each item* loop works for this particular code, and suggest a different way to set up the "*get last*" part of the code.

    The loop checks each of the four sub-lists one item at a time. When matches for sensor-measured item values are found, the *Status* text output displays the last item in the sub-list. Instead of using *get last* in the code, you could use *get #4* since the last item in each sub-list is the fourth item.

21. Determine the total number of possible temperature, humidity, and brightness combinations. On a separate sheet of paper, refer to Appendix A to create a table that identifies <u>one</u> plant for each possible temperature, humidity, and brightness combination. Add a column for the plant's watering preference. You must use all 10 types of plants, and many plants can be used more than once. There are many correct answers, so it is not likely for any 2 groups to have identical tables.

    There are 27 possible temperature, humidity, and brightness combinations. If students struggle to come up with the possible combinations, have them use a systematic approach such as list all the light level possibilities that start with high temperature and high humidity; then move to high temperature and medium humidity; etc. See the sub-lists in the sample code provided in the Improve section for one possible table.

    Student answers will vary; there are plenty of choices to make; no two groups are likely to develop identical lists.

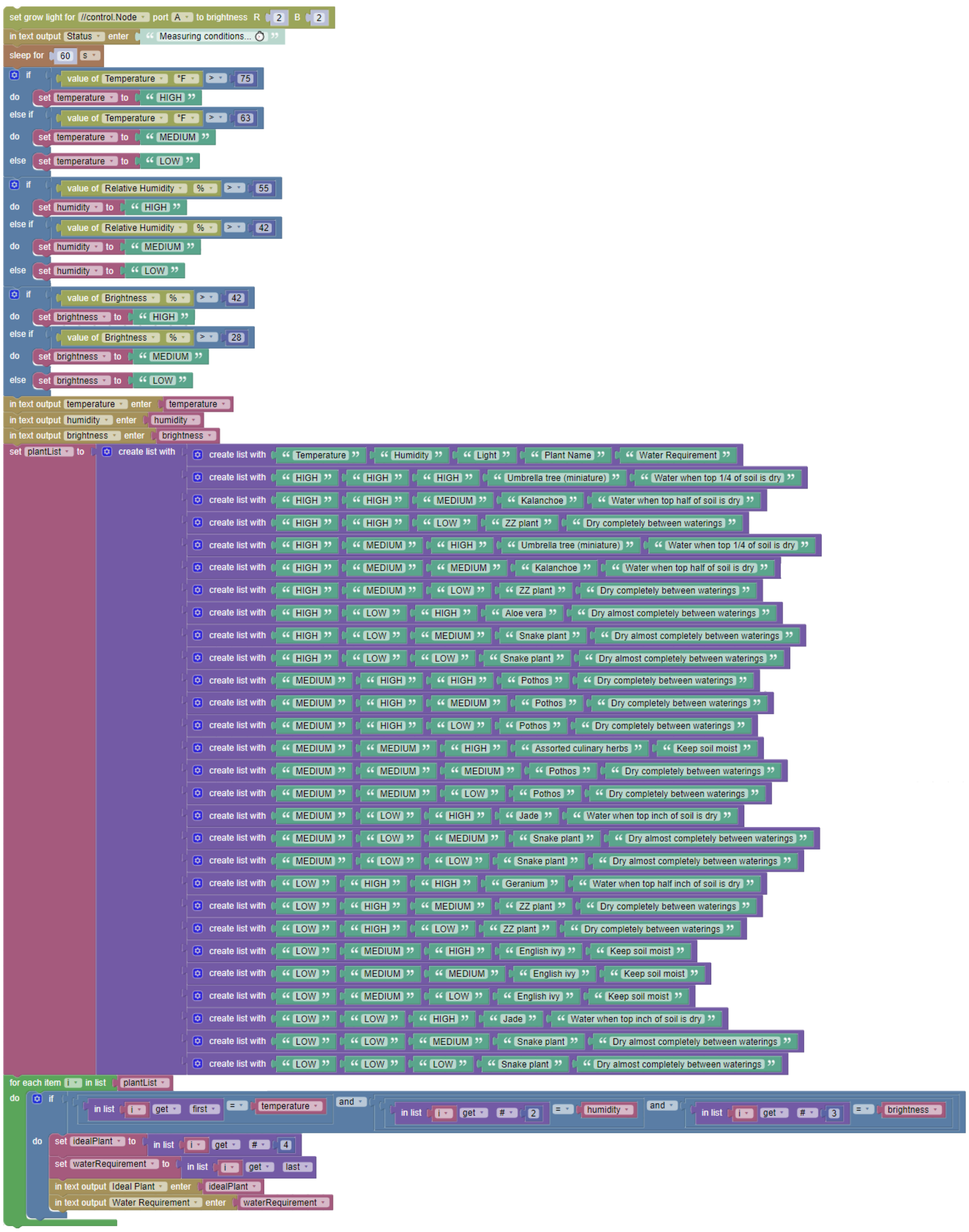
Test (Day 2)

4. Measure dry soil moisture level and record results in the space below.

   Dry soil = 2 %

Sample Results

(a) See Table 2 for sample measurement results. Plant name: Pothos. Water requirement: Dry completely between waterings. Dry soil: 2 % VWC (loam); ideally moist soil: 15 % VWC (loam). (b) Sample code below:

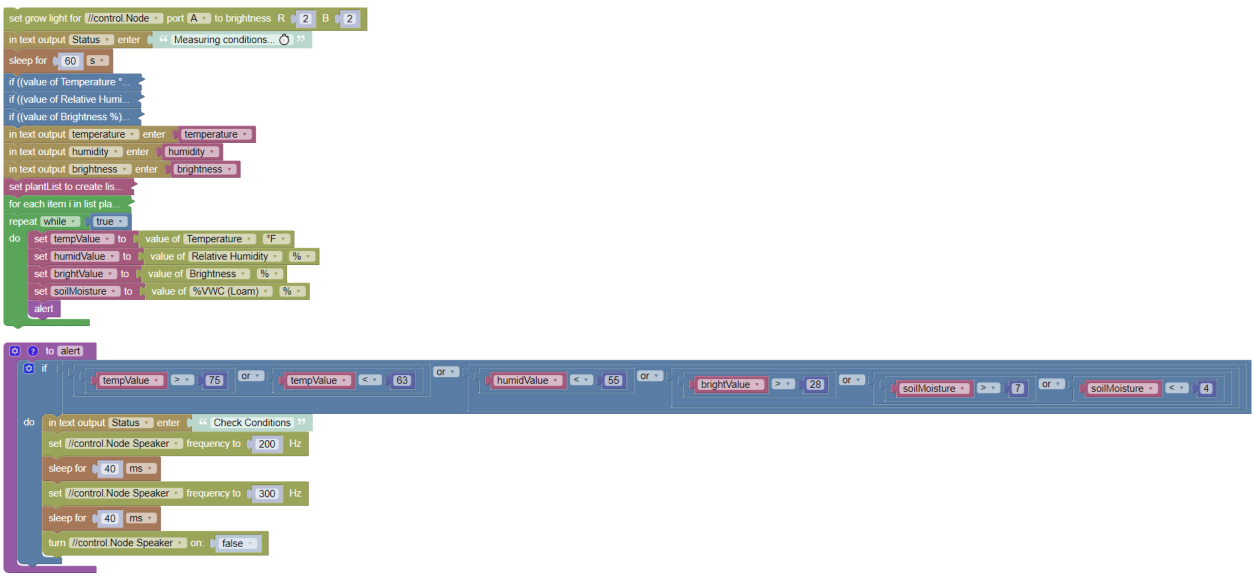


(c) Humidity is already high in the Greenhouse even before adding a plant, and pothos plants can tolerate either high or medium humidity. So running the fan periodically might help keep water movement in the Greenhouse ideal.

Improve (Day 2)

- Use a **Table** display instead of a **Digits** display to show plant identity and watering requirements in a table.
- Create text and audio alerts to indicate when temperature, humidity, brightness, and soil moisture conditions are outside the identified plant's ideal range.
- Use the dry soil moisture data as well as ideal soil moisture data to program the automatic watering system for a range of moisture levels the identified plant can tolerate.

Sample code for second bullet (unchanged code from Test is collapsed)



Technical Support

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