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Environmental Engineering Unit Guide

Summary

The Environmental Engineering Unit gives students an opportunity to collect and study data related to local weather and climate. Students will use Smartware to develop and program data collection devices to interact with their "Green Star" certified model buildings. The students will be immersed in the engineering design process to test materials, designs, and solutions, and re-engineer buildings.

Lesson Details

Estimated Unit Duration: 1.5 hours instructional time - 1.5-4+ hours for final project construction and redesign

Recommended Grade Level: Upper Primary School

Environmental Engineering Unit Table of Contents

Environmental Engineering
Cubit STEAM Unit

Learning Objectives

Science
Use evidence to justify the use of specific renewable and/or nonrenewable materials in design ● Contrast and categorize how different materials interact with light and heat ● Interpret weather data and analyze human needs related to temperature

Technology
Coordinate robotic components to form a system to solve a problem ● Analyze and graph sensor data to identify patterns, generate questions, and draw conclusions

Engineering
Engineer a building that allows people to live in extreme environments ● Minimize negative environmental impact in a design ● Use data collection to identify patterns and inform design ● Justify trade-offs in engineering

Arts & Design
Explore and apply aesthetics in structures, materials, design, and art making ● Integrate the needs and perspectives of diverse people when planning public art ● Explain how mindful design can improve the quality of life for inhabitants and others in the community

Mathematics
Interpret data outputs in order to create graphs ● Manipulate data using basic arithmetic operations ● Round data to the nearest whole number ● Calculate area and perimeter of shapes in structure designs ● Demonstrate accurate use of measurement tools ● Analyze and interpret data using inequalities

Scope and Sequence

Lesson 1: Using Cubit to Monitor Temperature
- Design Challenge Introduction
- Climate
- Temperature Data Collection

Lesson 3: Testing Insulating Materials
- Insulating Material
- Insulation Lab Data Collection
- Our Home, Our Resources

Lesson 3: Sustainable Design Using LEED Certification Requirements
- Container Lab Carousel Activity
- Engineering Design Introduction
- LEED Rating Introduction
- Cubit Designing for our Environment Challenge

Extension

Lesson 4: Climate and Sunlight in Building Design
- Transparency and Translucency
- Cubit Redesign for our Environment

Vocabulary

Architect
Heat
Fahrenheit
Insulation
Climate
Temperature
Celsius

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Smartware Required

Computer with Cubit Workshop Installed

Cubit Controller

Cables x4

USB Power Connector

Battery Pack

LED Strip

Light Sensor

Temperature Sensor

Other Materials

The following list provides ideas for materials to be used for prototyping projects. It is recommended to provide a selection of materials, and solicit additional materials from students' homes.

1. Cardboard
2. Paper
3. Toilet rolls or paper towel rolls
4. PVC pipe
5. Wire
6. String or yarn
7. Straws
8. Popsicle sticks
9. Paper clips
10. Binder clips
11. Toothpicks
12. Rubber bands
13. Pipe cleaners
14. Fabric
15. Plastic containers
16. Water bottles or other beverage containers
17. Small cereal boxes
18. Small snack containers
19. Particleboard
20. Pegboard
21. Paper cups
22. Hot glue guns
23. Various types of tape (double-sided, cellophane, packing, masking, painters, duct, electrical, etc.)
24. Cotton swabs
25. Modeling clay
26. Construction paper
27. Rulers
28. Plastic wrap
29. Fishing line
30. Thread
31. Transparencies
32. Take-out boxes
33. Hook and loop strips
34. Wooden dowels
35. Construction toy sets
36. Shoeboxes
37. Aluminum foil
38. Any other materials students find in their own homes

Lesson 1: Using Cubit to Monitor Temperature

Design Challenge Introduction

Use slides 3 -4 of the accompanying slideshow to introduce the unit and the final project: a model building that stays at a comfortable temperature. Instructional notes are included in the slides.

Community Connection: If desired, the introduction presents an opportunity to invite environmental, construction, and architecture professionals to visit the classroom. Consider asking them to share the considerations and challenges of their work with students as related to buildings and environmental design. Some potential outreach candidates are city planners, contractors, assessors, or environmental policy makers

Climate

Solicit student background knowledge about the local climate, weather, and general temperature patterns. Ask students what they would need to know in order to be able to ensure a building will stay at a comfortable temperature.

Possibly include a student-made KWL chart for this if needed.

Discuss human survival needs for resources, such as food, water, air, and shelter, and ask students to expand on the reasons for the need for shelter.

What does it mean to thrive and how can we ensure we do that in different climates?

Temperature Data Collection

Have students load **House Temperature.plan** file here

Using the programmed LED Thermometer plan, students will collect temperature data from various locations at various times throughout the day.

- Assign groups to locations that may be shaded at some points and sunny at others. Locations may be indoors and outdoors and may include different classrooms if accessible.

Debrief this activity with the class to discuss the data gathered and what it means about the weather in the area.

- Connect to how this informs the way people live in the area.
- Students may interpret collected data to calculate average temperatures over the day or several days.

Lesson 2: Testing Insulating Materials

Insulating Materials

Note: This activity may be run concurrently with the Our Home, Our Resources Research activity. Students may complete research and check for data readings as needed.

In preparation to choose building materials for the building prototypes, students will examine how different materials react to heat.

Provide a variety of materials (enough for each student to choose four different kinds of materials). It is best if materials vary in composition, color, mass, etc.

Insulation Lab Cubit Plan

Each group will need a Cubit system, USB connector, Power Source, Temperature Sensor, and a copy of the **Insulation Mini-Lab** handout.

Have students load **Insulation One Sensor.plan** file here

Allow students time to experiment with the sensor once it is programmed. Consider having them compare temperatures between different student's fingers or different spots in the classroom.

- Do not use the Temperature Sensor in liquids.

Insulation Data Analysis

Use the provided chart or another means for students to share out results from their testing. Additional extensions could include students creating bar graphs of the maximum temperature readings of each material, or averaging multiple tests of the same material

Our Home, Our Resources

Note: This activity may be run concurrently with the Insulators Mini-Lab. Students may complete research and check for data readings as needed.

Provide each group with a copy of the **Our Home; Our Resources** research capture sheet (at end of guide).

Students will research the climate and the resources available in their local area and document their findings. Assign different resources for student groups to focus on. If needed, provide students with links to work from.

Ask students to share their findings with the class to create a comprehensive overview of the resources available in the local area.

Lesson 3: Building Design and Prototyping

Container Temperature Lab Carousel Activity

Have students load **Insulation One Sensor.plan** file here

Prior to prototyping, students will test how containers covered in different materials respond to temperature changes. They will place Cubit Controllers and Temperature Sensor Smartwares inside containers covered with the Insulator Mini-Lab materials and record the temperature data of each material.

This can be run as a carousel activity, in which each student cycles through the containers, collecting data about each material type to compare the differences between them. Choose a type of container for students to test and provide one container for each Cubit, along with adhesive materials. Using one type of container allows students to compare differences between building materials, and offers an opportunity to discuss the purpose and benefit of controlling variables when testing.

- Container suggestions: food storage containers, coffee cans, cardboard boxes, shoe boxes.

The Container Lab data sheet provides space for students to collect data about material as they circle throughout the classroom.

Synchronize student timers by having students all hit Launch at the same time.

A debrief of the activity may include sharing student responses, comparing observations at the same time, and reflecting on program design.

Engineering Design Introduction

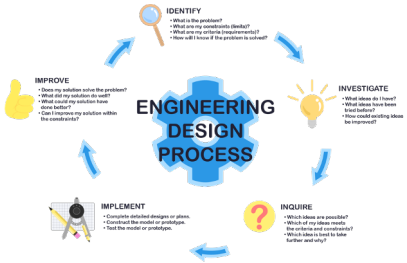
What do engineers do? Explore software, environmental, and architectural engineering.

- Consider assigning these roles to students during design iterations

Engineering Design Introduction

This graphic may be used if there is not one predetermined for use by the district.

- More information available in the slideshow and notes section of the slideshow.



Brainstorming practice. Use a simple idea for students to brainstorm (ex.: here is Cubit and the Smartware, what are some things you may be able to do with this? Or think of 50 uses for a pencil that do not involve writing. Have students draw a sketch of their best idea to share with the class).

Allow more time than you expect, so that ideas more complex and creative.

The Engineering Design Process will be used by students when they design their buildings.

- Remind students that they will be working as real engineers and mistakes happen -- engineers never get it right the first time, they keep testing, learning, and improving!

Lesson 3: Building Design and Prototyping (Cont.)

LEED Rating Introduction

Ask students why we may want to think about how our building materials impact our environment.
Introduce students to the “Green Star” rating system as a way of measuring the impact of a building on the environment
(GBCA: Green Building Council of Australia).
Explain some of the factors ”Green Star” ratings take into account in regard to materials.
Introduce material rating scale for classroom use.

Cubit “Designing for Our Environment” Challenge

Provide copies of the **Designing for Our Environment Activity** packet for students (found at the end of the guide).
Provide a variety of materials for building construction. Label these with “Green Star” values.
Students will design and create their own “Green Star” certified house that can regulate its internal temperature by design alone.
The materials should be based on locally accessible materials.
Pass out the handout to students and go over the challenge, challenge summary, criteria, and constraints.

- Check to see if students have any questions or concerns before beginning.

Prompt students to begin the design and construction process.
For student convenience, have the materials pre-labeled with their “Green Star” values for student ease. These values can be found in the student worksheet.

- Have students move on from one section of the design processes either at their own pace or teacher discretion.
- Circulate frequently around the room checking in on students and asking about their progress.
- When discussing suggestion or roadblocks with students, use open ended questioning to promote student thinking.
- If time allows, have the students perform two trials each in the sun and shade for better results.

Extension 1: Climate and Sunlight in Building Design

Measure Sun Changes Over the Course of the Day

Have students load the **Transparent and Translucent Lab.plan** file here.
Have a few designated testing locations for measuring sunlight.
Use the Cubit Light Sensor Smartware on a flat surface for each measurement, be sure no one casts shade on it.
Take measurements four times throughout the day if possible.
Have students draw a pictorial representation of the collected data.

- E.g. a sketch of the building indication where the light is brightest each time of day or something similar.
- Connect this information to the apparent path of the sun across the sky.

For an extra challenge, students may attempt to incorporate a buzzer into their design. It could be designed as a timer or as a threshold alarm.

Alternative Activity - Weather Testing: Sunlight and Heat

Using the *Light Sensor - Data Collection Activity,* have students repeat the measurements from the Local Weather Testing Lab; this time, using the Light Sensor Smartware along with the Temperature Sensor Smartware.
Once data is gathered, encourage students to create two bar graphs. One should be of the light data by area, the other of the temperature data by area.

- *Help students draw connections between sunlight and thermal energy as well as the lower impact of some artificial light over temperature.*

Transparency and Translucency

In preparation to choose building materials for the product redesign, students will examine how much light passes through different materials.
Provide a variety of materials (enough for each group to choose four different kinds of materials). It is best if materials vary in composition, color, mass, etc.
Each group will need a Cubit system, USB connector, Power Source, Light Sensor (2), Temperature Sensor (2), and a copy of the **Transparency and Translucence Mini-Lab** handout.
Have students load the **Transparent and Translucent Lab.plan** file here

Cubit Re-Designing for Our Environment Challenge

Have students revisit the Environmental Building Challenge to add windows, skylights, and/or a greenhouse to their building.
Reinforce that engineers are constantly redesigning things once they are built in order to improve on the design.
Remind students that they want the building to work for the climate. Should it be warm or cool inside?
Provide a variety of materials for building construction.
Have printed copies of the **Re-Designing for Our Environment Challenge** (same design packet may be used).
Pass out the handout to students and go over the challenge, challenge summary, criteria, and constraints.
Check to see if students have any questions or concerns before beginning.
Prompt students to begin the design and construction process. Refer to **Designing for Our Environment** activity notes if needed.

- If time is allowed, have the students perform two trials in the sun and shade for better results.
- For a culminating analysis activity, students may compare data between the two iterations of the design and chart data to draw conclusions regarding materials.

Interdisciplinary Extensions

Social Studies: Connections can be made to human needs, adaptation to the environment and migration patterns. Connections can also be made to historical figures such as Socrates and Aristotle as well as early Colonial architectural design.

Designing Automatic Shade Structures (students must complete Servo Motor Foundations prior to continuing)

- Servo motors may be used to create shade structures, such as window shades or awnings, that respond automatically to temperature or light changes.
  - For example, window shades can be used to block out the heat in warm climates, provide insulation in cold climates, controlling the temperature in a room...
- This activity offers an opportunity for students to research existing solutions for creating shade structures to regulate temperature.
- Support students in programming threshold conditions with the slides in the accompanying slideshow. Instructional notes are provided on each slide.
- Engage students in the Engineering Design Process steps to design and prototype their shade structure additions to their building.

Each group could be assigned a specific climate to build for. This would allow more individual research and creative processing.
Students could examine heat sink materials to discuss or design with materials that retain heat
Students could design individual wall sections and test different insulation types within the walls

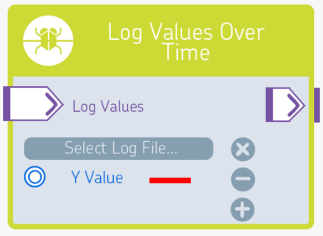
Differentiation Opportunities

Support: Use strategic grouping to partner students that may need extra help with students that are proficient with computers or experienced with programming. This can help facilitate the exchange of information and clarify activities for some students.
Scaffold: Use the attached Cubit block cards as support by providing them for struggling students. Students can use the block cards to think out, plan, and analyze a program before they create it in Workshop.
Challenge: The Custom Function block can be used by students who have more comfort in programming. Students can use this block to create their custom function in Workshop. Students wanting more data insight and coding insight can use the Log Values Over Time block to create graphs of data.

Community Connection Opportunities

This unit provides opportunities to connect to many community environmental awareness opportunities and organizations. Community members involved with or working in careers such as environmental engineering, architecture, construction, materials engineering, research, or city planning.

Block Informational Cards



What is Log Values Over Time for?

"Log Values Over" Time Block is used to log data on a chart over a span of approximately 2 minutes.

How to use Log Values Over Time

To use the "Log Values Over Time" block, you must use a block outputting data. Connect the corresponding outputting data pins to the "Log Values Over Time" block. You can then add or remove "Y" values as needed.

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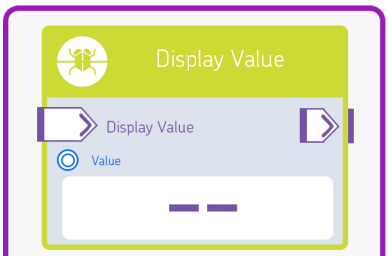

What is Display Value for?

"Display Value" allows you to display a value being outputted by a block.

How to use Display Value

To use the "Display Value" block, connect a block outputting data to the corresponding input pins on the "Display Value" block.

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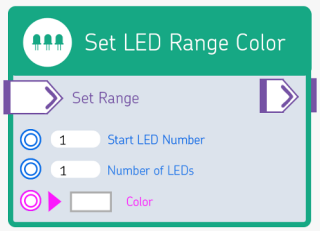

What is Set LED Range Color for?

The "Set LED Range Color" block is used to set a group of LEDs a certain color.

How to Use Set LED Range Color

To use the "Set LED Range Color" block, enter the number of the starting LED you would like to use within the "Start LED Number" box then the number of LEDs you would like to use in the "Number of LEDs" box. You can then set the color of your LED and launch your program.

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What is Wait for?

In a program, a "Wait" can be used to halt a program for a set duration. Whether it be blinking an LED or giving a pause to your looping program.

How to use Wait

To use the "Wait" block, simply select it from the "flow" drop down menu and create your program, implementing a wait wherever you see fit and set the duration for the desired amount of time.

The small + at the bottom shows more options.

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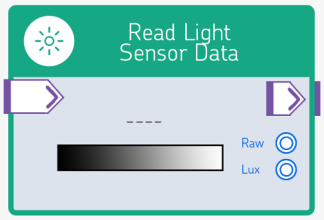

What is Read Light Sensor Data for?

The light sensor outputs data that can be read, interpreted, then converted to usable data within a program. The values range from 1 to 1000.

How to Use Read Light Sensor Data

To use the "Read Light Sensor Data" block, simply place the block in your program and connect the output pins to a block you would like to use to interpret the data being outputted by the light sensor. A convert block may be required to interpret data.

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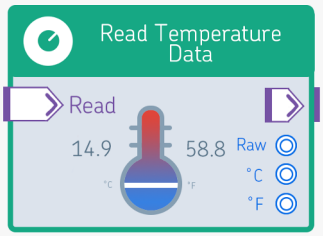

What is Read Temperature Data for?

The "Read Temperature Data" block is used to read the temperature data being received by the sensor. The data being received can then be used to trigger an event by using the corresponding output pins.

How to Use Read Temperature Data

To use the "Read Temperature Data" block, simply place the block in your program and connect the output pins to a block you would like to use to interpret the data being outputted by the temperature sensor. A convert block may be required to interpret data.

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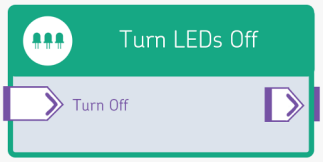

What is Turn LED's Off for?

"Turn LEDs Off" is used to to turn off any LEDs lit on the LED strip. The LEDs will remain on unless the program is stopped or if the program has a "Turn LEDs Off" block being used.

How to use Turn LEDs Off

To use the "Turn LEDs Off" block, simply place the block in your program using the input/output flow pins.

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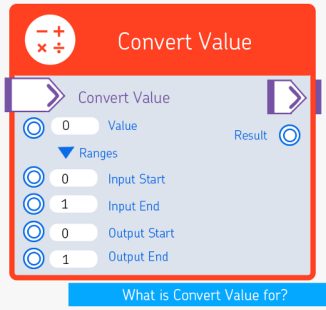

What is Convert Value for?

"Convert Value" is used to take data being received from a block and convert it to usable data in another block using received values to create an input range and output range. These can be set manually or through a data output.

How to Use Convert Value

To use the "Convert Value" block, you must set the ranges of the input and output events. Once the values are set, the converted values will be outputted through the "Result" output pin.

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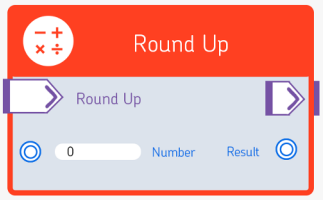

What is Round Up for?

"Round Up" will round up a value to the next whole integer value.

How to Use Round Up

To use the "Round Up" block, set the value within the "Number" box, manually or by connecting a data wire, and the next whole integer value up will then be outputted which can be sent through the "Result" output pin.

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Insulation Lab

List the materials you are testing across the top of the chart.]
Then record the reading from the Temperature Sensor at each time interval.
(Add rows to the bottom if you are doing more trials.)

Materials →	*Example:* *Light coloured fabric*				
Trial 1	*20 Degrees*				
Trial 2	*22 Degrees*				
Trial 3	*23 Degrees*				

Share this information with your class to compare your materials to those of your classmates.

Container Lab

List the materials you are testing across the top of the chart.]
Then record the reading from the Temperature Sensor at each time interval.
(Add rows to the bottom if you are doing more trials.)

Materials →	*Example:* *Light coloured fabric*			
Trial 1	*20 Degrees*			
Trial 2	*22 Degrees*			
Trial 3	*23 Degrees*			

Share this information with your class to compare your materials to those of your classmates.

Our Home, Our Resources

Goal: To be able to make concluding statements about the materials, resources, codes and ecology of your locality; and explain their significance in building an eco house.

Directions:

1) Your teacher will assign your group a particular area of study. Write your area of study in the first box of Table 1: Research grid.
2) Look over the grid with your group and identify the key information you need to extract from the article to create the concluding statement.
3) With your group, go over the data given to you and fill out the research table. You must cite the evidence used to create your conclusions
4) Use evidence from your research to develop a summary of how your information impacts building design.
5) Once all groups are finished, the class will share out information to fill out **Table 2: Class Findings**

<table>
<tr><td colspan="2">Our topic:</td></tr>
<tr><td>Prediction:
Why is this important for housing construction?</td><td></td></tr>
<tr><td colspan="2">List three facts that would be relevant to the project</td></tr>
<tr><td rowspan="2">1</td><td></td></tr>
<tr><td>Source:</td></tr>
<tr><td rowspan="2">2</td><td></td></tr>
<tr><td>Source:</td></tr>
<tr><td rowspan="2">3</td><td></td></tr>
<tr><td>Source:</td></tr>
<tr><td colspan="2">A concluding statement about how their information impacts housing design</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Table 2: Class Findings

Area of study	Summary of findings	Why these findings are important for building construction?
Climate		
Wood resources		
Stone resources		
Energy use		
Physiographic Information		
Geology		
Building codes		

Transparency and Translucency Lab

List the materials you are testing across the top of the chart.]
Then record the reading from the Temperature Sensor and Light Sensor at each time interval.
(Add rows to the bottom if you are doing more trials.)

Materials ⟶	*Example:* *Light coloured fabric*			
Trial 1	*20 Degrees* *92 Lux*			
Trial 2	*22 Degrees* *92 Lux*			
Trial 3	*23 Degrees* *92 Lux*			

Share this information with your class to compare your materials to those of your classmates.

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Summarize the design challenge:

Identify the problem:

What people have this problem?

What makes this a problem?

When does the problem occur?

Summarize the problem in one sentence:

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Brainstorm different solutions. As many as you can!

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Criteria:

Constraints:

Ideas from brainstorming that meet criteria and constraints

The top four ideas that meet our needs

1)

2)

3)

4)

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Sketch Idea #1 here	
List positives	List negatives

Sketch Idea #2 here	
List positives	List negatives

Sketch Idea #3 here	
List positives	List negatives

Sketch Idea #4 here	
List positives	List negatives

Draw your prototype here

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What worked best in your prototype?

What were some problems in your prototype? How did you fix them?

If you had to do this again, what would you do differently?