# Introduction to programming with LilyPad Arduino

**Year level band:** 7-8

**Description:**

This project will explore how a LilyPad wearable circuit can be programmed using the Arduino general purpose programming language.

**Lesson Type:** General purpose Programming Language

**Resources:**

- Lilypad ProtoSnap kit with rechargeable battery
- LilyPad LED's
- Conductive thread
- Alligator clips
- Arduino IDE installed onto computers
- Mini USB cable
- Chalk or pen for marking fabric
- Felt/Material
- Scissors
- Paper
- Needle
- Pencils for design sketches
- Embroidery hoop (suggested)
- Mac or PC with latest Arduino IDE installed:

    For Windows: http://arduino.cc/en/Guide/Windows
    For Mac: http://arduino.cc/en/Guide/MacOSX

**Prior Student Learning:**

A basic understanding of parallel and serial circuits is useful.
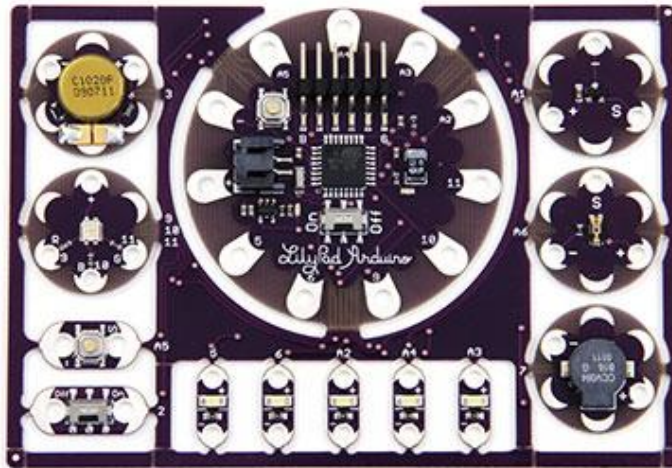
An understanding of general programming concepts - input and output, algorithms, loops and debugging.

| Digital Technologies Summary<br><br>Enter digital technologies summary specific to the level your lesson is tailored for. | This activity introduces students to programming in the Arduino language through exploration of the Lilypad Arduino. |
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| **Band** | **Content Descriptors** |
| **7-8** | Design the user experience of a digital system, generating, evaluating and communicating alternative designs (ACTDIP028)<br><br>Design algorithms represented diagrammatically and in English, and trace algorithms to predict output for a given |

|  | input and to identify errors (ACTDIP029)<br><br>Implement and modify programs with user interfaces involving branching, iteration and functions in a general-purpose programming language (ACTDIP030) |
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|  | The particular elements of Critical and Creative Thinking addressed by this content description<br>Inquiring – identifying, exploring and organising information and ideas<br>   ● Identify and clarify information and ideas<br>   ● Organise and process information<br>Generating ideas, possibilities and actions<br>   ● Consider alternatives<br>   ● Seek solutions and put ideas into action<br>   ● Imagine possibilities and connect ideas<br>Analysing, synthesising and evaluating reasoning and procedures<br>   ● Apply logic and reasoning<br>Reflecting on thinking and processes<br>   ● Transfer knowledge into new contexts |

| Element | Summary of tasks |
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| Learning hook | The LilyPad Arduino is a great introduction to wearable technology or e-textiles. You can create amazing projects and sew them into your clothes, toys, backpacks to make them light up, play music and vibrate.<br><br>Perhaps show some examples of wearable technology and e-textiles. There are plenty of examples on Pinterest, e.g. https://au.pinterest.com/vinidiktova_len/lilypad-arduino/ or https://au.pinterest.com/kitelder/e-textiles-lilypad-arduino/<br><br>Some examples of LilyPad projects can be found here - maybe show a couple of interesting ones: https://www.instructables.com/howto/lilypad/<br><br>We are going to learn to program the LilyPad Arduino - and begin exploring how to control the outputs (buzzer, motor, and lights) with different inputs (button, switch, light and temperature sensors).<br><br>*Alternatively you may want to introduce Arduino more generally as a prototyping platform. In simple terms, an Arduino is a little computer that you can program - it interacts with the world through sensors, lights, buzzers, and motors.*<br><br>*Some example videos of Arduino creations in action can be found here: http://www.makeuseof.com/tag/arduino-technology-explained/*<br><br>*20 Unbelievable Arduino projects:* |

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Explain that inputs can be digital or analogue. Digital has two states (on/off, high/low, or true/false) but analogue can take values in between. Identify the components of the kit that are analogue or digital.

Introduce the concept of functions and discuss how arduino has pre-defined functions for all the LilyPad components. Some of these functions include:

- loop - for repetition
- delay - delays action
- pinMode - for configuring the specified pin to behave either as an input or an output
- digitalWrite - for writing a low or high value to a pin

A full documentation and description of these functions is available at:

https://www.arduino.cc/en/Reference/ |
| **Achievement Standards** | Students plan and manage digital projects to create interactive information. They define and decompose problems in terms of functional requirements and constraints. Students design user experiences and algorithms incorporating branching and iterations, and test, modify and implement digital solutions. They evaluate information systems and their solutions in terms of meeting needs, innovation and sustainability. They analyse and evaluate data from a range of sources to model and create solutions. |
| **Learning Map (Sequence)** | - Students explore the components of the LilyPad Arduino
- Students run existing code and modify it to achieve planned outcomes
- Students identify the ways in which the algorithm can be decomposed into functions
- Students identify the key arduino functions and learn how to change parameters and use these these functions to achieve planned outcomes
- Students create new code and learn to debug to achieve outcomes
- Students work in teams to solve problems and improve their coding skills
- Students reflect on their work and make suggestions for improvements or extensions |
| Learning input | 1. Ask students to look at their LilyPads (being careful not to break it apart - yet). Explain that the big circle is the Arduino and the smaller parts are various inputs and outputs. In pairs ask students to examine the different components and try to determine which are inputs, which are outputs and what their features might be. |

2. Highlight the different components, explaining that the numbers are essential when we come to program our LilyPads:

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| Motor | 3 |
| RGB LED - Red | 9 |
| RGB LED - Blue | 10 |
| RGB LED - Green | 11 |
| Button | A5 |
| Slide Switch | 2 |
| White LED's | 5, 6, A2, A3, A4 |
| Buzzer (+) | 7 |
| Buzzer (-) | 12 |
| Light Sensor | A6 |
| Temp Sensor | A1 |

3. Now we are going to set up the Arduino software so we can run our first simple program. Demonstrate how to connect the LilyPad to the FTD1 and to the computer via mini USB. Open the Arduino software and show how to select the board and port. You will need to select the 'LilyPad Arduino' board. You may need to select the port as well - if you are using a PC, the correct serial port is usually the highest numbered "COM" port.
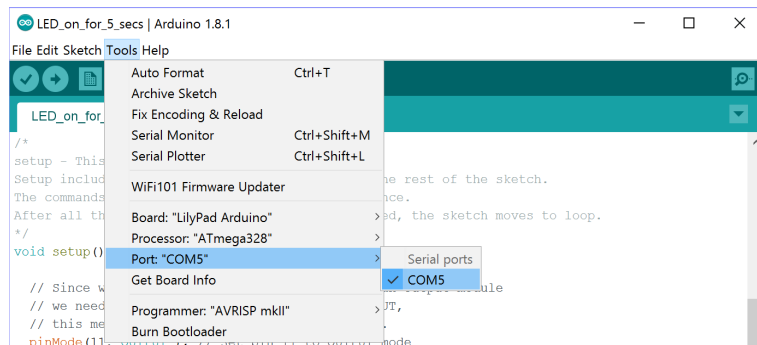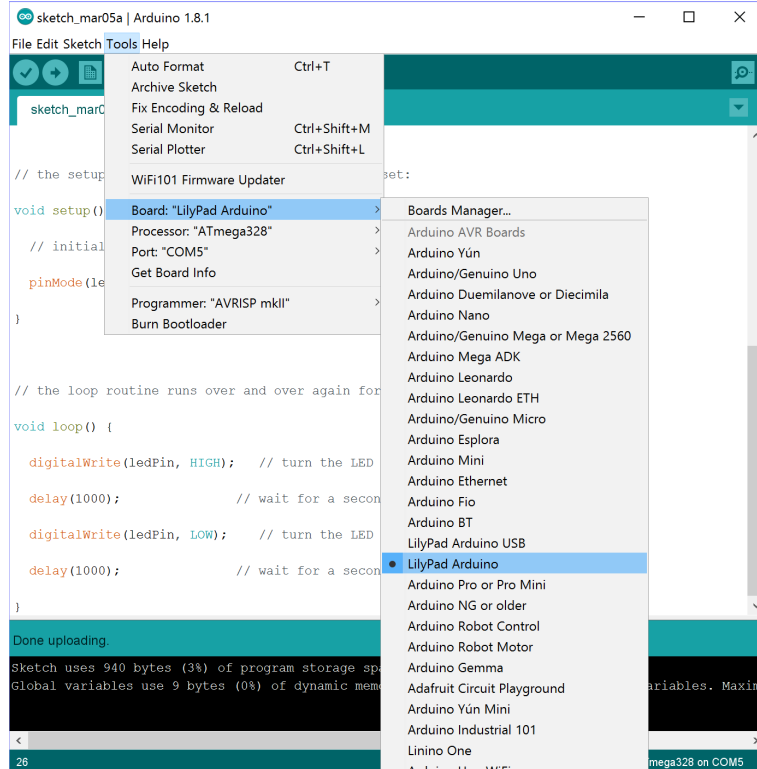
4. Open the example program 'Blink', verify it (click the tick mark) and upload it to your LilyPad (click the arrow mark):
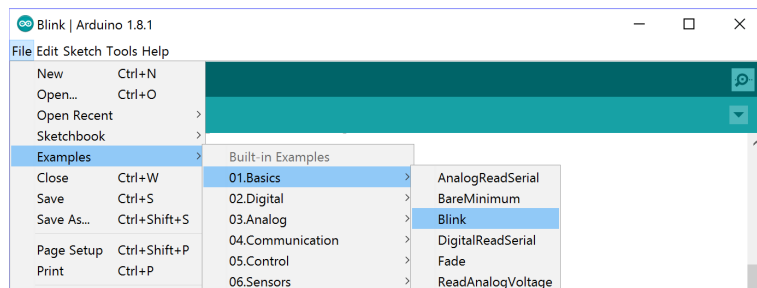


Show that the built in LED is blinking and demonstrate that the code is now stored in the LilyPad's memory so we don't need it to be connected to the computer. It can be run by battery - useful if we are going to sew it into our clothing, toys, etc.

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| | Highlight the code (Arduino uses a programming language called C) used in 'Blink'; show where the LED is defined; explain that HIGH and LOW refer to the voltage and is how outputs are turned on and off. |
| | Highlight the loop and ask students how we could change the code to make it blink faster or slower. What about blinking in an uneven pattern? |
| | ```c // the setup function runs once when you press reset // or power the board void setup() {   // initialize digital pin LED_BUILTIN as an output.   pinMode(LED_BUILTIN, OUTPUT); }  // the loop function runs over and over again forever void loop() {   digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)   delay(1000);                       // wait for a second   digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW   delay(1000);                       // wait for a second } ``` |
| | 5. Make a change to your code, e.g. `delay(500)` and show how to save your new program with a different name using "File > Save As…" |
| | 6. It is also a good idea to change any comments in the code - for your reference and it explains what you are doing if sharing with others. |
| | 7. Students write the pseudocode of this algorithm, focusing on how to decompose their algorithm into the key functions such as initializing the pins/board, writing a value to a pin and delaying. |
| | 8. Identify the key blocks of the code, in particular the setup() and loop() functions, and discuss their purpose. What about the delay() function? What other functions of interest can students find? |
| Learning construction | Students work in pairs to program their LilyPad Arduinos. |
| | The activity is about experimenting, trying new solutions, and debugging. |
| | Encourage students to help each other - and look for help on the internet. |
| | Some example questions for students to explore… |
| | 1. Load the 'Blink' example program and run it on your Arduino. |
| | 2. Can you identify the key functions in the code? |
| | 3. Can you make the LED blink faster or slower? What is the fastest it can go? Will the code work with decimal numbers? |
| | 4. Can you make one of the other LEDs blink? |
| | 5. Can you make the vibration motor turn on and off? |
| | 6. What would you add to your code to you turn on two or more LEDs at the same time? |

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| | 7. Can you alter the code so that one LED blinks on while another blinks off? |
| | 8. Write code for the five white LEDs to turn on one after another. |
| | 9. Load the 'Fade' example program - which LEDs will this work with? Why? |
| | We have only considered outputs so far - students may want to start considering inputs by themselves. The built in example 'Button' (Examples> 02.Digital> Button) would be a good start pointing point. Adapt this example to: |
| | 1. Write code for the buzzer to buzz when you press the button. |
| | 2. Write code to turn on a sequence of different LEDs when you flick the switch on. |
| Learning demo | While students are working in pairs, ask questions to give them the opportunity to demonstrate their thinking and understanding: |
| | What have you changed in this code and why? |
| | What do you think are the most important functions? |
| | Have you had to do any debugging? |
| | Can you think of an alternative way to achieve the same outcome? |
| | Check that students are adding comments in their code - and ask them to share with another to group to sense check. |
| Learning reflection | A. Reflect on students' experiences modifying and writing code. |
| | What challenges did you have when programming the LilyPad Arduino? How did you resolve those? |
| | Were you able to easily change existing code to produce a different outcome? |
| | Did you learn any new terminology? |
| | What were the rewarding parts of coding in pairs? |
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| | B. Remind students that the LilyPad Arduino is designed to be wearable or used in e-textiles. |
| | What real-world situations (not wearable tech) would you expect similar code to be used? - What has different inputs (buttons, switches) that affect an output (light, sound, motor)? |
| | What other components could be used as inputs or outputs? Consider what digital and analogue inputs and outputs you see each day at school, at home, in transport, sports grounds, etc.. |
| | Can you think of any exciting products that could be created with this sort of technology? |
| | Suppose next lesson we are going to start designing clothing, toys or homeware using the LilyPad - what sort of creations would be possible with your new knowledge and understanding of coding in Arduino? |
| | What are the advantages/disadvantages of using functions in code? |
| | Did they discover an interesting/useful function they want to share? |

**Assessment:**

Observation of students identifying input and output components of the LilyPad and the circuits that are made

Successful uploading of example sketches

Successful uploading of modified code - behaviour of LilyPad circuit reflects what is commented in the code

| | Quantity of knowledge | | | Quality of understanding | |
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| **Criteria** | **Pre-structural** | **Uni-structural** | **Multi-structural** | **Relational** | **Extended abstract** |
| Algorithms<br><br>Programming | Example code can be run. | Example code can be changed, e.g. delay or pin number. | A consistent and executable program is written, showing knowledge of inputs and outputs. | A consistent and executable program is written and commented throughout. Program shows understanding of inputs, outputs, loops and variables. | The program shows independent learning beyond the task and possibly includes functions.<br><br>Full use and understanding of programming interface is evident. |
| Vocabulary | No specific / technical terms used. | The terms program or code may be used as a general description. | The terms program or code are used as a general description. The terms analogue and digital are known and used correctly. | Specific terms such as program, loop, debug are used confidently with specific reference to learner's work. Code is commented in specific places. | Understanding of specific terms such as constant, function and variable. Understanding of terms in the code such as `digitalWrite`. Code is well commented throughout. |

# Teacher/Student Instructions:

It would be useful for teachers to work through the LilyPad Quickstart Guide: https://www.sparkfun.com/tutorials/308

Technical getting started guide here: https://www.arduino.cc/en/Guide/ArduinoLilyPad

If you encounter any problems setting up the software, check the Arduino troubleshooting site: http://arduino.cc/en/Guide/Troubleshooting

# CSER Professional Learning:

This lesson plan corresponds to professional learning in the following CSER Digital Technologies MOOCs:

**7 & 8 Digital Technologies: Next Steps**

Unit 2 - Next Steps 7 & 8

Project Stream: Maker Space

 See: http://csermoocs.adelaide.edu.au/moocs

# Further Resources:

ProtoSnap - LilyPad Development Board Quickstart Guide: https://www.sparkfun.com/tutorials/308

Beginning LilyPad Arduino: https://www.sparkfun.com/tutorials/312

Basic Arduino Concepts for Use with LilyPad: https://learn.sparkfun.com/resources/5

Create a light-up Backpack using LilyPad Arduino: https://m.commonsense.org/lesson-plans/create-a-light-up-backpack-using-lilypad-arduino