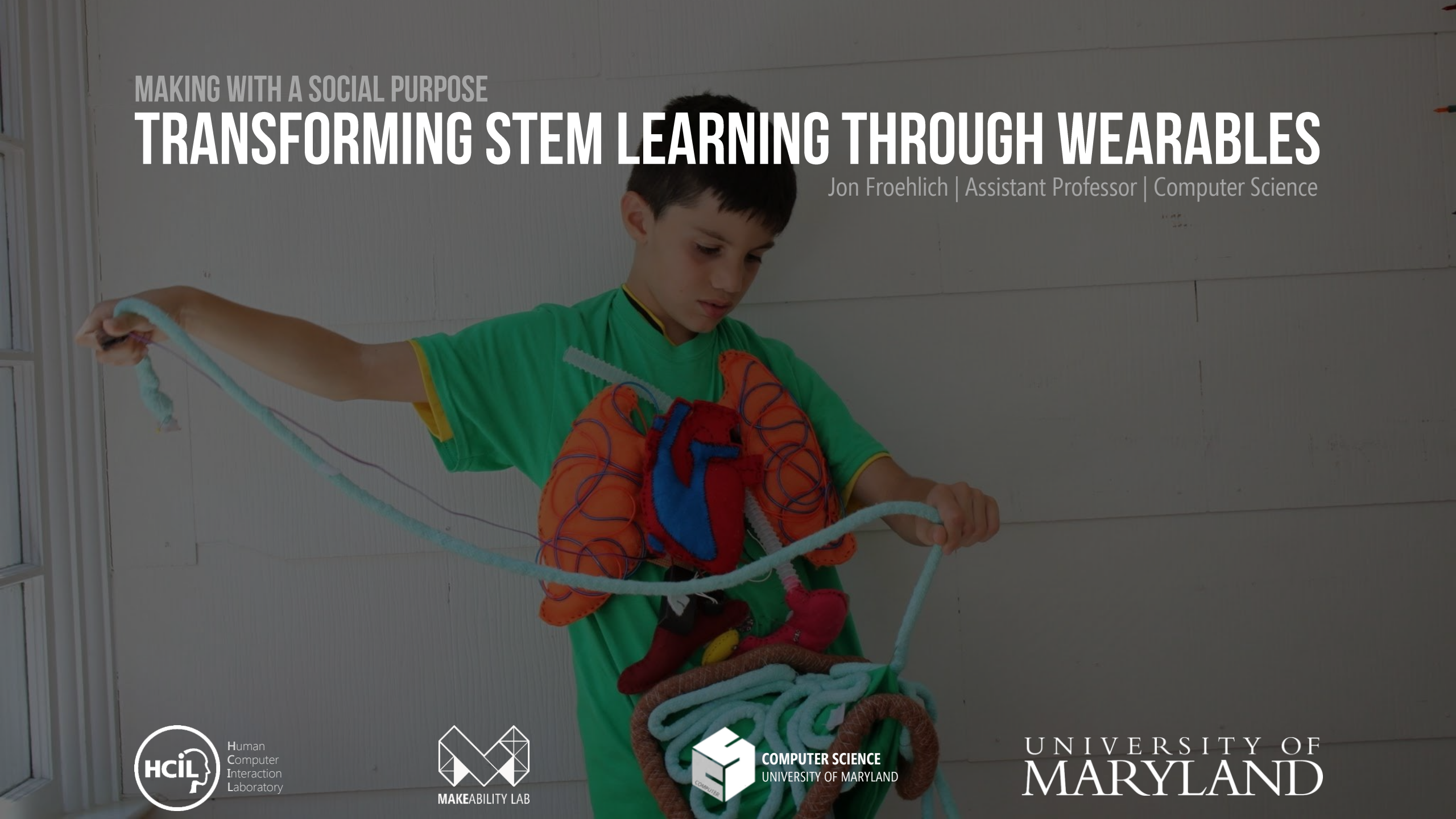


MAKING WITH A SOCIAL PURPOSE

TRANSFORMING STEM LEARNING THROUGH WEARABLES

Jon Froehlich | Assistant Professor | Computer Science

HCIL Human Computer Interaction Laboratory

MAKEABILITY LAB

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

UNIVERSITY OF MARYLAND

MAKEABILITY LAB

http://makeabilitylab.io


HCIL
MAKEABILITY LAB

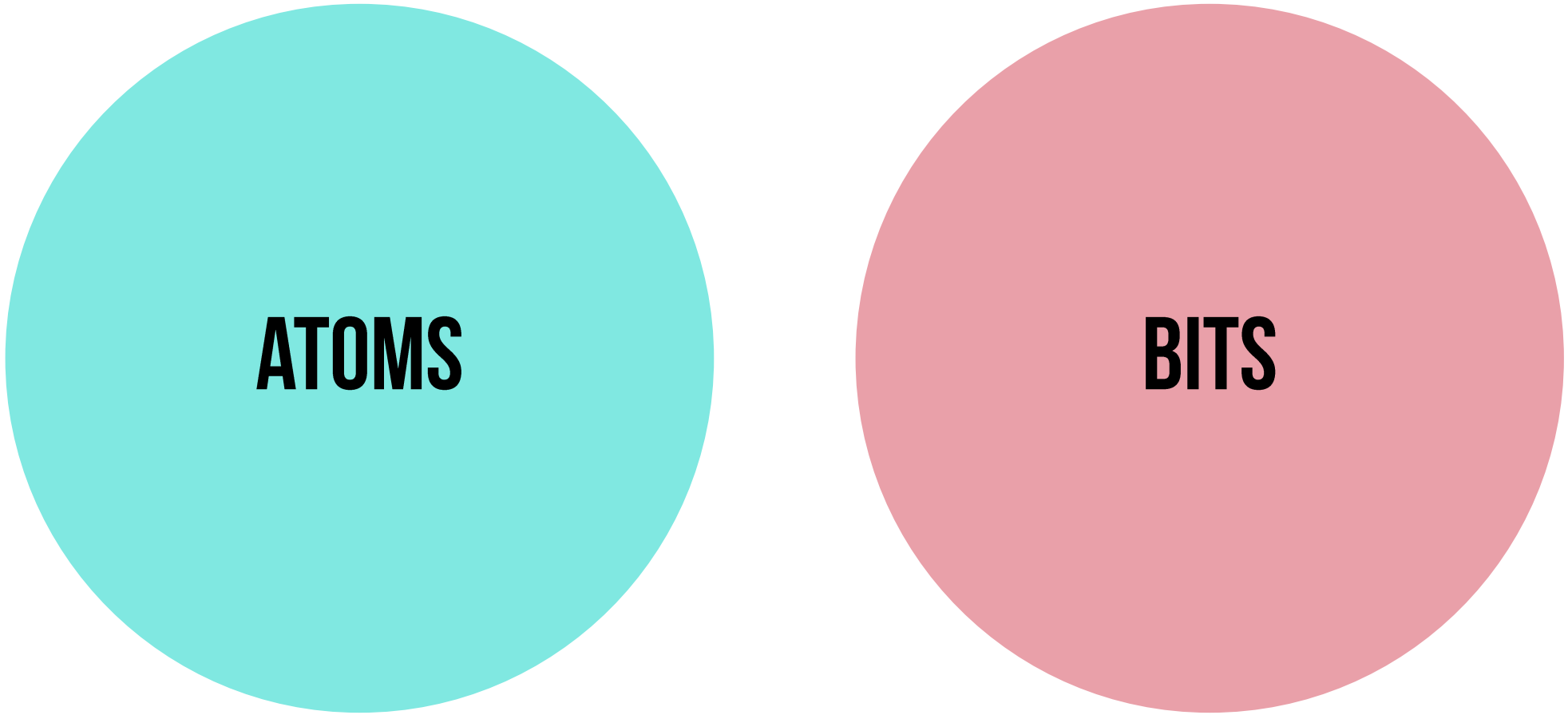

MAKEABILITY LAB

Our Mission

DESIGN, BUILD, & STUDY INTERACTIVE TOOLS & TECHNIQUES TO ADDRESS PRESSING SOCIETAL CHALLENGES

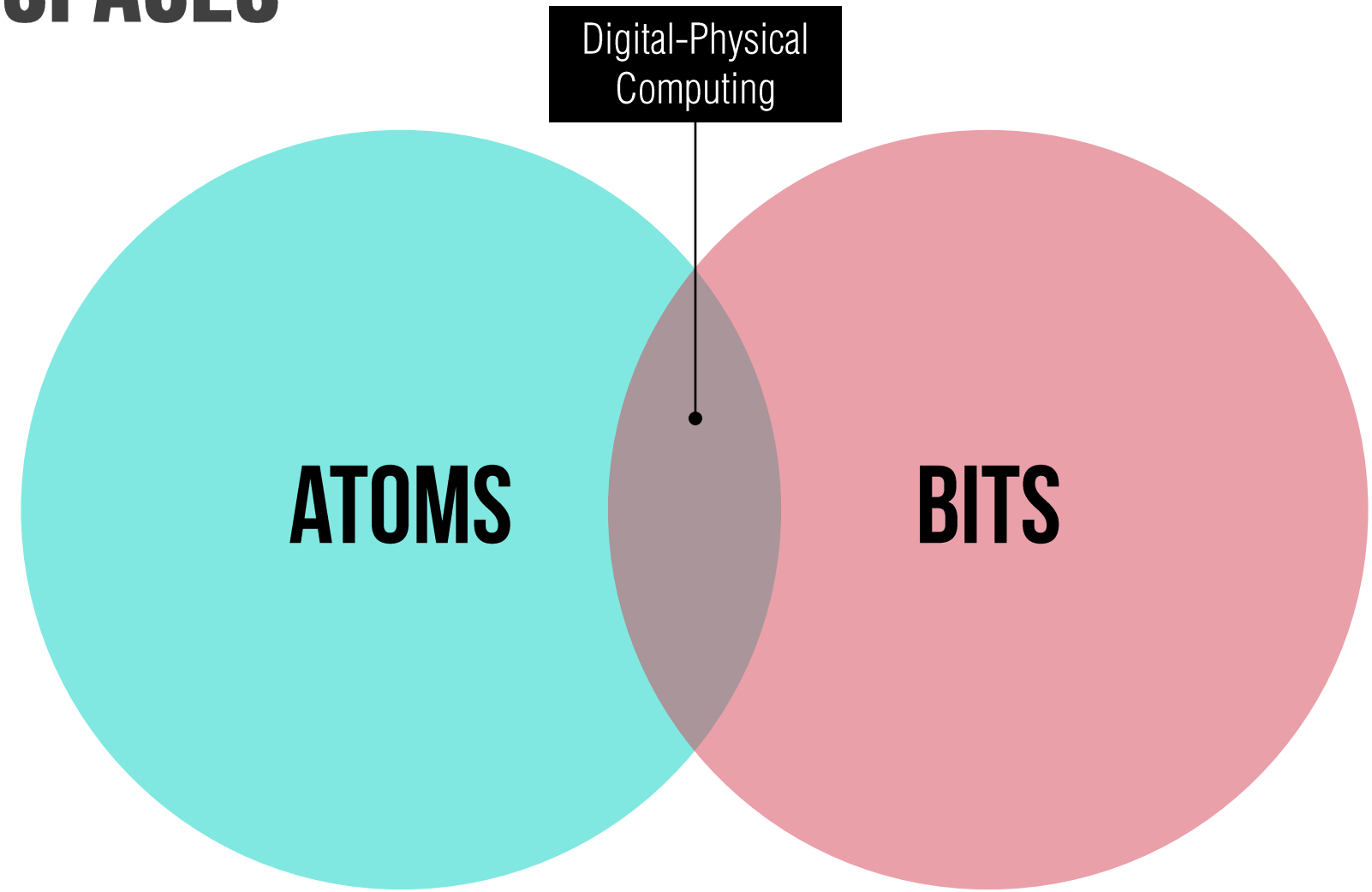
MAKEABILITY LAB

PROBLEM SPACES



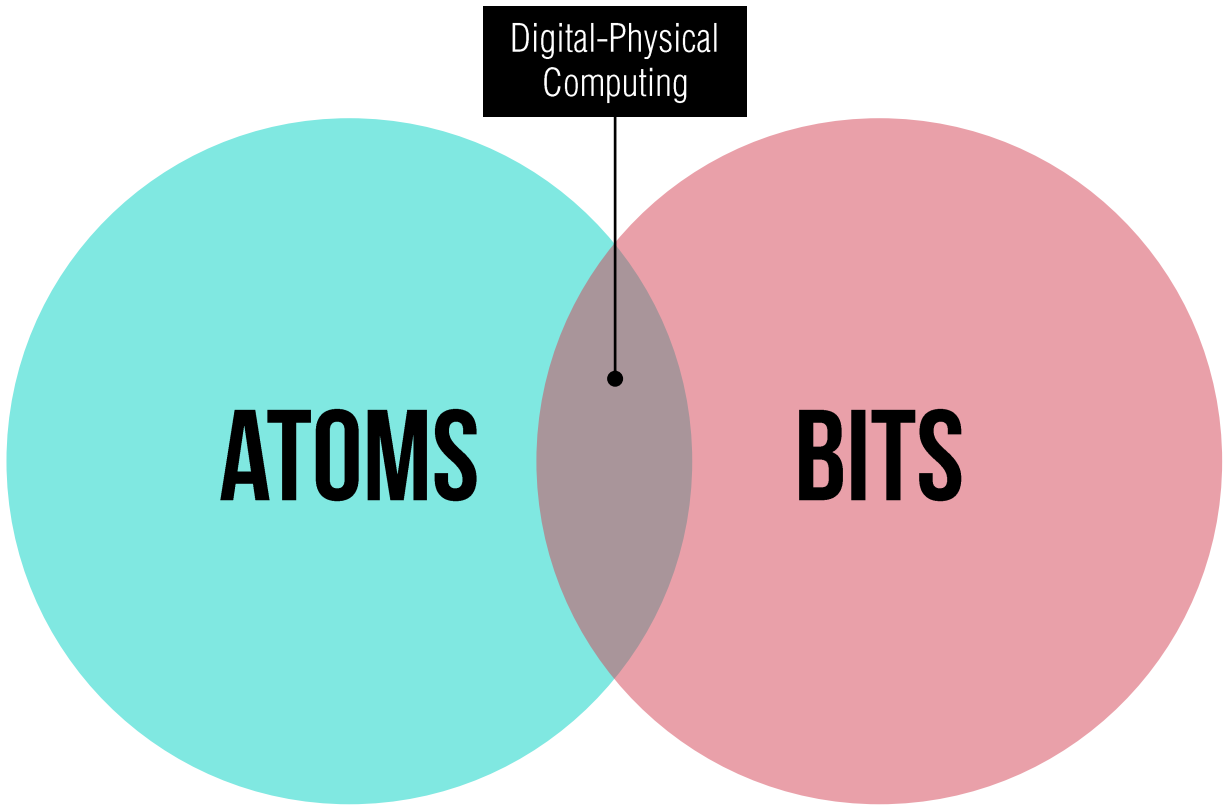
MAKEABILITY LAB

PROBLEM SPACES



MAKEABILITY LAB

PROBLEM SPACES



How can we...

leverage **computation** & human-computer interaction to increase knowledge about and access to the **physical world**?

How can we...

build new **physical** artifacts imbued with **computation** to seamlessly couple the **physical** and **digital** and create new interactive experiences?

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

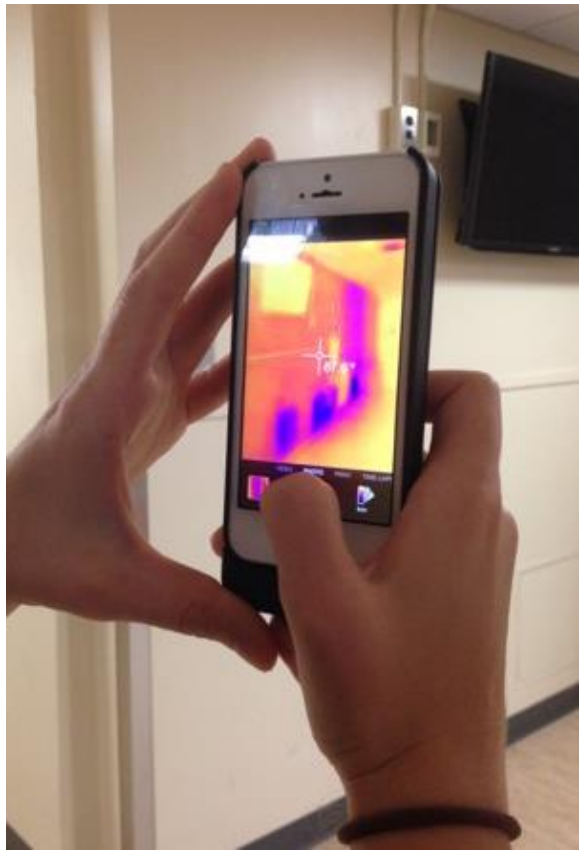
ACCESSIBILITY

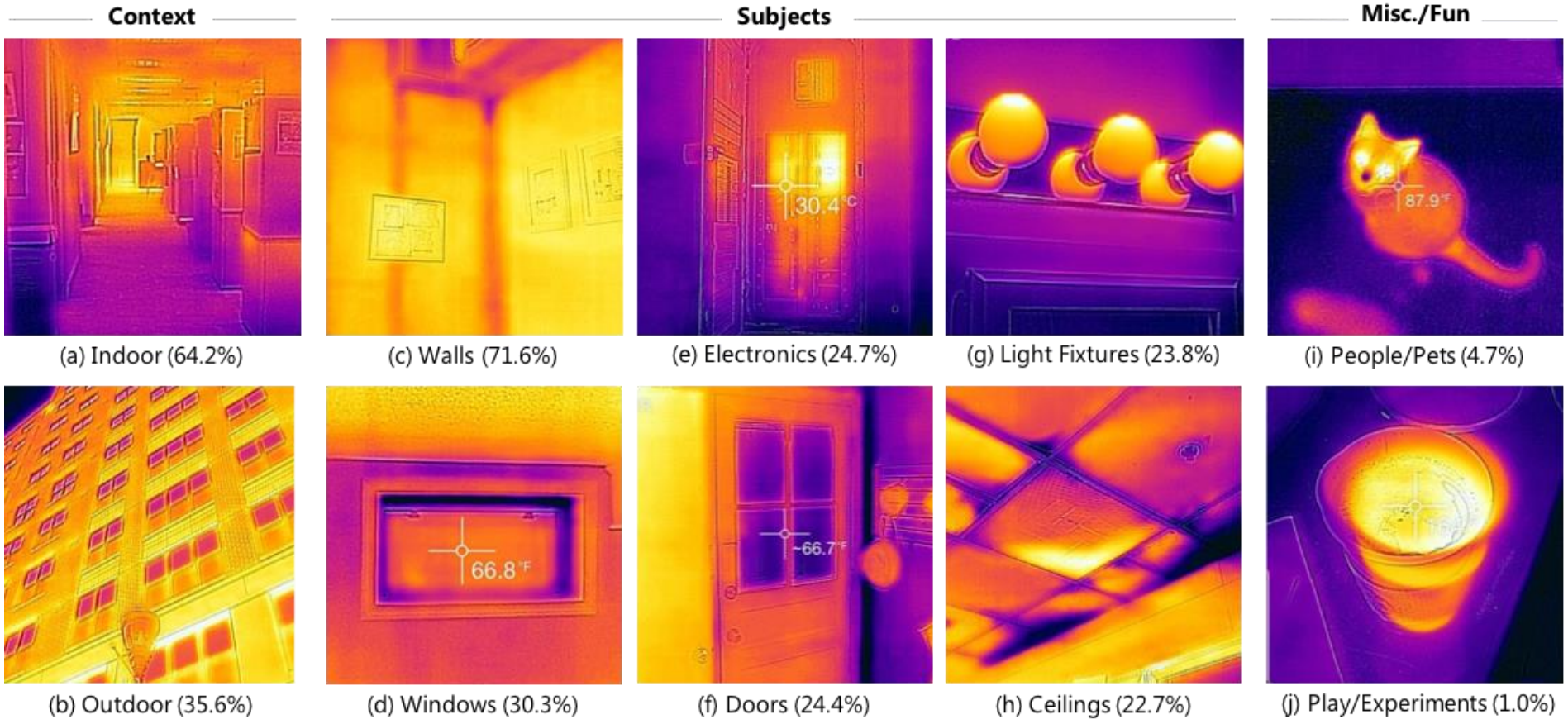
STEM EDUCATION

ENVIRONMENTAL SUSTAINABILITY

PERVASIVE THERMOGRAPHY

With UMD CS PhD Student Matt Mauriello





Mauriello & Froehlich, 2013; Mauriello, Norooz, & Froehlich, 2015; Mauriello *et al.,* 2016; Mauriello *et al.,* 2017

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

PROJECT SIDEWALK

HTTP://PROJECTSIDEWALK.IO

Find and label the following

Explore | Curb Ramp | Missing Curb Ramp | Obstacle in Path | Surface Problem | Other

Zoom In | Zoom Out | Undo | Redo

Current Neighborhood
Fort Stanton, D.C.

Sound

Jump

Feedback

Audit 1000ft of Fort Stanton

Your mission is to audit 1000ft of Fort Stanton and find all the accessibility features that affect mobility impaired travelers!

OK

MAPPING THE ACCESSIBILITY OF THE WORLD

PROJECT SIDEWALK TEAM

PROFESSORS


Jon Froehlich


David Jacobs

GRAD STUDENTS


Kotaro Hara


Manaswi Saha


Jin Sun


Ladan Najafizadeh

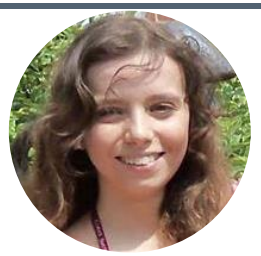

Soheil Behnezhad

UNDERGRADUATE STUDENTS


Vicki Le


Robert Moore


Christine Chan


Maria Furman


Daniil Zadorozhnyy


Zach Lawrence


Alex Zhang

HIGH SCHOOL STUDENTS


Jonah Chazan


Anthony Li


Niles Rogoff

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

See: Barton, *et al.,* 2008; Naiser & Hand, 2008; Kafai, *et al.,* 2014;


ROMJÄ
Kirjojen
tapahtuma
paikkoja

Lee & Drake, 2013; Lee *et al.,* 2015; Lee, Drake, & Thayne, 2016

Wearables: an engaging vehicle for building science skills?

Unprecedented data
Inherently personalized
Life relevant
Actively engage body in learning

1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

3 MAKERWEAR

Construction Kit

Complex Problems

ADVANCING SCIENCE LEARNING & INQUIRY EXPERIENCES THROUGH WEARABLES

BODYVIS & SHAREDPHYS TEAM

PROFESSORS


Jon Froehlich


Tamara Clegg

GRAD STUDENTS


Leyla Norooz


Seokbin Kang


Virginia Byrne


Rafael Velez


Amy Green

UNDERGRADUATE STUDENTS


Monica Katzen


Angelisa Plane


Vanessa Oguamanam


Thomas Outing


Anita Jorgensen

HIGH SCHOOL STUDENT


Sage Chen

ENGAGING YOUNG CHILDREN IN WEARABLE DESIGN

MAKERWEAR TEAM

PROFESSORS

Jon Froehlich

Tamara Clegg

GRAD STUDENTS

Majeed Kazemitabaar

Liang He

UNDERGRADUATE STUDENTS

Jason McPeak

Katie Wang

Alex Jiao

Thomas Outing

Tony Cheng

HIGH SCHOOL STUDENT

Chloe Aloimonos

STEM EDUCATION

PARTNERS

KID MUSEUM

BOYS & GIRLS CLUBS

futuremakers

KIDS MAKE THINGS BETTER™.COM

Center for Young Children

PGCPS

Great By Choice

Prince George's County Public School System

WE ARE CASA

CASA

SOMOS CASA

UNIVERSITY OF MARYLAND 1856

COLLEGE OF EDUCATION

STEM Masters in Education Program

University of Maryland Kidsteam

1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

3 MAKERWEAR

Construction Kit

1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

3 MAKERWEAR

Construction Kit

WHAT IF OUR CLOTHES REVEALED HOW OUR BODIES FUNCTIONED?

HOW COULD THIS CHANGE THE WAY CHILDREN LEARN ABOUT AND UNDERSTAND THEIR BODIES?

COULD A T-SHIRT BE A PLATFORM FOR EXPERIMENTATION AND INQUIRY

Norooz & Froehlich, IDC'13; Norooz *et al.,* CHI'15; Norooz *et al.,* ICLS'16; Clegg *et al.,* CHI'17

"Does my heart beat faster when running vs. reading a book? Why?"

"How does my breathing rate compare to my classmate's and why may this be?"

"How does food travel through my body?"

BODYVIS PROTOTYPES

BODYVIS: FOUR GENERATIONS

PROTOTYPE 1

Stuffed fabric organs
Heartrate Only
LEDs, EL-Wire
Arduino Uno

PROTOTYPE 2

Improved Anatomy
Heartrate, Breathing
LEDs
Lilypad Arduino

PROTOTYPE 3

Labeled, Removable Anatomy
Heartrate, Breathing, Digestion
LEDs, Sound, Touchscreen
Arduino Uno, Smartphone

PROTOTYPE 4

Added Organs (*e.g.,* Bladder)
Heartrate, Breathing, Digestion
LEDs, Sound, Haptics, Touchscreen
Arduino BLE Mini, Smartphone

BODYVIS PROTOTYPES

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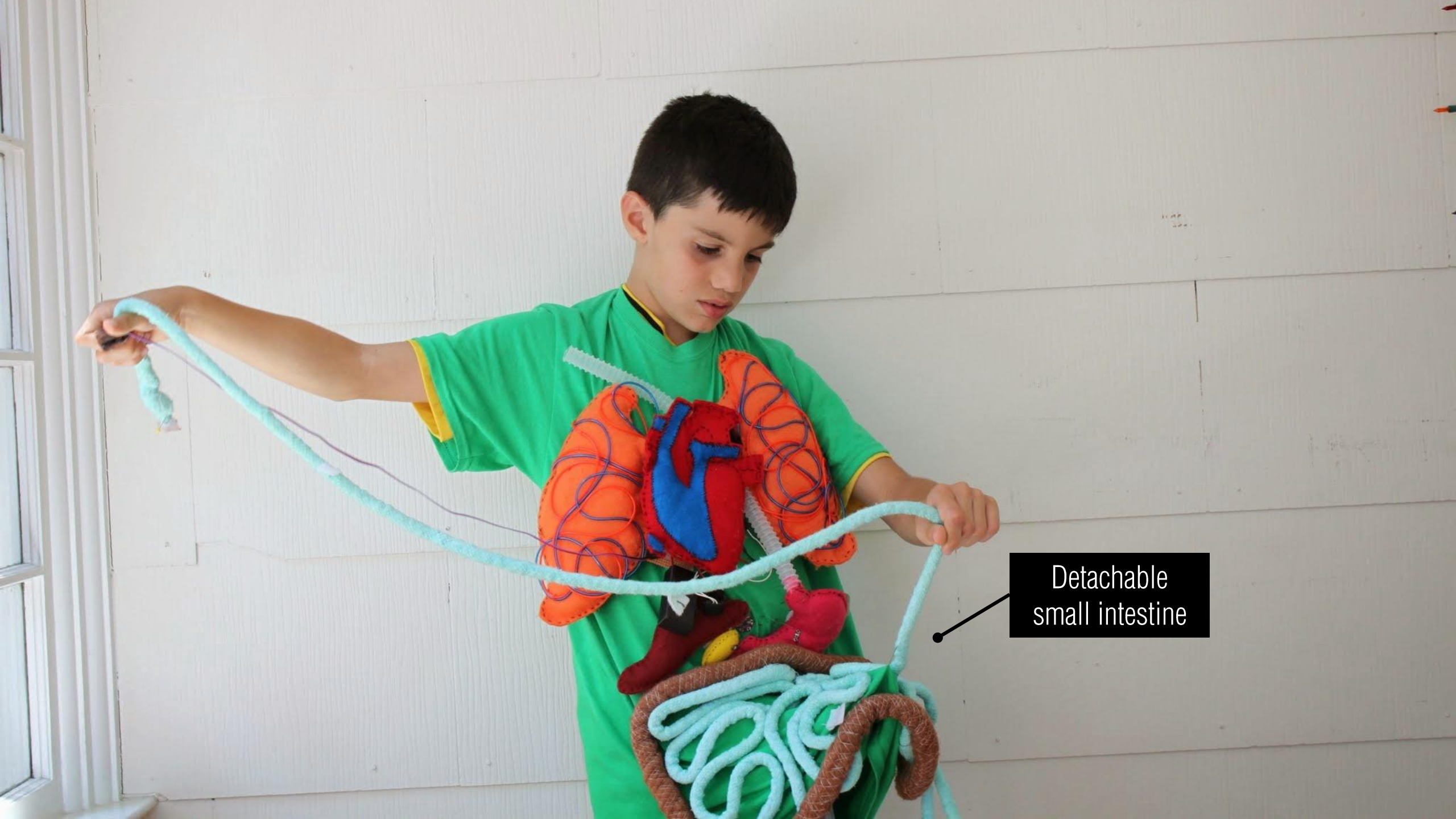
Heartrate, Breathing, Digestion
LEDs, Sound, Haptics, Touchscreen
Arduino BLE Mini, Smartphone


Optical heart
rate sensor


Optical heart rate sensor


Detachable
small intestine

BODYVIS PROTOTYPES

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Heartrate, Breathing, Digestion
LEDs, Sound, Haptics, Touchscreen
Arduino BLE Mini, Smartphone


Esophagus
Lung
Lung
Liver
Large Intestine
Small Intestine

BODYVIS

HOW IT WORKS

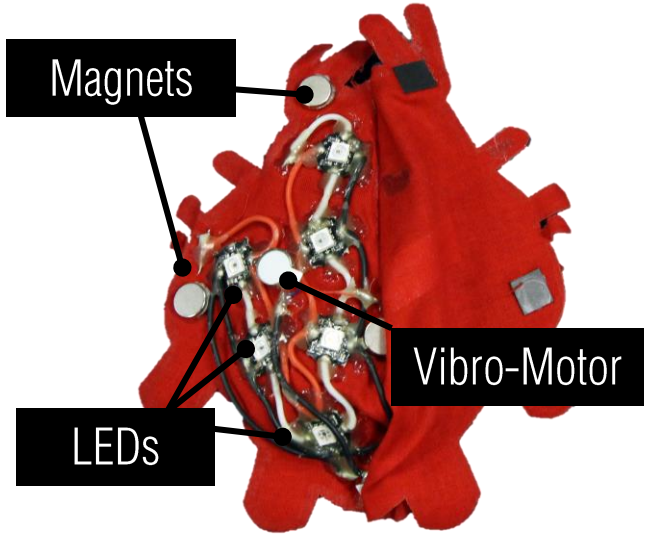
BODYVIS

HOW IT WORKS

BODYVIS

HOW IT WORKS

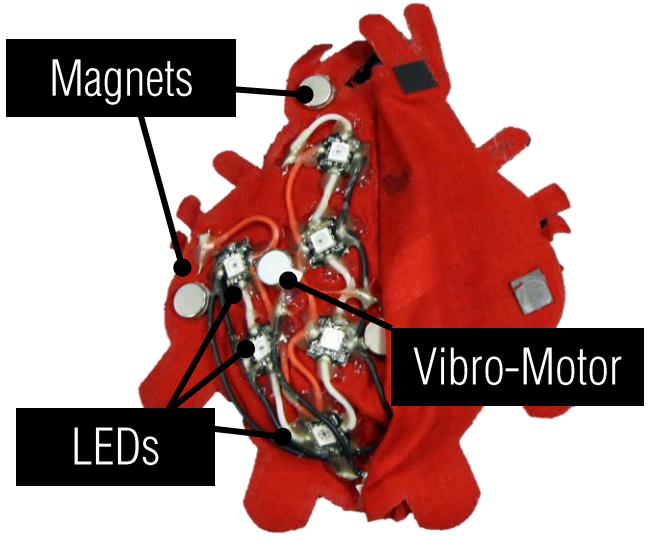
HEART



BODYVIS

HOW IT WORKS

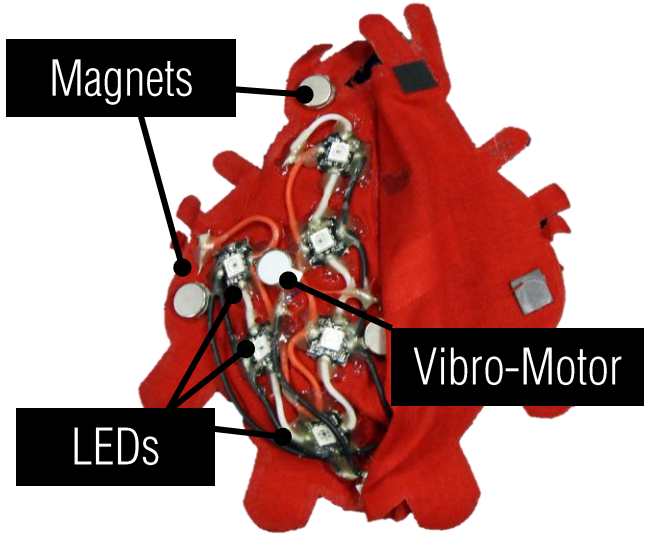
HEART



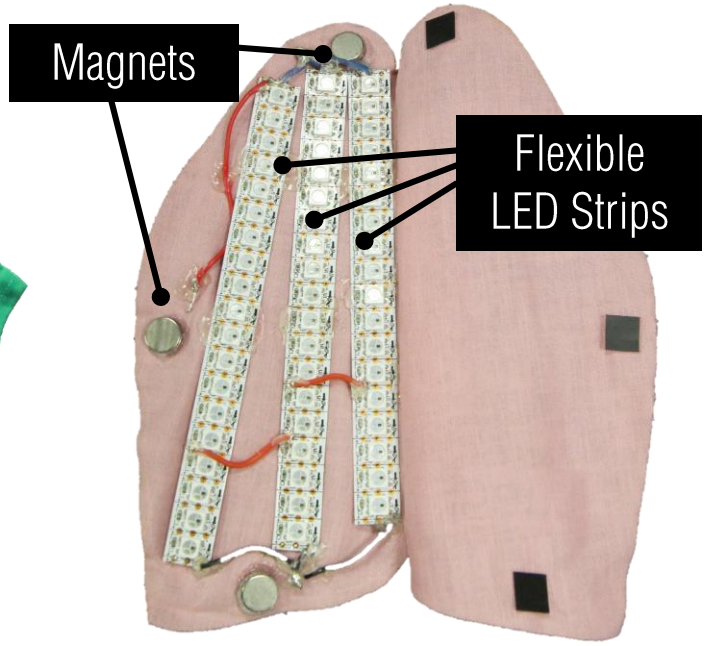
BODYVIS

HOW IT WORKS

HEART



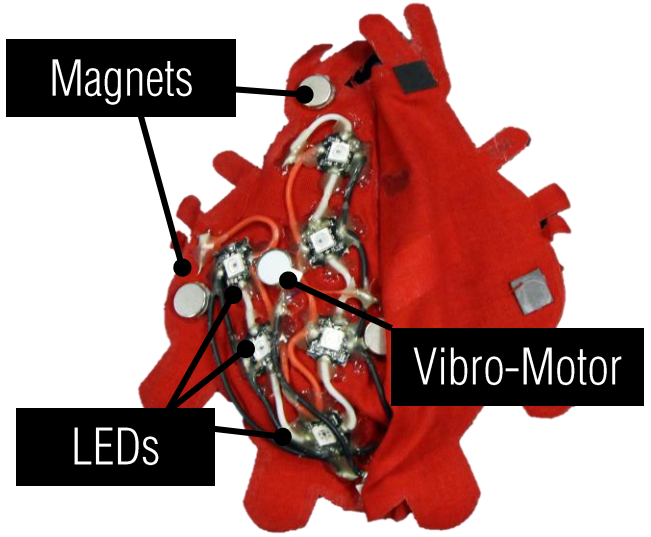
LUNGS



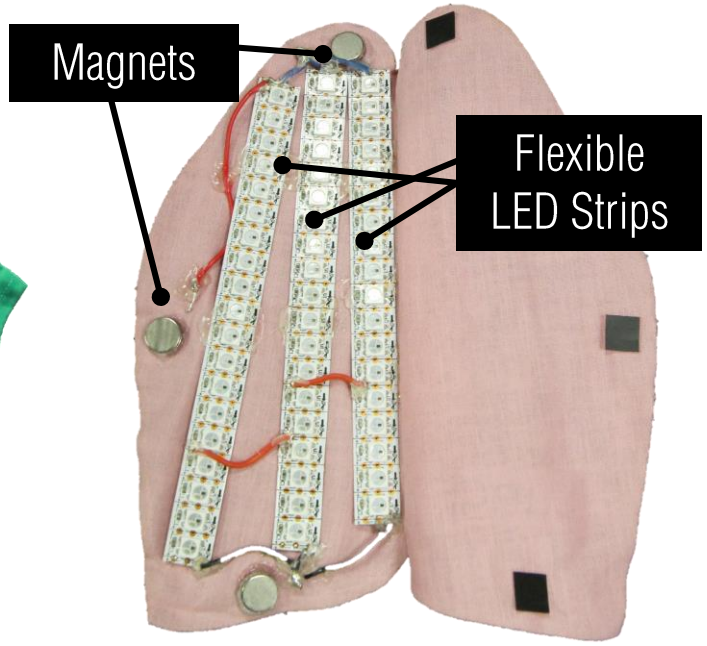
BODYVIS

HOW IT WORKS

HEART



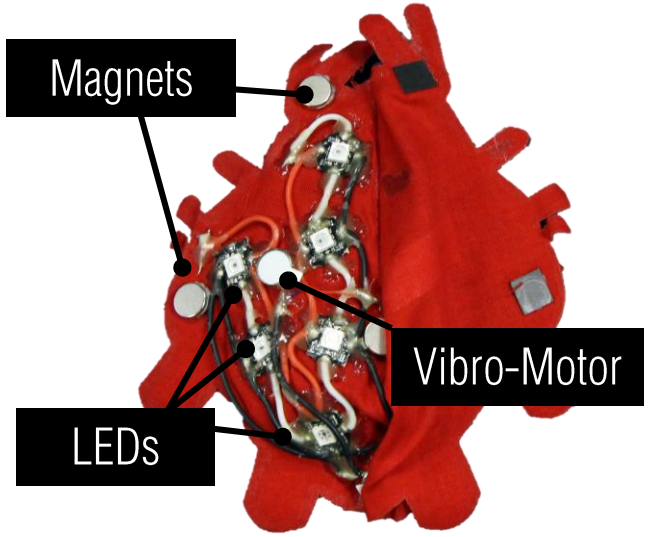
LUNGS



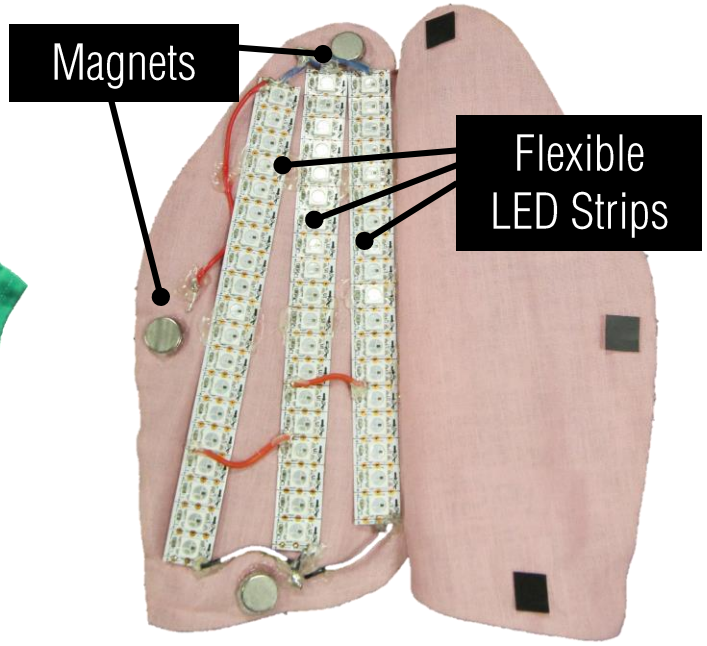
BODYVIS

HOW IT WORKS

HEART



LUNGS

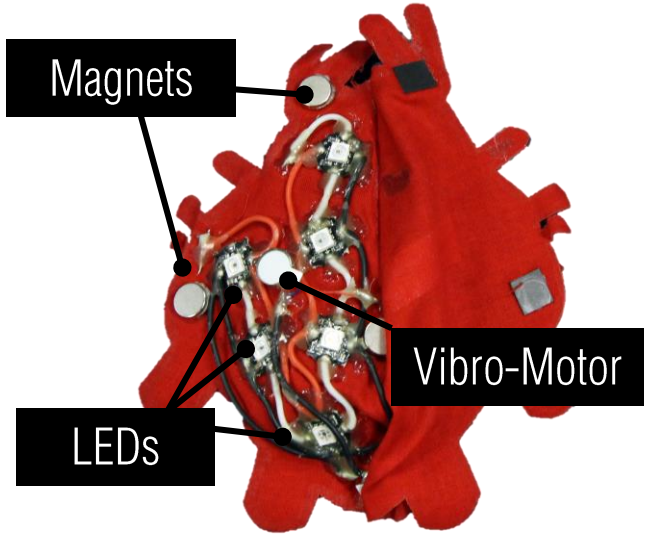


STOMACH

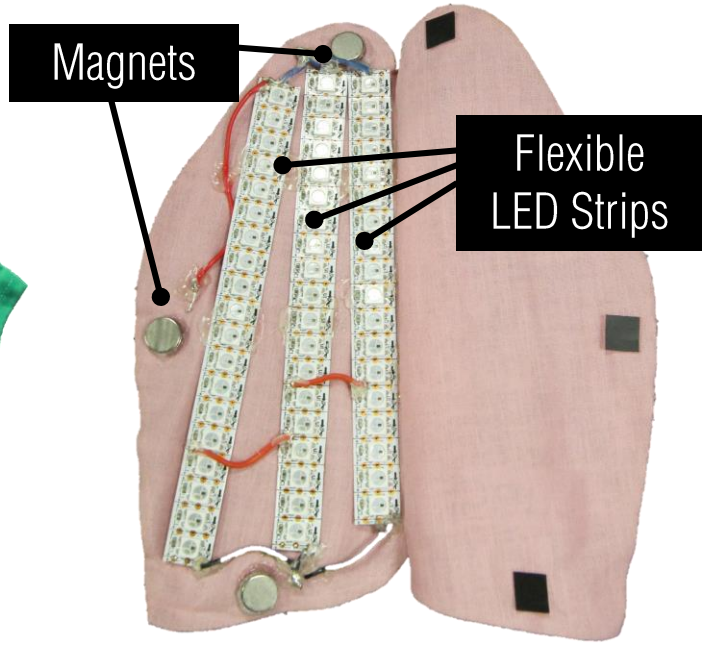
BODYVIS

HOW IT WORKS

HEART



LUNGS

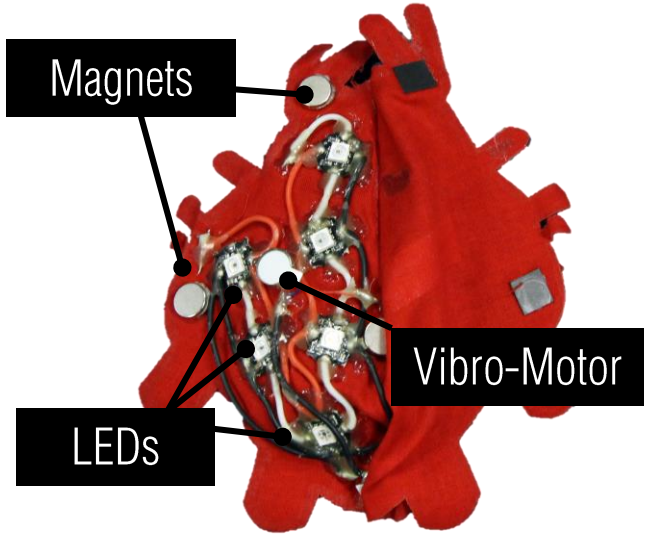


STOMACH

BODYVIS

HOW IT WORKS

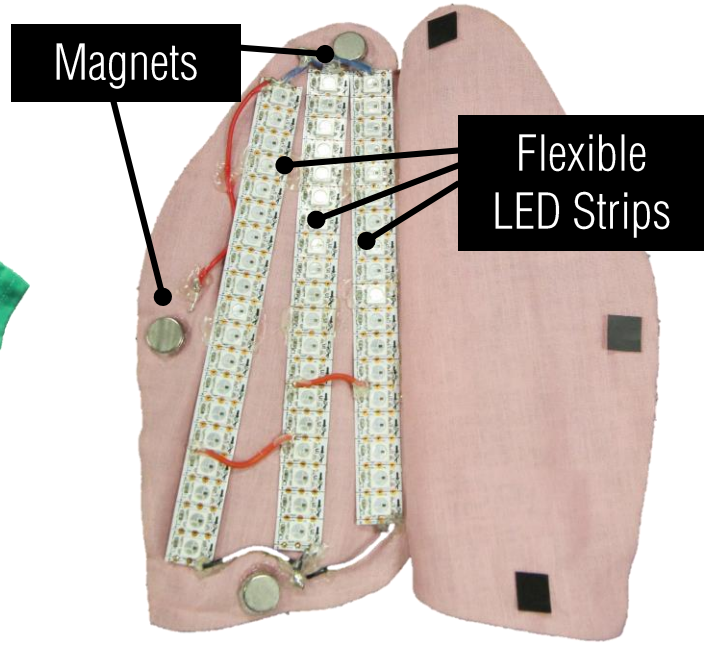
HEART



PHYSIOLOGICAL SENSOR

Zephyr
BioHarness 3

LUNGS



STOMACH

BODYVIS

SENSING SYSTEM

ZEPHYR BIOHARNESS 3

Wirelessly transmits
via Bluetooth

SAMSUNG GALAXY S4 MINI

BODYVIS

SENSING SYSTEM

Wirelessly transmits
via Bluetooth

Wirelessly transmits
via BLE

ZEPHYR BIOHARNESS 3

Worn directly on skin
Senses heart, breathing, movement

SAMSUNG GALAXY S4 MINI

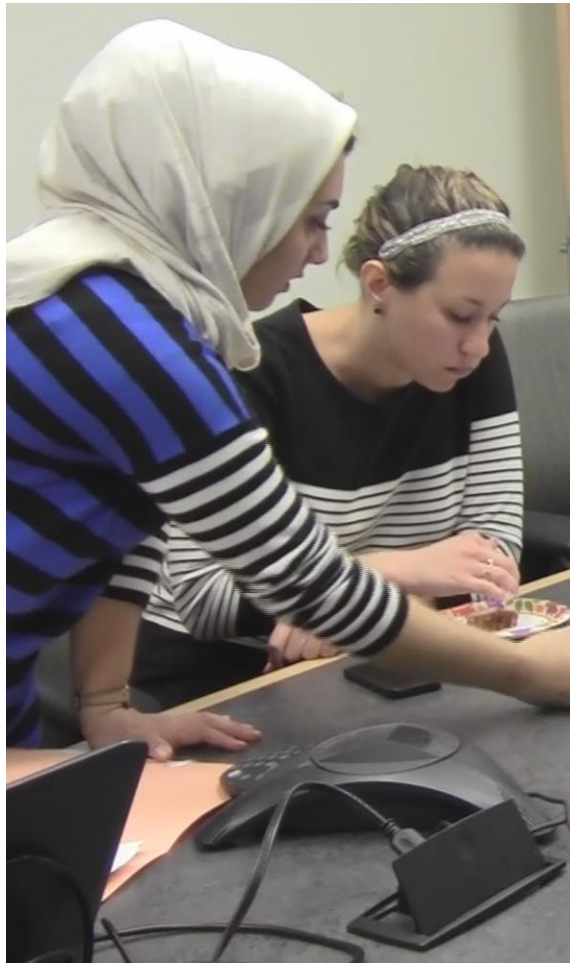
Serves as stomach
Processes physiological data
Plays sound & vibrates
Ultra-lightweight (battery removed)

REDBEARLAB BLE MINI ARDUINO

Sewn into shirt
Directly wired to LEDs, Vibro-motors,
digestion button, etc.

BODYVIS

EVALUATIONS



TEACHER INTERVIEWS

AFTER-SCHOOL PROGRAMS

SCIENCE CAMPS

ELEMENTARY SCHOOLS


BODYVIS INTERACTIONS
High Engagement


BODYVIS INTERACTIONS
High Engagement

BODYVIS INTERACTIONS

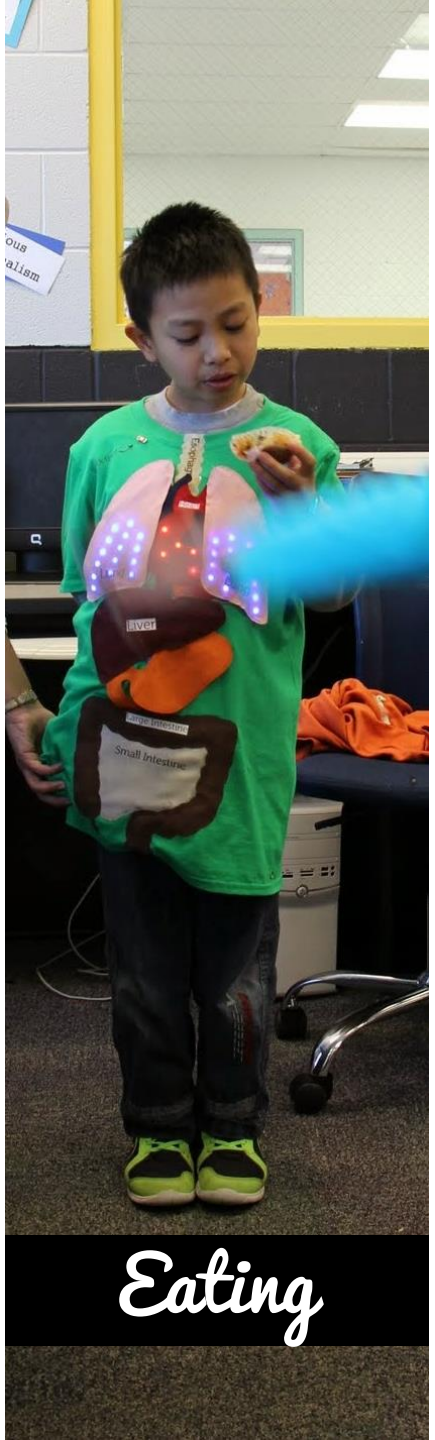
Actively Engaging Body

BODYVIS INTERACTIONS

Actively Engaging Body

Balancing

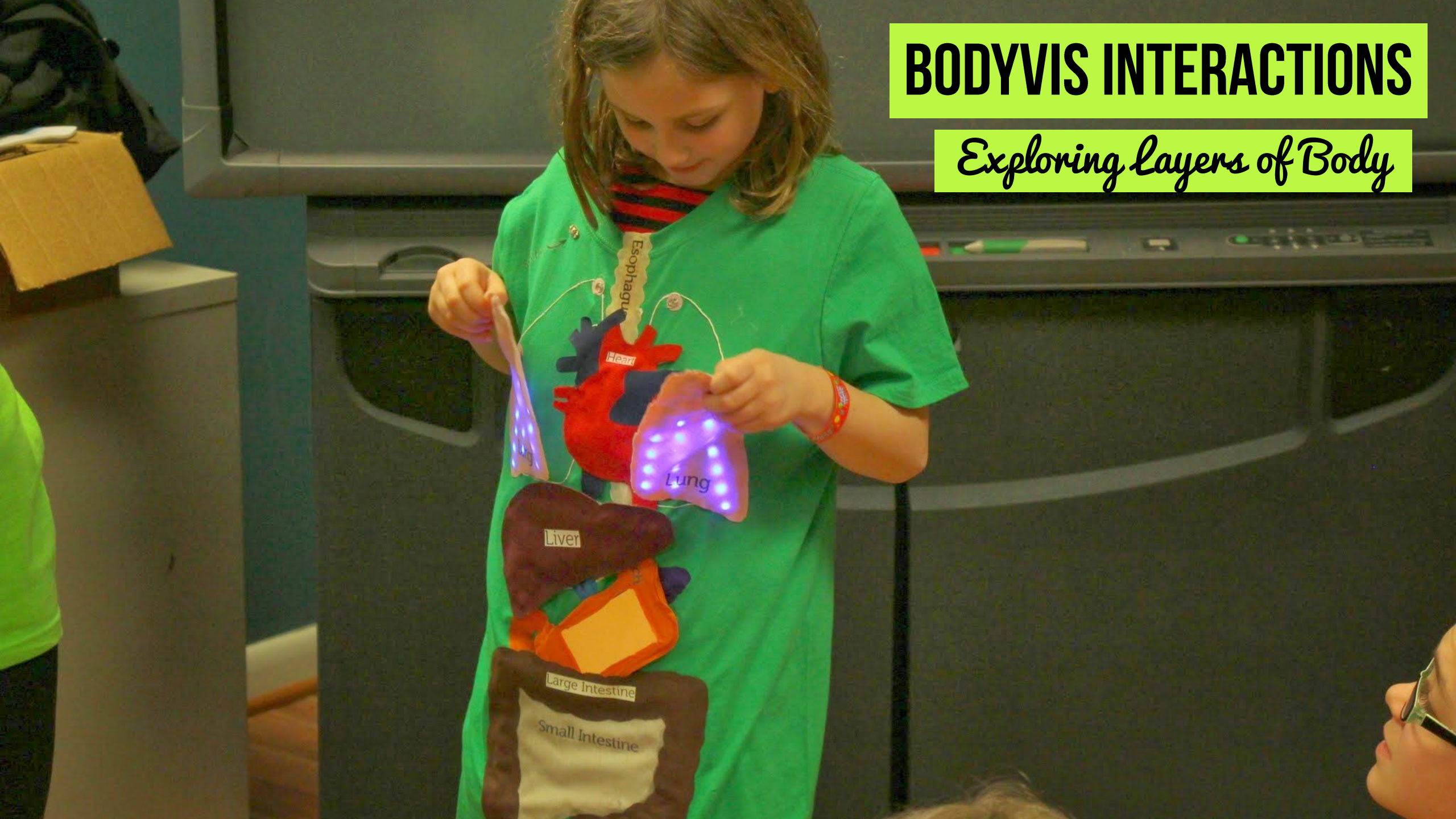
Running



Eating

Touching

Flexing



BODYVIS INTERACTIONS

Exploring Layers of Body


BODYVIS INTERACTIONS
Exploring Layers of Body
Esophagus
Heart
Liver
Large Intestine
Small Intestine

BODYVIS INTERACTIONS

Promoting Social Interaction

BODYVIS INTERACTIONS

Supporting Pretend Play

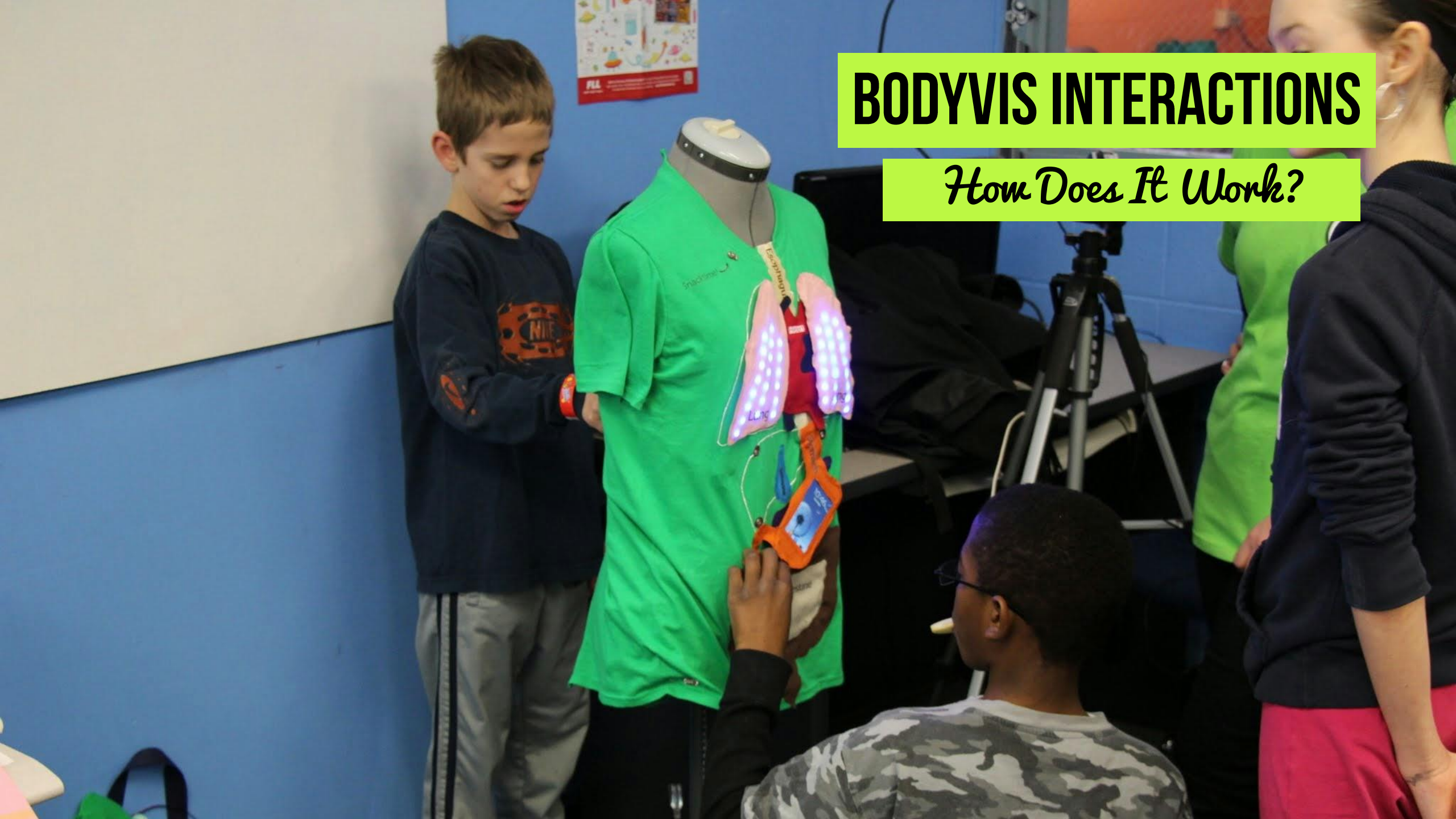
Some Unexpected Things


BODYVIS INTERACTIONS
Disembodied Use

BODYVIS INTERACTIONS

Disembodied Use


GREAT FUTURES START HERE!
BODYVIS INTERACTIONS
Disembodied Use
Her physiology visualized on shirt
She's wearing sensor


BODYVIS INTERACTIONS
How Does It Work?

BODYVIS INTERACTIONS

How Does it Work?

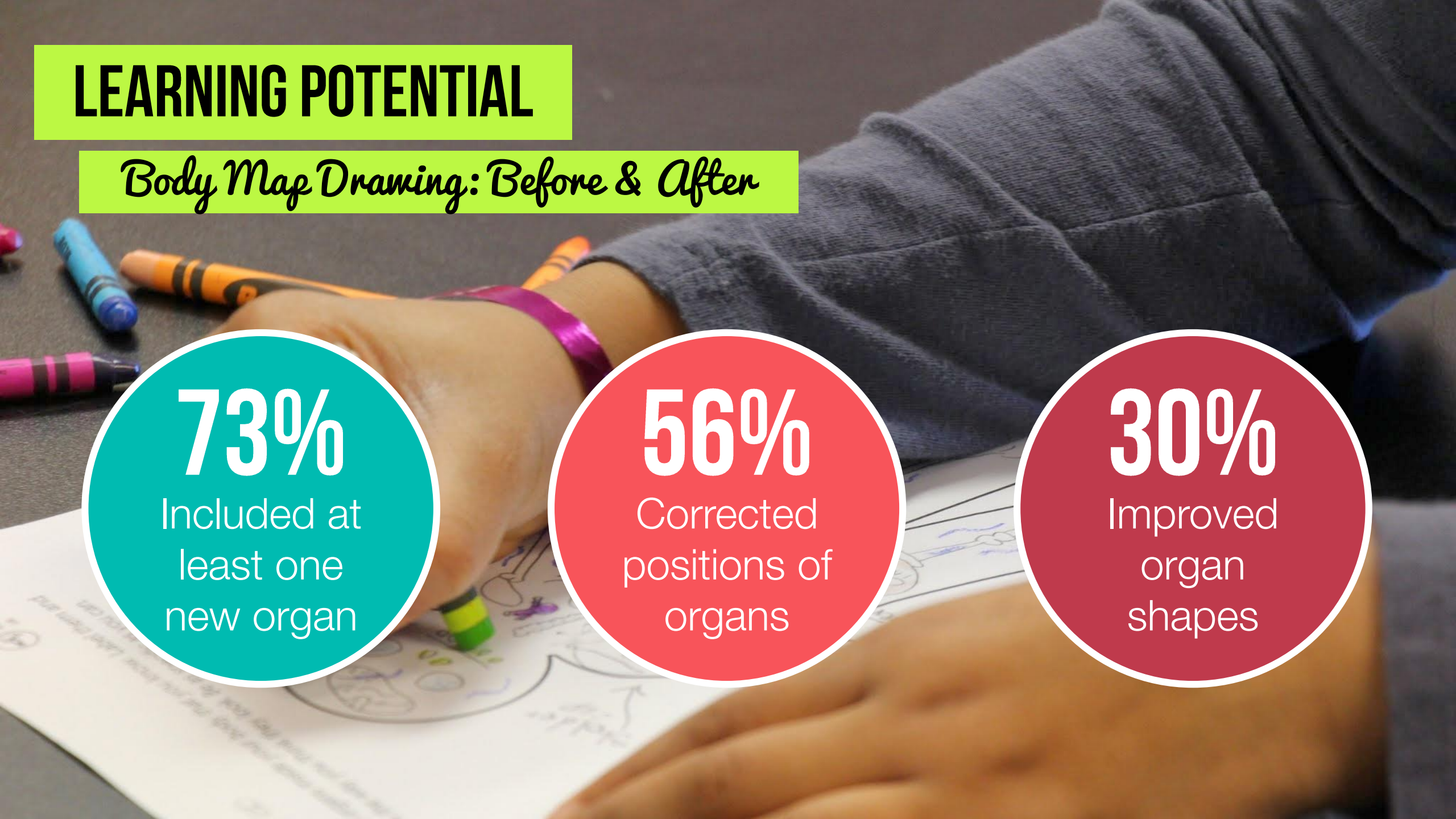

LEARNING POTENTIAL
Pre- & Post-Questionnaires

LEARNING POTENTIAL

Body Map Drawing: Before & After

LEARNING POTENTIAL

Body Map Drawing: Before & After



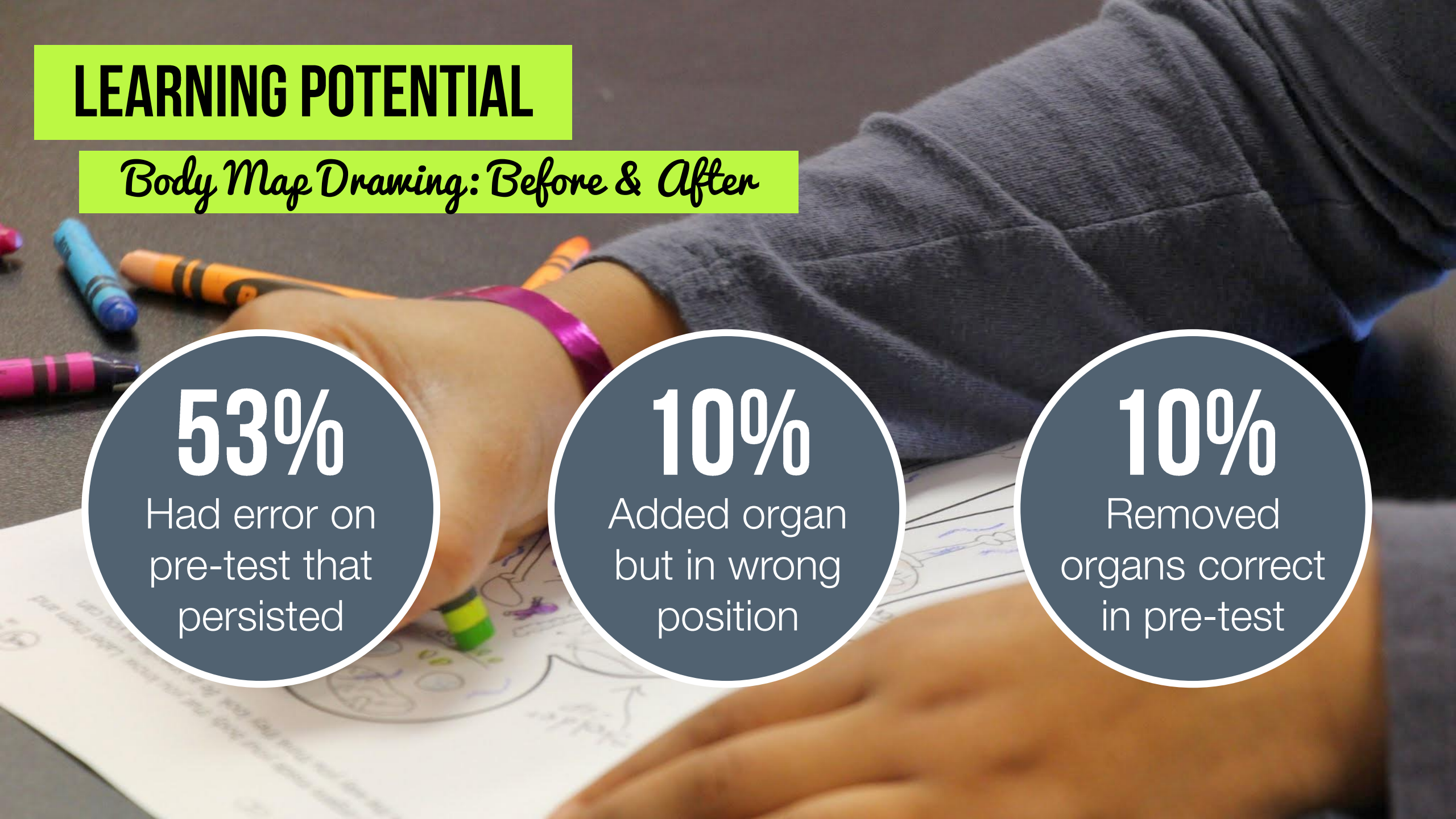
73%
Included at least one new organ

56%
Corrected positions of organs

30%
Improved organ shapes

LEARNING POTENTIAL

Body Map Drawing: Before & After



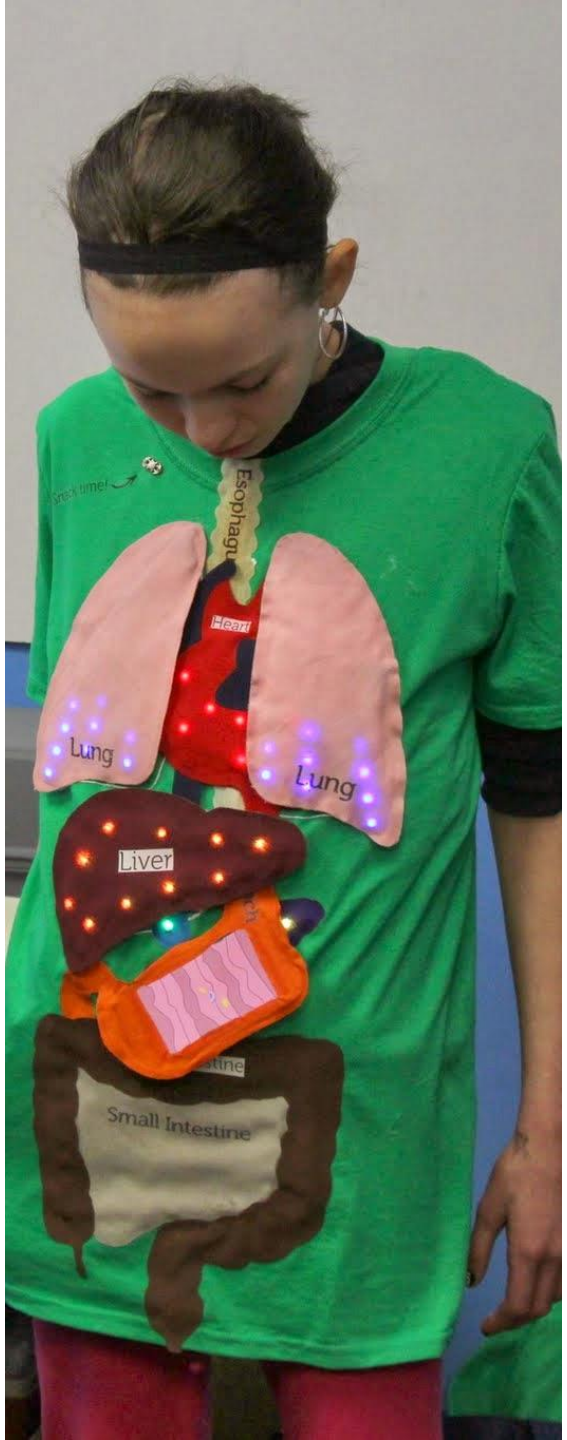
53%
Had error on pre-test that persisted

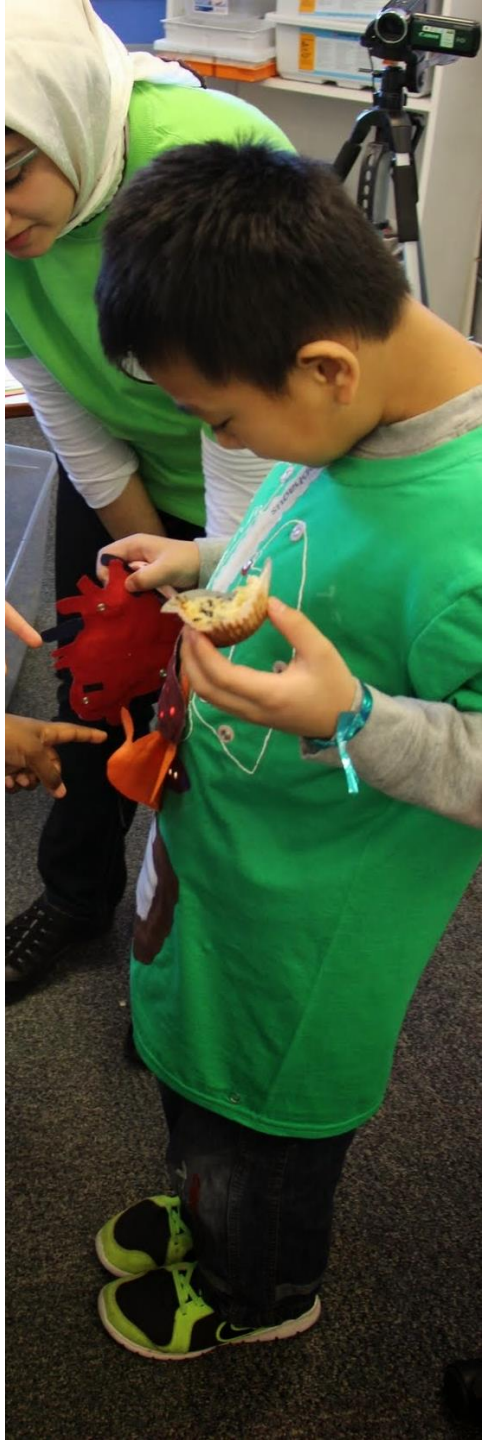
10%
Added organ but in wrong position

10%
Removed organs correct in pre-test


Snack time!
Esophagus
Heart
Lung
Liver

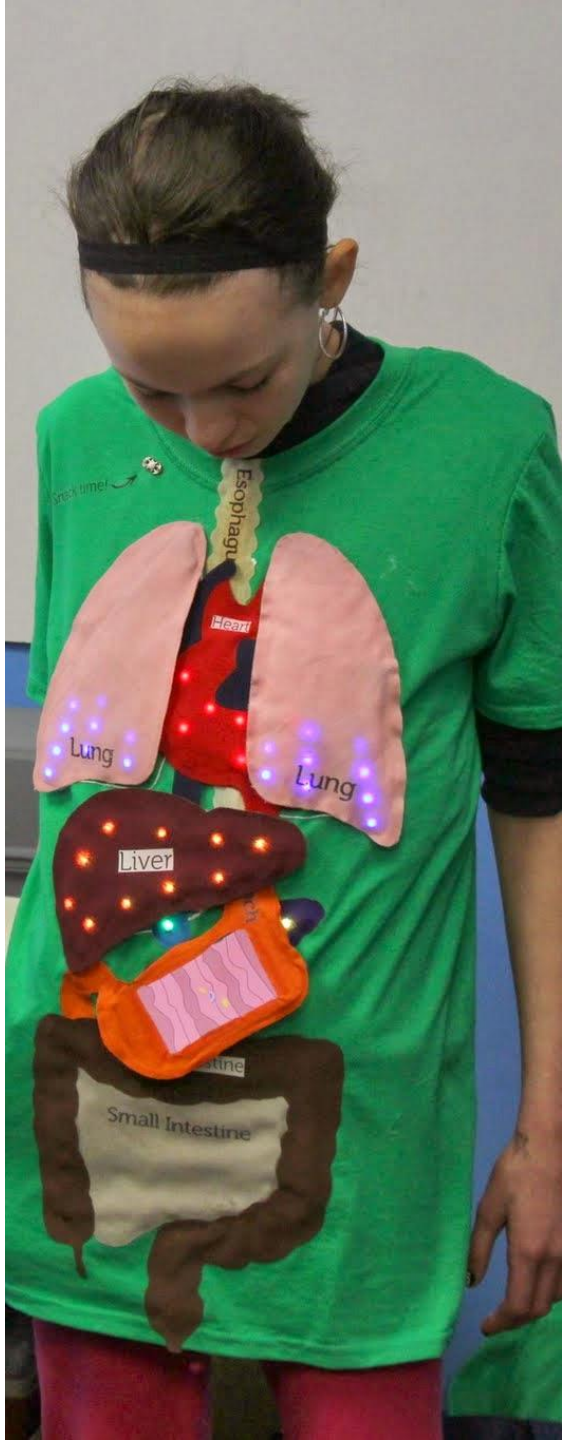

Snack time!
Liver
Large Intestine
Small Intestine

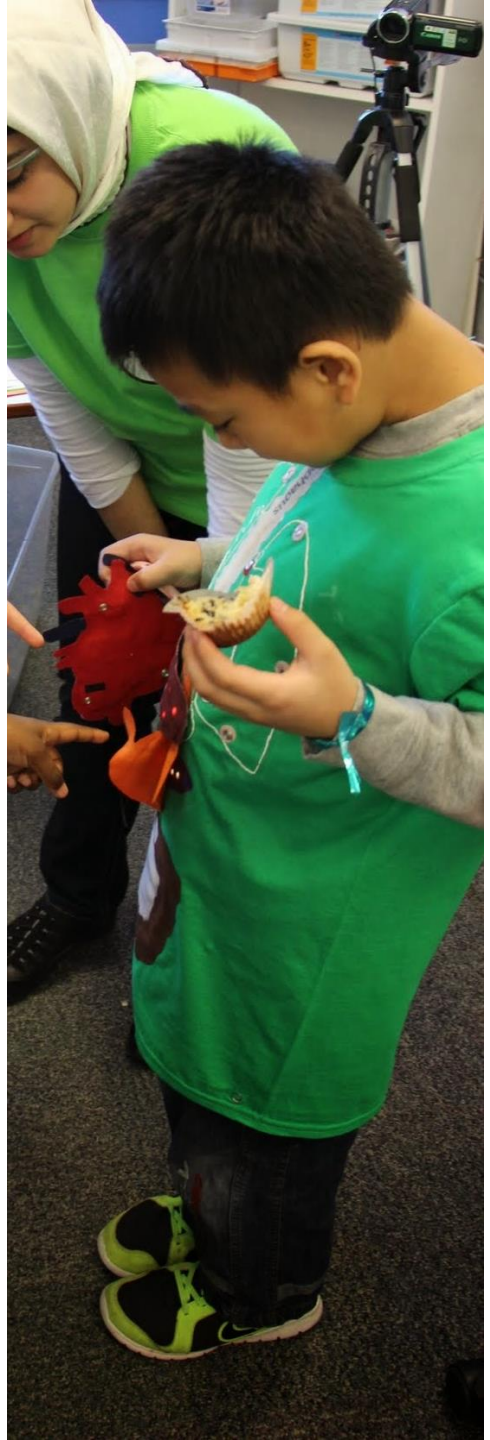

Snack time!
Esophagus
Heart
Lung
Lung
Liver
Small Intestine



BODYVIS INTERACTIONS

Wearers Look Downwards





1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

3 MAKERWEAR

Construction Kit

1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

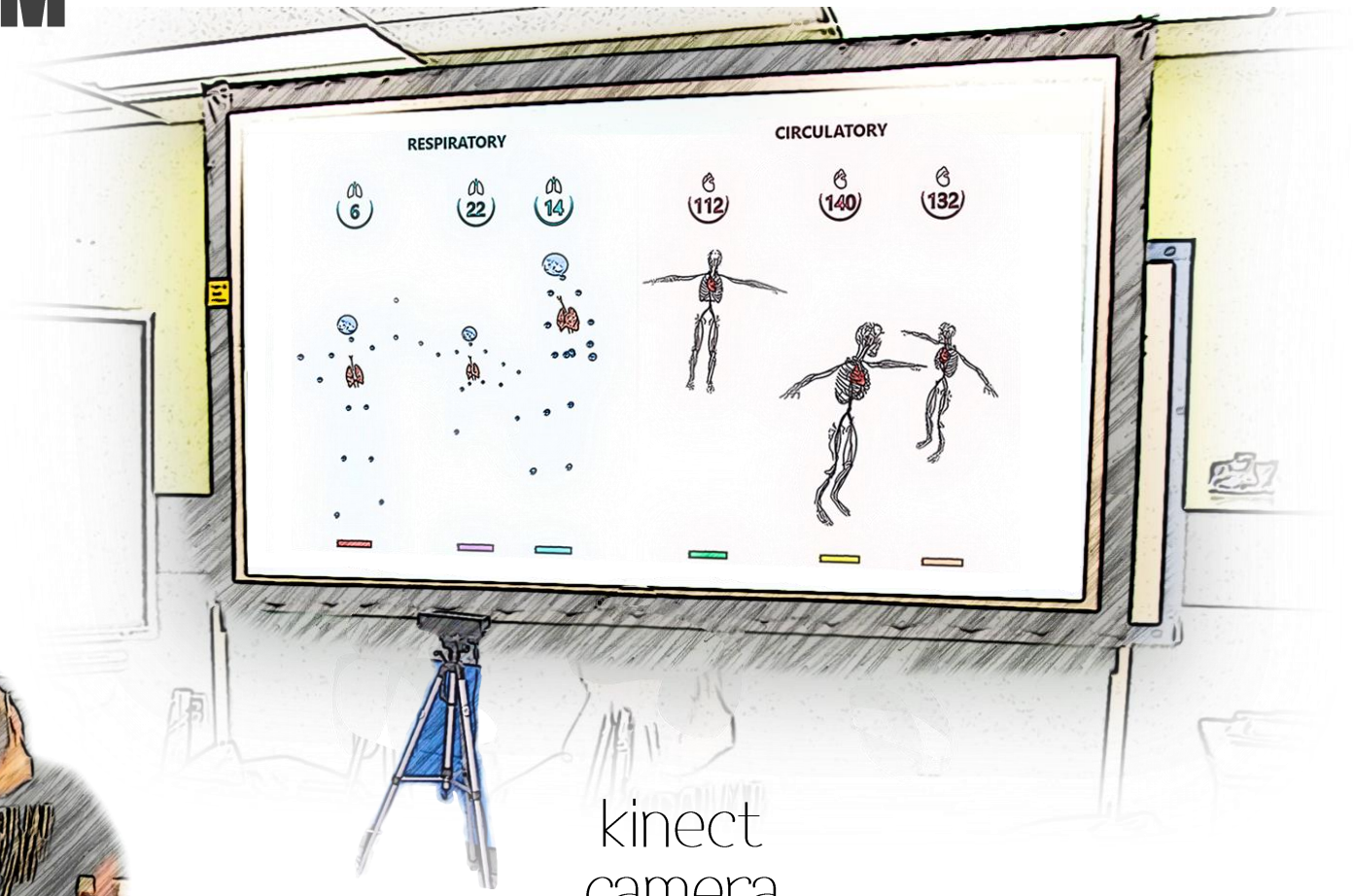
3 MAKERWEAR

Construction Kit

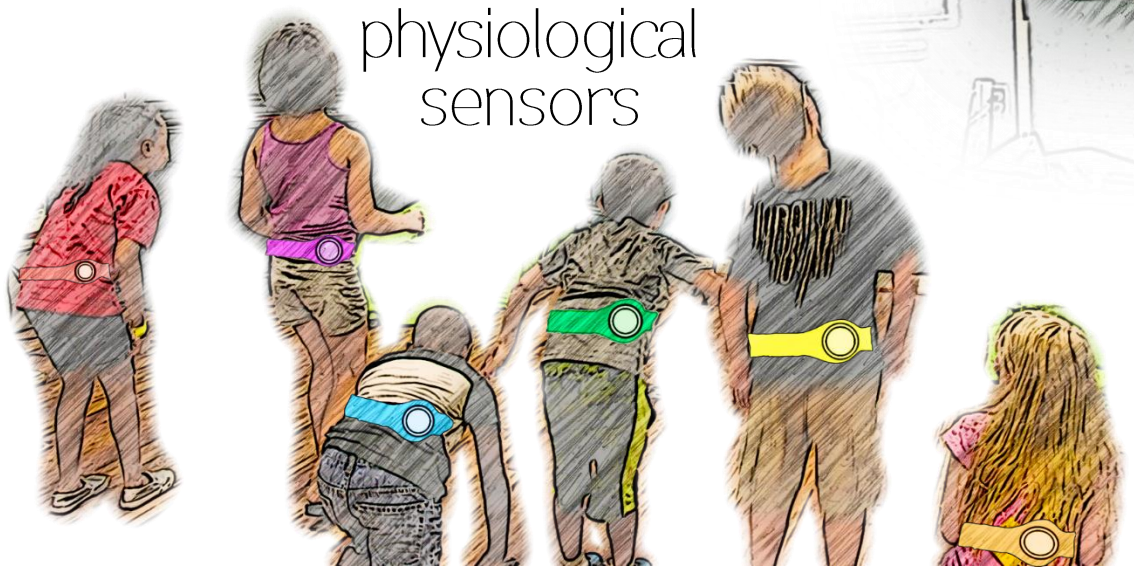
SHAREDPHYS

MIXED-REALITY SYSTEM

large
display



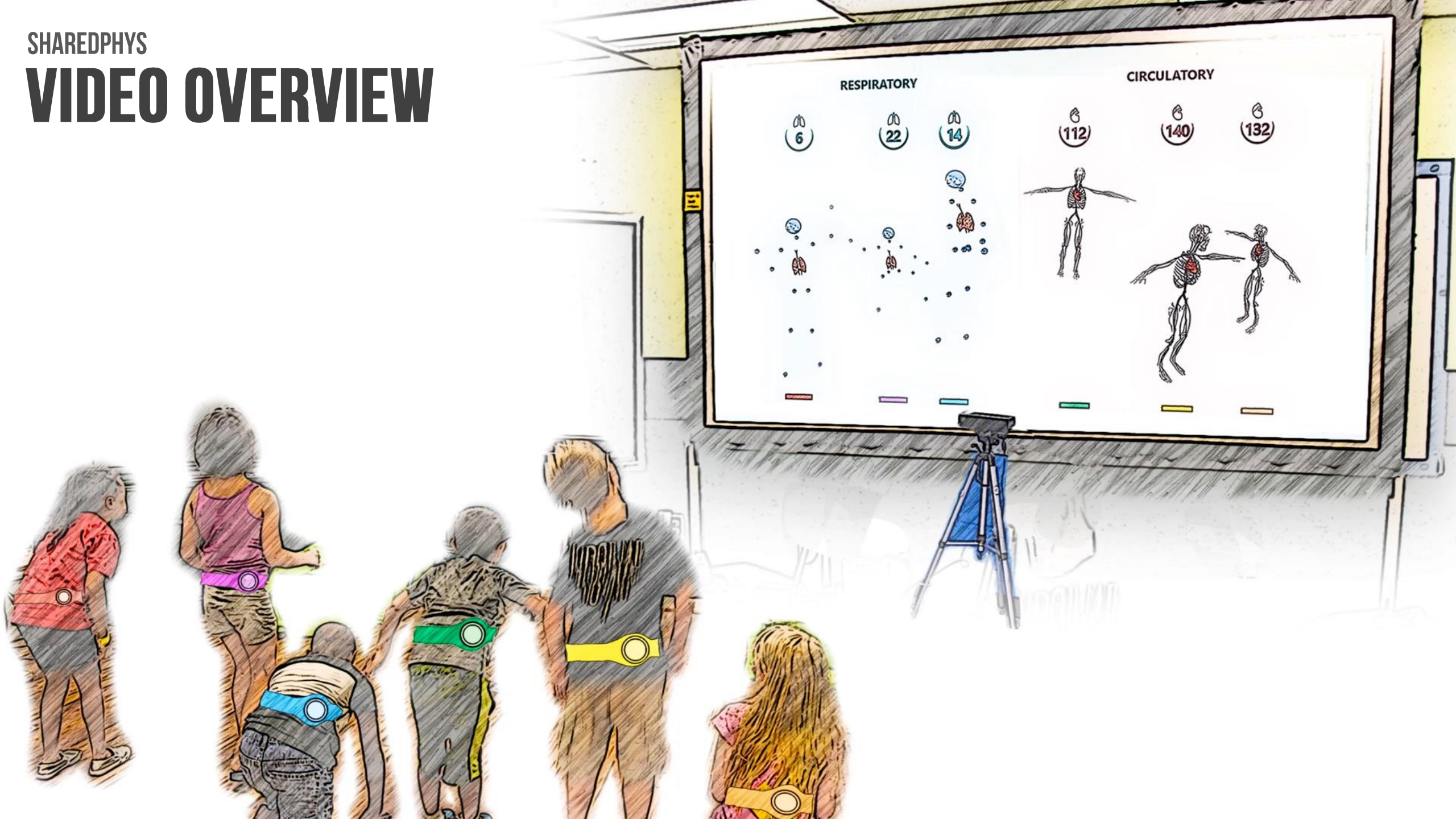
physiological
sensors

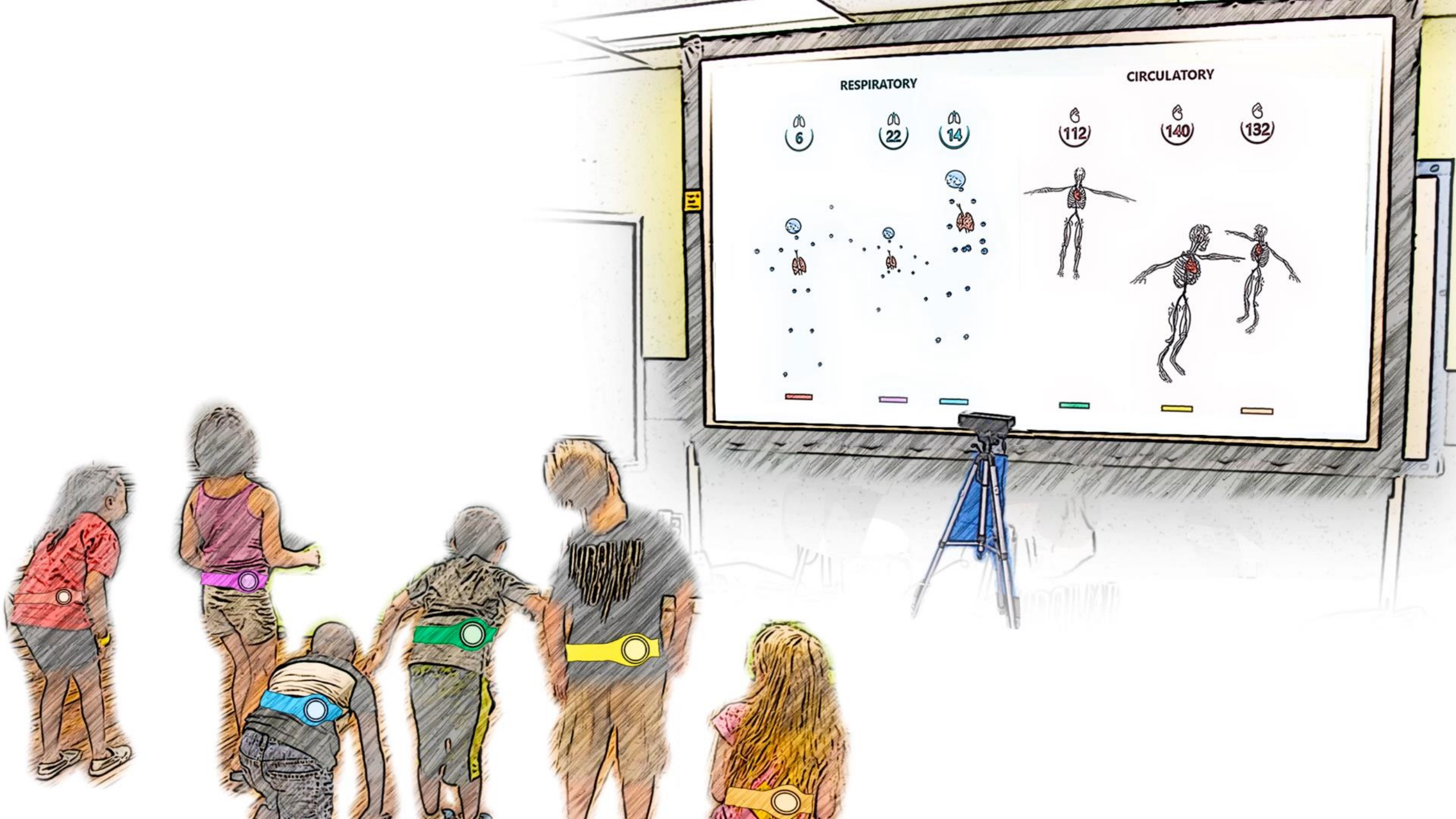


kinect
camera

SHAREDPHYS

VIDEO OVERVIEW




RESPIRATORY
CIRCULATORY
6
22
14
112
140
132

1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

3 MAKERWEAR

Construction Kit

1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

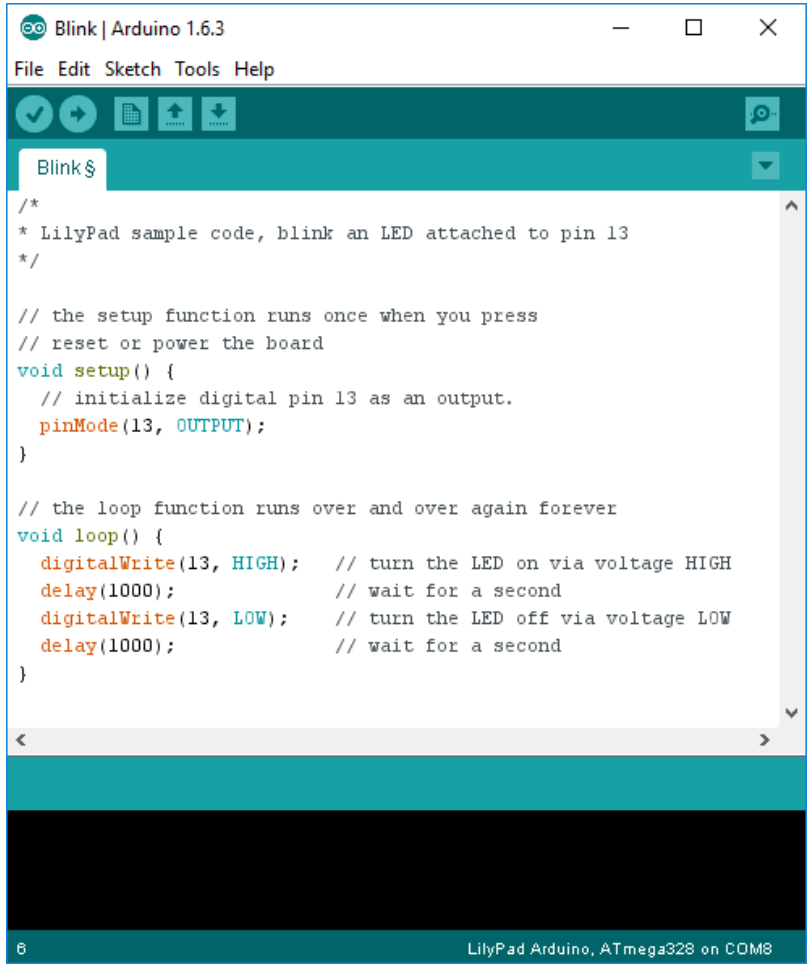
3 MAKERWEAR

Construction Kit


LILYPAD ARDUINO

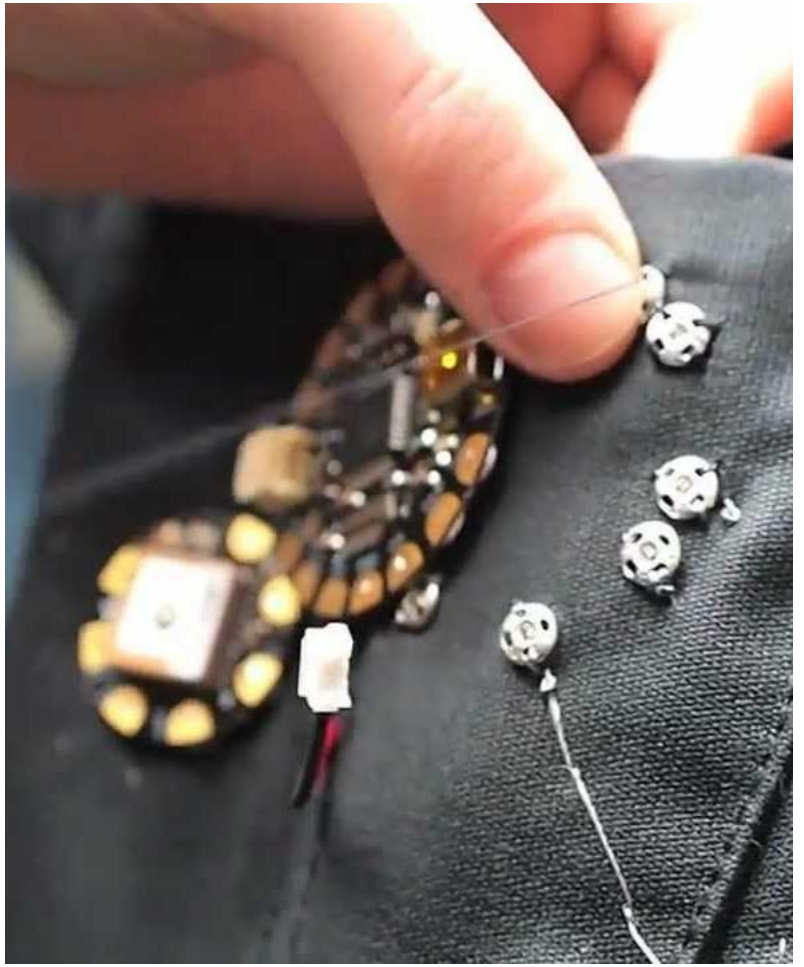
See: Buechley & Hill, 2010; Kafai, Lee, *et al.,* 2014; Kafai, Fields, & Searle, 2014

CURRENT WEARABLE TOOLKITS

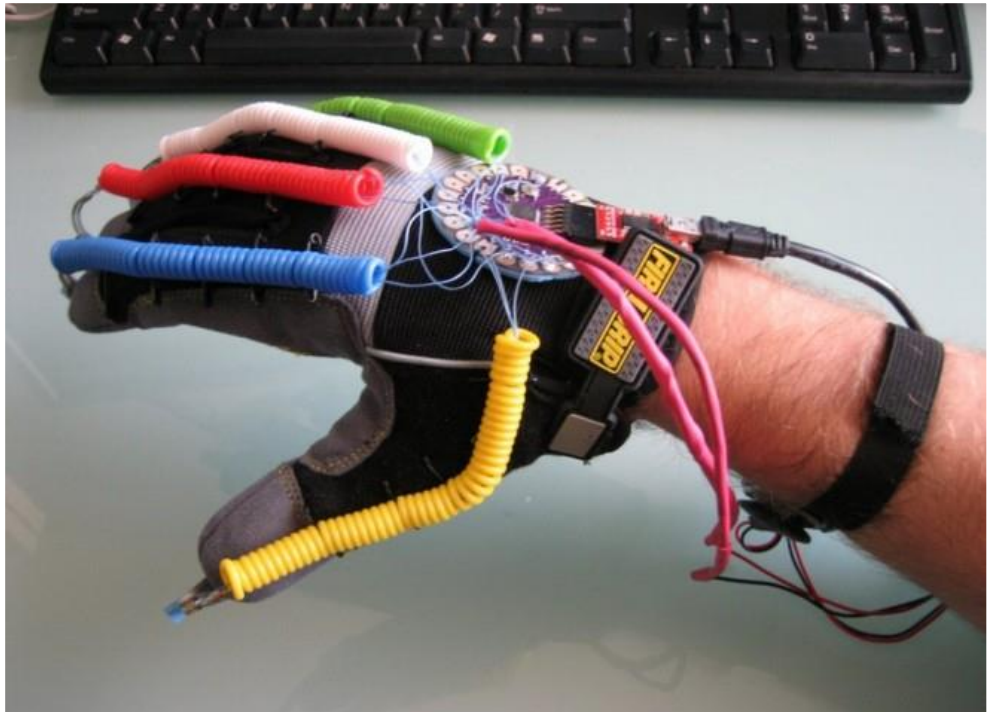


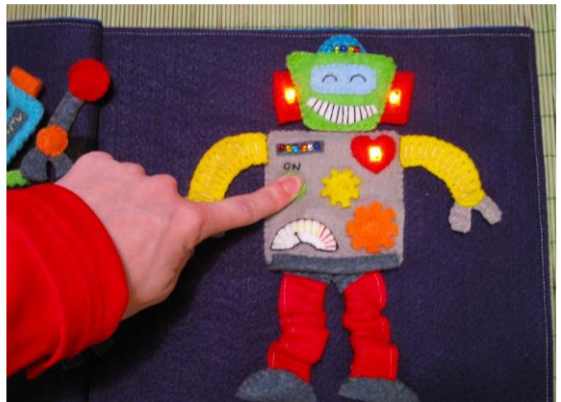
EMBEDDED PROGRAMMING

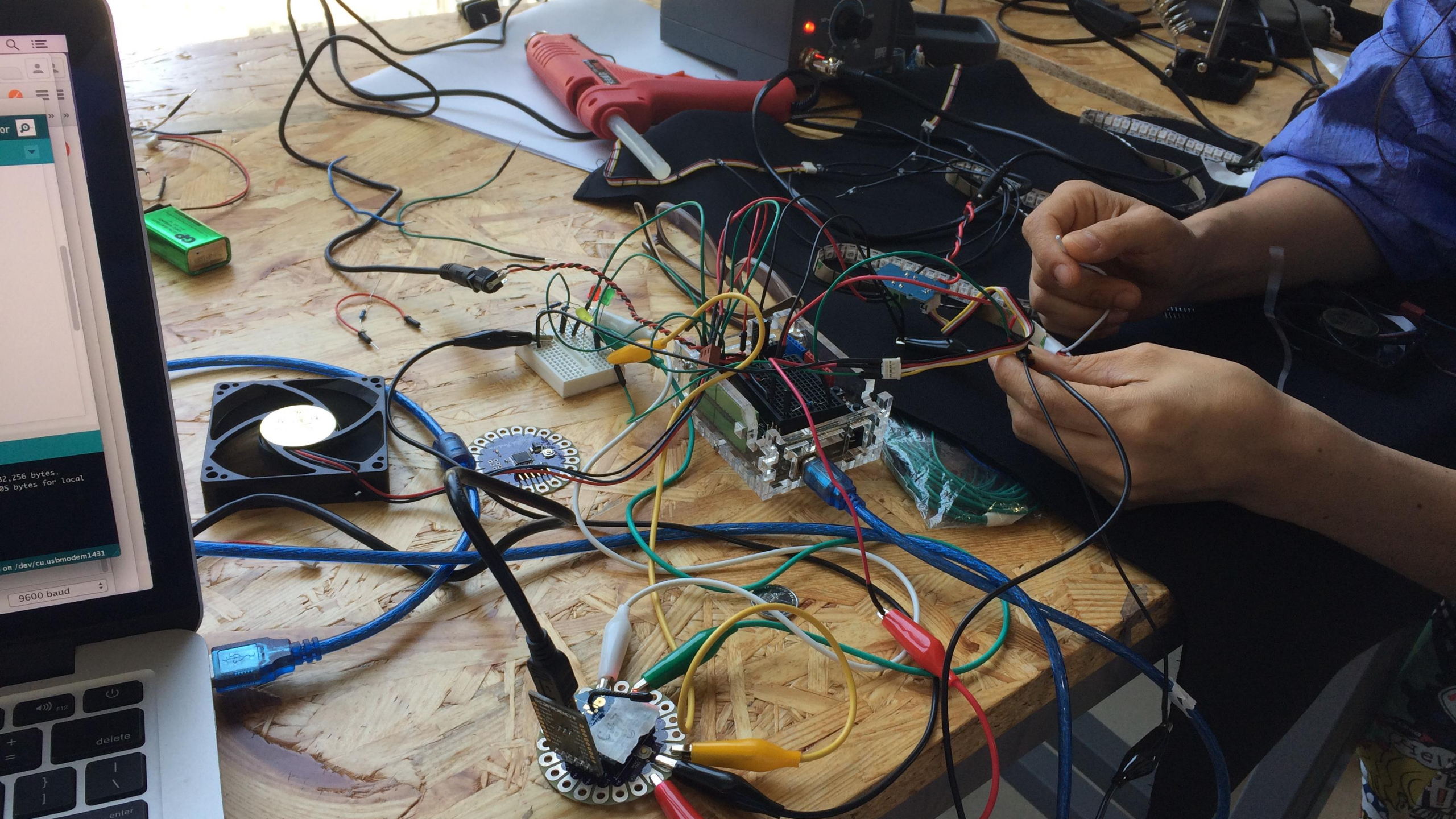
BASIC CIRCUIT & ELECTRONICS KNOWLEDGE



MANUAL SKILLS LIKE SEWING / SOLDERING




ON


32,256 bytes.
05 bytes for local
on /dev/cu.usbmodem1431
9600 baud
delete
enter

Buechley, 2006; Davis, *et al.,* 2013; DuMont & Lee, 2015; Dunne *et al.,* 2015; Kafai *et al.,* 2014; Katterfeldt *et al.,* 2009; Ngai *et al.,* 2013; Richard & Kafai, 2015; Searle, *et al.,* 2014

OVERARCHING RESEARCH QUESTIONS

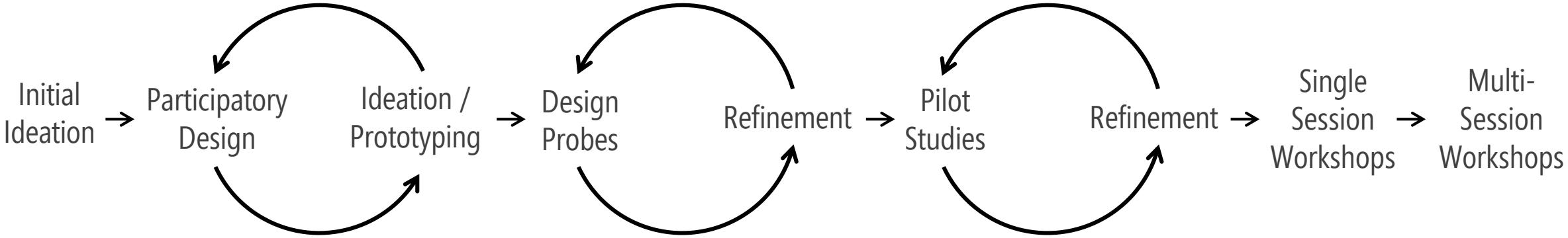
How can we enable young children (elementary age) to design & build their own interactive wearables?

What do children *want* to build and *how* can we support these goals?

How does working with our tools & techniques impact skill development & perceptions of STEM?

MAKERWEAR

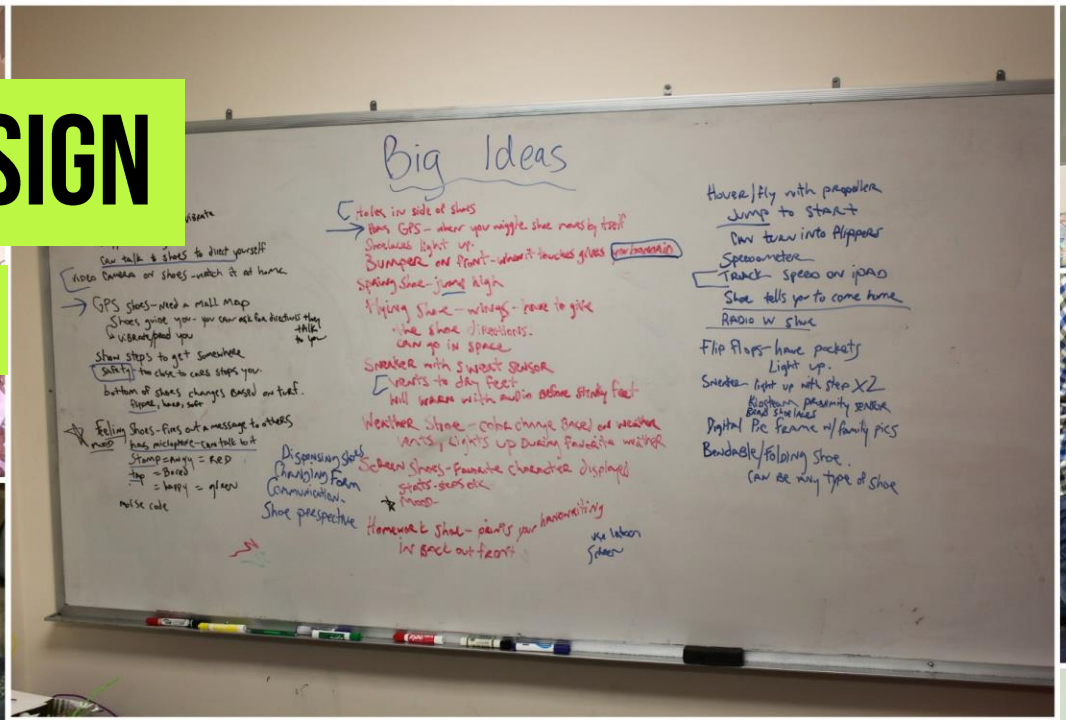
DESIGN & EVALUATION PROCESS

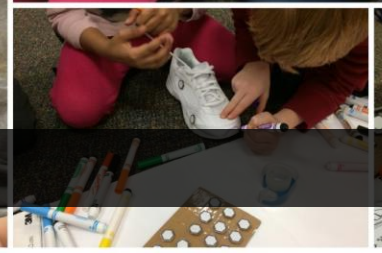


TWO YEAR ITERATIVE DESIGN PROCESS

PARTICIPATORY DESIGN

Cooperative Inquiry





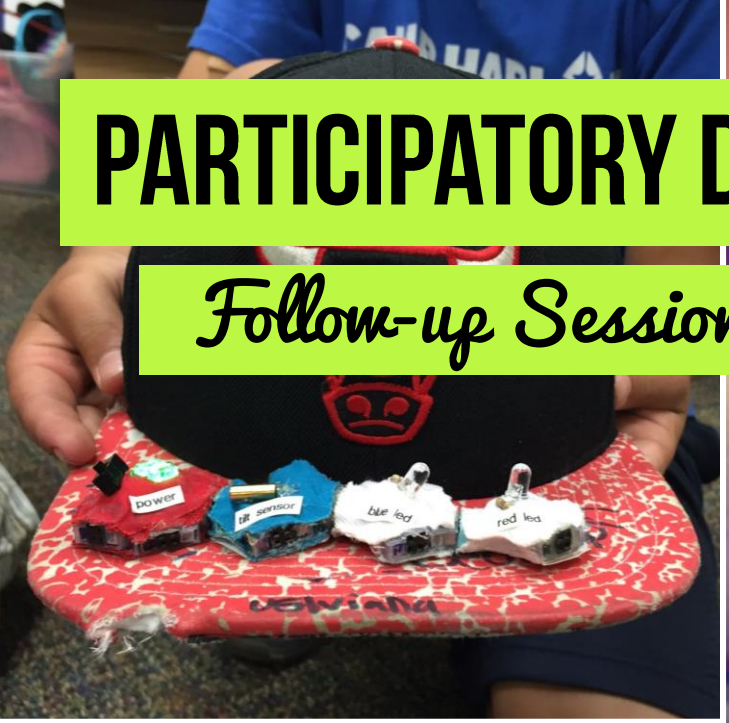
Cooperative Inquiry: Guha, Druin, & Fails, 2013

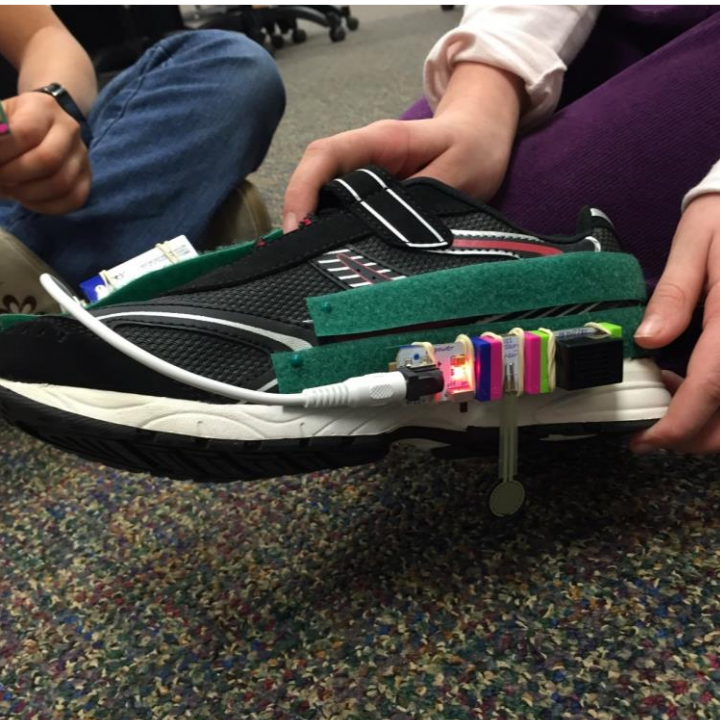
PARTICIPATORY DESIGN

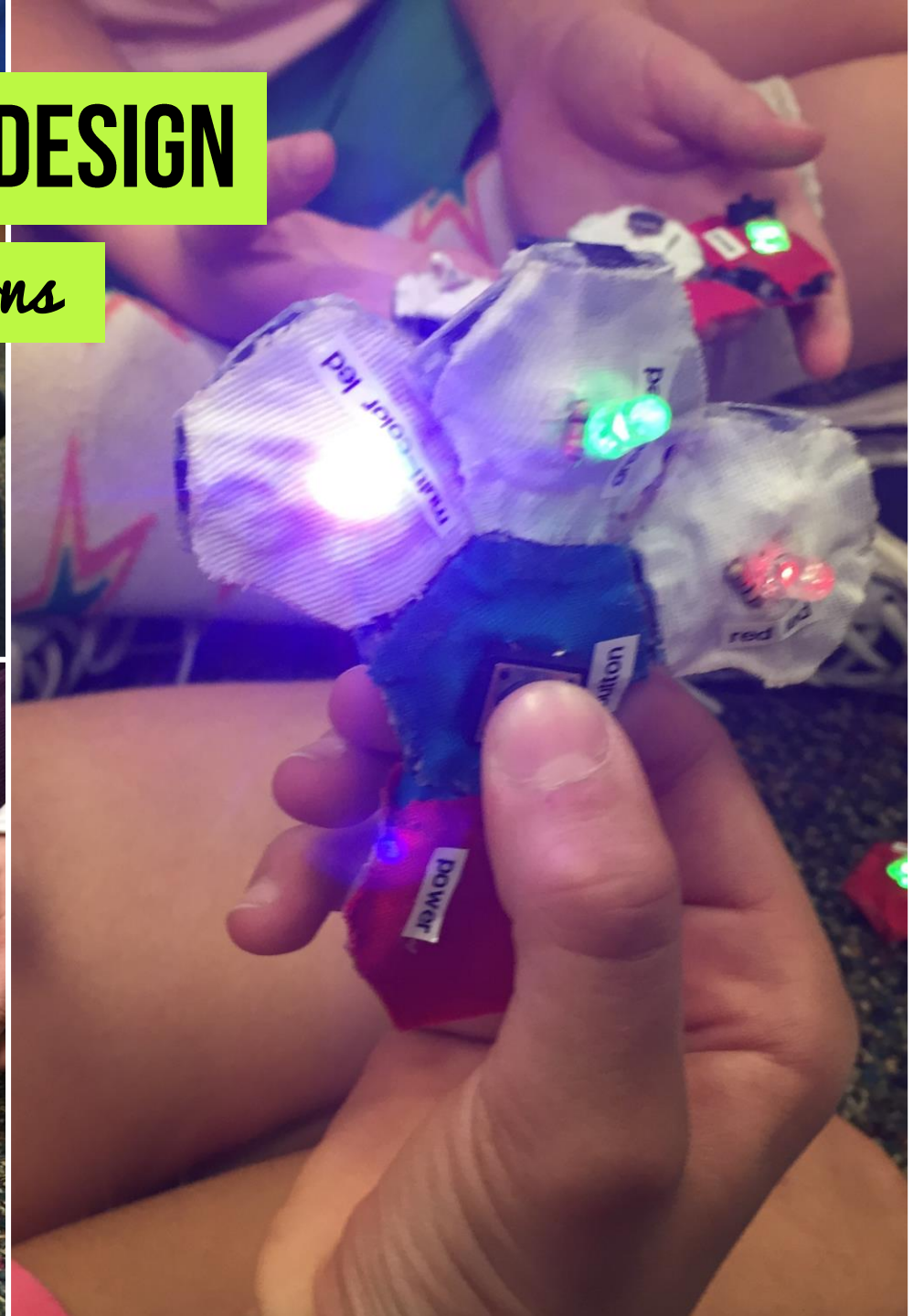
Initial Sessions

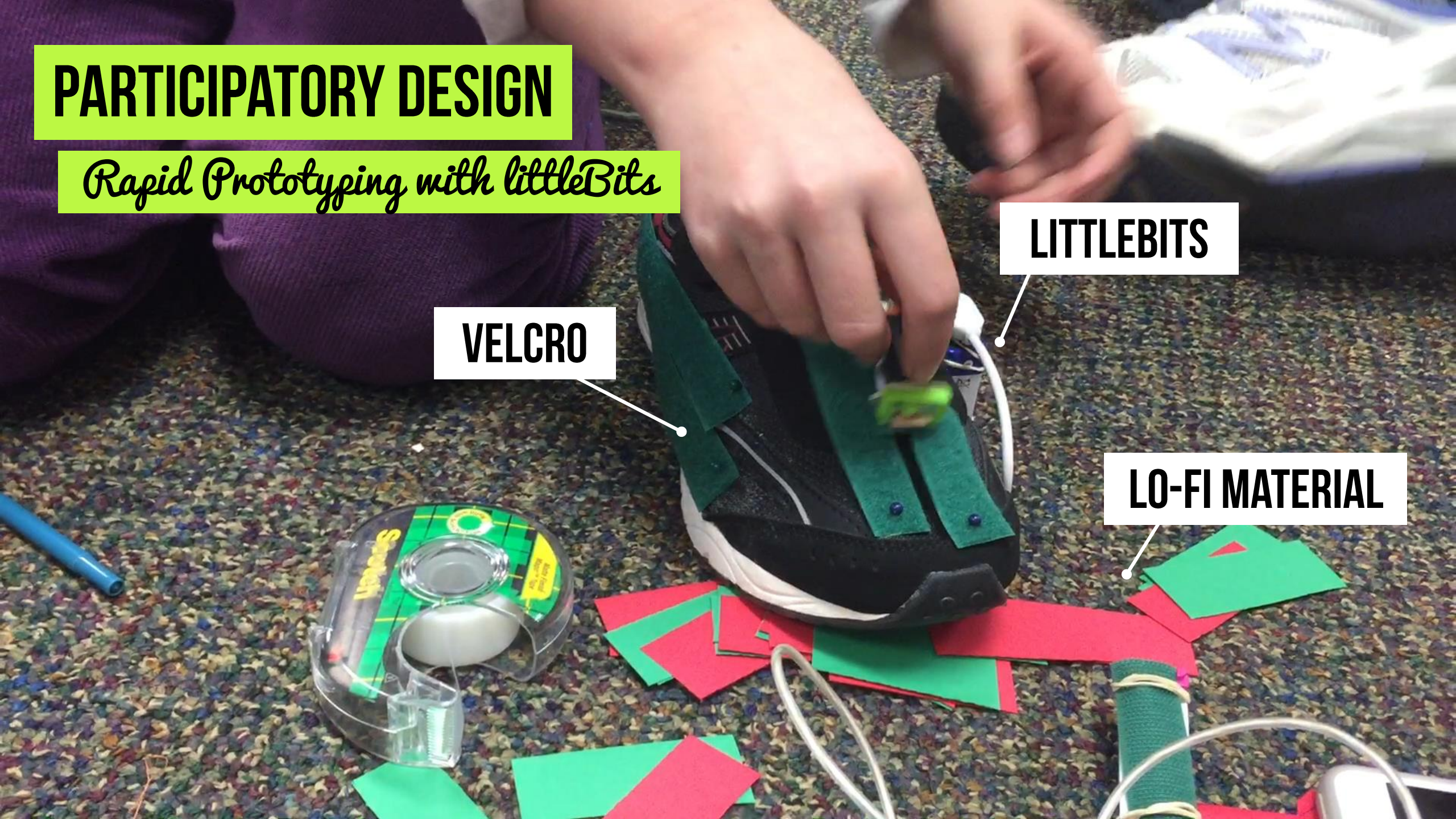
PARTICIPATORY DESIGN

Follow-up Sessions








PARTICIPATORY DESIGN
Rapid Prototyping with littleBits
LITTLEBITS
VELCRO
LO-FI MATERIAL

PARTICIPATORY DESIGN

Rapid Prototyping with littleBits

MAKERWEAR PARTICIPATORY DESIGN

WHAT DO CHILDREN WANT TO DESIGN WITH WEARABLES?

React to body movement & physiology (*e.g.,* heartrate)

Recognize gestures & physical actions (*e.g.,* recognize a jump)

Support social interaction (*e.g.,* vibrate when friend nearby)

Augment play experiences (*e.g.,* freeze tag)

Respond to environment (*e.g.,* increase visibility at night)


DESIGN PROBE
STEM Educators

MAKERWEAR DESIGN PROBE

STEM EDUCATOR FEEDBACK

REACTIONS

Wearables as a design platform

High tinkerability

Wide walls

DESIGN IDEAS

New modules

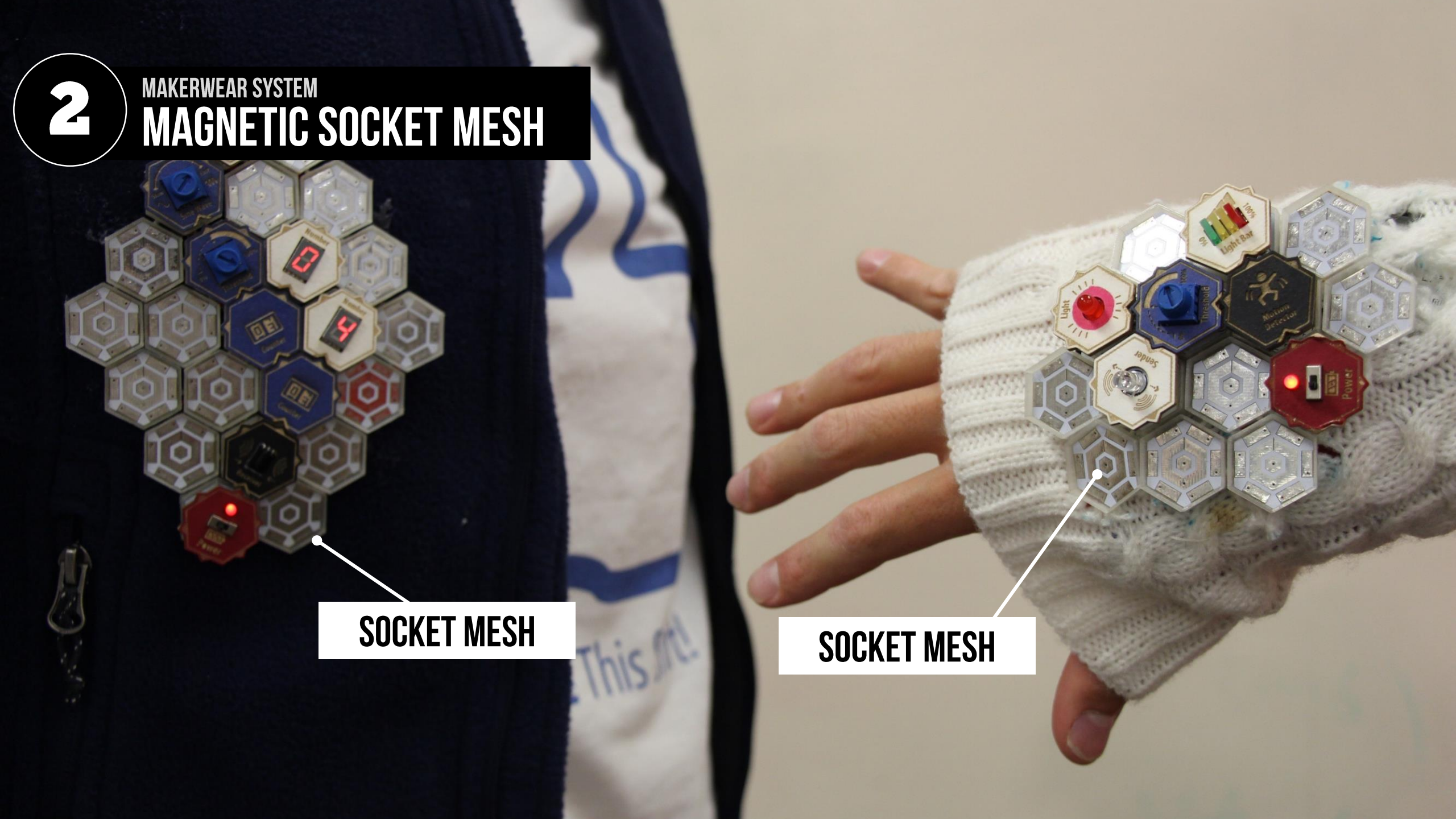
Better support for lo-fi materials

Child-friendly iconography & text


THE MAKERWEAR SYSTEM
https://github.com/MakerWear

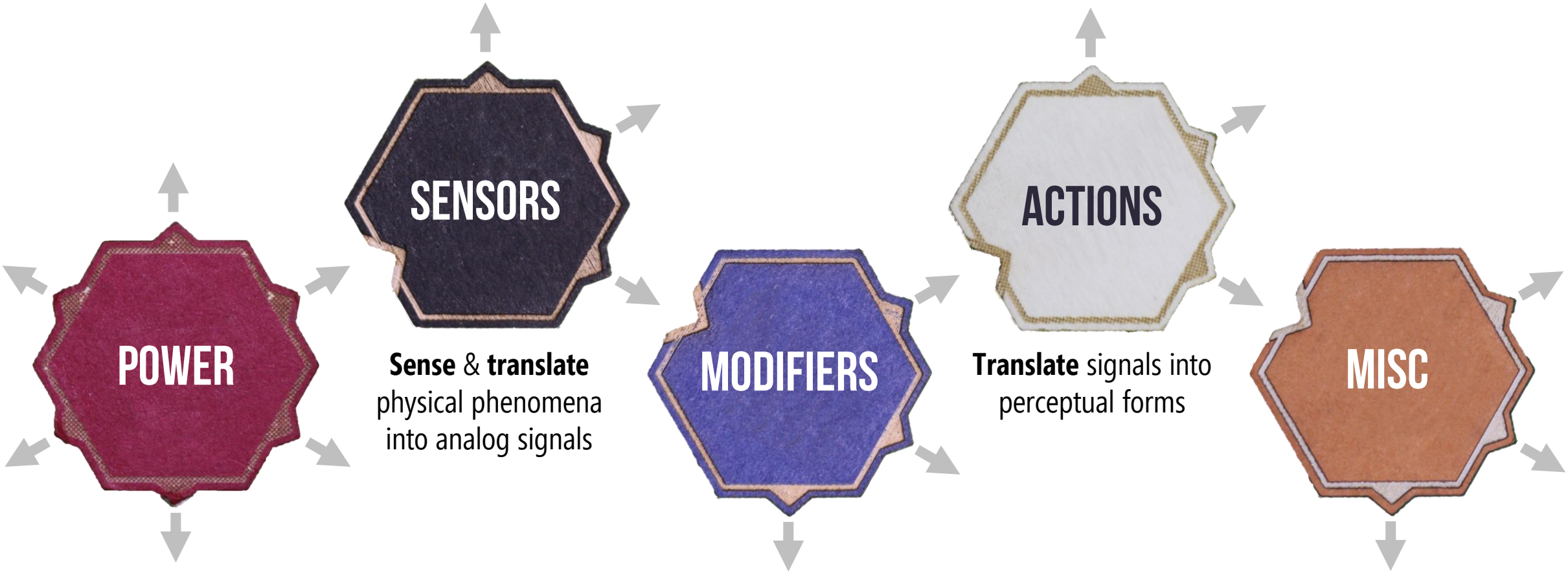

Light
Light
Light
Vibration


1
MAKERWEAR SYSTEM
TANGIBLE MODULES
Power
Vibration
Number
Sound Maker
Light
Spinner
Tilt Sensor
Counter
Motion Detector
Fade
Slow
Fast
Vibration
Number


2
MAKERWEAR SYSTEM
MAGNETIC SOCKET MESH
SOCKET MESH
SOCKET MESH

MAKERWEAR SYSTEM

5 MODULE TYPES



Provides **power** to all connected modules

Sense & **translate** physical phenomena into analog signals

Transform signals into other types of signals

Translate signals into perceptual forms

Miscellaneous (*e.g.,* DIY module)

MAKERWEAR SYSTEM

MODULE LIBRARY: 32 MODULES

12 SENSORS

Motion Detector

Distance

Sunlight Detector

Tilt Sensor

Light Sensor

Receiver

Impact Sensor

Color Detector


Heartbeat

Button

Temperature

Sound Sensor

9 ACTIONS

Light Bar

Yellow Light

Rotator

Green Light

MultiColor Light

Spinner

Blue Light

Number

Vibration

Red Light

Sender

Sound Maker

7 MODIFIERS

Volume Knob

Sine Wave

Threshold

Counter

Fade

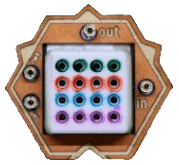
Inverter

Square Wave

3 MISC

Wire Start

Wire End


DIY Electronic


Bridge

1 POWER

Power

MOVEMENT & PHYSIOLOGY

Motion Detector

Distance

Heartbeat

Impact Sensor

Tilt Sensor

Button

Rotator

Vibration

Spinner

CHANGING ENVIRONMENT

Sunlight Detector

Color Detector

Temperature

Sound Sensor

Light Sensor

Single Light

Sound Maker

MultiColor Light

COMMUNICATION

Wire Start

Receiver

Wire End

Sender

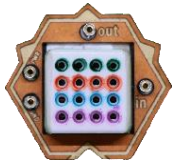
DEBUGGING

Number

Light Bar

DIY


Bridge



DIY Electronic

SIGNAL MODIFIER

Volume Knob

Inverter

Fade

SIGNAL ANALYZER

Threshold

Counter

SIGNAL GENERATOR

Square Wave

Sine Wave

MOVEMENT & PHYSIOLOGY

Motion Detector

Distance

Heartbeat

Impact Sensor

Tilt Sensor

Button

Rotator

Vibration

Spinner

CHANGING ENVIRONMENT

Sunlight Detector

Color Detector

Temperature

Sound Sensor

Light Sensor

Single Light

Sound Maker

MultiColor Light

COMMUNICATION

Wire Start

Receiver

Wire End

Sender

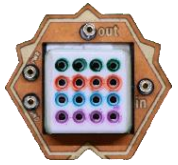
DEBUGGING

Number

Light Bar

DIY


Bridge



DIY Electronic

SIGNAL MODIFIER

Volume Knob

Inverter

Fade

SIGNAL ANALYZER

Threshold

Counter

SIGNAL GENERATOR

Square Wave

Sine Wave

MOVEMENT & PHYSIOLOGY

Motion Detector

Distance

Heartbeat

Impact Sensor

Tilt Sensor

Button

Rotator

Vibration

Spinner

CHANGING ENVIRONMENT

Sunlight Detector

Color Detector

Temperature

Sound Sensor

Light Sensor

Single Light

Sound Maker

MultiColor Light

COMMUNICATION

Wire Start

Receiver

Wire End

Sender

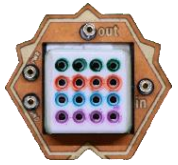
DEBUGGING

Number

Light Bar

DIY


Bridge



DIY Electronic

SIGNAL MODIFIER

Volume Knob

Inverter

Fade

SIGNAL ANALYZER

Threshold

Counter

SIGNAL GENERATOR

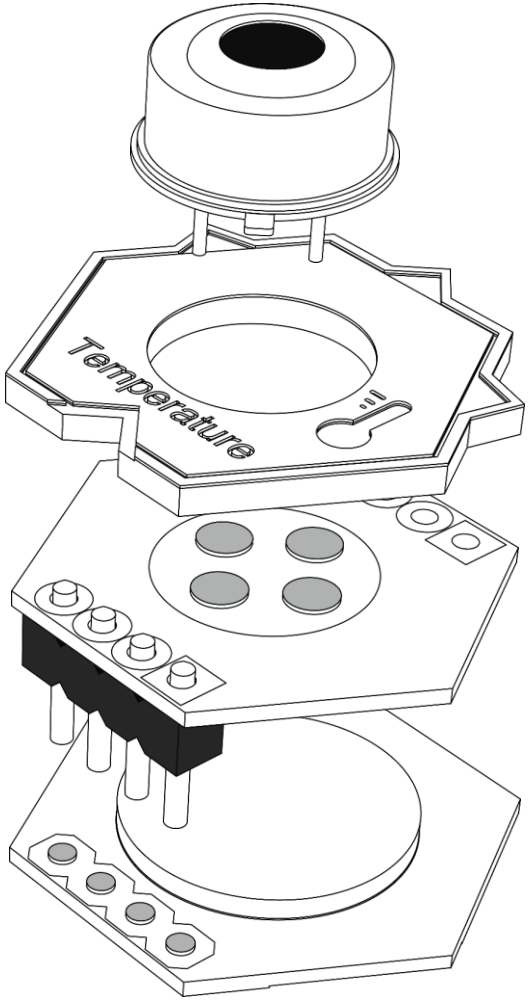
Square Wave

Sine Wave

MAKERWEAR SYSTEM

MODULE EXPLODED VIEW

Temperature Sensor

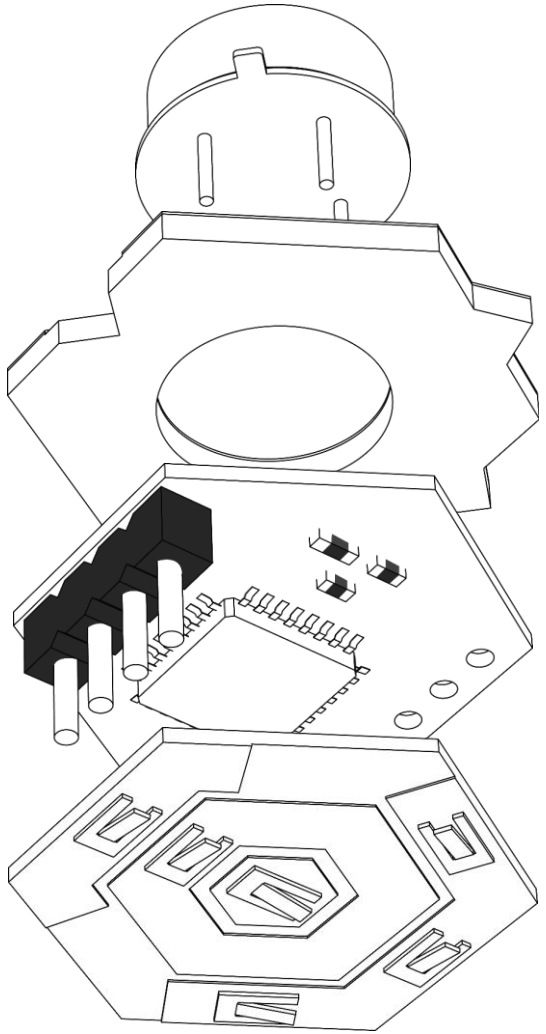


LAYER 1
Exposed electronic component

LAYER 2
Laser cut module cover

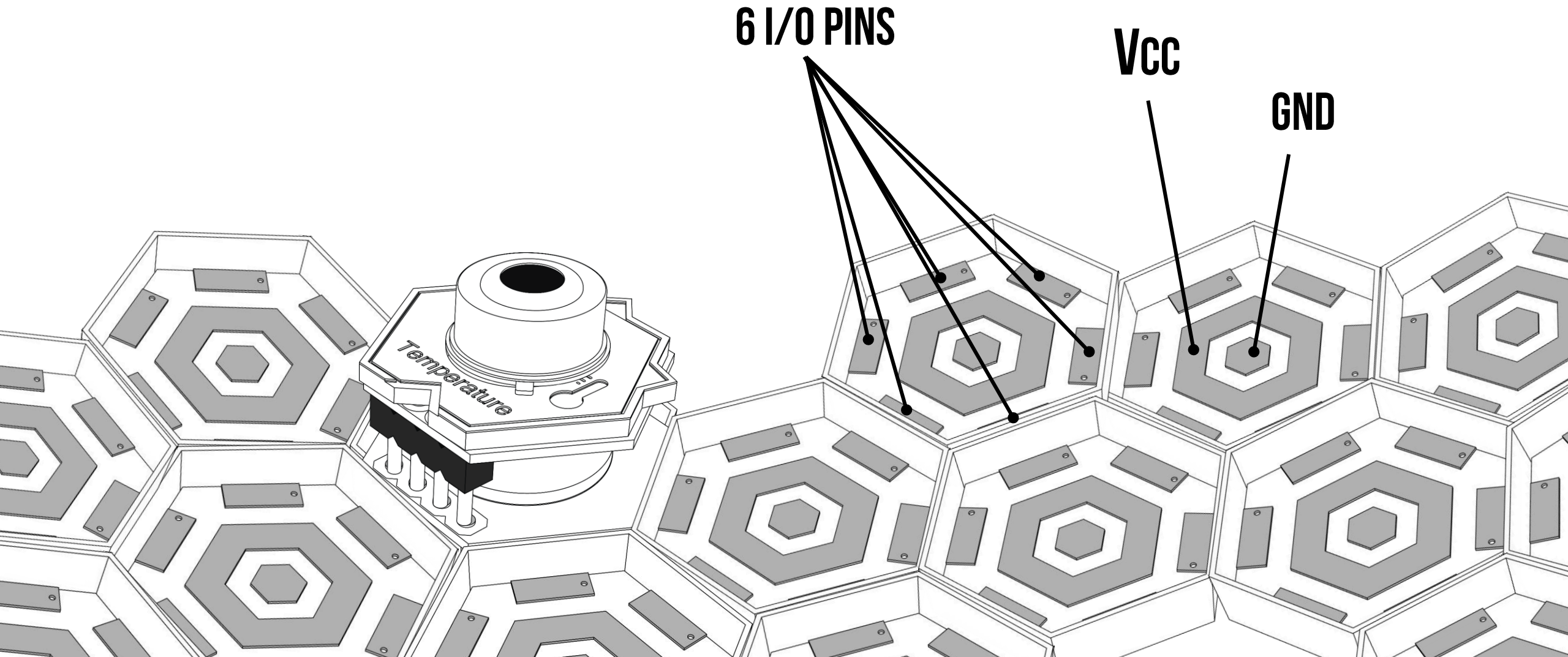
LAYER 3
Custom PCB with embedded microcontroller & SMD components

LAYER 4
Custom PCB with neodymium magnet & contact spring for socket connection



MAKERWEAR SYSTEM

SOCKET MESH



MAKERWEAR SYSTEM

TWO TYPES OF SOCKET MESHES

1. SEWN INTO CLOTHES

2. FABRIC PATCH

MAKERWEAR SYSTEM

CREATING WITH MAKERWEAR

MAKERWEAR SYSTEM

CREATING WITH MAKERWEAR


MAKERWEAR EVALUATION

MAKERWEAR EVALUATION

WORKSHOP-BASED EVALUATIONS

32 children (16 female; ages 5-12; *avg*=8.3)

Two single-session workshops (*N*=13)

Three four-session workshops (*N*=19)

Workshops common method for e-textile studies. *E.g.,* Buechley *et al.,* 2006; Katterfeldt *et al.,* 2009; Searle *et al.,* 2014; Richard & Kafai, 2015;

WORKSHOP SESSIONS & DEMOGRAPHICS

	Group	Ages (Avg)	N (female)
SINGLE SESSION	1	5-7 (6.0)	5 (5)
	2	8-12 (9.9)	8 (3)
MULTI-SESSION	1	5-7 (6.3)	7 (3)
	2	8-9 (8.8)	6 (1)
	3	8-12 (10.2)	6 (4)
	Total	**5-7 (8.3)**	**32 (16)**

WORKSHOP SESSIONS & DEMOGRAPHICS

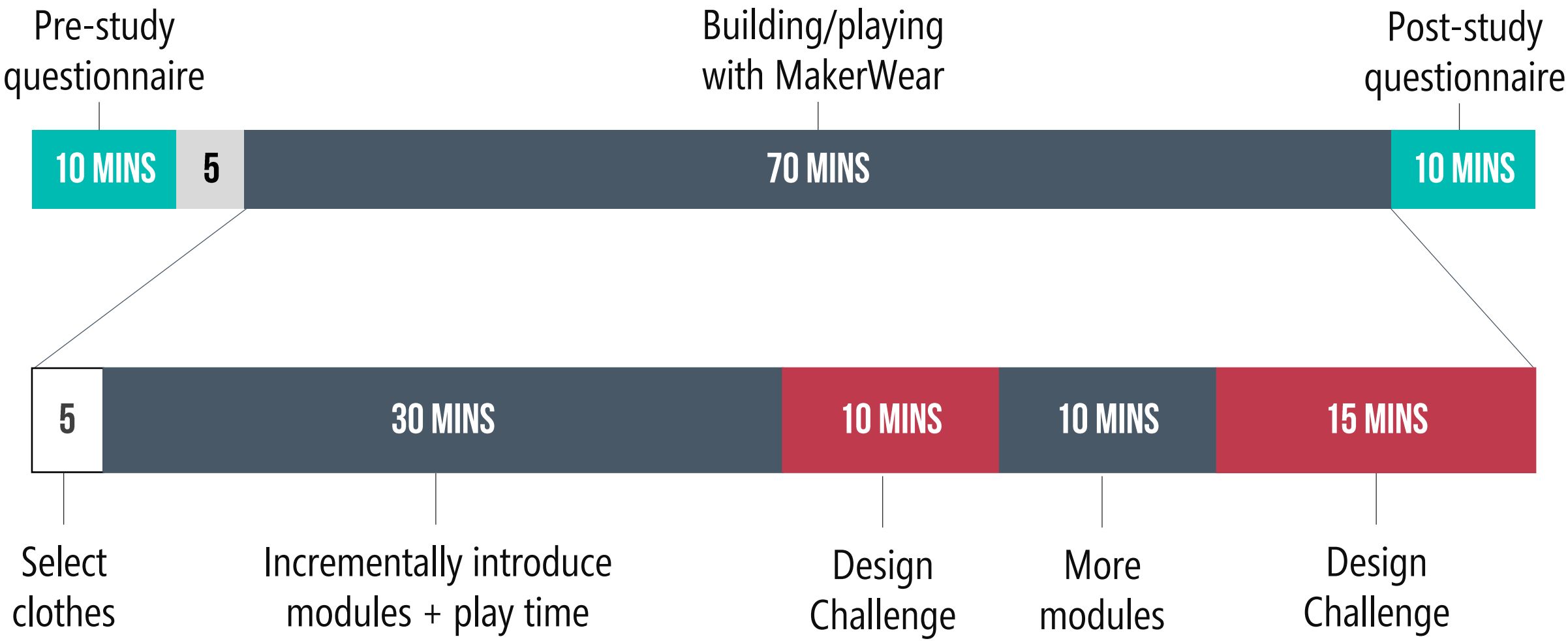
	Group	Ages (Avg)	N (female)	Uses computer at least a few times a week	Has used a graphical programming system (*e.g.,* Scratch)	Has used an electronic kit (*e.g.,* Snap Circuits, Lego Mindstorms, littleBits)
SINGLE SESSION	1	5-7 (6.0)	5 (5)	100%	40%	20%
	2	8-12 (9.9)	8 (3)	88%	38%	50%
MULTI-SESSION	1	5-7 (6.3)	7 (3)	100%	57%	57%
	2	8-9 (8.8)	6 (1)	83%	50%	66%
	3	8-12 (10.2)	6 (4)	83%	83%	66%
	Total	**5-7 (8.3)**	**32 (16)**	**91%**	**53%**	**53%**

MAKERWEAR EVALUATION

SINGLE-SESSION WORKSHOP PROCEDURE

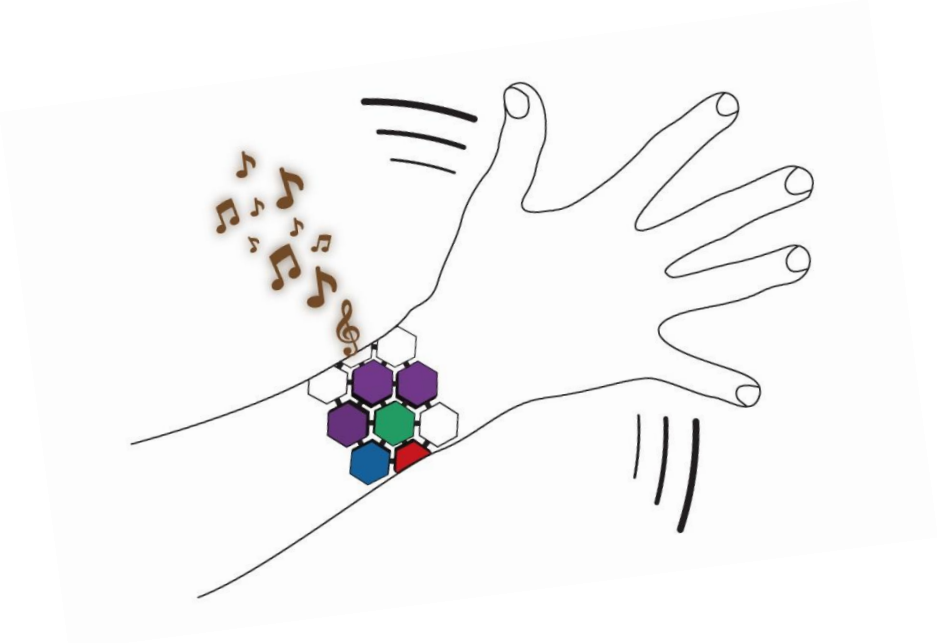
MAKERWEAR EVALUATION

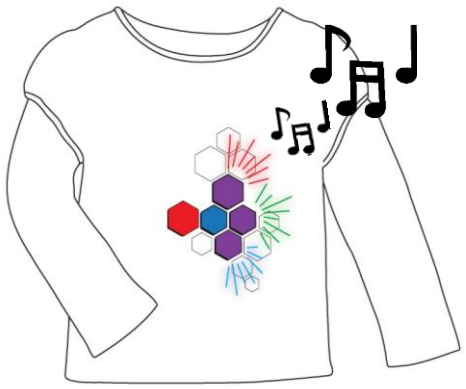
SINGLE-SESSION WORKSHOP PROCEDURE

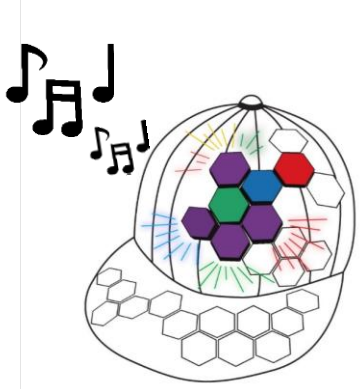


MAKERWEAR EVALUATION

EASY DESIGN CHALLENGE





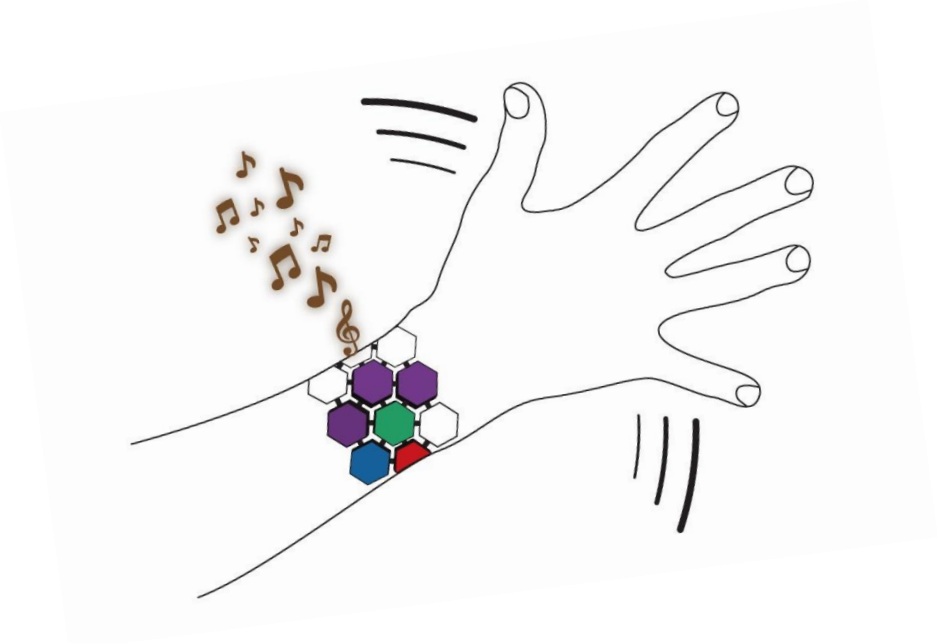


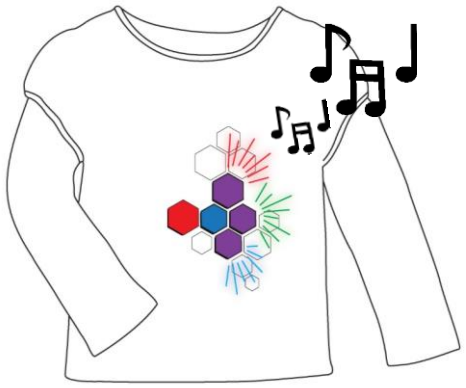
DESIGN PROMPT: WEARABLE INSTRUMENT

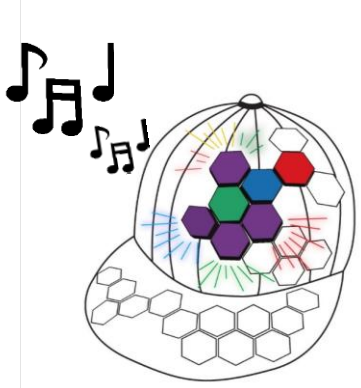
Build your own wearable instrument that **makes music** and **lights up** when you **move.**

MAKERWEAR EVALUATION

EASY DESIGN CHALLENGE







DESIGN PROMPT: WEARABLE INSTRUMENT

Build your own wearable instrument that **makes music** and **lights up** when you **move.**

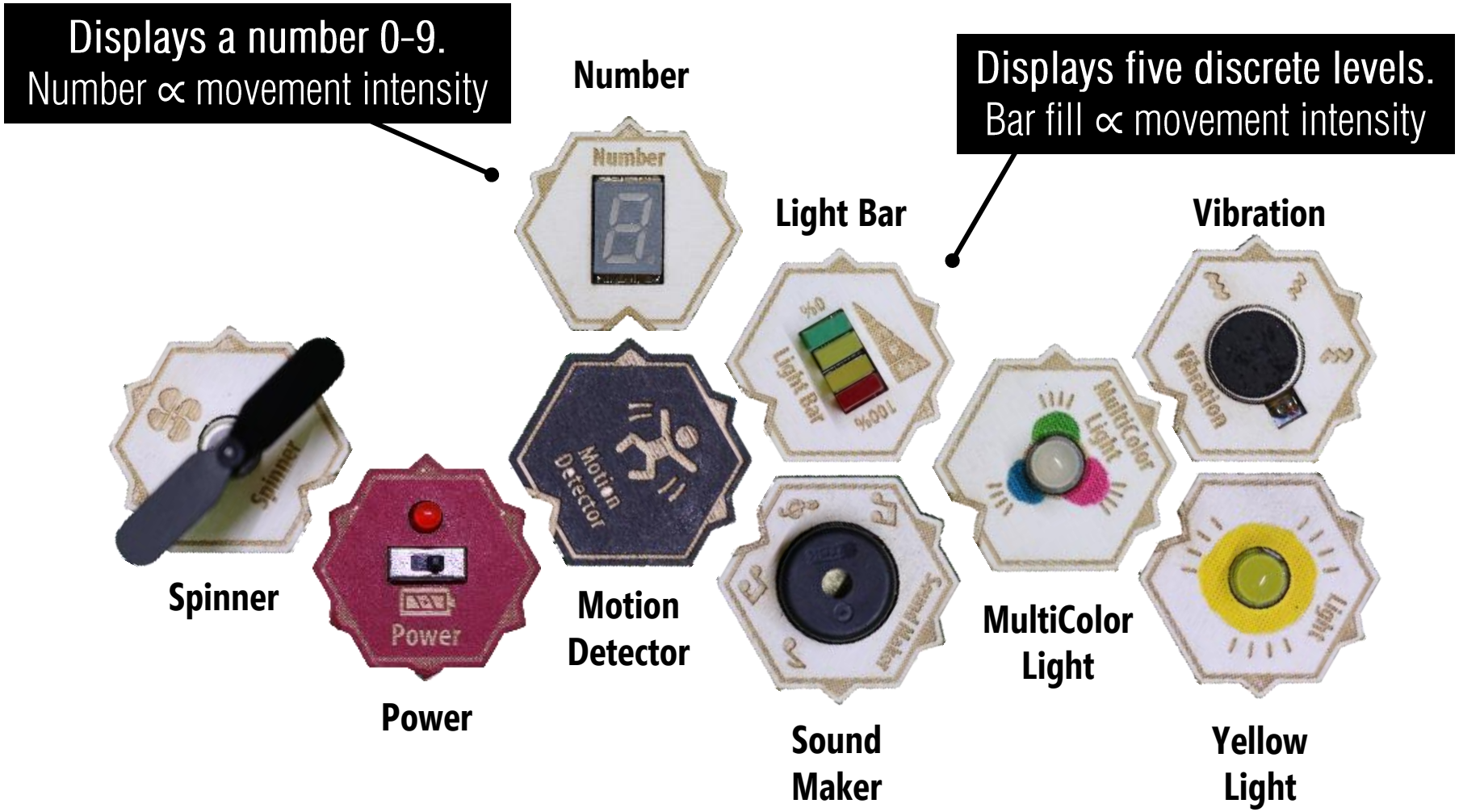
EXAMPLE SOLUTION

Power

Motion Detector

Sound Maker

MultiColor Light


Displays a number 0-9.
Number ∝ movement intensity
Number
Displays five discrete levels.
Bar fill ∝ movement intensity
Light Bar
Vibration
Spinner
Power
Motion Detector
Sound Maker
MultiColor Light
Yellow Light

MAKERWEAR EVALUATION

HARDER DESIGN CHALLENGE

DESIGN PROMPT: BUZZ LIGHTYEAR

Build a wearable for **Buzz Lightyear** that has two modes:

1. In attack mode, you shoot “laser beams” (lights).

2. In defend mode, you activate a LEGO shield.

The two modes are **automatically activated** based on your arm’s position (up *vs.* out) but the **catch** is that you cannot attack & defend at the same time.

MAKERWEAR EVALUATION

HARDER DESIGN CHALLENGE

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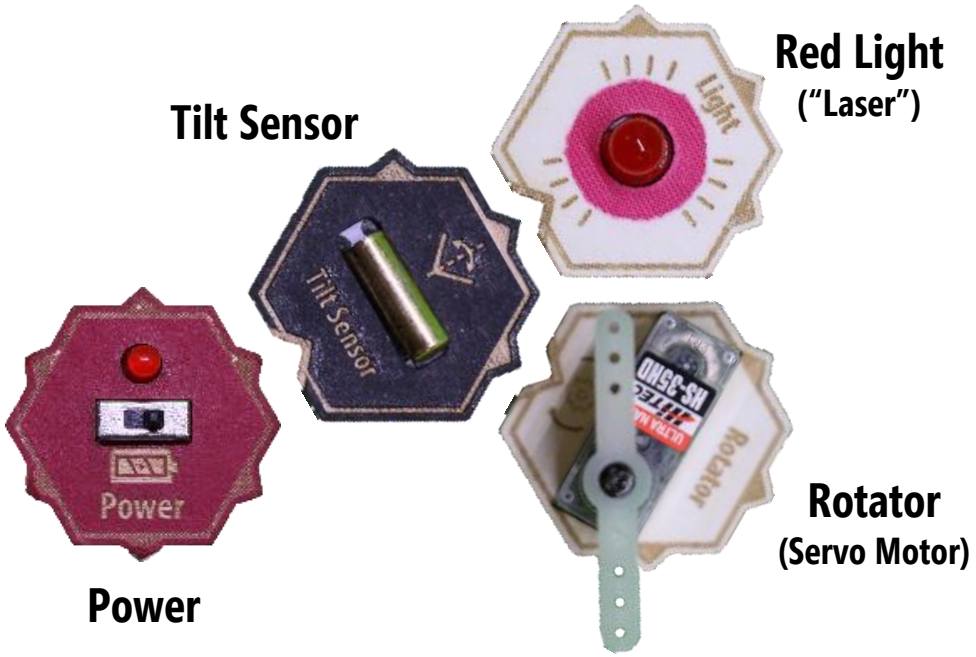

MAKERWEAR EVALUATION

HARDER DESIGN CHALLENGE

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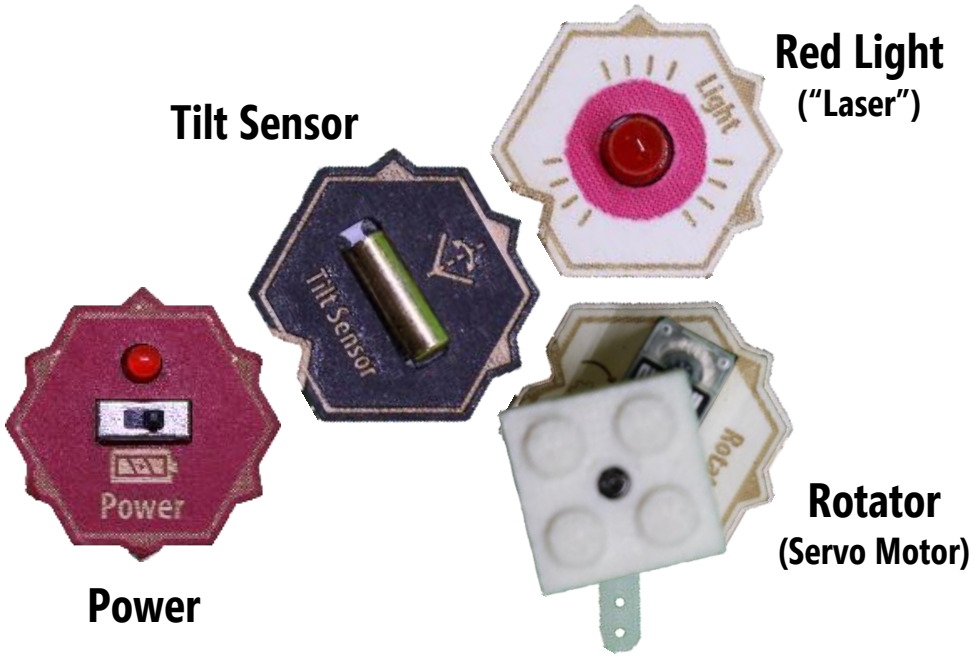

Oops! Both the "laser" and shield are activated at the same time!

MAKERWEAR EVALUATION

HARDER DESIGN CHALLENGE

DESIGN PROMPT: BUZZ LIGHTYEAR

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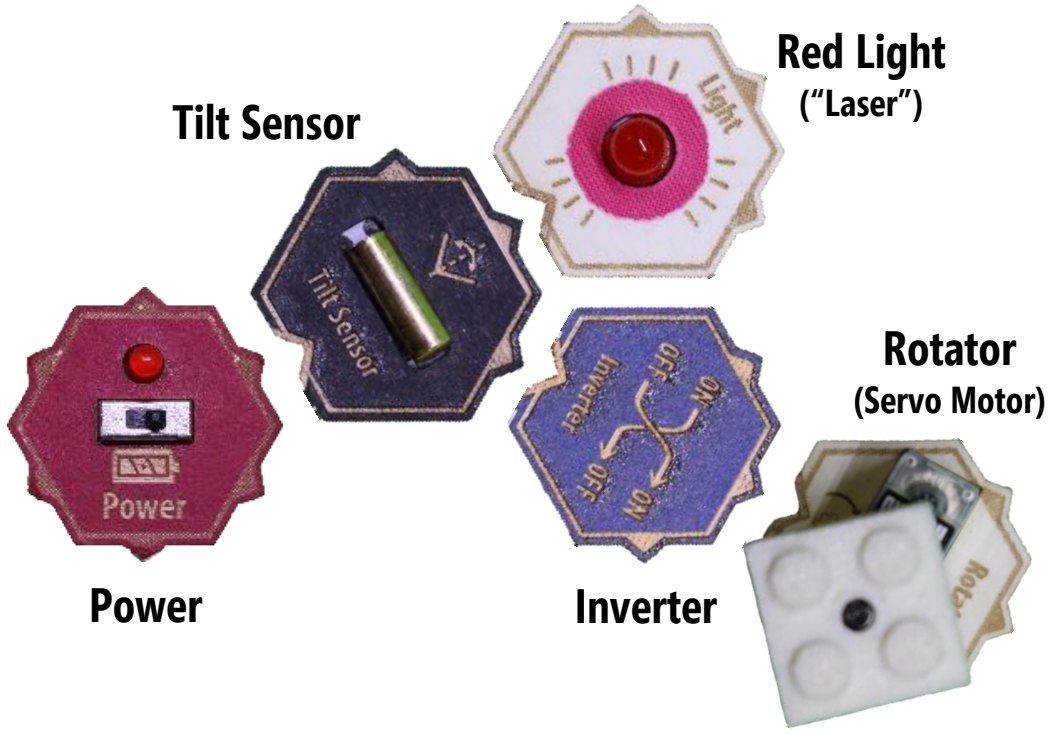
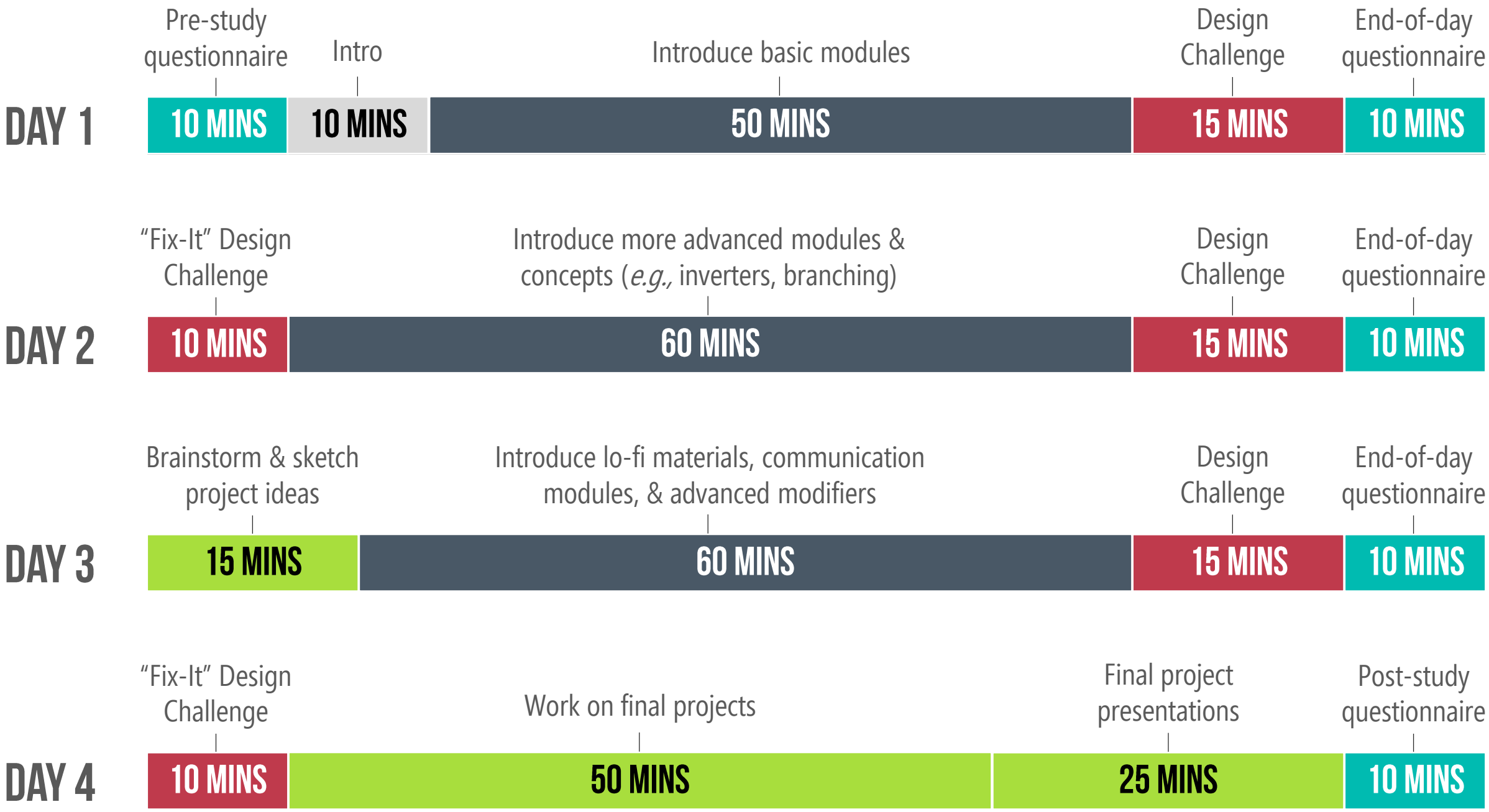
EXAMPLE SOLUTION



MAKERWEAR EVALUATION

MULTI-SESSION WORKSHOP PROCEDURE

Aspects of multi-session procedure based on Marina Bers *TangibleK Robotics Program;* Bers *et al.,* 2014; Sullivan & Bers, 2016


DAY 1
Pre-study questionnaire
10 MINS
Intro
10 MINS
Introduce basic modules
50 MINS
Design Challenge
15 MINS
End-of-day questionnaire
10 MINS
DAY 2
"Fix-It" Design Challenge
10 MINS
Introduce more advanced modules & concepts (e.g., inverters, branching)
60 MINS
Design Challenge
15 MINS
End-of-day questionnaire
10 MINS
DAY 3
Brainstorm & sketch project ideas
15 MINS
Introduce lo-fi materials, communication modules, & advanced modifiers
60 MINS
Design Challenge
15 MINS
End-of-day questionnaire
10 MINS
DAY 4
"Fix-It" Design Challenge
10 MINS
Work on final projects
50 MINS
Final project presentations
25 MINS
Post-study questionnaire
10 MINS

MAKERWEAR EVALUATION

RESEARCH FOCI

How children make with MakerWear, what they make, & challenges therein

Overall understanding (*e.g.,* actions vs. sensors)

Computational thinking (*e.g.,* sequencing, branching)

Subjective factors (*e.g.,* enjoyment)

RESEARCH FOCI (MULTI-SESSION ONLY)

What children designed & built for their final projects & why

How children progressed in their understanding & use of MakerWear

Age-related differences

MAKERWEAR EVALUATION

DATA & ANALYSIS

Session video

Design challenge performance (Radar *et al.,* 1997)

End-user creations (Duncan *et al.,* 2014; Hansen *et al.,* 2015)

Artifact-based interviews (Brennan & Resnick, 2012)

Post-study questionnaires


MAKERWEAR FINDINGS

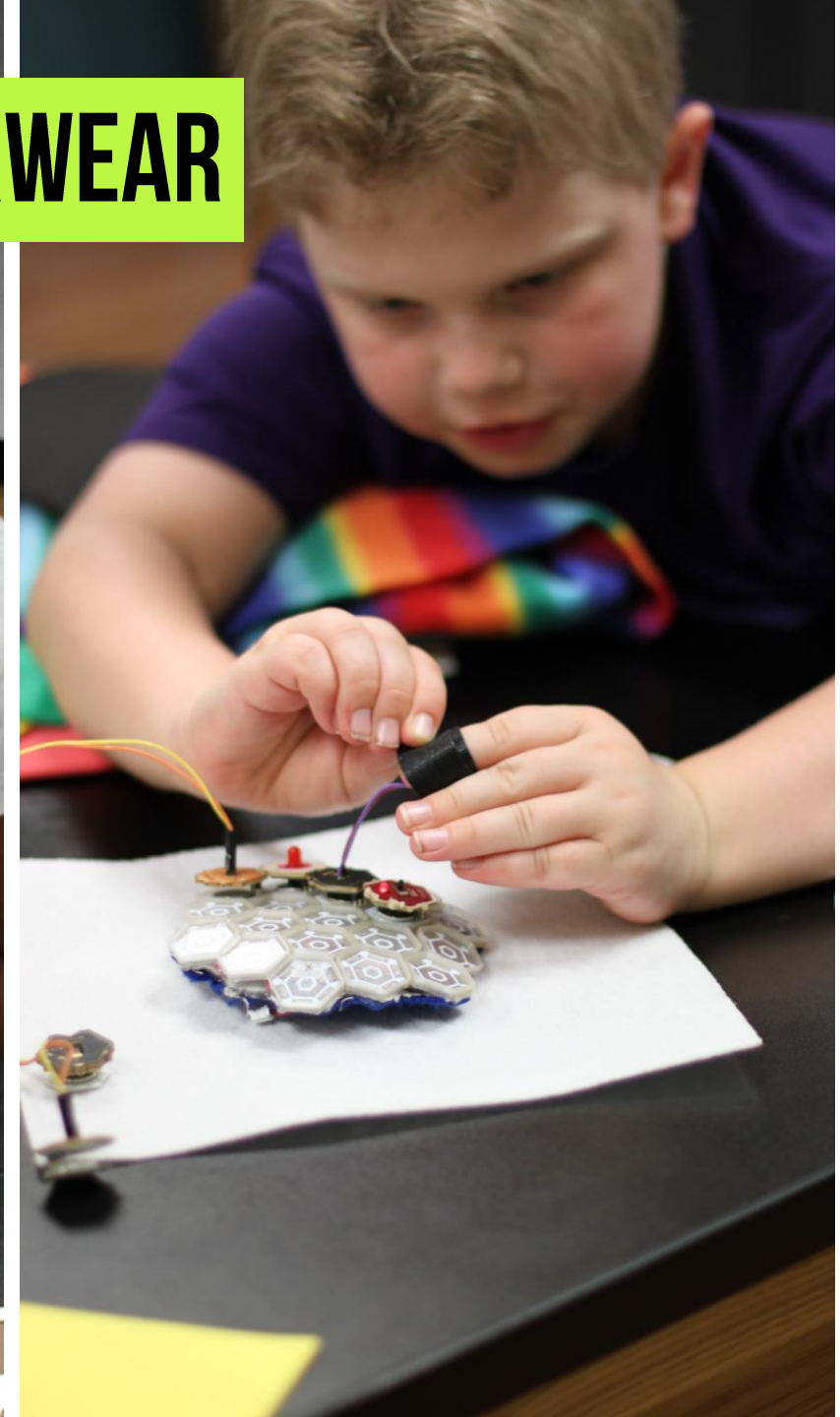

Helelle


Linka


MAKING WITH MAKERWEAR
Two Work Styles

MAKING WITH MAKERWEAR

Two Work Styles



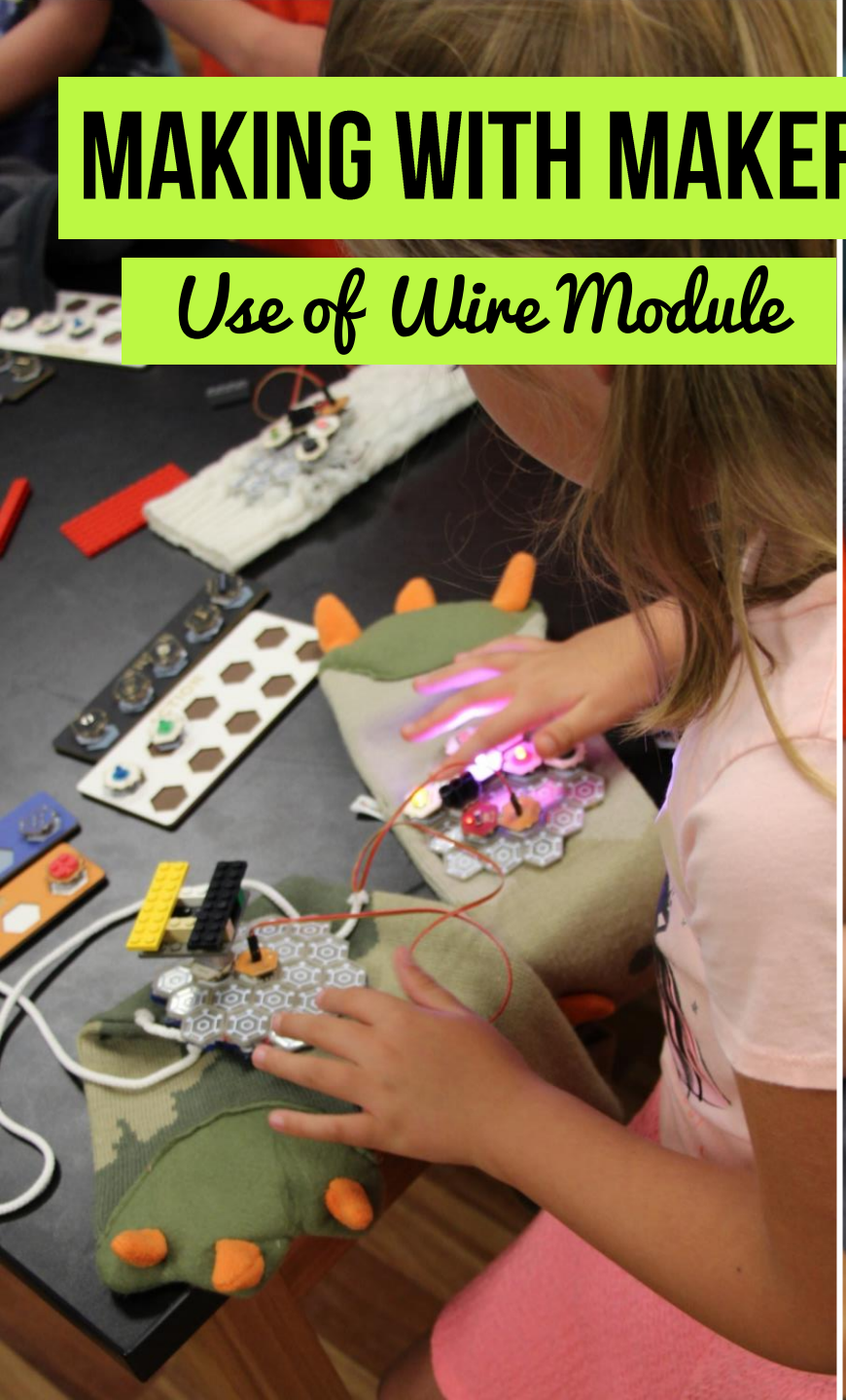
MAKING WITH MAKERWEAR

Appropriating Modules for Debugging


SENSORS
Motion Detector
Sensor

MAKING WITH MAKERWEAR

Use of Wire Module




MAKING WITH MAKERWEAR
Use of Wire Module

MAKING WITH MAKERWEAR

Wire Mediates Play & Facilitates Co-Design


MAKING WITH MAKERWEAR
Creating New Behaviors

MAKERWEAR FINAL PROJECTS

WHAT DID CHILDREN MAKE?

SPORTS/FITNESS

38%

ROLE PLAY

31%

SOCIO-DRAMATIC PLAY

19%

OTHER

13%

MAKERWEAR FINAL PROJECTS

WHAT DID CHILDREN MAKE?

Temperature

Motion Detector

Distance

Volume Knob

Sunlight Detector

Light Sensor

Wire Start

Receiver

Impact Sensor

Tilt Sensor

Button

Color Detector

Sound Sensor

Heartbeat

Wire End

Sender

MOVEMENT

33%

MANUAL INPUT

24%

ENVIRONMENT

19%

PHYSIOLOGY

14%

SOCIAL

10%

MAKERWEAR FINAL PROJECTS

VIDEO SUMMARY

Wrecking Ball

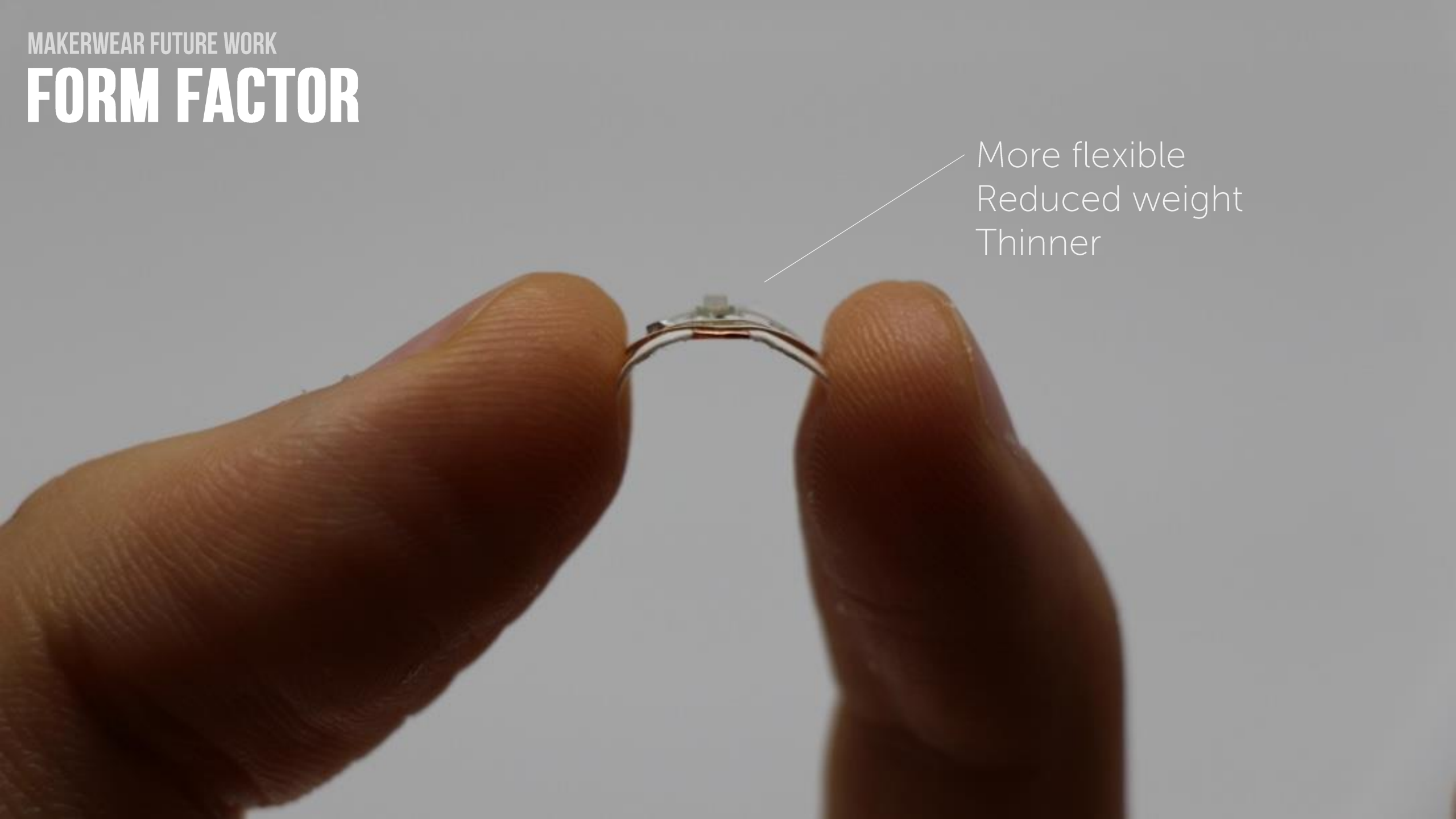
Maker: Boy, 6 year old

A button-activated superhero wrecking ball armband


MAKERWEAR FUTURE WORK

MAKERWEAR FUTURE WORK

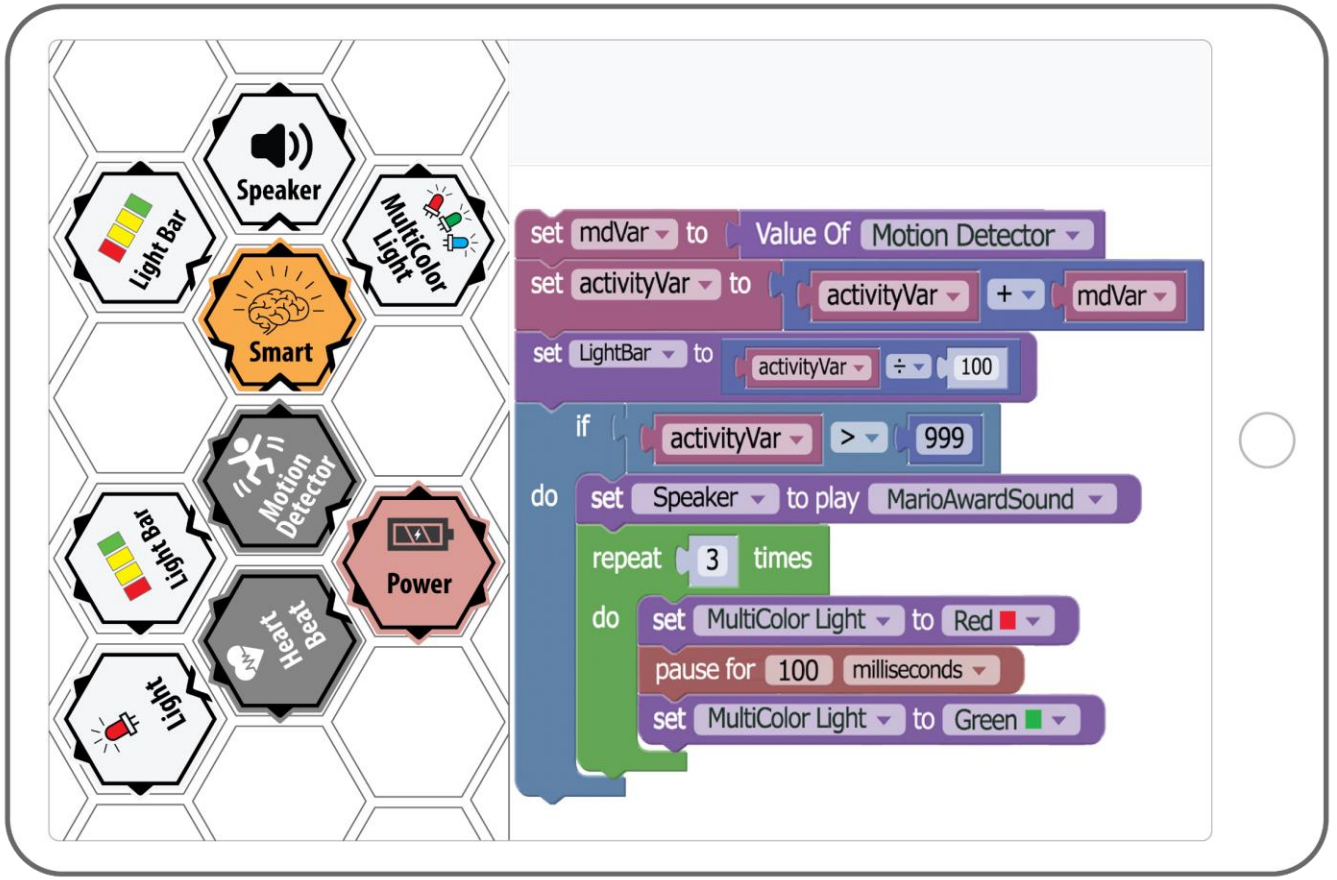
FORM FACTOR



FUTURE WORK

HYBRID TANGIBLE-GRAPHICAL PROGRAMMING INTERFACE

Modules will be wirelessly programmable via a custom tablet programming interface



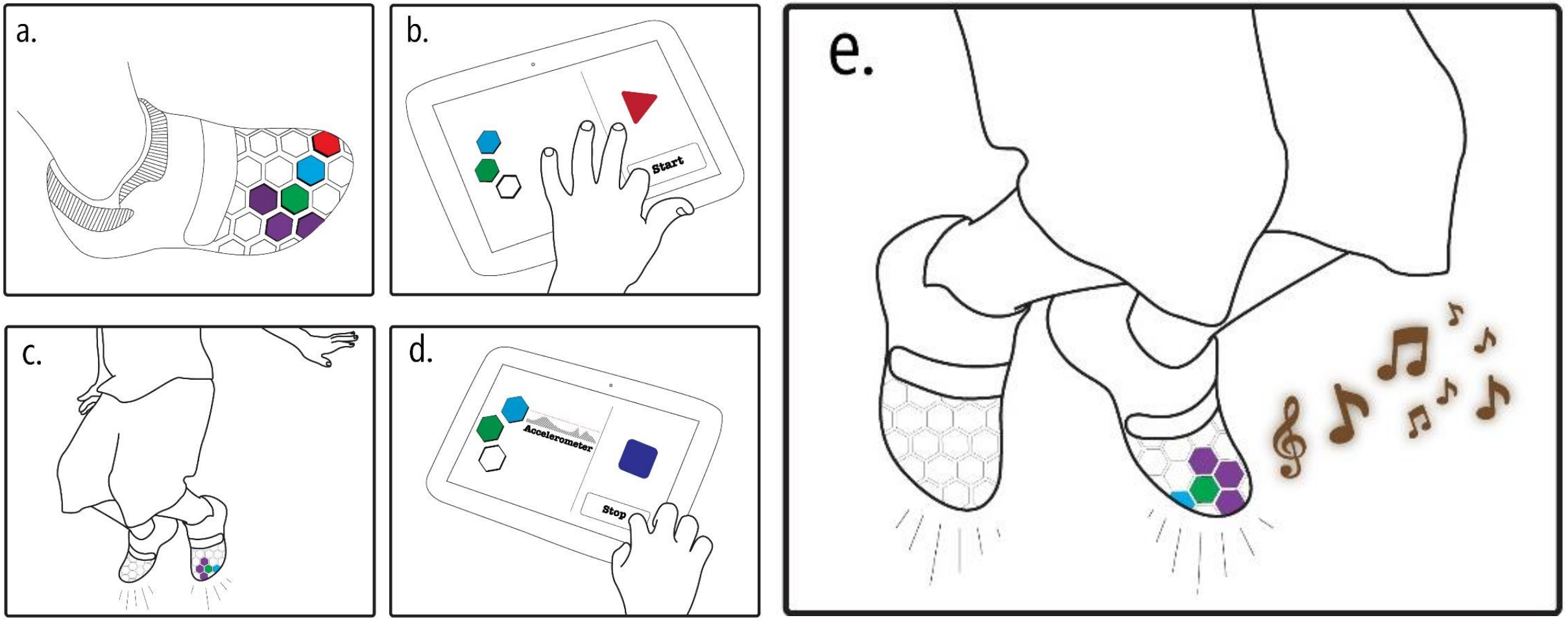
Sample Application:

Making a fitness tracker using a *Motion Detector* and a *HeartBeat Detector*.

FUTURE WORK

INTERACTIVE MACHINE LEARNING

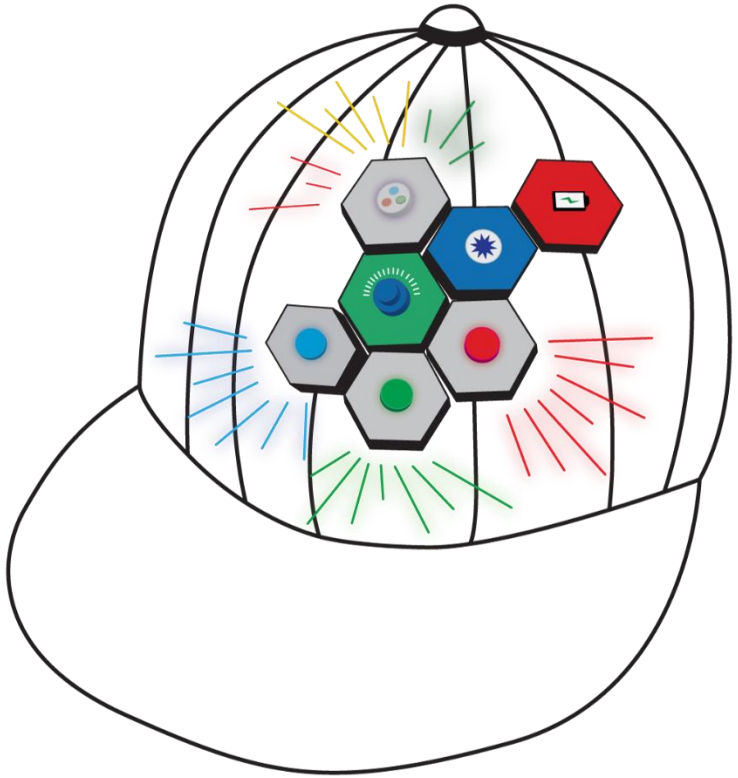
Children can program complex behavior via a novel machine learning interface



FUTURE WORK

SUPPORTING SCIENTIFIC INQUIRY

Children can build their own scientific instruments that allow them to investigate and compare phenomena over time and across contexts.



1 BODYVIS

Responsive E-textile

2 SHAREDPHYS

Collaborative Display

3 MAKERWEAR

Construction Kit

How many generations in all of human history have had the opportunity to **rise to a challenge** that is **worthy of our best efforts**? A challenge that can pull from us more than we think we can do.

-AL GORE

TED CONFERENCE, MARCH 2008

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BODYVIS & SHAREDPHYS

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MAKERWEAR

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University of Maryland Kidsteam

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IMAGE CREDITS

All photos by Jon Froehlich or Makeability Lab students except

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Electronic Fashion Camp by Amy Florence
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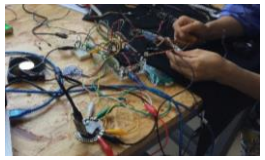
Found https://www.slideshare.net/Rainycat/i-lt3-lilypad-Arduino

Manual Sewing Skills by Leah Buechley
Found https://www.flickr.com/photos/leahbuechley/2595747031/

Example E-Textile Projects
Please see respective PowerPoint slide in notes section for attributions



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Leaf by Thomas Helbig
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Health by Timothy Miller
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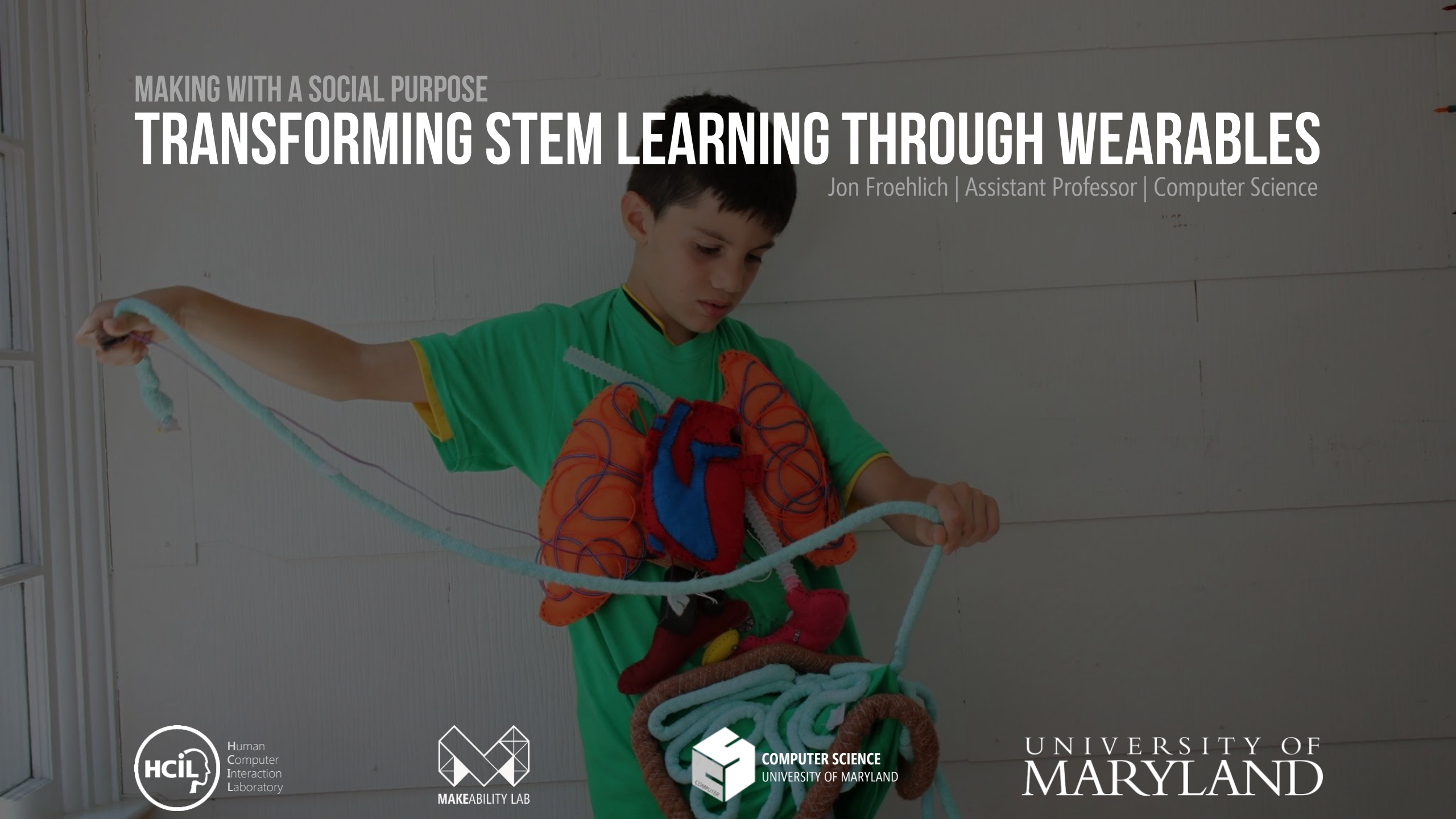

MAKING WITH A SOCIAL PURPOSE

TRANSFORMING STEM LEARNING THROUGH WEARABLES

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HCIL Human Computer Interaction Laboratory

MAKEABILITY LAB

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

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