Building New Clubhouses of Computing

Introductory equity-oriented computer science with electronic textiles for high school students

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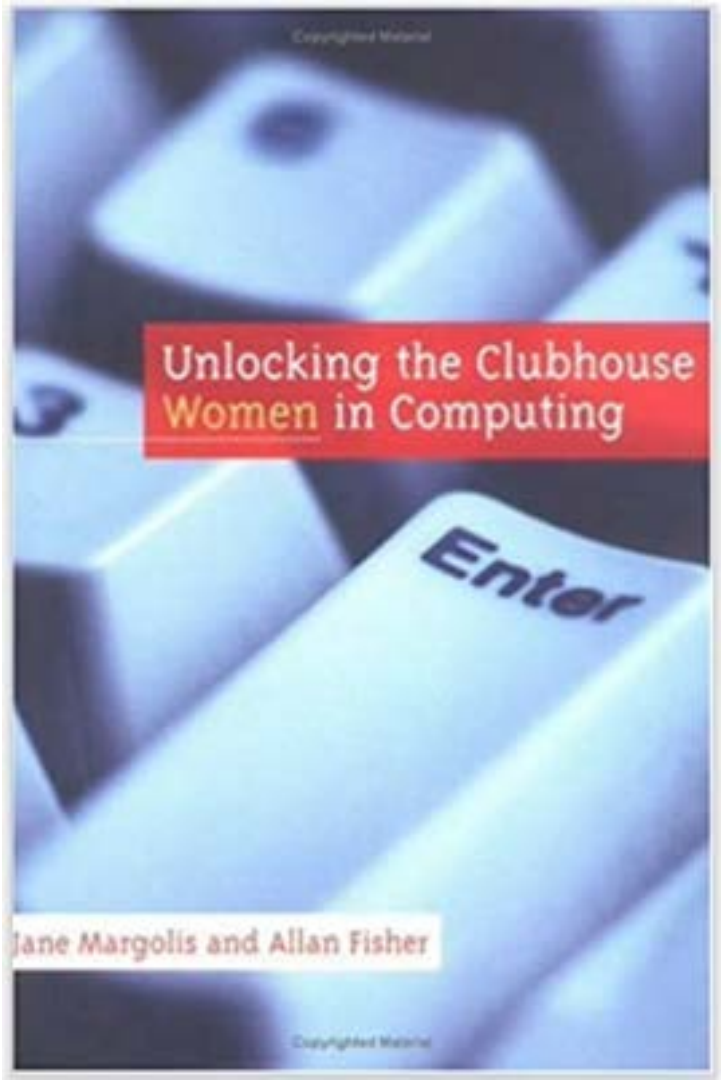
OVERVIEW

1. Clubhouses of Computing
2. ECS Stitching the Loop
3. Classroom Results
4. Portfolio Assessments
5. BREAKOUT DISCUSSIONS
6. What's Next?



PART 1

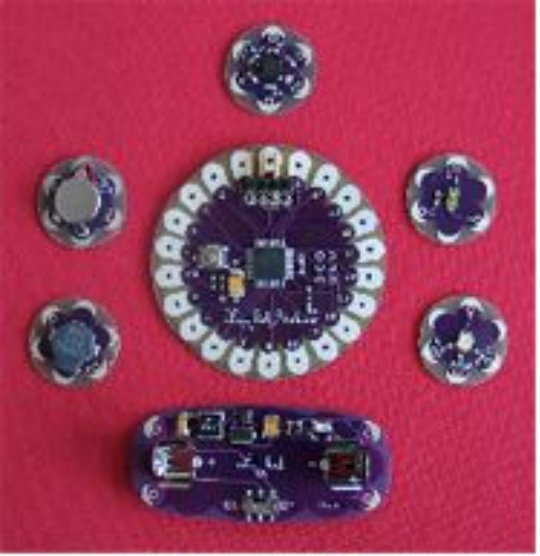
BUILDING CLUBHOUSES OF COMPUTING


Map
Satellite
K12 COMPUTER SCIENCE FRAMEWORK
After the reboot:
computing education
in UK schools
THE ROYAL SOCIETY
Iceland
Norway
Algeria
Mali
Niger
South Atlantic Ocean
Australia
Google

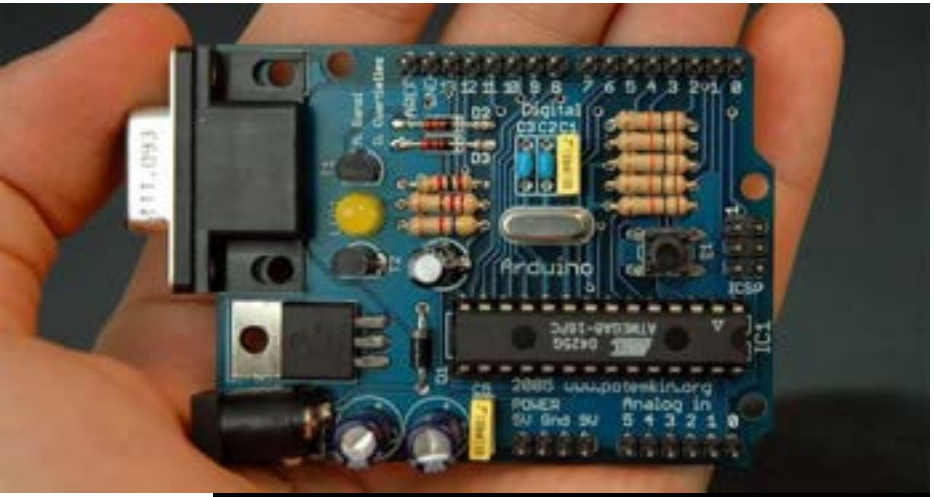

unesco
K-12 AI curricula
A mapping of government-endorsed AI curricula
ED-2022/PI/U-ICT/K-12
Education 2030


A High-School Curriculum Exploring What Computer Science Is and What It Can Do
ECS
EXPLORING COMPUTER SCIENCE

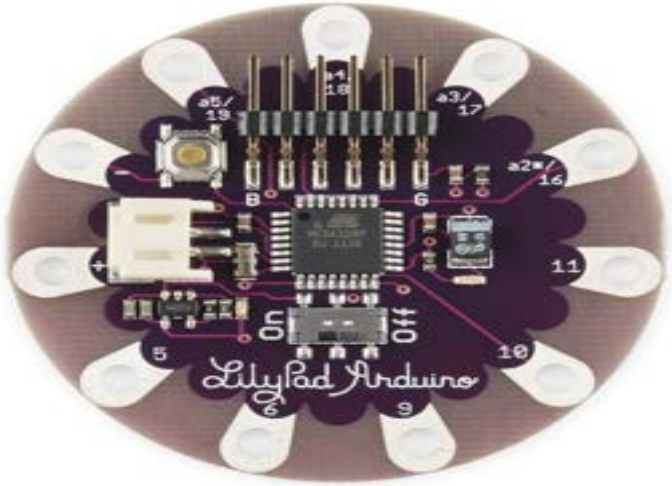

Computer Science Discoveries
urriculum Adoption
IONAL MATERIALS COMMITTEE REVIEW
Curriculum Guide
2019-2020
omputer Science
Discoveries



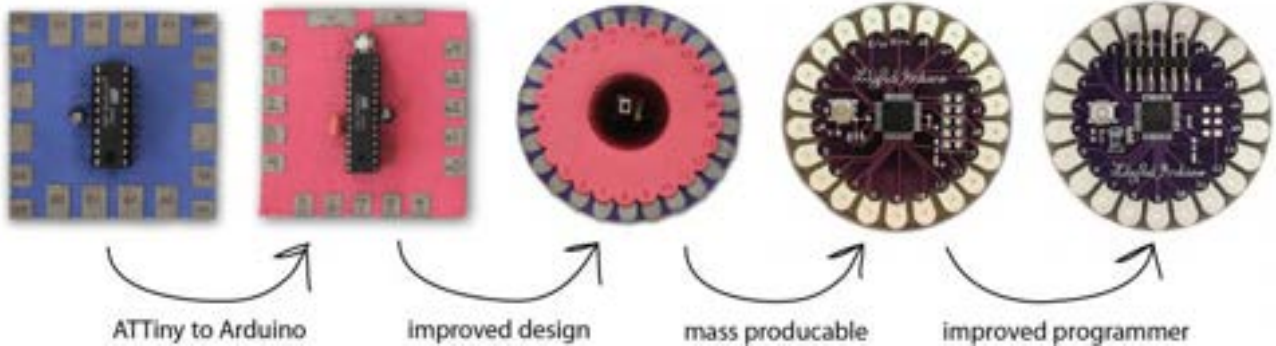
Electronic Textiles

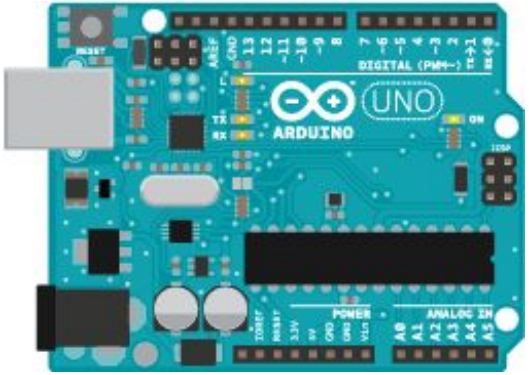


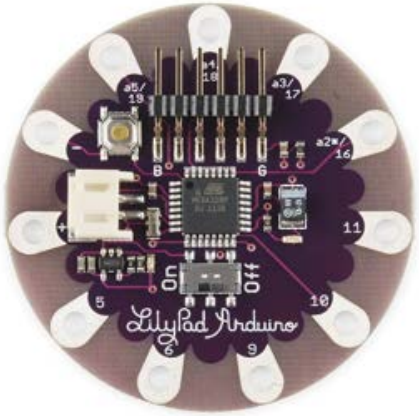
Arduino



LilyPad Arduino




UNO
ARDUINO
DIGITAL (PWM~)
POWER
ANALOG IN


LilyPad Arduino

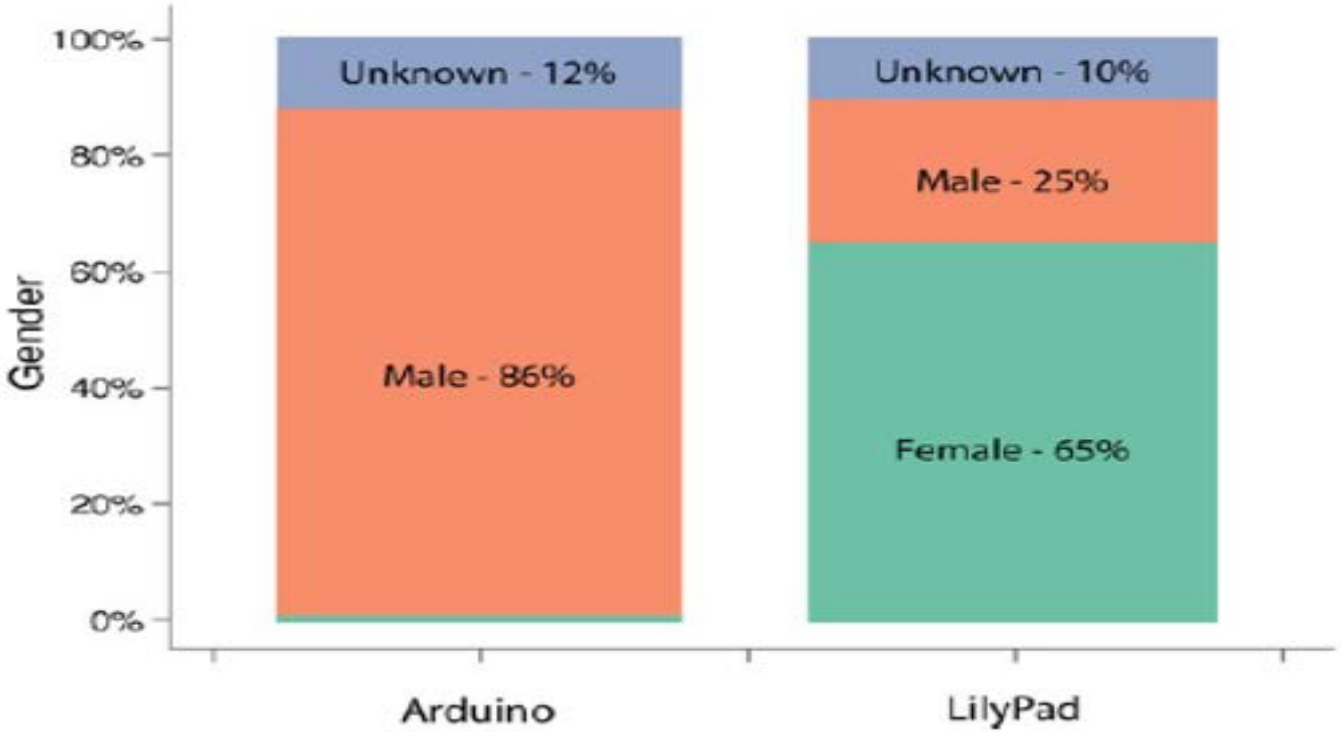
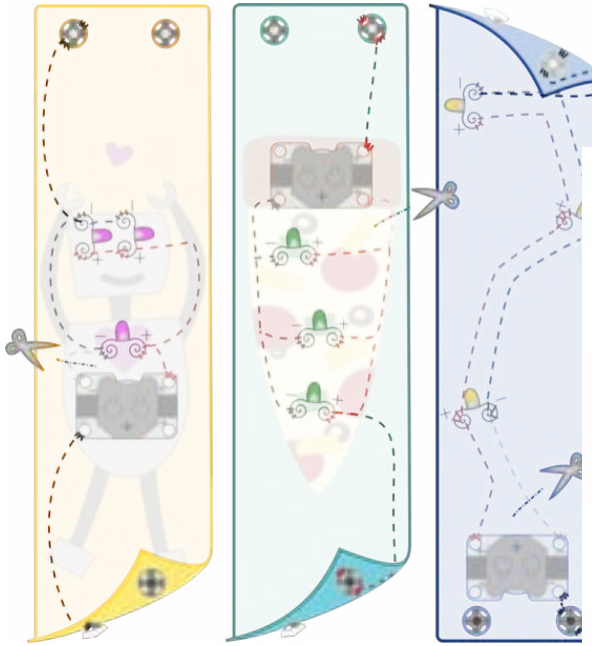
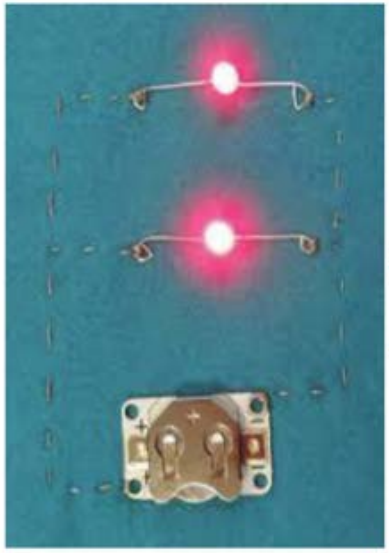


Figure 4. LilyPad and Arduino projects by gender.
(Arduino N = 114, LilyPad N = 57)

Buechley & Hill, 2010)





Circuits

```
void loop() {
 /* The third section is for things that happen repeatedly in the program loop
while the program is running. The code is executed in the order coded. */

  int switch1storage = digitalRead(switch1);
  int switch2storage = digitalRead(switch2);
  Serial.println(switch1storage, switch2storage);
  /*The three lines above make the computer 1) look at
    whether the switches are open (i.e., "read" them)
    and print 1 or 0 to the serial monitor so we can look at them
 */
  delay (100); //delay for 1/10 of a second every time it reads
  if (switch1storage == HIGH && switch2storage == HIGH) { //if b
    blinkingPattern1();
  }
  else if (switch1storage == HIGH && switch2storage == LOW){ //i
   blinkingPattern2();
```

Coding

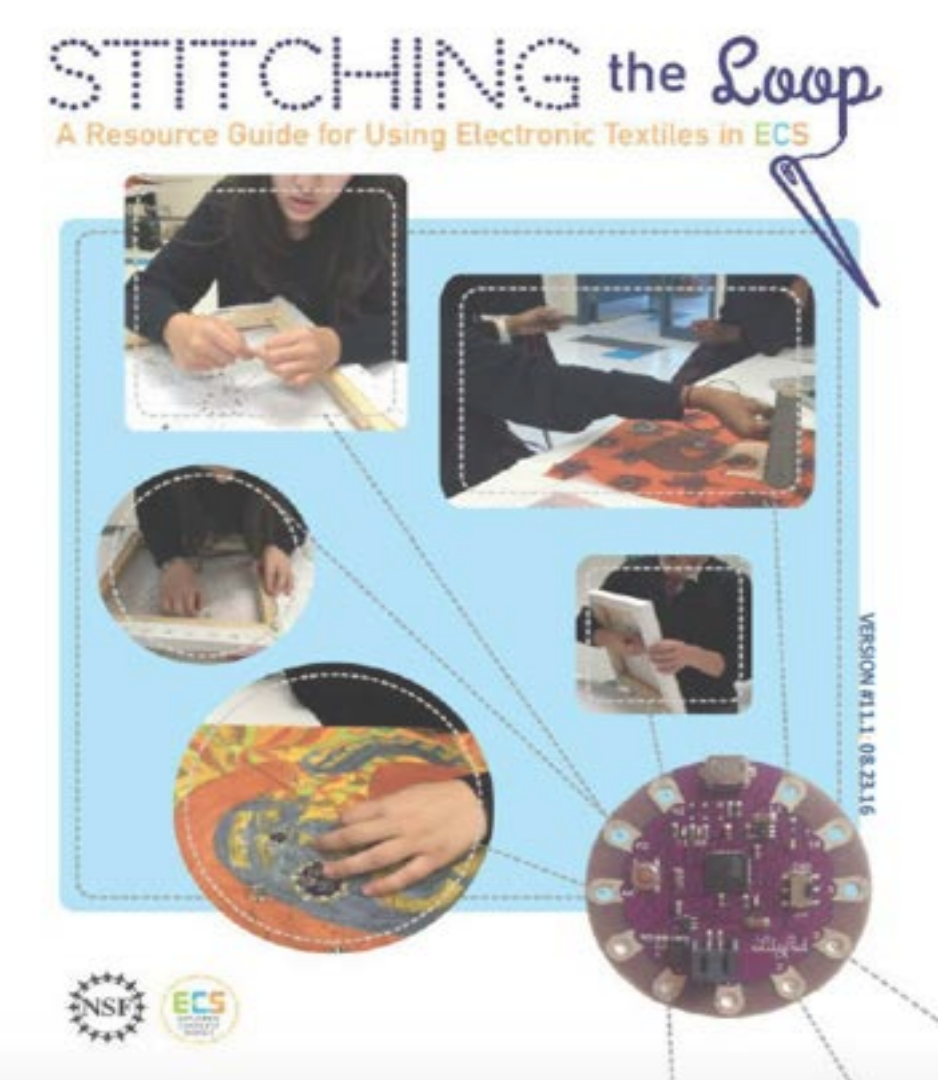
Crafts

```
if (sensorValue < 500)
                {
  analogWrite(5, brightness);
  analogWrite(6, brightness);
  . . .

  brightness = brightness + fadeAmount;
if(brightness == 0 || brightness == 255) {
    fadeAmount = - fadeAmount;
                }
    delay(50);
                }
  else
                {
  . . .
```

We may say most aptly that the Analytical Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves.

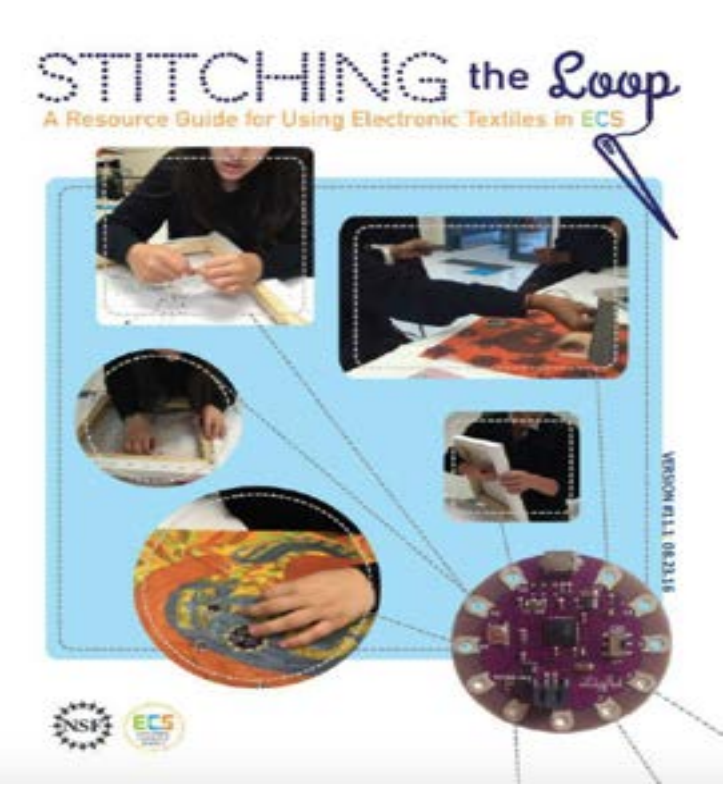
Augusta Ada King,
Countess of Lovelace
1843



PART 2

STITCHING THE LOOP OVERVIEW

Putting Making into Classrooms



- CONTENT: How do we create a scenario where all kids are learning rigorous concepts about CS? *In schools?*
- PERSONAL & CULTURAL: How do we support *personal and cultural relevance* in such a space?
- TEACHING SUPPORT: How do we do this with just *one instructor* in the room?
- EQUITY: How do we make sure that we promote equity?

Design Principles of E-textiles Curriculum

- **Four Projects** *(building on experience, no single point of failure)*
- **Drawing on Diverse Expertise** *(everyone brings something, everyone must learn something*
- **Foregrounding Aesthetics** *(personal ownership & perseverance)*
- **Valuing Mistakes** *(process is important, portfolios)*

2018 STEM FOR ALL VIDEO SHOWCASE

Transforming the Educational Landscape, May 14-21

E-Textile Projects

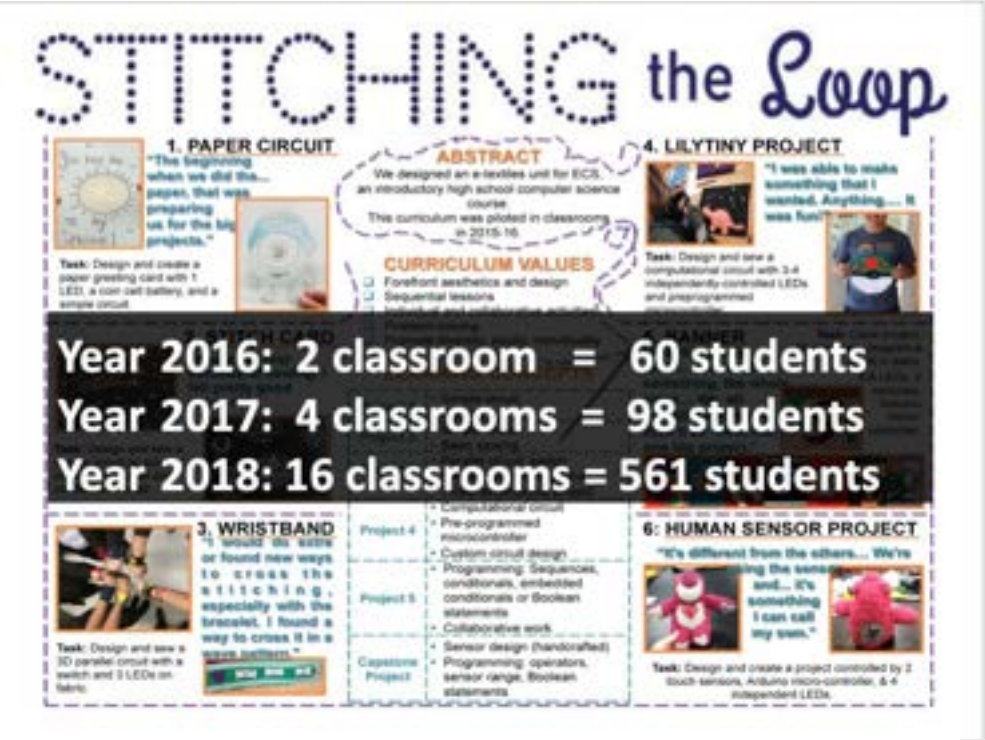
Project 1: E-Cards

Project 2: Wristbands

Project 3: Class Banner

Project 4: Human Sensor

Project	Content	Description
#1 Paper Circuit (~1-2 hrs)	Single circuit project design: Create a simple paper circuit greeting card that includes one LED. Introduce the concept of aesthetic design and personalization.	· Simple circuit · Polarity · Materials: LEDs, copper tape (wire), paper
#2 Wristband (~5-6 hrs)	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.	· Parallel circuit, switch · Reading circuit diagrams · Three-dimensional project · Deconstruction · Materials: Conductive thread, LEDs, fabric
#3 Collaborative Mural Project (~10 hrs)	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.	· Programming: Sequences, conditionals, embedded conditionals *or* Boolean statements · Collaborative work & division of labor · Materials: Conductive thread, LEDs, fabric
#4 Human Sensor Project (~10-14 hrs)	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.	· Sensor design (handcrafted) · Programming: operators, sensor range, Boolean statements · Materials: Conductive aluminum foil, human body, LEDs, fabric



PART 3

STITCHING THE LOOP RESEARCH

Iterations of Curriculum Design

Year 1 (2015-16): Two teachers + 65 students

- Revisions: Consolidated projects, added portfolios
- **Focus: Teaching practice**

Year 2 (2016-17): Three teachers + 102 students

- Revisions: Further improved computing lessons
- **Focus: "Average" student development (case studies)**
- **Focus: Portfolios as assessment and mode of student voice**

Year 3 (2017-18): Fifteen teachers + 456 students

- Final touches: Better commented code

Quant research on the curriculum

School Demographics

- **LARGE URBAN PUBLIC SCHOOL DISTRICT**
  > 500,000+ students in K-12
- **HIGH PERCENTAGE OF MINORITIES (72-99%)**
  Predominantly African-American and Latino high school students
- **HIGH PERCENTAGE OF REDUCED LUNCH**
  Low SES

Research on the curriculum

School level characteristics				
ID	%Gen	%Min	%ESL	%RL
1	F-49%	72.5%	3%	49%
2	F-50%	99.5%	24%	97%
3	F-64%	99.0%	2%	91%
4	F-51%	83.4%	5%	58%
5	F-23%	100%	19%	97%
6	F-43%	95.9%	41%	88%
7	F-51%	100%	8%	77%
8	F-45%	99.3%	19%	95%
9	F-46%	84%	10%	77%
10	F-47%	98%	4%	75%
11	F-100%	73.7%	2%	47%
12	F-43%	96.1%	12%	99%
13	F-53%	98.1%	14%	93%
14	F-53%	99.7%	14%	90%
15	F-100%	73.7%	2%	47%
16	F-53%	98.1%	14%	93%
17	F-100%	73.7%	2%	47%

Min=Minority (defined as non-white), ESL=English as a second-language, RL=Reduced lunch, Sam=Sample

Survey Instrument (Validated!)

Confidence/Competency in STEM: Sample questions

- I think I am very good at: Figuring out how to fix things that don't work.
- I think I am very good at: Explaining my solutions to technical problems.

Fascination with STEM: Sample questions

- I love designing things!
- I want to learn as much as possible about computer science

Expression: Computer Science & Creativity/Personal Expression

- I can be creative in computer science.
- I can express myself in computer science

Value of CS

- Knowing computer science is important for contributing to my community.
- Knowing computer science is important for me in the future

Quant research on the curriculum

FINDING 1: CS Perceptions

Variable	Pre-Survey Mean (SD)	Post-Survey Mean (SD)	Demographic Differences
Confidence	15.04 (2.2)	15.54 (2.397)*	None
Fascination	12.58 (2.334)	12.89 (2.307)*	None
Expression	9.6 (2.00)	10.03(1.808)*	None
Value	6.33 (1.314)	6.27 (1.364)	Gender**

Note *p<0.05, **p<0.001

Quant research on the curriculum

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Quant research

No differences with regard to gender, ethnicity, home language, or family education

Rubric for Human Sensor Project

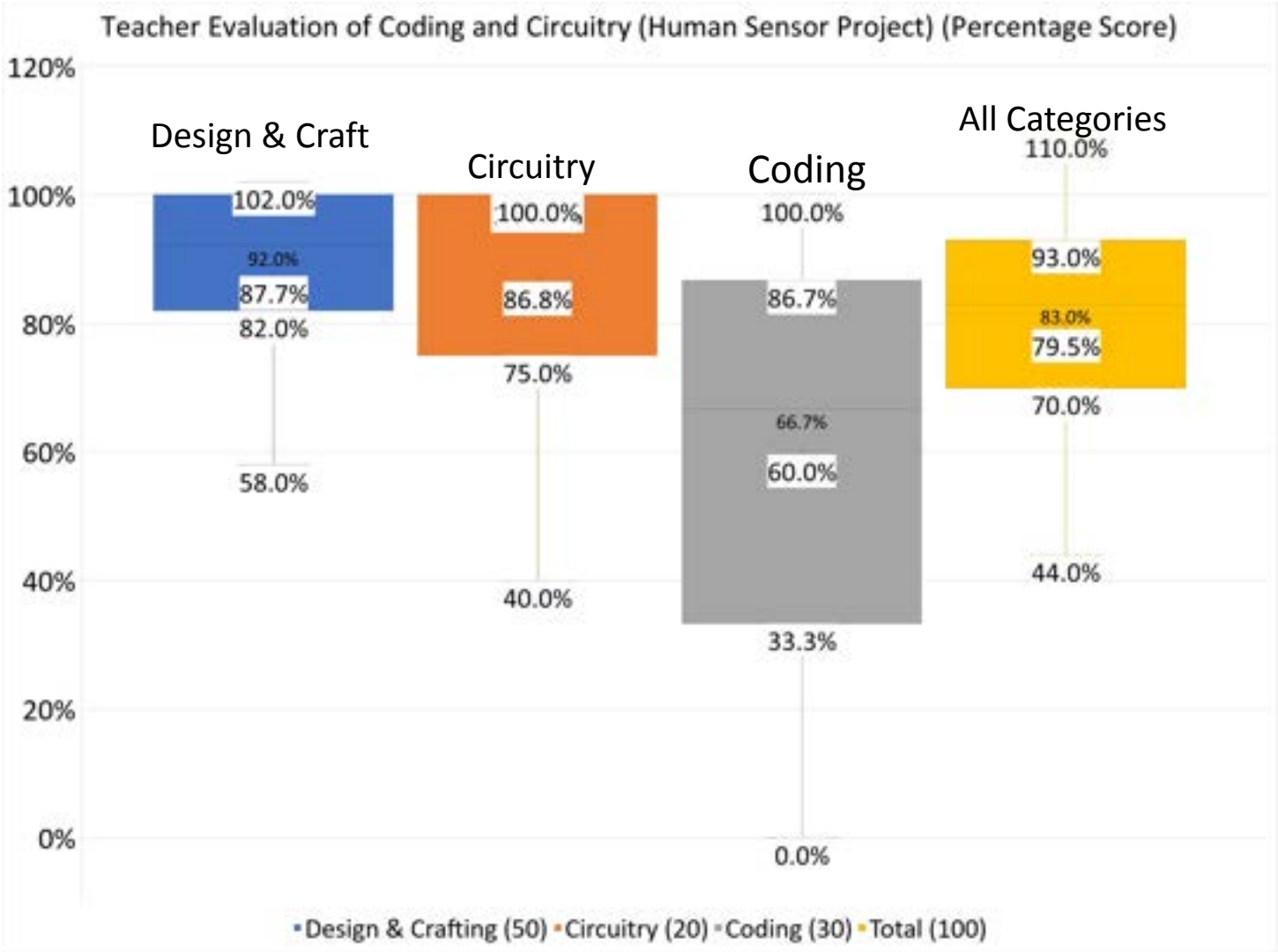
- Coding (30 points)
  - for having the general structure of code including variable declaration, input/output setup and the appropriate conditionals (15 points),
  - four complete lighting pattern functions (5 points),
  - appropriately commented code (5 points
  - functional sensors (5 points).
- Circuity (20 points)
  - for the completion and clarity of the circuit design (15 points),
  - functionality of the LED circuits themselves (5 points).
- Design & Craft (50 points)
  - for fulfilling the basic requirements of having four independently controllable lights and two sensor patches (10 points),
  - aesthetics and finishing (15 points),
  - sewing (15 points),
  - design notebook completion (10 points).

Quant research on the curriculum

Rubric for Human Sensor Project

	Coding				
	5 pts	**3 pts**	**1 pts**	**0 pts**	
Four Complete Lighting Patterns	• There are four functional lighting patterns (i.e., would work if circuits were perfect). Each is different in some way.	• Two or three lighting patterns have been programmed. Each is different in some way.	• Only one lighting pattern has been programmed.	• No lighting patterns have been programmed	
	15 pts	**10 pts**	**5 pts**	**0 pts**	
Coding	• The code is great! • Each input and output has been declared in the Naming Section and set to output/input as needed in the Setup Section. • Needed variables are entered correctly and used consistently. • Conditionals are programmed	• The code is there but some minor improvements are needed (mostly syntactical). • Examples: There are extra (or missing) brackets; a variable/pin has been mislabeled; an input/output is missing or mislabeled.	• The code is there but a lot of improvements are needed. • Some sections need to be finished (maybe not all variables are listed, inputs/outputs are missing, conditionals are poorly programmed). • Or perhaps the conditionals are semantically	• There is no code at all. Or it is so poorly done that there might as well be no code.	

FINDING 2: CS Competencies



FINDING 3: Perceptions & Learning

For students who finished the <u>final, human sensor project</u>:

- Overall **good performance on the final project** was significantly correlated with increases in:
  - Fascination in CS
  - Expression with CS
  - Confidence in problem solving
  - Confidence in coding
- **Performing well in coding** (on final project)was significantly correlated with:
  - All of the above
  - + Valuing CS
- **Prior teacher experience with e-textiles** unit
  - Positive correlation with final project performance & portfolio performance

Quant research on the curriculum

Self as a Computer Science (CS) Person	
	Hard Skills: Students explicitly linked growth as a computer scientist with specific skills they learned, such as sewing, coding, or making circuits.
	Problem-Solving: Students called themselves problem-solvers and related this to doing computer science or being a type of computer scientist.
Self and CS as Personal	
	Socioemotional: Students described how doing the project or the project itself demonstrated personal characteristics they held, such as dedication, perseverance, patience, getting out of one's comfort zone, making mistakes, or collaborating with others.
	Relational: Students expressed a relationship with a friend, family member, or teacher that either provided feedback on the e-textile project, involved collaboration, or made a project intended for someone else.
Self and the CS Field at Large	
	Future Intentions: Students discussed themselves in a future tense in relation to computer science in the context of applications outside the classroom such as future jobs or in other projects.
	New Realizations: Students describe new realizations of what computer science is or what it can include.

QUAL - ground-up research on portfolios

TAKE-HOME POINTS

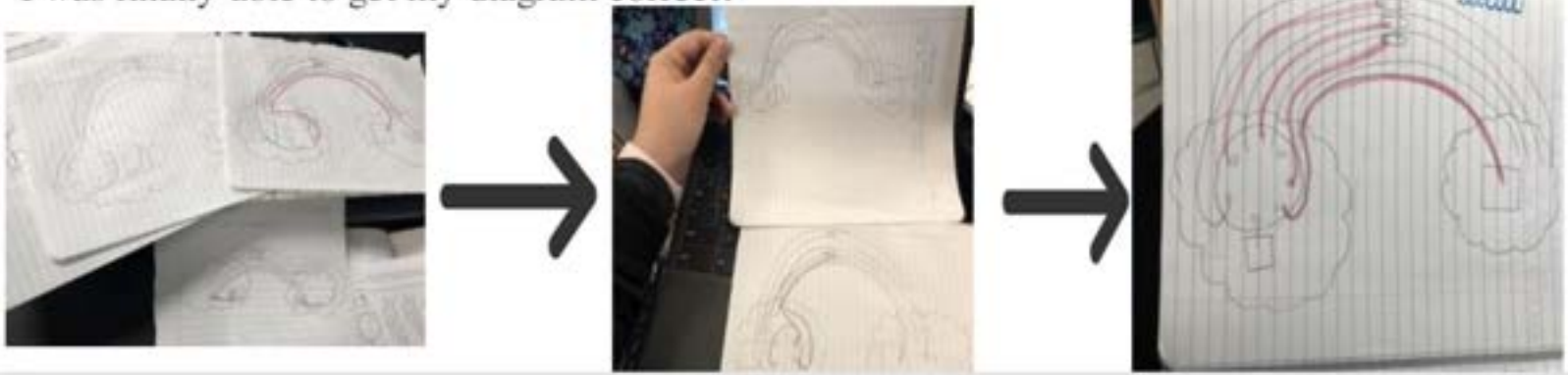
- E-textiles unit helped to broadening CS Perceptions
  - No gender differences, even male students benefited from e-textiles.
  - Similar for ethnicity, student home background.
- Validated survey that looks at Creativity/Expression within CS
- A Series of projects is important.
  - Performance was stronger where they encountered a concept a second time.

PART 4

ETEXTILE PORTFOLIO ASSESSMENTS

Process of making your project

One main challenge that I faced while making this project was setting up my circuit diagram. I had trouble setting up where all of my lights were gonna be placed at , and I had trouble color coding where the negatives and positives would be at . I sketched about 6 different papers and the 6th page was the one that came out fine because all of the other ones had negative and positives crossing which was not gonna help the program work , so I was finally able to get my diagram correct.



Student Portfolio

Analyzing Student Process-based Portfolios

- What do you see in the student's portfolio on the next several slides?

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Analyzing Student Process-based Portfolios

- What do you see in the student's portfolio on the next several slides?

If it were you, what would you be interested in analyzing?

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Analyzing Student Process-based Portfolios

- What do you see in the student's portfolio on the next several slides?

Things to consider:

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Analyzing Student Process-based Portfolios

- What do you see in the student's portfolio on the next several slides?

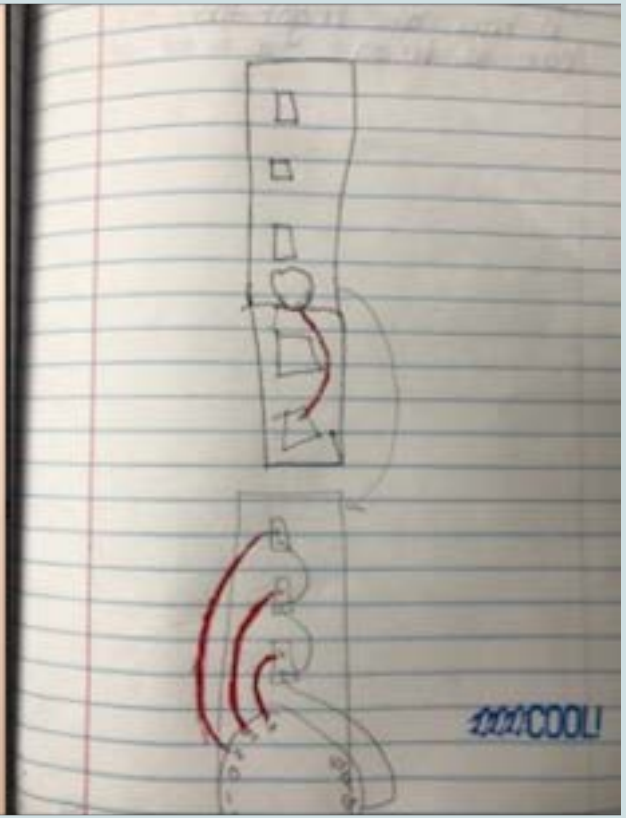
Things to consider:

- Problem solving/debugging/troubleshooting
- Identity & personal relevance
- Content learned
- Communication through text, images, and annotation

QUAL - ground-up research on portfolios

Part 1

- For my project I created a lightsaber from star wars
- I put the foil on the gray part/handle which connected to my lights and circuit playground/blue part.
- They are 4 lighting patterns and you squeeze the foil at different strengths to get the different patterns.
- Pattern 1 is for them all to turn on at the same time and then turn off at the same time
- Pattern 2 is for one to turn on the n the 2nd light and lastly the third light Then the 1st lights turns of then the second light and lastly the 3rd light to turn off.
- Pattern 3 is the first one turns on then it turn off. Then the second light comes on then off. Lastly the third lights turns on then of.
- Pattern 4 is they flash like pattern1 but at a much faster pace.



Student Portfolio

Coding Challenge

Wrong Version

```
if(sensorValue>=1000){pattern1()};
if(sensorvalue>=900 &&
sensorValue<1000){pattern2()};
if(sensorvalue>=800 && sensorValue<900){pattern3()};
if(sensorvalue<800){pattern4()};
```

This is the wrong code. The problem I had was that I was putting the semicolon outside of the bracket. But the revision I needed was putting the semicolon inside of the bracket. That problem was a hard one to see because it is a very minor problem and most people wouldn't have caught it

Right Version

```
 if(sensorValue>=1000){
    pattern1();  }
if(sensorValue>=900 && sensorValue<1000)
{pattern2();}
if(sensorValue>=800 && sensorValue<900){pattern3();}
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```
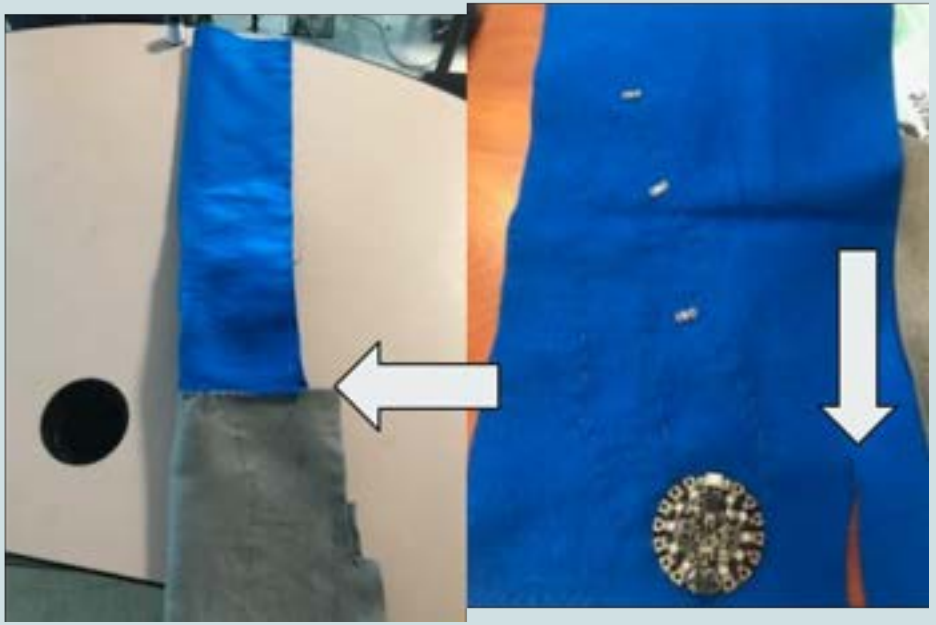

Student Portfolio

Sewing Challenge

The challenge I had sewing was trying to connect the handle to saber part, or the gray to the blue part. Once I sewed that I had to figure out how to connect the foil which was on the gray part to the circuit playground on the blue part. Another sewing challenge is that there was a tear in the blue strip so i had to sew the blue strip together



Student Portfolio

Reflection

During the e-textiles unit the major thing that I have improved on was my sewing. Before this unit I didn't know how to sew. I first thought you need a sewing machine to sew but now I realize that that isn't true. You can just use your arms, needle and thread with no machine. Learning how to sew is amazing .This skill will be helpful because I no longer need to ask my mom to sew something if I get a small tear in my clothes. So this new skill I learned will be able to help me once I get to college and I will not have to pay cleaners to fix my clothes, but instead I will be able to fix them.



Student Portfolio

Here's some of what we saw…

- Thoughtful Practices Expressed in Portfolios:
  - Observing a problem
  - Isolating a problem/root cause
  - Testing and/or refining something iteratively
  - Describing a solution
  - Planning to avoid a problem preemptively
  - Changing a project to make it more usable to a wider audience

QUAL - ground-up research on portfolios

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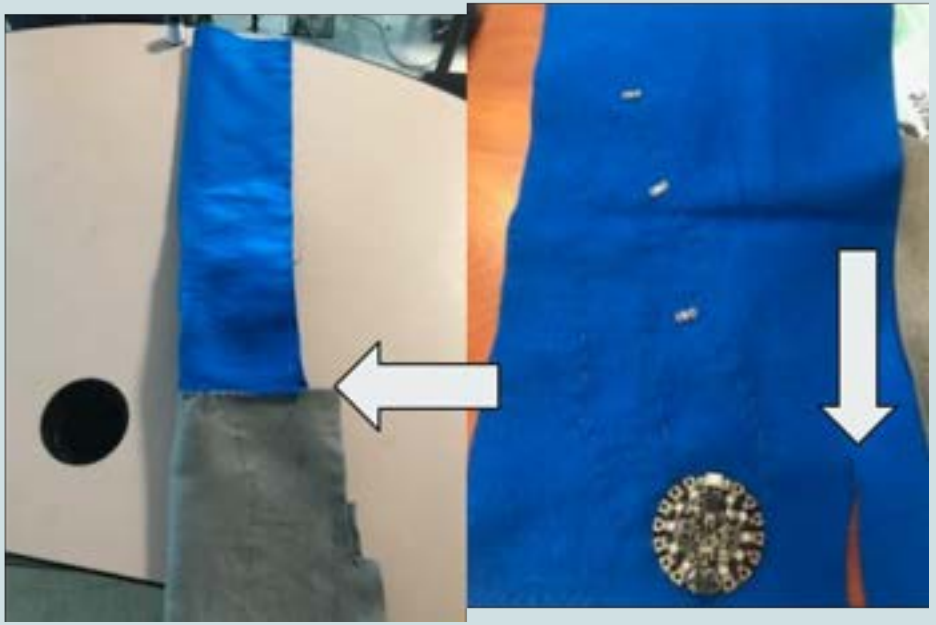


Student Portfolio

Challenge #2 Programing

Challenge #2 was programing. During this project since it was all on our own , it was really hard for me to program because I had trouble starting it. I didn't know exactly where things needed to be , or needed to go . When I input my code into code bender the results came back with many errors but with the help of Selegna and Hector I was able to know what to do. Even though all of my lights were lighting up, I still needed to add some patterns into my program in order for it to work completely and in order for me to get full points . Here are some images of my program on the right .

```
/*Write your actions here. Your sets of if/else statements
for your human sensor along with which lighting patterns
you want to call
*/
if(sensorValue>=1000){
  pattern1();
}
   if(sensorValue>=900&&sensorValue<1000){

pattern2();
}
  if(sensorValue>=800 && sensorValue<900){
    pattern3();
   }
if(sensorValue<800){
   pattern4();

}
```

Students Creating Identities through Portfolios

- Thoughtful Identities & CS Descriptions Expressed in Portfolios:
  - CS is personal & social (collaborative)
  - Students could see themselves in the CS community
  - Students identified as different types of computer scientists
    - Functional skills
    - Problem solvers

QUAL - ground-up research on portfolios

1 Can you think of other examples for new clubhouses of computing?

2 Bringing e-textiles into your classrooms: What do you see as challenges? What as opportunities?

3 What will you take from e-textiles back to your classroom/research?

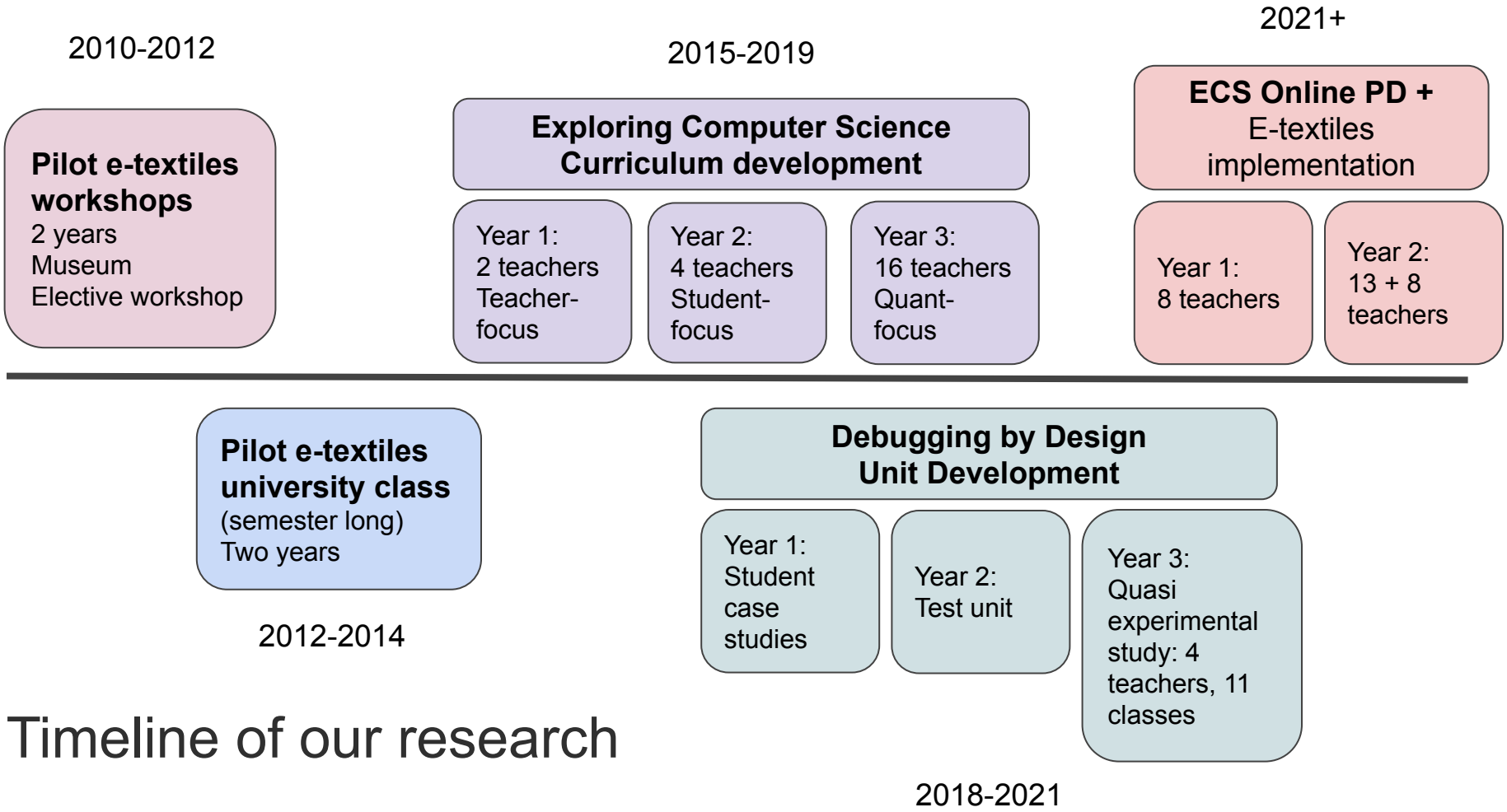
PART 5

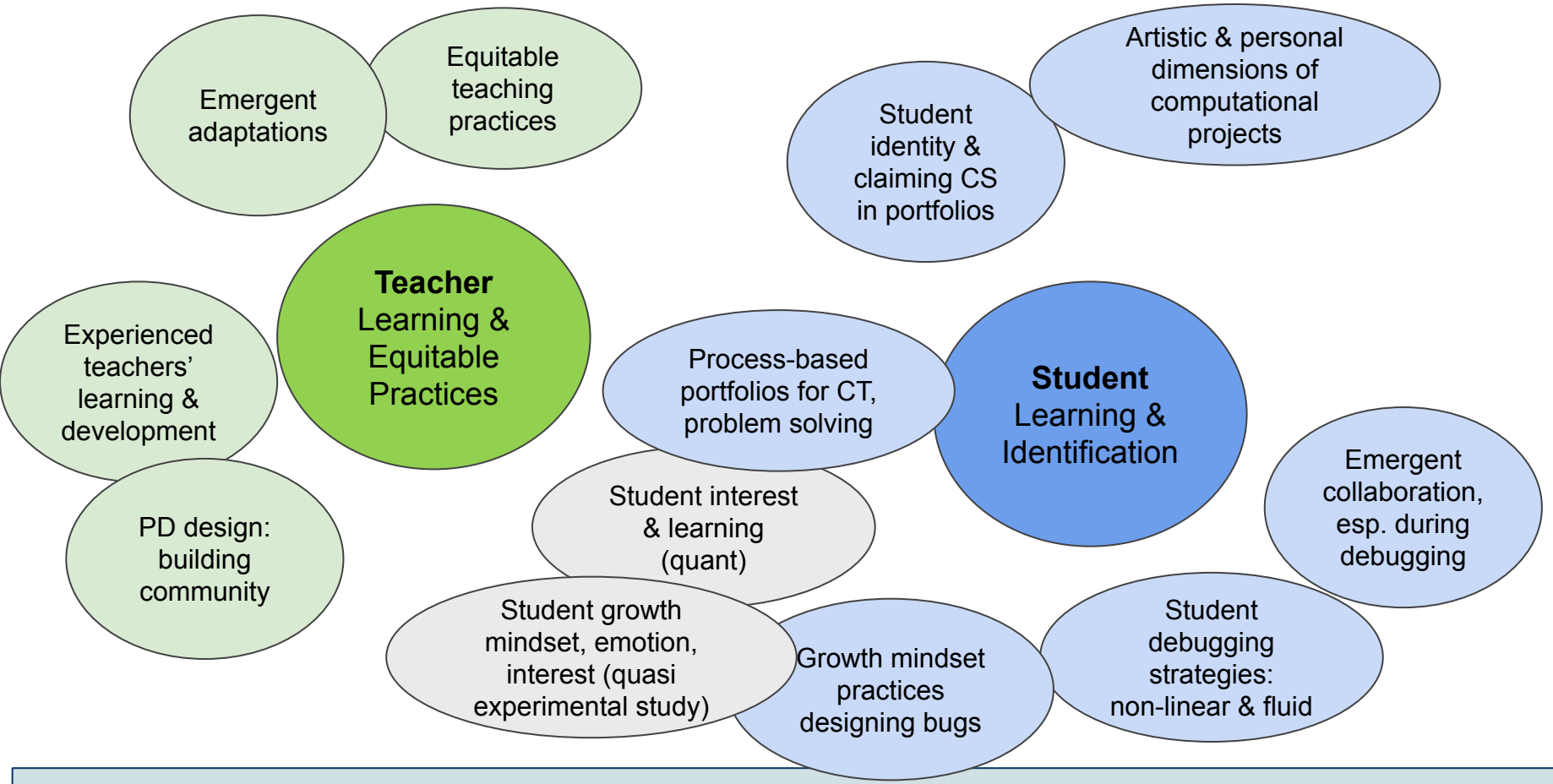
BREAKOUT DISCUSSIONS

PART 6

What's NEXT?

Timeline of our research





QUAL & QUANT - research on e-textiles curriculum in schools

- **Debugging by Design**
  - Validated instrument on student self-beliefs
  - Quasi experimental study: did DbD make a difference versus the normal e-textile unit?
  - Pre/post clinical interviews about debugging
- **Online Teacher PD**
  - Online professional development + implementation of e-textiles curriculum
  - Experienced CS teachers, over 1-year, 2-years
- **Critical Computing** (Mia Shaw)
  - Recoding CS Identities
  - E-textile Mural Project for Collaborative Inquiry into What and Who Computing is for
- **Debugging Wearable AI** (Luis Morales-Navarro)
  - Making Wearables Work
  - What do students know about AI?
  - Science Center workshops