**Development of a Greenhouse Temperature Control System**

Equipment Needed:

* Arduino
* Jumper Wires
* Computer Fan
* Resistive Heater
* Temperature Sensor (such as TMP37)

*Equipment Notes:* If you do not have a resistive heater or computer fan, these can be replaced with two, different colored LEDs to simulate the experience.

Learning Objectives:

* Feedback control loops
* Programming
* Temperature Sensors
* Digital Logic

Description for Instructor:

This PBL is designed to provide students with the opportunity to improve their programming skills while also learning about feedback control theory through practical application. The student will create a system that is to control the temperature inside of a greenhouse. You may simulate the temperature with a cold soda and your own body heat to raise and lower the temperature of the temperature sensor in order to cause the heater or fan to turn on respectively. To go a step further, you can have the student design a small greenhouse model that the fan and heater can fit inside of utilizing CAD software and then have them fabricate it through traditional or additive-manufacturing techniques. This expanded version of the PBL is discussed as well within the respective heading.

Description for Student (Standard Version):

You have been tasked with designing a temperature control unit for the new greenhouse! The owners would like to use resistive heating and fan cooling for their structure. They have indicated that for this particular greenhouse they would like to maintain as close to 72 °F as possible but have indicated that they are willing to accept ± 1 °F. You will be able to use the supplies at your station in order to complete this task.

Description for Student (Expanded Version):

You have been tasked with designing a temperature controlled greenhouse! The owners would like to use resistive heating and fan cooling for their structure. They have indicated that for this particular greenhouse they would like to maintain as close to 72 °F as possible but have indicated that they are willing to accept ± 1 °F. You will be able to use the supplies at your station in order to complete this task.

Standard Version Instructions:

Using the supplied Arduino and peripherals, develop a temperature control system for the greenhouse. Your system should begin a heating process if the temperature is below 71 °F and a cooling process if it is above 73 °F. You will need to show flowcharts, the written program, a wiring schematic, and a working system. You will also be required to develop a one-page technical report detailing your design, design process, and future work. Be sure to explain what would happen if you were to set the temperature for 72 °F exactly.

Expanded Version Instructions:

Your first task is to design a small greenhouse structure that can appropriately house your control system, heating element, and fan (including an appropriate method of intake/exhaust). Before manufacturing, you will need to get approval of your working drawings from your client and project manager. Once you have their approval you may begin the manufacture process. Once your greenhouse structure is approved you may move on to developing the temperature control system.

Using the supplied Arduino and peripherals, develop a temperature control system for the greenhouse. Your system should begin a heating process if the temperature is below 71 °F and a cooling process if it is above 73 °F. You will need to show flowcharts, the written program, a wiring schematic, and a working system. You will also be required to develop a one-page technical report detailing your design, design process, and future work. Be sure to explain what would happen if you were to set the temperature for 72 °F exactly.

Notes to the Instructor:

This PBL can also be expanded to include project planning and management skills. You can have the students develop Gantt charts, budgets, oral presentations, written presentations, and more.