The LilyPad Arduino

Hakan YUKSEL
Applied Science University of Isparta

Introduction

LilyPad is a wearable combination of Arduino that helps create interactive textiles or e-textiles (electronic textiles) (Buechley et al., 2008). The LilyPad project started in 2006 as an academic research project (Buechley, 2006). However, given on October 2007, SparkFun Electronics and Leah Buechley has become a commercial venture for sales (Buechley & Hill, 2010). LilyPad has found its place in the literature as the first kit designed for electronic textiles. Electronic textile design involves the use of several modules sewn with conductive thread to provide the necessary electrical connections to the fabric. LilyPad; it consists of a series of sewable electronic modules, including a spool of conductive thread RGB LED, accelerometer, temperature sensor and a sewable Arduino microcontroller. E-textiles are created by sewing these modules onto a fabric backing with conductive thread that provides both physical and electrical connections between parts. This structures, LilyPad microcontroller, it is determined by programming using the Arduino development environment (Buechley, 2009). The microcontroller can be programmed like regular Arduino boards using the usb connection.

LilyPad ‘s first version released in 2006 (Buechley, 2006). LilyPad the first version of the microcontroller structure and top/bottom view is shown in Figure 1. This structure to form conventional and electrically conductive fabric of a fabric PCB, a packed hole of a microcontroller ATTiny26 combination is connected. The patch consists 63.5 x 63.5 x 12 mm of (2.5 x 2.5 x 0.5 inches) and hard cover area 20 x 46 mm (0.825 x 1.825 inches) dimensions. There are 17 conductor transitions from the microcontroller to the pins. An electrical connection between the fabric and the yarn is established by means of a conductive yarn. Two of these conductors provide power and ground on the microcontroller. The remaining conductors serve as general-purpose input/output (I/O) channels that can be used to receive sensor input and control output devices such as light-emitting diodes (LEDs), loudspeakers, and vibrating motors (Buechley & Eisenberg, 2008).

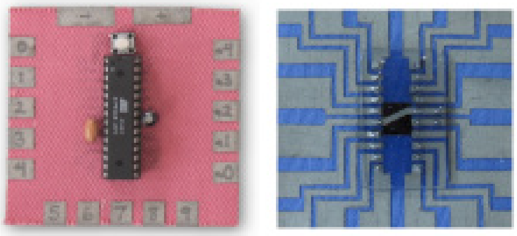

Figure 1. First Version of LilyPad

The circuit board layout was redesigned to make it both aesthetic and functional (Figure 2). First of all, it has made it easier to use circular format surface mount (SMD) components. Reproducing the thin right-angle lines of traditional circuit boards with precision conductive fabric at SMD scale was extremely challenging, while a circular layout allowed it to create solid triangular traces radiating from the center of the board (Buechley & Eisenberg, 2009).

Figure 2. LilyPad Enhanced Design Interface

Hardware

LilyPad ProtoSnap is a development board with twelve LilyPad components connected via conductive means to the LilyPad Arduino Simple microcontroller (Table 1). The connection component that performs the tracks in most is hidden, but by reference ProtoSnap (LilyPad and the combined circuit formed by hardware board) of each component on is attached LilyPad to the number of acid sewing tab white screen printed with a close tag is located (Sparkfun. (n.d. -a)).

LilyPad ProtoSnap, LilyPad simple Arduino and pre-wired LilyPad component classic with a set LilyPad Arduino protosnap development card is a kit (Figure 3).

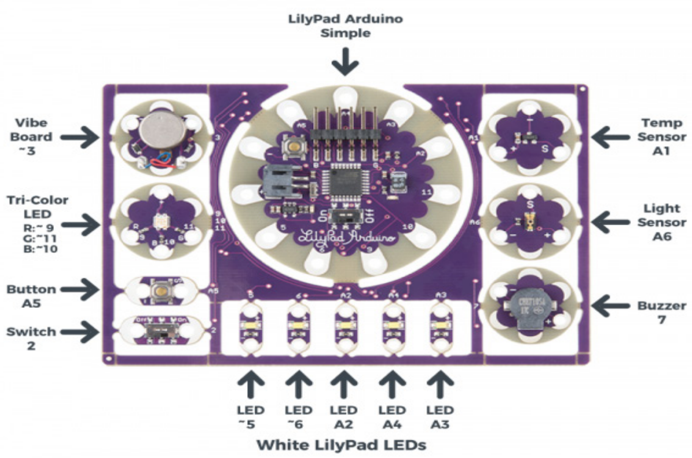

Figure 3. LilyPad Arduino ProtoSnap

LilyPad Arduino that has a special function of some sewing tab:

- The 'A' in front of the number denotes a tab that can act as an analog input. These strut tabs can read sensors that generate variable voltage, such as the light sensor built into the LilyPad Arduino Simple.
- The '~' symbol in front of LilyPad Protosnap indicates that the tab supports PWM (Pulse Width Modulation) output. These tabs, LEDs etc. It can output an "analog" signal that can be used to change the brightness.

Table 1. LilyPad Components

LilyPad Component	Arduino Pin	Connected to LilyPad Arduino Simple Sew Tab	Description
LilyPad Vibe Board	~3		Haptic feedback is provided with the motor's vibration and is controlled by the LilyPad Arduino Simple.
LilyPad Tri-Color (RGB) LED - Red	~9	✓	The tri-color LED's red is controlled by the LilyPad Arduino Simple.
LilyPad Tri-Color (RGB) LED - Blue	~10	✓	The tri-color LED's blue is controlled by the LilyPad Arduino Simple.
LilyPad Tri-Color (RGB) LED - Green	~11	✓	The tri-color LED's green is controlled by the LilyPad Arduino Simple.
LilyPad Button	A5	✓	LilyPad Arduino Simple receives button presses as an input.
LilyPad Slide Switch	2		LilyPad Arduino Simple receives switch state (on/off) input.
LilyPad White LEDs	~5, ~6, A2, A3, A4	✓ (all 5 LEDs)	A set of white LEDs controlled by the LilyPad Arduino Simple.
LilyPad Buzzer (+)	7		A buzzer that create tones controlled by the LilyPad Arduino Simple.
LilyPad Buzzer (-)	12		A buzzer that create tones controlled by the LilyPad Arduino Simple. While normally connected to GND, it can be connected to an Arduino pin.
LilyPad Light Sensor	A6		LilyPad Arduino Simple receives ambient light level input from light sensor.
LilyPad Temperature Sensor	A1		LilyPad Arduino Simple receives temperature from a physical touch based on ambient conditions and body heat with the analog sensor.

Hardware: Components

LilyPad Vibe Board

LilyPad Vibe Board is a small vibration motor controlled by LilyPad Arduino that can be sewn into projects with conductive thread. The component can be used as a physical display on clothing and costumes for haptic feedback.

LilyPad Vibe Board the two upright tabs located: supply (+) and ground (-). A white label for reference next to each tab there. For power, an input voltage is connected to anywhere between 3.3V and 5V. The more voltage provides; the motor can vibrate faster. Due to the amount of current each I/O pin can source, it is recommended to connect the (+) tab to a MOSFET to power the motor when using it with an Arduino. To adjust the density, it would be convenient to use a PWM-capable stitch tab on the LilyPad Arduino (Sparkfun. (n.d. -b)).

Figure 4. LilyPad Vibe Board

LilyPad Tri-Color (RGB)

There are three small LEDs (red, green, blue) inside an RGB LED. Each of these LEDs connected to a sewing tab on all LED and a common anode (positive) connected to the pin.

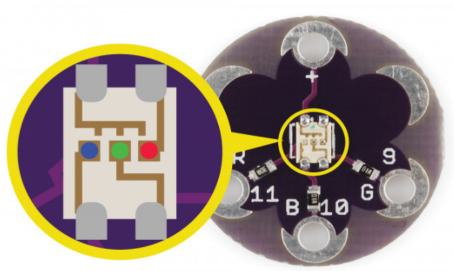

Figure 5. LilyPad Tri-Color (RGB)

The RGB LED on the tri-color LED has 4 connections. These are respectively; indicated as red, green, blue and common anode (Figure 5). R ‘on the LED (Red) tab temporarily 11A, G (Green) 9, B (blue) 10 are connected and used (Sparkfun. (n.d. -c)).

In the scope of analogWrite() from Arduino functions, 0 is 0% (off) and 255% is 100% (on). However, since the component used is the common anode, in the software part it is 100% (on) and 0 for 255, 0% (off). Mixing values for tricolor LED are shown in Figure 6.

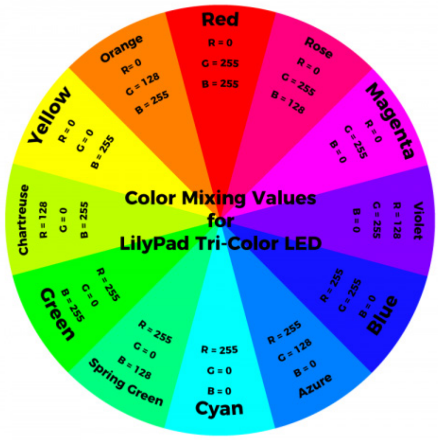

Figure 6. Mixing Values Tri-Color

LilyPad Buttons

Buttons and switches are electronic components that control the flow of current in a circuit. They can act as a simple way to light up an LED or as an input for a microcontroller. Buttons are generally considered to be a kind of switch with a momentary push action.

This compenent is also a type of switch (Figure 7). When you press the button in the middle of the board, it connects the two sewing tabs and allows the current to pass. When the button is released, the connection reopens and the button returns to its place. This button is an example of an instant toggle (Sparkfun. (n.d. -d)).

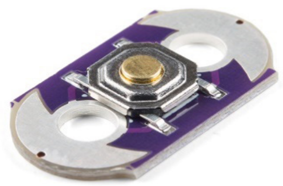

Figure 7. LilyPad Buttons

LilyPad Slide Switch

One condition, to change from one state to another, usually a flip, slide or push so on. physical action is required. This action is called operating the switch for short. Different types have different working methods. There are different types of switches in the LilyPad series by sliding, pushing or even using a magnet to trigger.

LilyPad Slide Switch is shown Figure 8; On/Off label has a small switch. When set to the “Off” position, the parts inside the switch diverge and open (disconnect) the circuit. No current will flow from the switch to components connected to the seam tabs. When the toggle switch is set to the “On” position, the two seam tabs on the switch connect, allowing current to flow through and close the circuit (Sparkfun. (n.d. -d)).

Each of the components of switches, the supply current of 300mA and voltage is 4 volts stated. However, given current with a reduction in the 5-volt work.

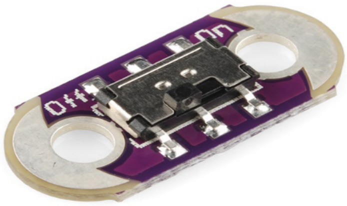

Figure 8. LilyPad Slide Switch

LilyPad White LEDs

LilyPad White LEDs (5 pcs) are attached to each other (Figure 9). LilyPad white LEDs are creatively designed and easily sewn into fabric. Component, various input, output, power and sensor together with the board comes. LilyPad White LEDs are washable. LilyPad White LEDs offer a slim 0.8mm build and a 5.5mm x 12.5mm PCB layout (Sparkfun. (n.d. -e)).

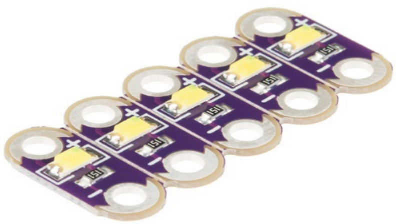

Figure 9. LilyPad White LEDs

LilyPad Buzzer

Lillpad Buzzer are the two I/O pins (Figure 10). With this I/O change, different melodies are formed depending on different frequencies. Volume enough is more, but annoying as it is not loud (Sparkfun. (n.d. -f)).

Figure 10. LilyPad Buzzer

LilyPad Light Sensor

The LilyPad Light Sensor, its stand-up component with a built-in and ready-to-use ALS-PT19 light sensor, is shown in Figure 11. Each sensor generates a voltage between 0 V and 3.3 V, depending on the level of ambient light shining on it. As more light is applied to the sensor, more current will flow from the board via the signal hop to the microcontroller to which the sensor is connected. If the sensor does not receive light, no current flows through it. In a typical indoor lighting situation, the sensor outputs around 1 to 2V. (Sparkfun. (n.d. -g)).

Figure 11. LilyPad Light Sensor

LilyPad Temperature Sensor

Temperature sensor, the set temperature in each 10mV for a Celsius degree to (° C) to give a certain voltage set. The current flowing through the signal tab can be read with an analog tab on the LilyPad Arduino board and converted to degrees Celsius or Fahrenheit via a formula.

The sensor generates an analog voltage that represents the temperature near it. The voltage output of the sensor is linearly proportional to the temperature in degrees Celsius. Once the output voltage of the sensor is known, these equations 1 and 2 can be used to calculate the temperature (Sparkfun. (n.d. -h)).

$$^{O}Celsius = (voltage - 0.5) * 100 \quad (1)$$

Equation 2 is used to convert to Fahrenheit.

$$^{O}Fahrenheit = (^{O}Celsius * 9.0/5.0) + 32.0 \quad (2)$$

LilyPad Arduino Simple

The LilyPad Arduino Simple is the brain of the ProtoSnap process. Microcontroller is divided into various modules in terms of digital pins, analog pins, programming interface and battery inputs as shown in Table 2 (Sparkfun. (n.d. -i); Nayyar, & Puri, 2016).

Table 2. LilyPad Models

Board	Microcontroller	Digital Pins	Analog Pins	Programming Interface	Attachment of the Battery
LilyPad Arduino Simple	ATMega328	9	4	FTDI	JST Connector
LilyPad Arduino USB	ATmega32U4	9	4	USB	JST Connector
LilyPad Arduino SimpleSnap	ATMega328	9	4	FTDI	Built in LiPo
LilyPad Arduino 328 Main Board	ATMega328	14	6	FTDI	Sew Tabs
LilyPad USB Plus	ATMega32U4	10	7	FTDI	Built in LiPo

LilyPad Arduino Simple has an ATmega328 microprocessor controller at its core. A microprocessor is a small computer that can be programmed to interact with LEDs, beeps, and many other peripherals. The ATmega328 microcontroller has many features (Table 3) besides the input and output set and works very well with Arduino software (Lakshmi Lasya, 2021). The features of LilyPad Arduino Simple are as follows:

- 5 I/O pin (Digital),
- 4 pin (Analog),
- ATMega328p microcontroller,
- LED on pin 13,
- On/Off switch,
- Onboard JST connector for charging circuit and 3.7V LiPo battery.

Table 3. LilyPad Arduino Simple Features

I/O Devices	Range Of Value
Microcontroller	ATMega328V
Operating Voltage	2.7 – 5.5.V
Input Voltage	2.7 – 5.5.V
Digital I/O pins	14
Analog Input pins	6
Current per I/O pin	40 mA
Flash Memory	16 KB
SRAM	1 KB
EEPROM	512 bytes
Clock Speed	8 MHz

ATMega328p is a multifunctional microcontroller with command voice working in single cycle. The ATMega328p is generally an 8-bit RISC processor with low power consumption and high performance (Figure 12) (Sparkfun. (n.d. -i)).

It contains 131assembly instructions, known as single-cycle,32 8-bit general-purpose registers and has a completely static operation support. In addition, the ATMega328p microcontroller has an operating speed of up to 20 MHZ. ATMega328p system microcontroller also has 1 KB EEPROM and 32 KB Flash Memory system. For these reasons, it is a frequently used microcontroller system (Nayyar & Puri, 2016).

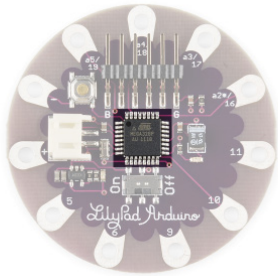

Figure 12. ATMega328p Microcontroller of LilyPad Arduino Simple

As shown in Figure 13, there is a small LED to the right of the ATmega328. This can be classified as the most important component in Arduino. The LED is connected to Arduino pin 13 and can be used for all your flashing needs. In the top left is a momentary button used to reset the ATmega328. This will restart the sketch the Arduino is running from the beginning.

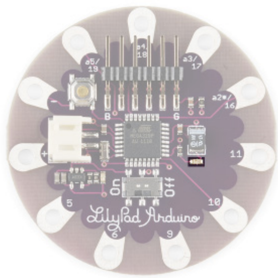

Figure 13. LED of LilyPad Arduino Simple

In Figure 14, there is an On/Off slide switch at the bottom of the ATmega328. There are several ways to power the ProtoSnap LilyPad Development Board, and in most cases the built-in FTDI board is used, possibly to power it using the computer's USB. If the card is powered by the FTDI card, the On/Off switch has no function. The switch controls power to the Arduino only if powered through the small white connector to the left of the ATmega (Nayyar & Puri, 2016).

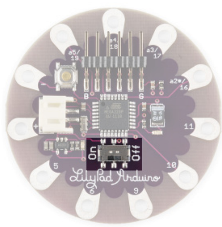

Figure 14. On/Off Slide Switch of LilyPad Arduino Simple

The white connector in Figure 15 is a fairly common power connector from the JST family of connectors. Mainly for connecting one of the Lithium Polymer batteries (Sparkfun. (n.d. -i)). LiPos are rechargeable batteries, a battery can be connected to the LilyPad Arduino Simple via the JST connector. P is installed, and a FTDI Basic Breakout is connected, the battery ignorant half of the charge can be investigation.

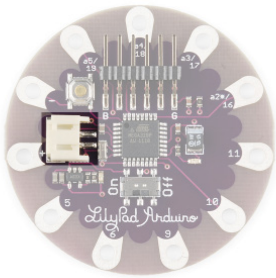

Figure 15. JST Connector of LilyPad Arduino Simple

Powering the LilyPad Development Board

LilyPad can be run in two ways (Sparkfun. (n.d. -j)):

- If you have an available USB power source (computer, 5V USB adapter, USB battery pack, etc.), A USB cable and a card from FTDI can run (Figure 16a).
- If the project is desired to be portable, a rechargeable Lithium-polymer battery can be connected to the JST connector end (Figure 16b).

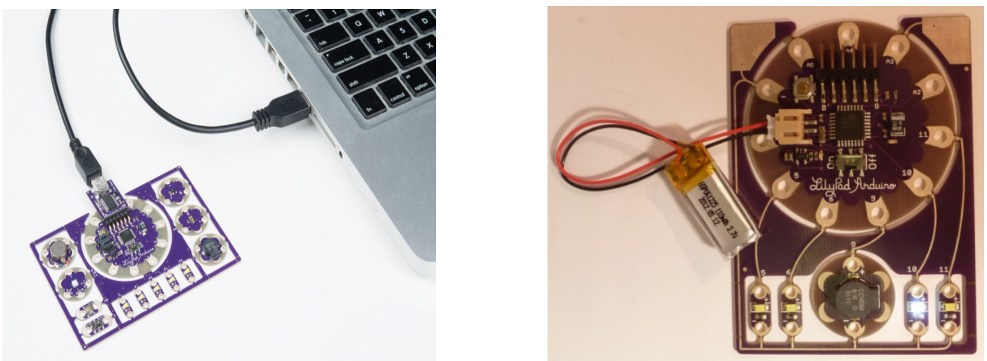

Figure 16. (a) USB Connection (b) LiPo Battery Connection

LilyPad Coding Editor: Arduino Sketch

LilyPad is for programming the Arduino' s used languages, is a simplified version of the C ++ programming language. This simplified structure is provided by workpieces called functions. The complexity of the details of the definitions for microprocessors or microcontrollers is greatly simplified with Arduino. In addition, it enables the programmer to write code without tiring the programmer with small work pieces that will dominate many hardware (Sparkfun. (n.d. -k)).

The programming language consists of three main structures. These (Galadima, 2014);

I. *The part with definitions.* In this section, variables can be defined, libraries can be included in the program or operations such as naming pins can be done. For example; For a pin that is constantly used in the program, instead of using it as the 13^{th} pin; 13p to the LED 13 connected pine "LED" name largely ensured by ease of use.

II. *Installation part.* This section in which the pins which input of the pins to be output, serial data communication related settings used in the program to be written like an Arduino make the necessary installations for properties. The installation part will run once when the program first starts and will not run again unless the Reset is triggered or the power is cut off.

III. *The Cyclic Part,* is the part where the actual program is executed. All functions of the project we will do are written in this part. This section runs the codes we have written continuously until the energy is cut off or reset. When the program starts from the beginning of this section and reaches the end, it returns to the beginning of this section and continues to run. This is called an infinite loop.

LilyPad Programming

When you want to program LilyPad, you will need to perform the following three steps.

1. LilyPad Development Board, FTDI card and your computer using a USB cable to connect.
2. Arduino the "Board" menu "LilyPad Arduino w/ ATmega328" choose.
3. Arduino's "Port" menu LilyPad the serial port that is connected to select.

1. LilyPad Development Board

After the LilyPad FTDI Board is connected to the headers on the LilyPad Arduino Simple, a mini USB-B cable is attached to the other side of the FTDI board. Plug the other end of the USB cable into any USB port on the computer. The connection process is completed by sliding the switch on the LilyPad Arduino Simple to the on position. If the switch is in the off position, the code is not loaded.

2. Select LilyPad Arduino w/ ATmega328

LilyPad Arduino Simple Tools to Tools > Boards menu LilyPad Arduino w/ ATmega328 is selected (Figure 17).

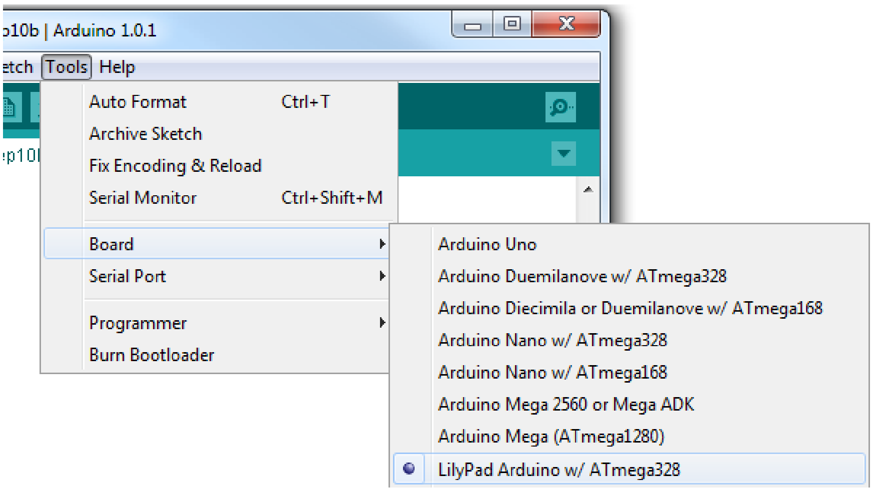

Figure 17. Board Menu LilyPad Arduino is Selected

3.Select Port

The Arduino needs to know which port the LilyPad Arduino is connected to in order to program it. When a USB device is plugged into the computer, the computer will assign a port number to that port. Tools > Serial Port menu, the port to which the LilyPad Arduino is connected is determined (Figure 18).

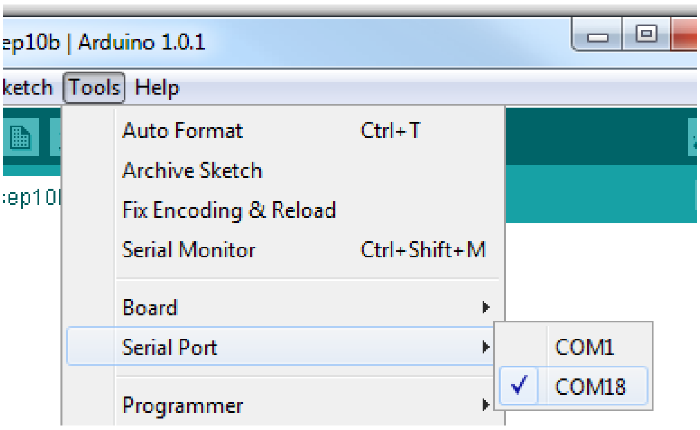

Figure 18. Determining the LilyPad Arduino Port from the Serial Port Menu

Lilypad Application

LilyPad offers a very useful structure for e-textiles and wearable technologies. In particular, the increase in the use of portable technology indicates that the control that consumers can exert over their environment will also increase (Baurley, 2004). Wearable technology can monitor health functions and vital signs, help improve the physical performance of athletes or rehabilitation patients, provide feedback from stimuli in one's environment, and create new opportunities for aesthetic improvement and decoration in the clothing industry (Berzowska & Bromley, 2007). Mohsen et al. (2021), a medical practice can be worn for long-term health of the sensor system is designed (Mohsen et al., 2021). LilyPad Card was used as a wearable technology in the design of this system. Because of the various functions provided by wearable technology, this type of technology offers numerous opportunities for new product development (Ariyatum, 2005).

LilyPad Arduino is a sewable microcontroller used in textile-based wearable technology and runs on Arduino, an open source programming and prototyping platform. Originally designed as a pedagogical teaching tool, it taught a variety of user's basic computer and electronics skills through an embedded computer system (Buechley & Eisenberg, 2008). Users can sew the LilyPad into a textile-based project and connect the components with conductive fabric and thread (Buechley et al., 2008). It was largely created to expand on what its creators saw as an impressive extension of already existing tech themes as entertainment and automation, which in turn led to the creation of a new demographic (Buechley & Hill, 2010). Lasya (2021), in his study, aimed to help visually impaired individuals reach their goals without any difficulty by using shoes that are uniquely designed for the visually impaired and can be produced to fit easily inside.

The creators of LilyPad point out that human computer interaction and technology use is a third dimension that focuses on whether users can perform tasks or express themselves in ways that were previously thought impossible using a particular technology (Buechley et al., 2008). That is, people can easily purchase the device online and learn how to use it themselves through various open source tutorials. Buechley and Hill (2010) state that the mass consumerism that marked the 20th century will soon be replaced by a context where niche users will maximize their internet resources to create, find, share and consume content that suits their unique interests and needs (Buechley & Hill, 2010). This is in line with the stance of Smelik, Toussaint and Van Dongen (2016) that the relevance of wearable technology will only increase when users interact with design and discover new values and significance through it (Smelik et al., 2016). The Internet has facilitated the rapid spread of DIY concepts to the wider population; Open source tools such as Arduino allow collaborations and sharing to happen easily and quickly and are becoming more and more common in production architecture and design disciplines, creating a context where consumption is no longer passive. Rather, it is an opportunity to build one's creative experience and can lead to a change in attitudes and behaviors that characterize the broader consumer population (Lin, 2014).

Conclusion

Giving open source code application examples of microcontrollers brings development boards to the forefront today. One of the important advantages of development boards is that most development boards are inexpensive and do not require a separate power supply or can be operated with a normal power supply designed by the designer. The emergence of different development boards leaves the designer obliged to make different circuits and develops them in the direction of electronic circuit design. LilyPad offers a different alternative to other development boards as it offers a more flexible and softer content compared to other circuit boards in both wearable technology projects and e-textile projects.

Lilypad, by collecting data on the health system, analyzing and transmitting patient safety enhancing projects also clothes, watches and so on shoes. Considering that it is easy to place, it is quite easy to get values from different sensors.

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About the Authors

Hakan YUKSEL, PhD, Isparta, is an Assistant Professor of Computer Technologies at Isparta University of Applied Sciences. His main interests are in artificial intelligence technologies, development boards, sensor and 3D modeling applications.

E-mail: hakanyuksel@isparta.edu.tr, Orcid: 0000-0003-2186-533X

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