Project Overview:

A drought in South Africa has caused a famine in Zimbabwe and local students are quitting school and soccer to stay home and help grow food for the family. What can be done differently in regards to the watering of crops to allow students to stay in school, instead of working the fields?

In this TI-Innovator™ project, students will design a smart irrigation system that could be used to monitor and meter water from a rain collection cistern that might be used to irrigate a small family garden in Zimbabwe. This model also applies to other related scenarios where "smarter water" usage makes sense. For example, water restrictions are often put in place during the hot summer months in areas of excessively hot and dry climates. A smart water irrigation system could alleviate some of these restrictions as well, if people are smarter about the way they water their yards.

Students will have to utilize math skills, computer programming and engineering to design and build a smart watering system to solve a real world problem like the drought in Zimbabwe or, even the problem right in their backyard! Students can explore related topics such as the water cycle, soil types, and/or native plant needs.

Students will accomplish the following Student Tasks as they design a smart irrigation system:

- ✓ Students will write and execute "Hello World" program with the intent of introducing the basic skills and knowledge to write a program on the graphing calculator
- ✓ Students experience identifying and writing down the steps in a repeated pattern, physical actions to turn a light on and off repeatedly. Experience with controlling a digital output, blinking an LED. Introduction to For loop as a way to execute a repeated pattern
- ✓ Students complete the blink an LED program. Apply knowledge from previous sessions: outputs, For loop, design/plan before coding.
- ✓ Students learn about inputs from sensors (brightness sensor) and if-then-else decision logic to control an output (sound) based on the sensor readings.
- ✓ Students learn about external inputs from sensors (light level sensor) and if-then-else decision logic to control an output (sound) based on the sensor readings
- ✓ Students extend the solution from previous tasks to apply to the other external input/output devices that will be part of the Smart Irrigation project including: Digital Humidity and Temperature Sensor (DHT), soil moisture sensor, MOSFET and water pump.
- ✓ Given the design challenge, a graphing calculator, a TI-Innovator™ Hub, sensors and outputs; students will design, build and code a solution to the posed challenge. Overall structure of the control program should be part of the design process.
- ✓ Team Presentations to explain their solutions to the problem. These can be in the form of a traditional presentation, or a gallery-walk style to encourage a more interactive peer review of student designs.

Background Science:

Refer to the science background information covered in the Teacher Resources_PPT and share these additional resources with students as desired. Web links on these science topics can also be found in the Teacher Resource PPT and the resources section below.

Compatible TI Technologies and Materials:

The Smart Water project is compatible with the following technologies:

- TI-Nspire™ CX Handhelds (update to OS 4.5), or
- TI-84 Plus CE calculators,(update to OS 5.3) and
- TI-Innovator Hub (sketch vs.1.3) (1 per group of 3-4 students)
- *Optional*- TI-Nspire Teacher Software or TI-Connect CE computer software (to lead and guide students through typing code in to the calculators)

In addition to the above TI technology, the following materials are also required, per group of students building the model:

- 4 AA Batteries and Battery Holder
- Temperature & Humidity Sensor
- Moisture Sensor
- Light Sensor
- MOSFET
- Water Pump Motor DC 3V Mini Submersible Water Pump for Fountain Aquarium 120L/H Max Lift 3.6FT
- 2 male to male breadboard jumper cables
- 1/4" I.D. (Inner Dimension) x 3/8" O.D. Outer Dimension) tubing.
- Drinking straws
- Duct Tape
- 1 Gallon milk jug
- *Perlite or other medium/soil for plants to grow in
- *Fast germinating seeds like radish, lettuce or similar

**Optional- If desired, the project can be continued over a longer period of time where the watering water system can be leveraged to grow an indoor garden*.

Note: For more information on the TI-Innovator accessories and sensors, and how to purchase, visit https://education.ti.com/en/products/micro-controller/ti-innovator?category=accessories

Recommended Grade Level and Experience:

- This project is appropriate for students in grades 7-12, although at the earlier grade levels, more time may be required to establish an understanding of the underlying science concepts.
- Some prior coding experience is strongly suggested and familiarity with the graphing calculator is a must.
- *The "DIY Mood Ring" project is considered the entry point for the "STEM Projects using TI-Innovator™ Technology". It is strongly suggested that if your students do not have much familiarity with the coding on the TI calculator, they complete the Mood Ring Project first and/or complete the 10 Minutes of Code Lessons.*

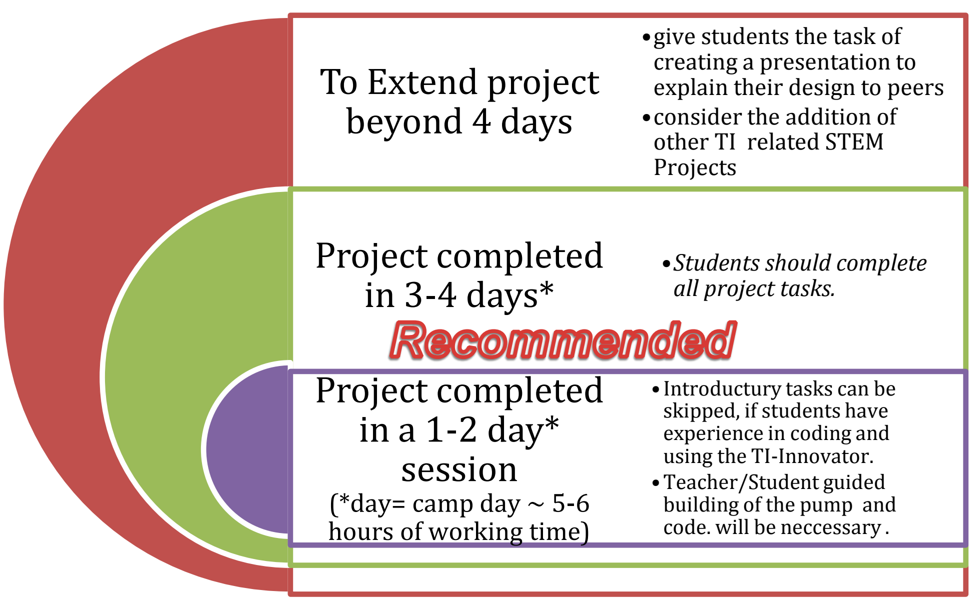
Standards:

NGSS 3-D Standards:

- MS-LS2: Ecosystems Interactions, Energy, and Dynamics.
  - How and why do organisms interact with their environment and what are the effects of these interactions?
- Science and Engineering Practices:
  - Constructing Explanations and Designing Solutions.
- Crosscutting Concept- Cause and Effect.
  - Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Pacing Guide:

- The project can be adapted for a variety of time lengths and environments including, but not limited to, after school clubs, project-based STEM camps, in-class special projects, etc. If time is an issue, and students do not have much previous experience with coding, you may choose to give them parts of the program(s) to modify and then walk them through the construction.
- *Note: The "DIY Mood Ring" project is considered the entry point for the "STEM Projects using TI-Innovator™ Technology". It is strongly suggested that if your students have limited experience with the coding on the TI calculator, they start with the Mood Ring project first to build coding skills and confidence, and then progress to more complex projects like the Pet Car Alarm, or Smart Water project.*



Project Outline, Description of Student Tasks, and Classroom Presentation:

The following slides have been taken from the **Smart Water_Classroom Presentation PPT**. The Classroom Presentation PPT is designed to be used in the classroom/camp to guide students through the tasks they will complete. Although it is strongly recommended that students begin with the introductory project "DIY: Mood Ring", references to the 10 Minutes of Codes lessons that support the coding skills utilized in this project, can be found in the slide notes and below in the outline. *Note that if students have already completed the related STEM projects: DIY: Mood Ring project, and/or the Pet Car Alarm project, some of the initial tasks will be familiar to students, but will provide a good opportunity for review of skills.*

1. ***Project Overview and Introduction to Programming***

   Summary: Students are acquainted with the Smart Water project and a review of the calculator platform and basic coding. Students are tasked to create and execute a program to display "Hello World". If students struggle with the initial task, and have not yet completed 10 Minutes of Code lessons previously, it is recommended that they do so before moving forward with this project.

   ✓ Student Task: Write a program that displays "Hello World" on the calculator using the Disp command. *Note that if the student has done the related Mood Ring project, this task will likely be review, and will test their recall of basic coding skills.*

   ✓ If students struggle with the above task, refer students to the following 10 Minutes of Code lessons for review, or to get an introduction to coding before moving forward.

   ➢ **For TI-84 technology: https://education.ti.com/en/activities/ti-codes/84/10-minutes**

   - Unit 1: Program Basics and Displaying on the Screen
     - SB 1: Using Program Editor and Syntax
     - SB 2: Editing the Programs Clearing the Screen
     - SB 3: Output to the Home Screen ***(****optional****)***
     - Application: Create a Title Screen ***(****optional****)***

- Unit 3: Conditional Statements (If…)
  - SB 1: Conditions and the If Statements
  - SB 2: If…then…end and compound conditions
  - SB 3: If…then…else statements ***(optional)***
- Unit 4: Repetition
  - SB 1: For…Next…statements

- **For TI-Nspire CX technology: https://education.ti.com/en/activities/ti-codes/nspire/10-minutes**
  - Unit 1: Program Basics
    - SB 1: Introducing the Program Editor
    - SB 2: Arguments and Expressions
  - Unit 3: Conditional Statements
    - SB 1: Request and If
    - SB 2: If… Then… Statements
    - SB 3: If…Then…Else…Statements
  - Unit 4: Repetition
    - For…Next…Statements

2. ***Introduction to the TI-Innovator Hub***

Summary: Students are acquainted with the TI-Innovator Hub. Students will create and execute a program using COLOR command to display different colors using the Red-Green-Blue LED, and also write a program to blink the LED.

✓ Student Task: Write a program that explores the different colors produced on the Hub RGB LED by setting the red, green and blue components with the COLOR command.
- Extension: Using a For loop, blink the RGB LED10 times.

✓ If students struggle with the above task(s), refer students to the following 10 Minutes of Code lessons for additional review or instruction, before moving forward.

- **For TI-84 Plus CE technology**: https://education.ti.com/en/activities/ti-codes/84/10-minutes-innovator
- **For TI-Nspire CX technology:** https://education.ti.com/en/activities/ti-codes/nspire/10-minutes-innovator
  - Unit 1: Getting Started with TI-Innovator Hub
    - SB 1: Your first program!
    - SB 2: Input and Color
    - SB 3: Request/Input and Sound (optional)
    - Application: Traffic Light (Mini-Project)
  - Unit 2: For Loops with TI-Innovator Hub
    - SB 1: Blink the Light
    - SB 2: Loop Through Colors
    - SB 3: Loop through the musical notes (optional**)**

3. ***Introduction to Input and Output***

Summary: Students are acquainted with using the internal Brightness sensor on the Hub as well as using it to trigger the output of sound and/or light.

- ✓ Student Task: Mini-Project: Using what you learned from the example program using the Brightness Sensor, write a program that will use the brightness of the sensor as input to trigger different sounds as output.
  - Extension - Create a function to determine the frequency of the sound that is triggered
- ✓ If students struggle with the above task(s), refer students to the following 10 Minutes of Code lessons for additional review or instruction.
  - ➢ **For TI-84 Plus CE technology**: https://education.ti.com/en/activities/ti-codes/84/10-minutes-innovator
  - ➢ **For TI-Nspire CX technology:** https://education.ti.com/en/activities/ti-codes/nspire/10-minutes-innovator
    - o Unit 3: BRIGHTNESS, IF and WHILE with TI-Innovator Hub
      - ▪ SB 1: Brightness measurements
      - ▪ SB 2: Brightness & Light with IF, WHILE (optional)
      - ▪ SB 3: Brightness and Color (optional)
      - Application: Lite Music
        - Note that the Application in this unit is almost identical to the task in the PowerPoint, and can be used alternative for a more step-by-step experience.

4. ***Using <u>External</u> Input and Output Devices***

*Summary: Students are acquainted with using **<u>external</u>** input devices including the light level sensor, digital temperature and humidity sensor (DHT) soil moisture, and output devices including the MOSFET transistor.*

- ✓ Student Task: Mini Project: Students use external input from the light sensor and use if-then-else decision logic to control an output (sound or color LED) based on the sensor reading.
- ✓ Student Task: Mini Project: Students use digital temperature and humidity (DHT) sensor Write a program that controls an output (Sound, Color and/or Disp) based on the sensor reading.
- ✓ Student Task: Mini Project: Students add the soil moisture sensor, to the previous program and write a program to connect and read the values of these additional sensors at a prepared soil station/or outdoors.
  - Note that there are two options for soil testing:
    - *Indoors*- Prep at least three different soil stations each with a different moisture saturation. Prepare one that is extremely dry that should indicate the soil should be watered to support plant life. Prepare another one that is too moist to indicate overwatered terrain. The last one should be at an “ideal” level for plant growth. These three stations will give students different reference readings for their final Smart Water project**.**

- *Outdoors*- If possible, have students do data collection outdoors choosing different areas to test. Ideally, there should be several places students can test. Students should have readings that indicate the soil is too dry, too wet and ideal for plant growth. Students need to take care when using the soil sensor. If necessary, students might need to pre-dig a small hole with a stick to be able to use the sensor in soil that is firm. Students might also want to use this time to measure the different light levels in sunny and shady locations.

*** Inform students that the moisture sensor should be handled somewhat delicately as the prongs can/will bend and break:*

- *Do not force into hard dirt, and*
- *Only the tines of the moisture sensor should come in contact with liquid.*

✓ Student Task: Students practice setting up the MOSFET (Field Effect Transistor) and Water Pump Set Up and write the code to turn on the pump for 3 seconds.

5. ***Putting it all together: Smart Irrigation Pump***

Summary: Students are now tasked with assimilating the code snippets and skills, and what they learned in the mini projects, to design a "smart" irrigation pump that only turns on, when certain conditions are met.

✓ Student Task: Students will use the programming skills in the above mini projects, to design and build a Smart Watering System. Students will be challenged to incorporate multiple sensors and a MOSFET and submersible water pump, and other materials provided.

- Soil Moisture Sensor
- Temperature and Humidity Sensor
- Light Sensor
- MOSFET
- Submersible Water Pump
- External Battery Source

7. ***Presentation: Present and Explain***

Summary: Teams share their final solutions. Have teams host a gallery-walk format, encouraging peer review of solutions in a less formalized manner. Or, have teams prepare presentations to deliver to their classmates

✓ Student Task: Have student teams present their designs/solutions to their classmates, emphasizing the identified problem including the science behind it, and the functionality of how it works. As time allows, encourage students to get creative, allowing them to create a presentation to "sell it" to their peers. They can consider creating a commercial, jingle, etc. It is always good practice for students to speak in front of their peers, and make a persuasive presentation.

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Description of Additional Teaching Resources & Lesson Materials:

Title	File Format	Intended Audience	Description
Smart Water Classroom Presentation_Nspire Smart Water Classroom Presentation_84CE	PPT	Student	Used by teacher to lead students through the flow of the entire project, and tasks. Designed for classroom presentation.
Smart Water _Nspire_Student Smart Water_84CE_Student	DOC/ PDF	Student	Student handouts are technology specific and will include sample code snippets for students.
Teacher Notes (you are reading these now!)	PDF	Teacher	Essential guide for teaching the activity.
Smart Water Teacher Resources	PPT	Teacher	Additional resources to assist the teacher in preparation to teach the project including sample programs, background content).
Sample Programs	TNS/.8xv	Teacher	Completed programs ("answers" for teacher's reference

References and Additional Resources

- Football and Famine in Zimbabwe
  https://www.theguardian.com/global-development/2016/apr/21/drought-southern-africa-heavy-toll-students-fainting-malawi-zimbabwe

- Climate and Agriculture of Zimbabwe
  http://www.our-africa.org/zimbabwe/climate-agriculture

- Conservation Agriculture in Zimbabwe
  http://www.fao.org/in-action/conservation-agriculture-contributes-to-zimbabwe-economicrecovery/en/
- Capturing Rainwater in Cisterns
  https://www.thestandard.co.zw/2017/01/15/zimbabweans-capture-rainwater-future-use/
- Videos created by young people in Zimbabwe
  http://www.our-africa.org/zimbabwe

If you are interested in other STEM projects using TI-Innovator, check out these related projects on education.ti.com: