
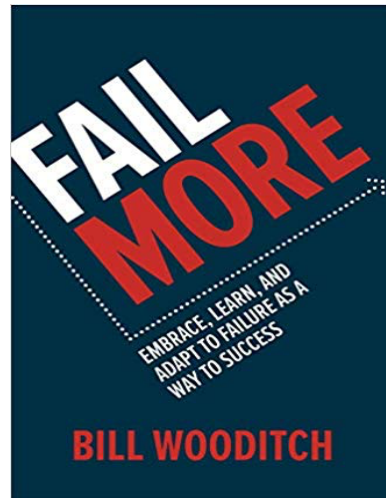


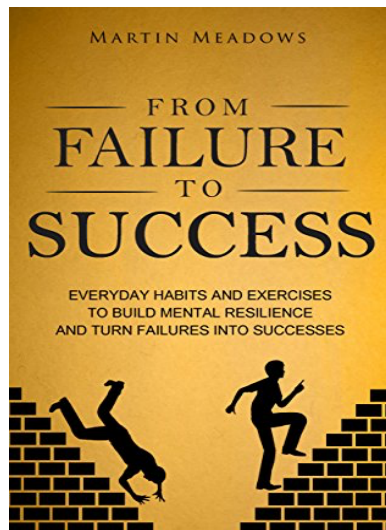
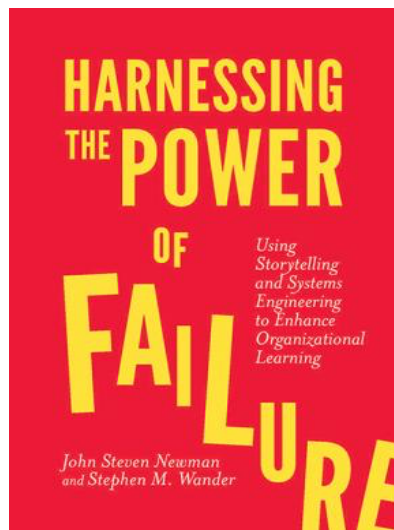
Engineering Failure for Learning

A chalkboard with two arrows. The top arrow is labeled 'SUCCESS' in blue and the bottom arrow is labeled 'FAILURE' in red. A hand is holding a white chalk marker near the top arrow.

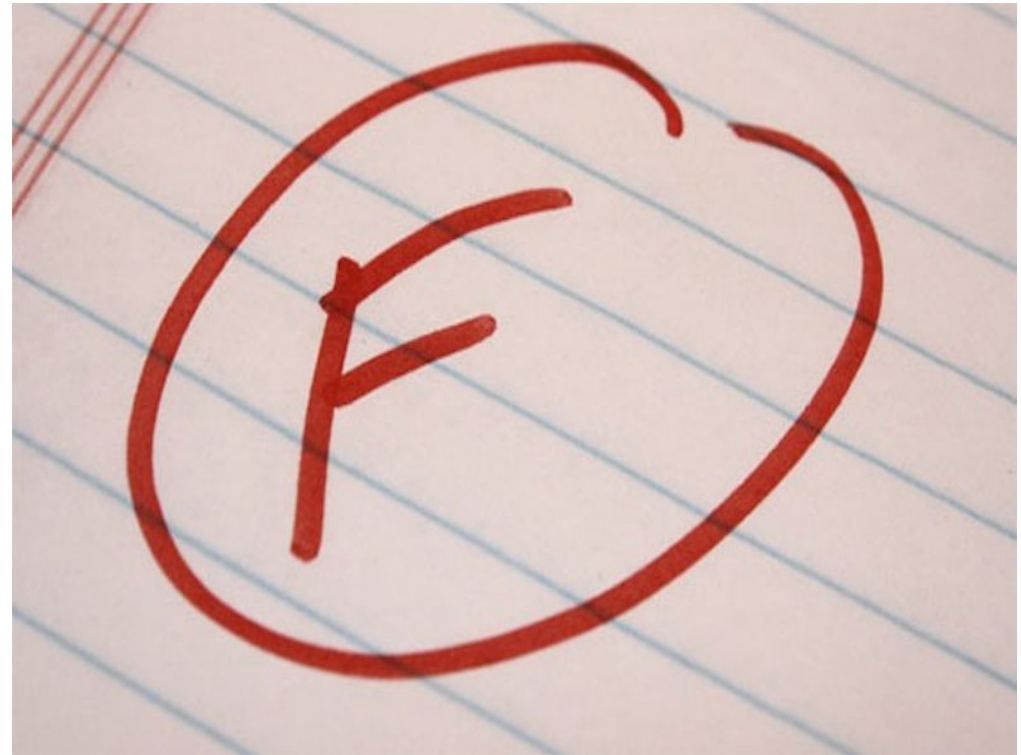
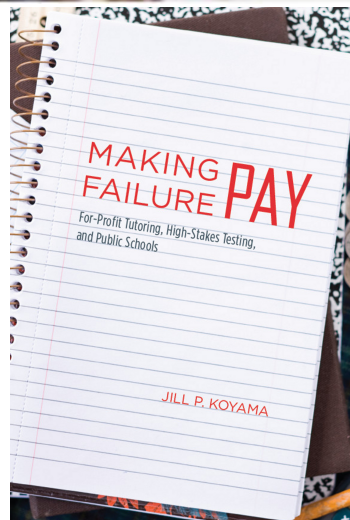
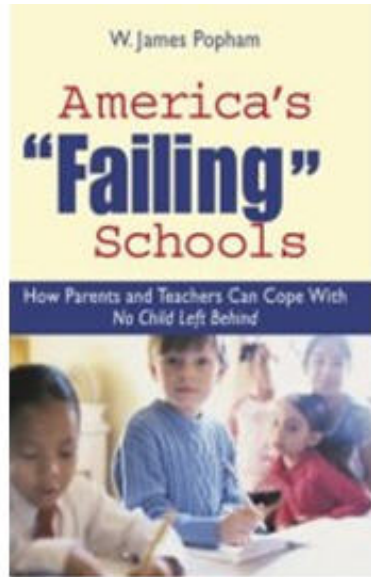
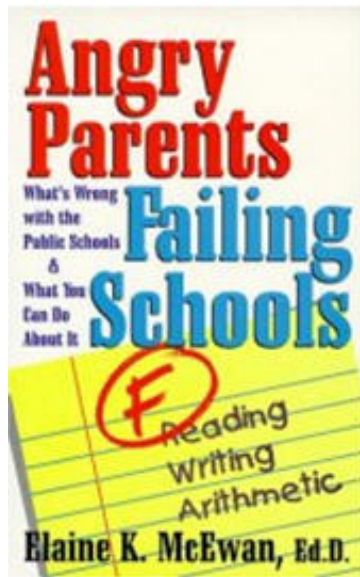
Yasmin B. Kafai
University of Pennsylvania



FAIL FESTIVAL







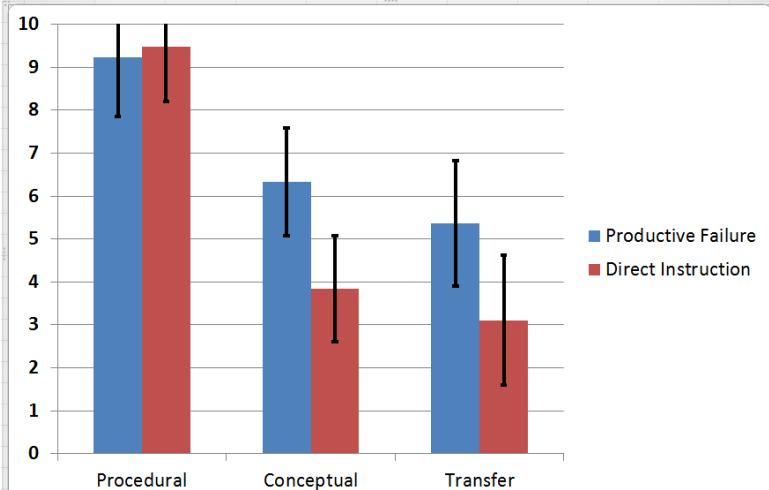


The
Failure
Toy

Turns Out Designing a Toy That Teaches Failure is Really Hard

My 3 year journey designing the world's first Failure Toy

“designing for and bootstrapping failure for deep learning...”



PRODUCTIVE FAILURE



Exploring
Computer
Science

[E-Textiles Home](#)

[Curriculum & Projects](#)

[Resource Guides](#)

[Gallery](#)

[Files & Downloads](#)

Exploring Computer Science would like to introduce you to:

STITCHING the Loop

A stylized illustration of a needle and thread. The thread is green and forms a loop. The needle is silver and is positioned as if it has just finished stitching the loop.

An Electronic Textiles Unit in Exploring Computer Science



E-Textile Curriculum



Project 1: Paper Circuit

Single circuit project design:

Create a simple paper circuit greeting card that includes one LED. Introduce the concept of aesthetic design and personalization.

Key Concepts & Materials:

- Simple circuit
- Understanding polarity
- Materials: LEDs, copper tape (wire), paper

(1-2 hrs)



Project 2: Wristband

Simple wearable project:

Create a wristband with three LEDs in parallel and a switch that turns on the project when the ends of the wristband are snapped together.

Key Concepts & Materials:

- Parallel circuit, switch
- Designing and reading circuit diagrams
- Three-dimensional project
- Deconstruction
- Materials: Conductive thread, LEDs, battery and holder, fabric

(5-6 hrs)



Project 3: Collaborative Mural

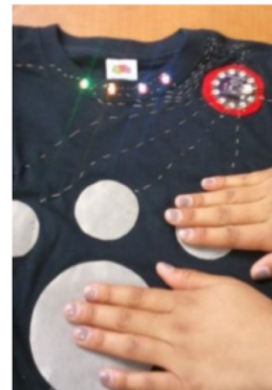
Collaborative project:

As a class create a mural, with each panel made by two students. Each panel must have five independently programmable LEDs and two switches, allowing for four blinking light patterns.

Key Concepts & Materials:

- Programming for digital input: Sequences, conditionals, embedded conditionals or Boolean statements
- Collaborative work & division of labor
- Materials: Conductive thread, LEDs, fabric, microcontroller

(10 hrs)



Project 4: Human Sensors

Capstone project:

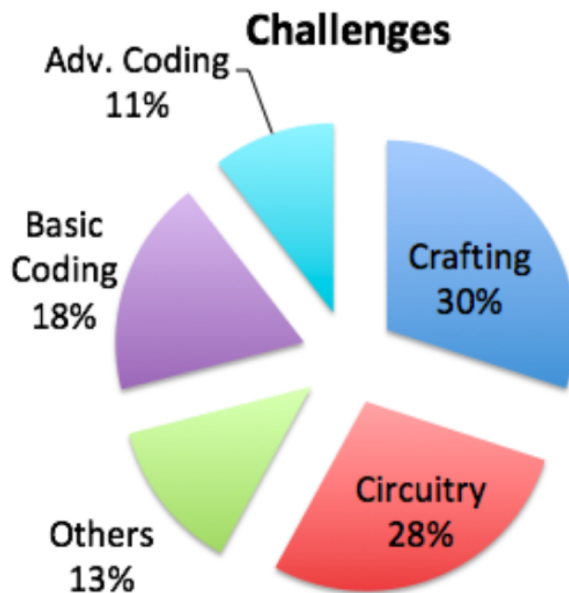
Create a project with two aluminum foil patches that act as a sensor when both are touched by a person. Program four+ lighting patterns based on different sensor readings.

Key Concepts & Materials:

- Sensor design (handcrafted)
- Programming for analog input: operators, sensor range, Boolean statements
- Materials: Conductive aluminum foil, human body, LEDs, microcontroller, fabric

(10-14 hrs)

Debugging Challenges



36% of coding challenges were advanced computational concepts


“So from my last project, it was a human sensor and **my scales were... pretty much wrong**”

64% of coding challenges were basic computational concepts

“If you plan to do a certain pattern, **sometimes you may not have a delay() with the right number**. The pattern could be really slow or too fast, depending on what you want it. And then, that can mess it up.”



Celebrating Mistakes!

A woman with dark hair, wearing a patterned sweater, is holding up a piece of dark fabric with visible stitching. She is smiling and looking towards a group of students. The background shows a classroom setting with a window and some furniture.

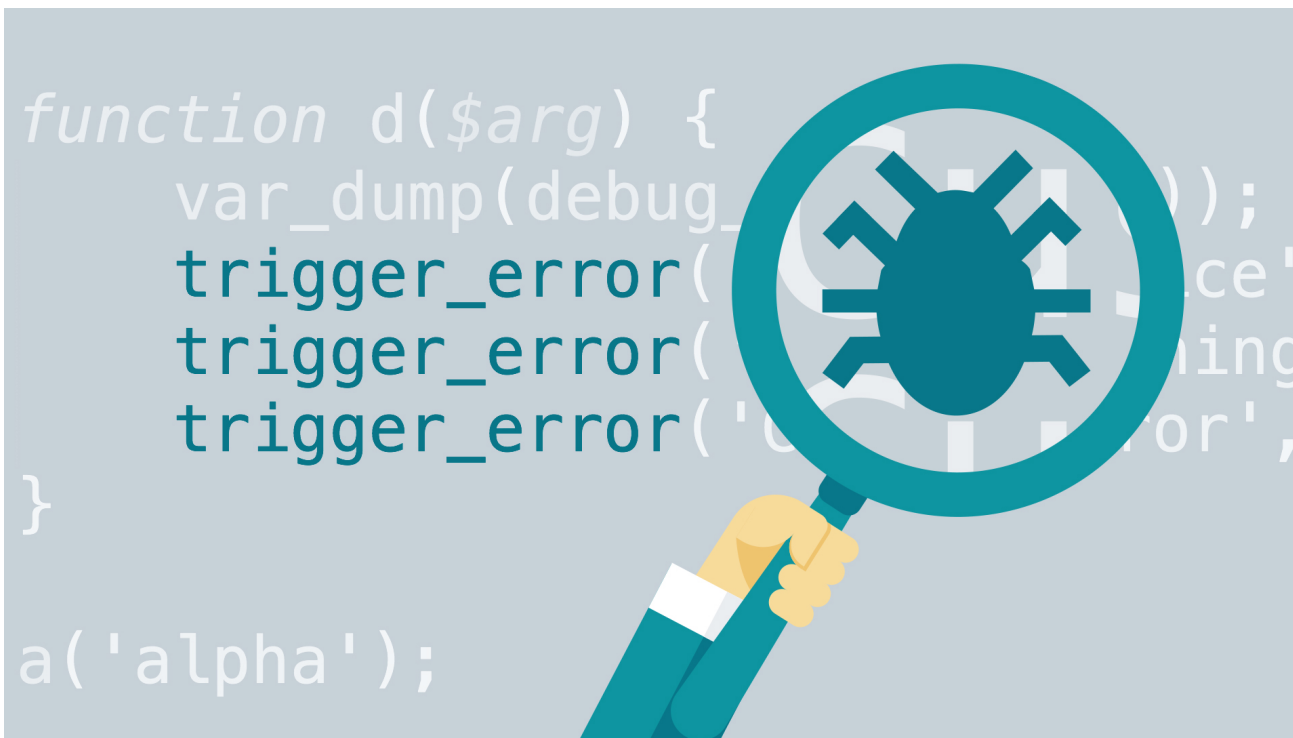
'Look at my stitching. There are some good stitches and some bad stitches. Where are the bad ones?' Angela said, showing her project to students.

'The long ones,' a student replied.

'The long ones. **These are me being lazy.** If these are long ones, I'm going to come and pull on them and if it comes out it comes out. The long ones are easier to snag on something. **You are not lazy like me, you are efficient** so you're going to make smaller stitches,'

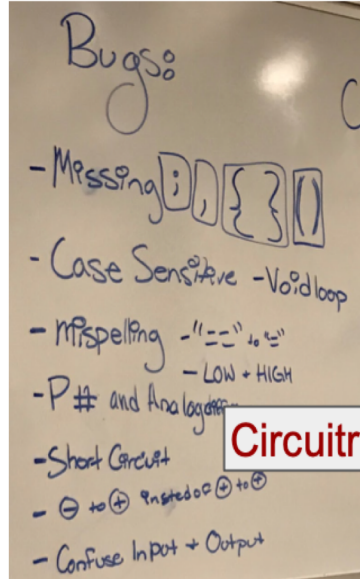
- **Favorite Mistake of the Day!** (Students' mistakes)
- Show the **teacher's mistakes** on their project

Debugging by Design

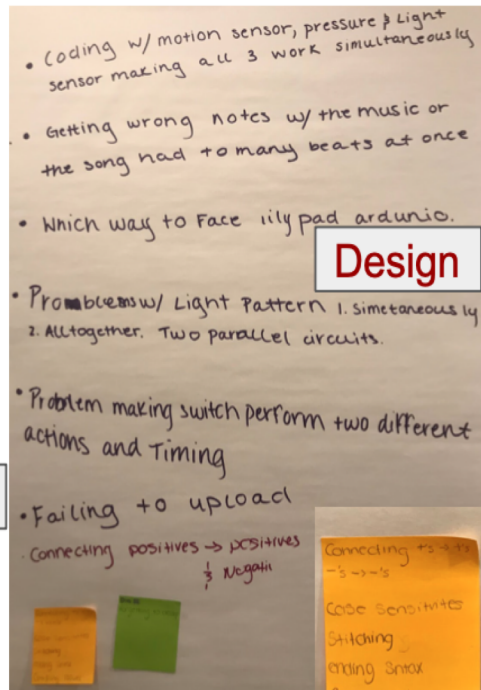


Hall of Failure

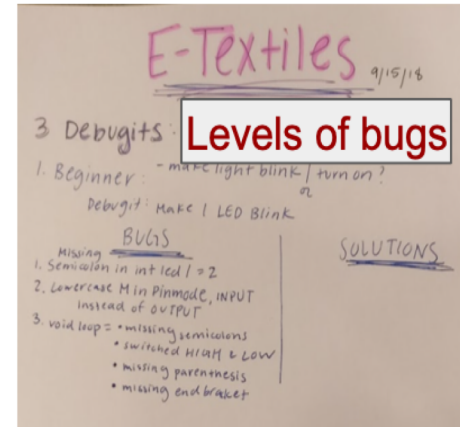
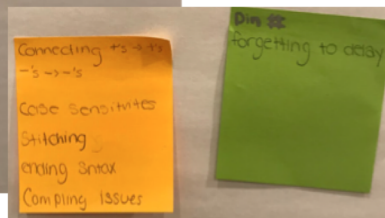
Plan/Design a DebugIt



Coding



Gallery Walk

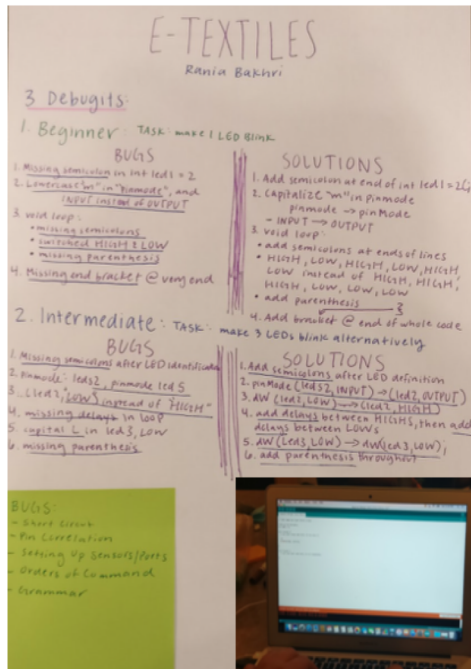


Types of bugs

Make the Debugt & Reflect

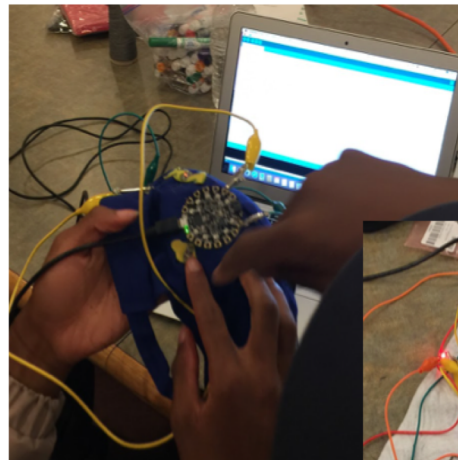
Solve each other's Debugts

Overall Reflection

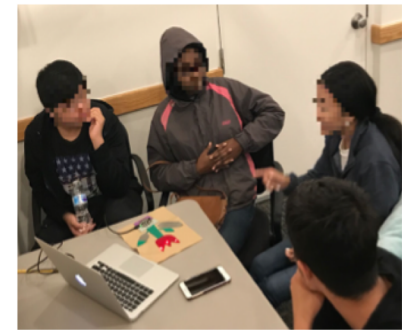
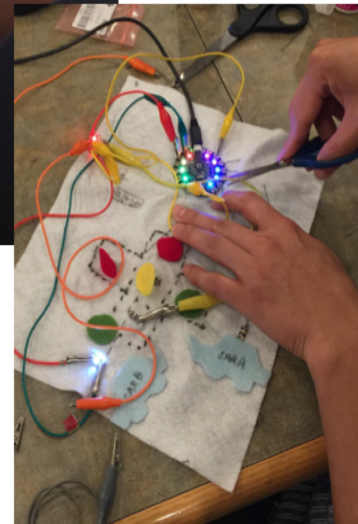


Levels of bugs

Supports



Buggy Circuits



"Get it from the Design notebooks"

Debuglt (buggy project)

"Our project is a sick cloud throwing up a colorful rainbow. Our project is supposed to successfully blink all together at half a second when button 1 (pin19) is pressed with the colors of the rainbow. Otherwise the lights would just be all on. All of our LEDs are connected to one pin so they would all have to do the same things. All of the negatives go to ground and all of the positives go to pin #6"



```

int rainbow = 5;
int yellow = 7;
int green = 8;
int blue = 9;
int pink = 10;
int button1 = 4;

void setup()
{
  pinMode(rainbow, OUTPUT);
  pinMode(button2, INPUT)
  pinMode(button1, INPUT);
}
void loop()
{
  int butt1Val = digitalRead(button1);
  if(butt1Val == LOW && butt2Val == HIGH) //both buttons on
  {
    blink1()
  }
}

```

Intentionally deceptive code

```

void blink1()
{
  digitalWrite(ranbow, HIGH);
  delay(500);
  digitalWrite(rinbow, HIGH);
  delay(500);
}

```

Debbie: 'Okay, what do you think the hardest parts will be for your peers?'

Student: *turned the project over and pointed to the circuits with the thread.* 'We connected all the lights to one pin but put in lots of pins for the code, so I think that will confuse people.'

Debbie: 'I think that the part about Butt2Val and digitalread will throw people off, but I could be wrong.'

Learning Gains:

- Familiarity with a broader range of problems
- Avoided mistakes in later project
- Identified problems more easily
- Learned new code

Feelings & Growth Mindset:

- Felt more comfortable with problems*
- Felt more confident and less stressed in solving problems*
- Felt more able to ask for help because “a lot of people make mistakes”
- Felt mischievous and fun: Creating problems “challenging enough to stress someone out is kind of funny and good”

*Significant pre/post survey results

Student Reflections

Teacher Reflection - Ben

So the initial highlight was **seeing the mischief on students' faces when they realized 'oh my god we get to mess with other people.'** Um. you know so, that was on some of them.

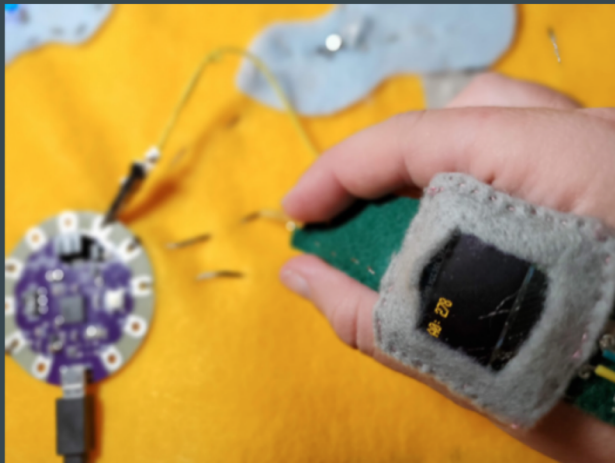
And others - like **there was excitement.** Which was kind of fun to see...

When they were all writing out their - the bugs they wanted to create - you could see that **they were making connections that otherwise they had not made earlier.** Right, so like, **actually having to like think through all of the different things that could go wrong and trying to plan them in advance made some sort of like click** in, in some of them.

Tools

Handheld Probe

Rona Sadan



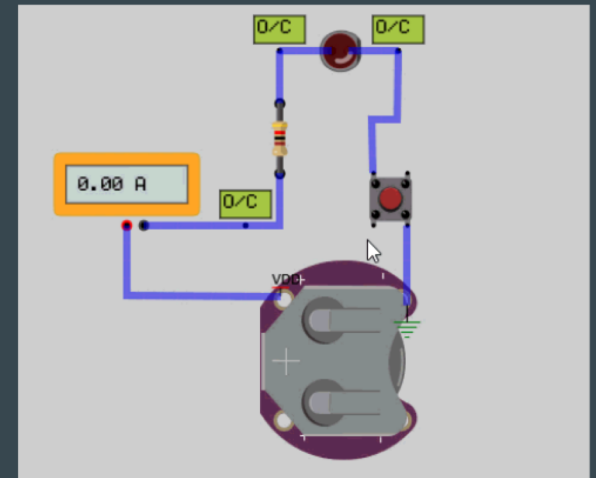
Software Library

Michael Schneider

```
1 #include <Adafruit_CircuitPlayground.h>
2 #include <PinStatus.h>
3
4
5 PinStatus PinStats;
6 void setup() {
7   CircuitPlayground.begin();
8   pinMode(3, INPUT);
9   pinMode(1, OUTPUT);
10  Serial.begin(9600);
11 }
12 void loop() {
13
14   bool lightOn = digitalRead(3); //Check Pin 3
15   if(lightOn)
16   { //If Pin 3 is Receiving Power, turn ON Pin 1
17     digitalWrite(1, HIGH);
18   }
19   else
20   { //Else turn OFF Pin 1
21     digitalWrite(1, LOW);
22   }
23   PinStats.showPinStatusDigital(false, true);
24   // (false) Do not flash
25   // (true) Display debug info
26   PinStats.pauseProgram();
27   //Pause to read debug info
28 }
```

Circuit Simulator

Christian Hill



Comparative Classroom Implementations in 2020



Project 1: Paper Circuit

Single-circuit project design:
Create a simple paper circuit greeting card that includes one LED. Introduce the concept of aesthetic design and personalization.

Key Concepts & Materials:

- Simple circuit
- Understanding priority
- Materials: LEDs, copper tape (pen), paper

(7-9 hrs)



Project 2: Wristband

Simple wearable project:
Create a wristband with three LEDs in parallel and a switch that turns on the project when the ends of the wristband are snapped together.

Key Concepts & Materials:

- Parallel circuit, switch
- Designing and reading circuit diagrams
- Three-dimensional project
- Personalization
- Materials: Conductive thread, LEDs, battery and holder, fabric

(2-4 hrs)

Project 3: Collaborative Mural

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As a class create a mural, with each panel made by two students. Each panel must have four independently programmable LEDs and two switches, allowing for four linking light patterns.

Key Concepts & Materials:

- Programming for digital input: Sequences, conditionals, embedded conditionals
- Boolean statements
- Collaborative work & division of labor
- Materials: Conductive thread, LEDs, fabric, microcontroller

(10 hrs)

Project 4: Human Sensors

Optimative project:
Create a project with two aluminum foil patches that act as a sensor when both are touched by a person. Program four lighting patterns based on different sensor readings.

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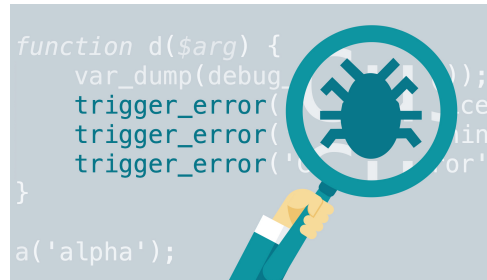
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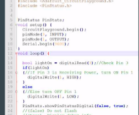


Tools


Handheld Probe
Rona Sadan

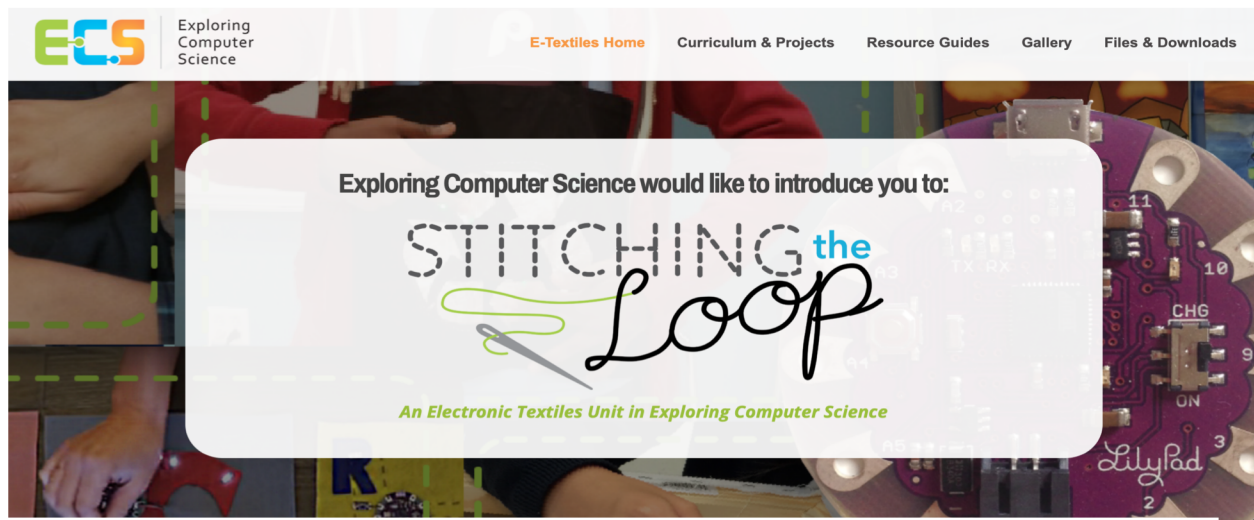


Software Library
Michael Schneider



Circuit Simulator
Christian Hill





www.exploringcs.org/e-textiles

FALL

2018

CURRICULUM

TECHNICAL Guide

RESOURCE List

CS STANDARDS

FALL

2019

**micro::bit
Adaptation**

**Extension
Activities**

FALL

2020

**CLASS
Activities**

**Debugging
TOOLS**

PROJECT TEAM

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Mark Gross

Ariel Bloom

Christian Hill

Rona Sadan

Michael Schneider

University of Boulder Colorado