# MAKING WITH A SOCIAL PURPOSE

@jonfroehlich

DESIGN USE BUILD

MAKEABILITY LAB

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

UNIVERSITY of WASHINGTON


MAKEABILITY LAB


HCIL
MAKEABILITY LAB


MAKEABILITY LAB

# Our Mission

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

MAKEABILITY LAB

# FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

MAKEABILITY LAB

# FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

MAKEABILITY LAB

# FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY



HEALTH & WELLNESS



ACCESSIBILITY

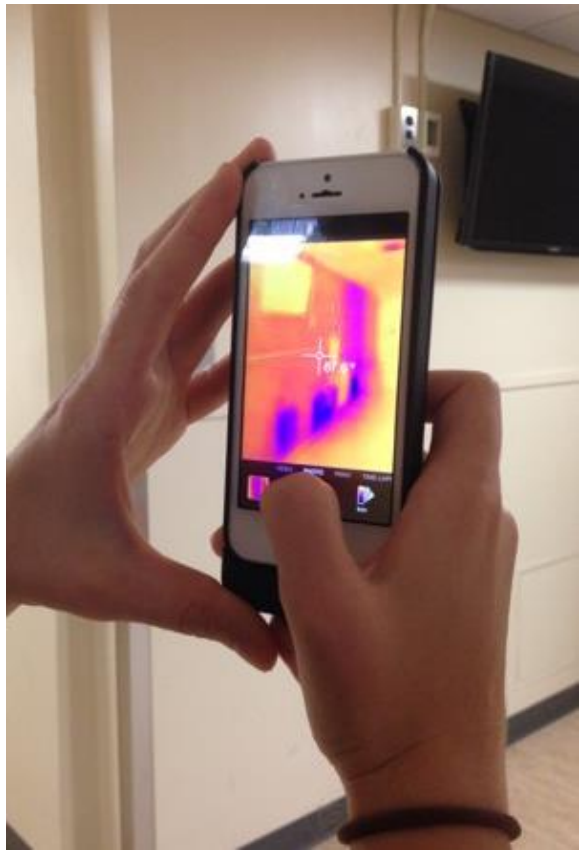


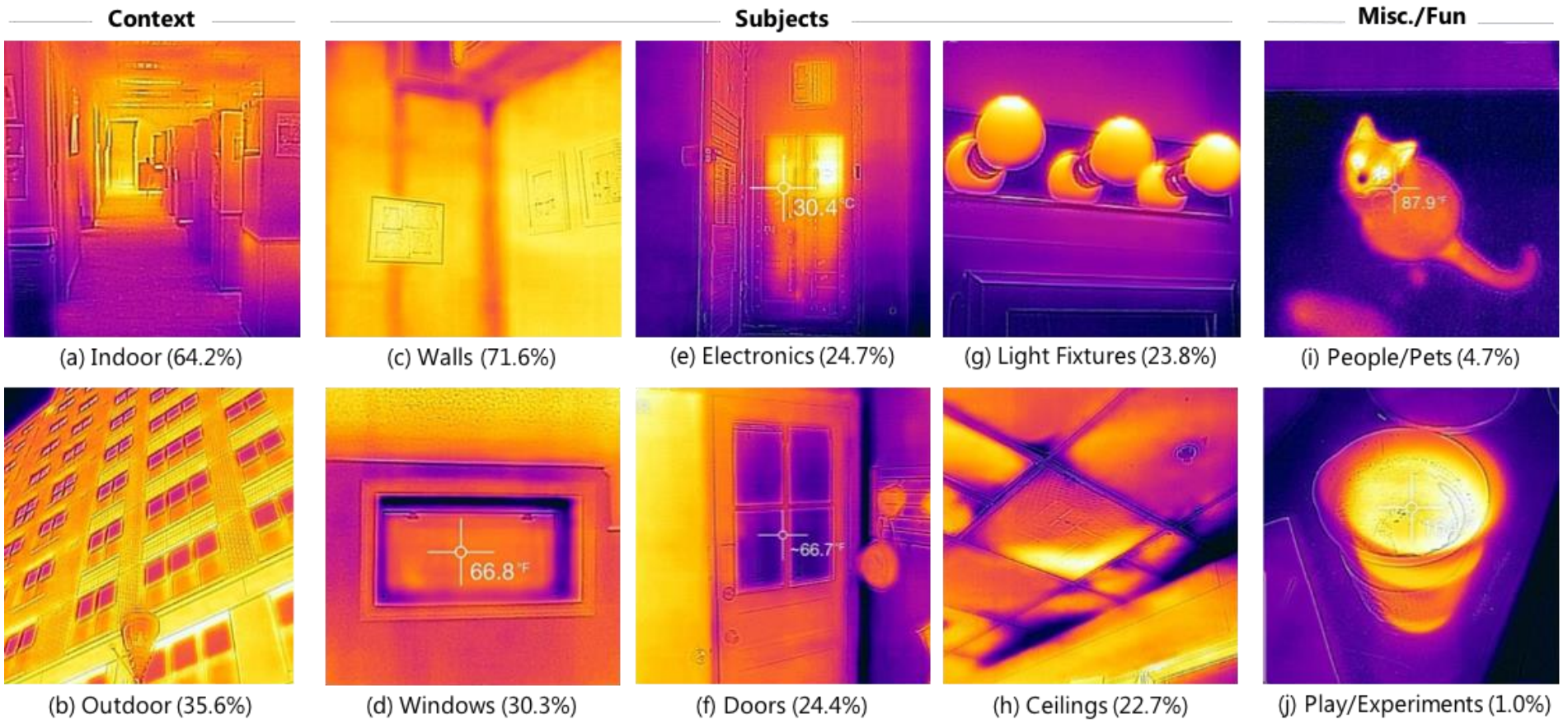
STEM EDUCATION

ENVIRONMENTAL SUSTAINABILITY

# PERVASIVE THERMOGRAPHY

With UMD CS PhD Student Matt Mauriello






[UbiComp'13 Poster, CHI'15 Honorable Mention, HBI'16, CHI'17, UbiComp'17 Poster]

MAKEABILITY LAB

# FOUR FOCUS AREAS



ENVIRONMENTAL SUSTAINABILITY

**HEALTH & WELLNESS**



ACCESSIBILITY



STEM EDUCATION

HEALTH & WELLNESS

# DESIGNING HEALTH SUPPORT SYSTEMS

[CHI'13 Best Paper, CHI'14]

MAKEABILITY LAB

# FOUR FOCUS AREAS



ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS



ACCESSIBILITY

STEM EDUCATION


[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

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

HEALTH & WELLNESS

## ACCESSIBILITY

STEM EDUCATION

***How to...***

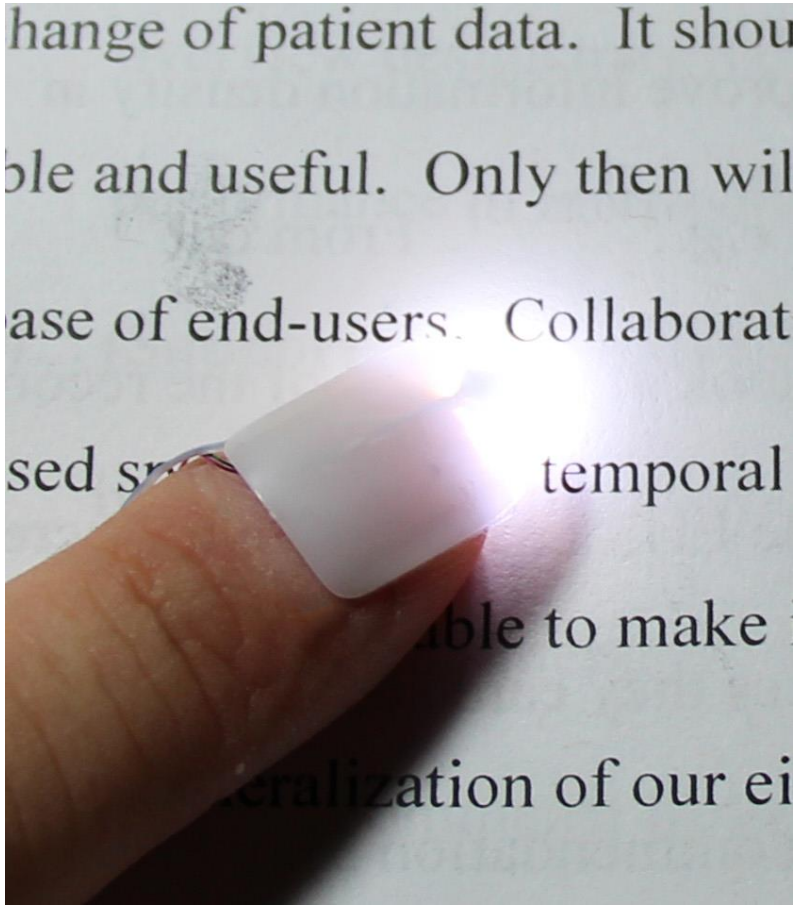
make the *physical world* more accessible for people with disabilities

THREAD 1: ACCESSIBILITY

# IMPROVING ACCESS TO THE PHYSICAL WORLD

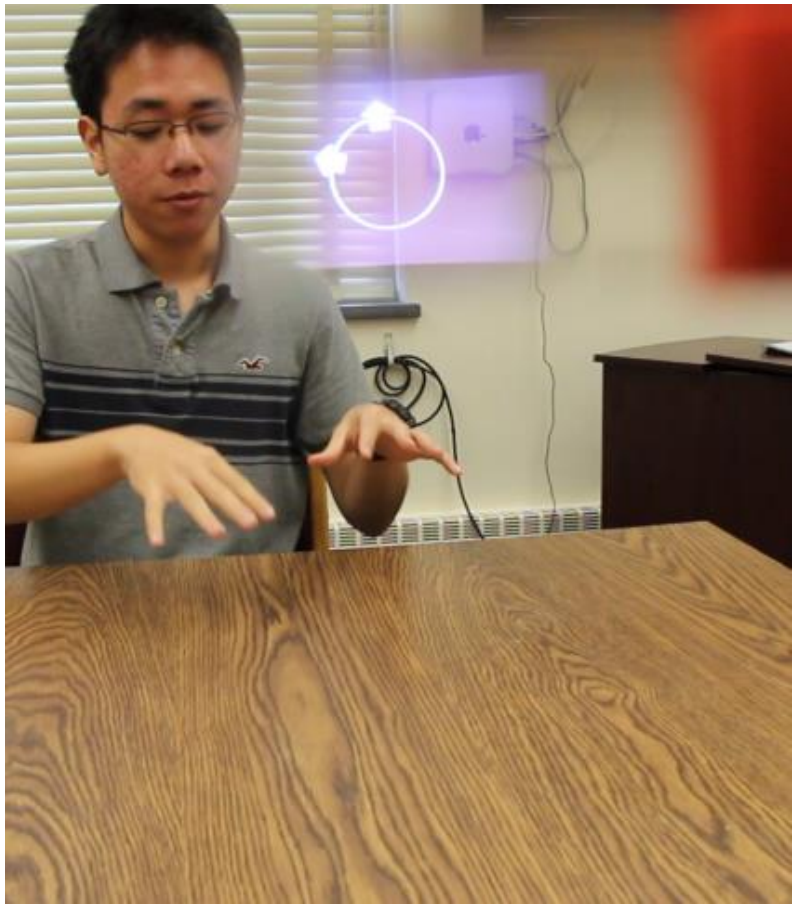
## PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16, ASSETS'17]




## HANDSIGHT

[ACVR'14, ASSETS'15, GI'16, TACCESS'16, ASSETS'17 x3, IMWUT'17]



## GLASSEAR

[CHI'15]

THREAD 1: ACCESSIBILITY

# IMPROVING ACCESS TO THE PHYSICAL WORLD

With UW CSE PhD Student Manaswi Saha

## PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16, ASSETS'17]

***How can we...***

develop scalable solutions that map the accessibility of urban infrastructure?

THREAD 1: ACCESSIBILITY

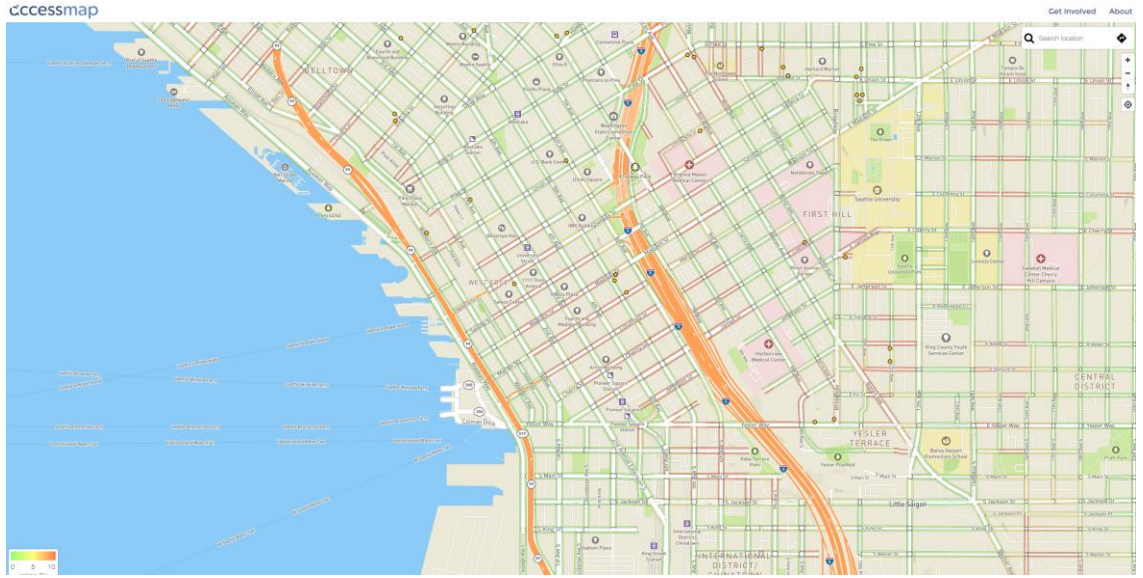
# PROJECT SIDEWALK

Nicely intersects and complements work already at UW in Taskar Center.

**ANAT CASPI**

Director of Taskar Center

TCAT The Taskar Center for Accessible Technology




cccessmap

OpenSidewalks

# 30.6

**million U.S. adults have a mobility impairment**

Source: US Census, 210


Source: US Census, 210


CHANEL
CHANEL
CHANEL
CHANEL
ONE WAY
NO PARKING
DIESEL


NO CURB RAMPS
CHANEL
ONE WAY
DIESEL


PHYSICAL OBSTACLES


FedEx
INCOMPLETE SIDEWALKS


SURFACE PROBLEMS


PHYSICAL OBSTACLES
NO CURB RAMP
SURFACE DEGRADATION

Accessible infrastructure has a significant impact on the independence and mobility of citizens

[Thapar *et al.*, 2004 ; Nuernberger, 2008]


Central Av
Tokyo
Salon
GINZA
GINZA

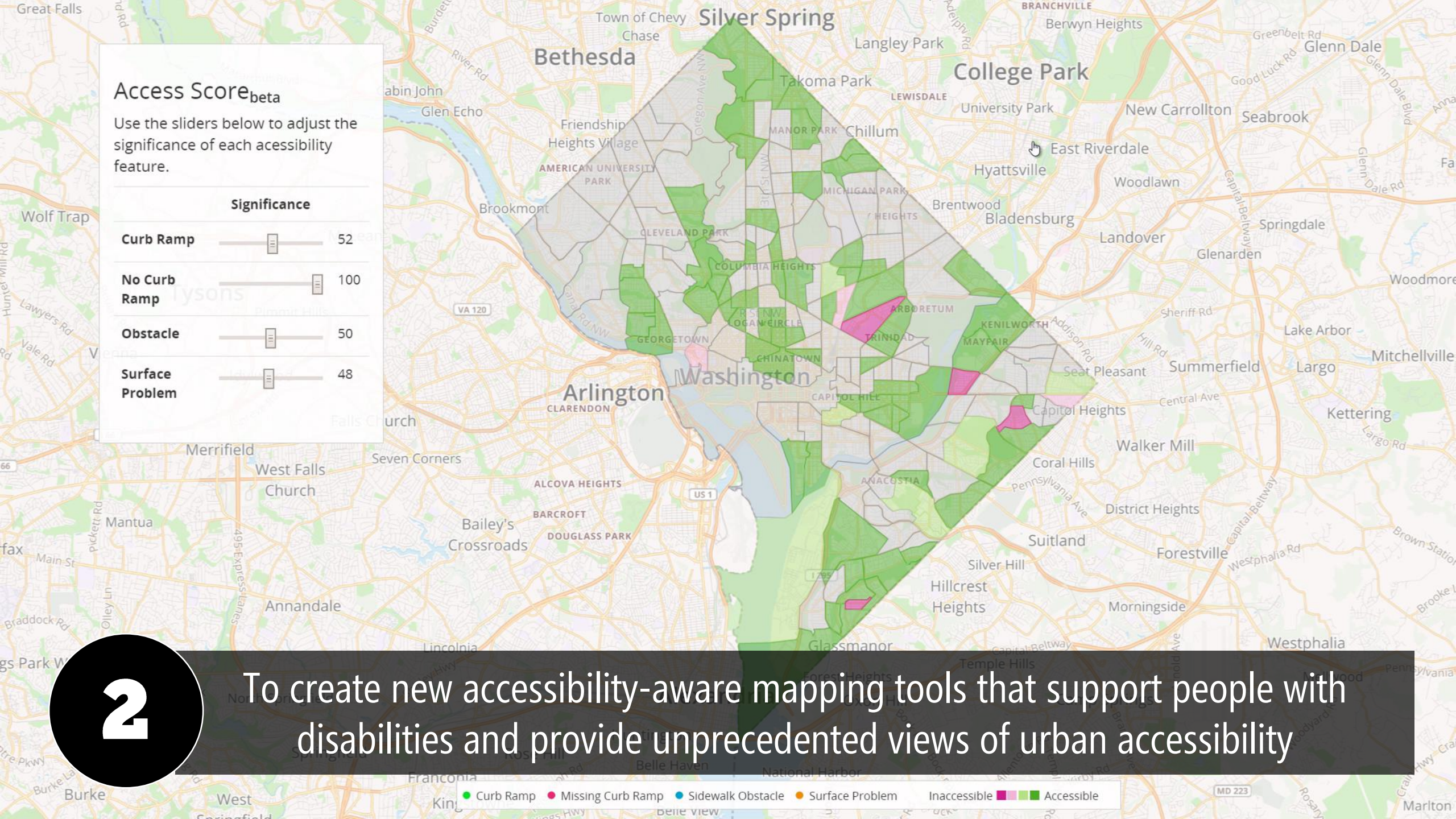
The National Council on Disability noted that there is **no comprehensive information** on "the degree to which sidewalks are accessible" in cities.

**National Council on Disability, 2007**
The impact of the Americans with Disabilities Act: Assessing the progress toward achieving the goals of the ADA

We are pursuing a **two-fold solution**


1

To develop scalable methods that mine massive repositories of online map imagery to identify accessibility problems semi-automatically



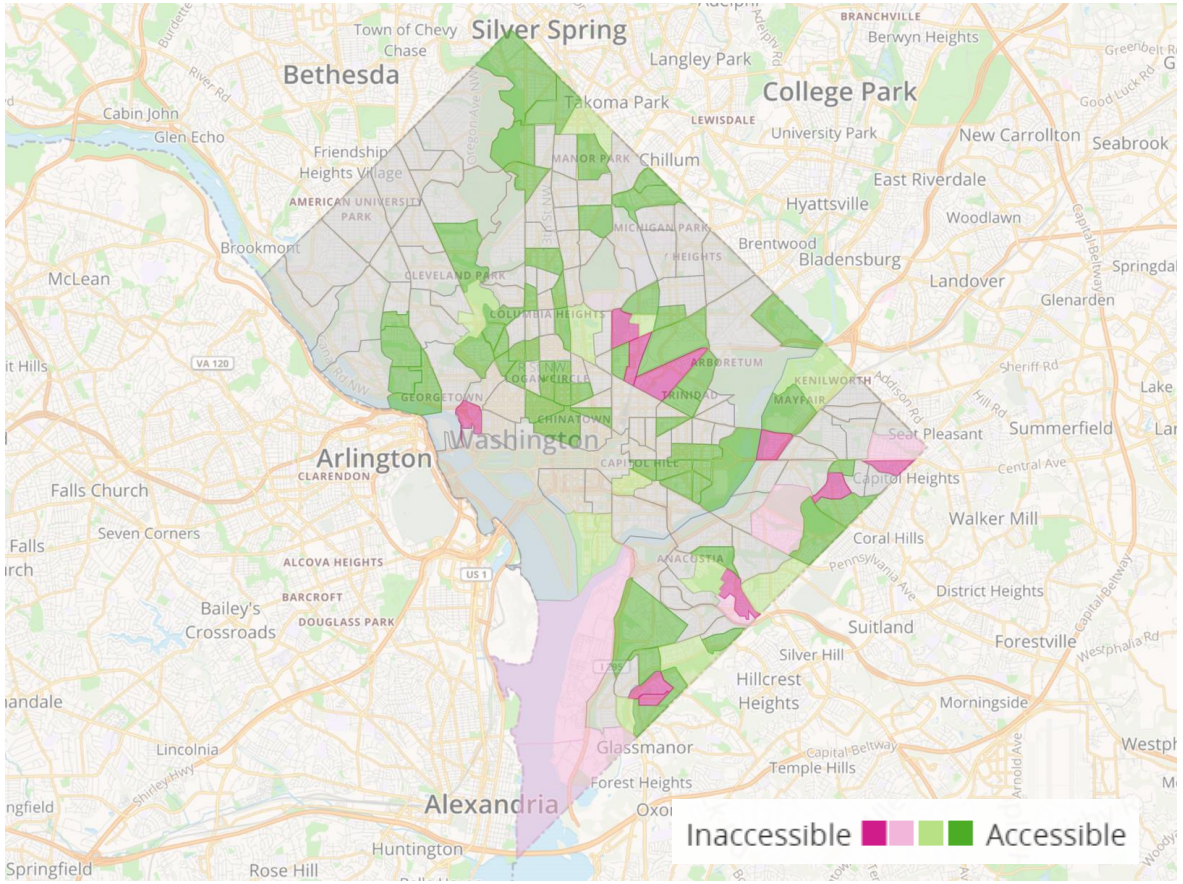

**2** To create new accessibility-aware mapping tools that support people with disabilities and provide unprecedented views of urban accessibility

MAPPING THE ACCESSIBILITY OF THE WORLD

# TWO FOCUS AREAS

## SCALABLE DATA COLLECTION METHODS

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13, UIST'14, TACCESS'15, ASSETS'17]




## NEW ACCESSIBILITY GIS TOOLS

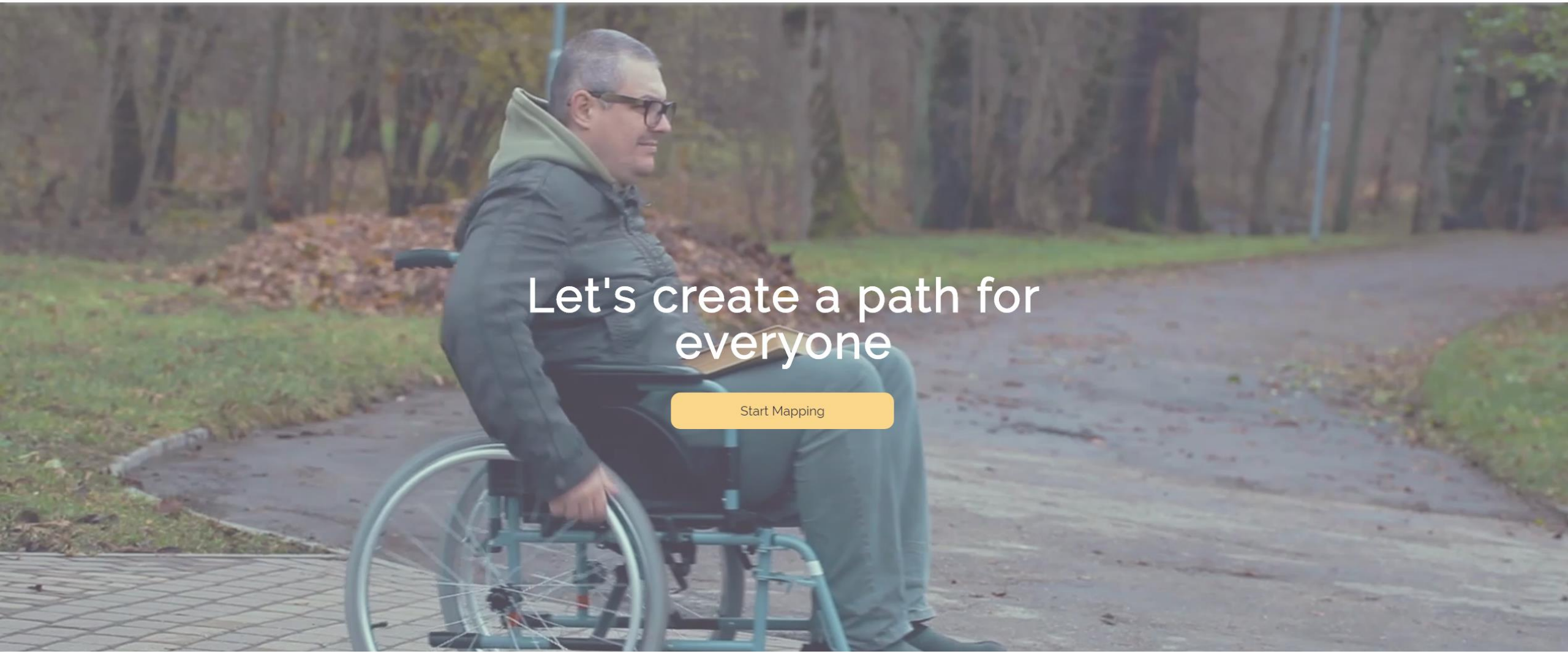
[SIGACCESS '15, CHI'16]

# PROJECT SIDEWALK

HTTP://PROJECTSIDEWALK.IO

PROJECT SIDEWALK

Start Mapping | Jon Froehlich




# How you can help

Virtually explore city streets to find and label accessibility

Project Sidewalk beta 2

View Results FAQ Retake tutorial Jon Froehlich

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!

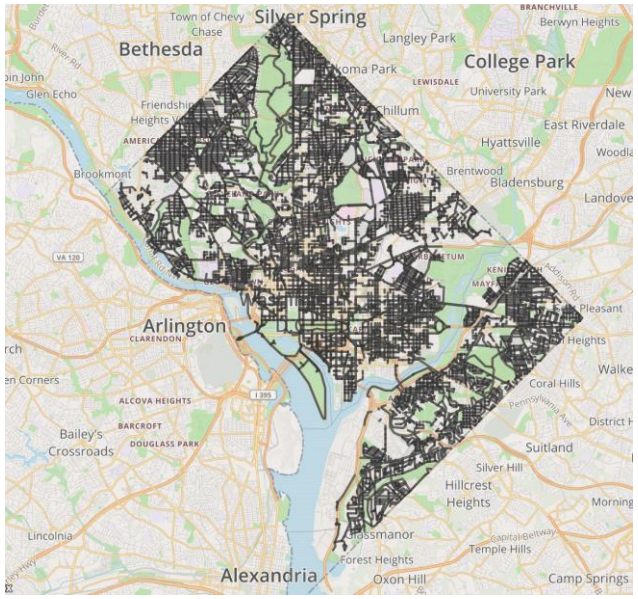
OK

CURRENT & FUTURE WORK

# PROJECT SIDEWALK USER CONTRIBUTIONS

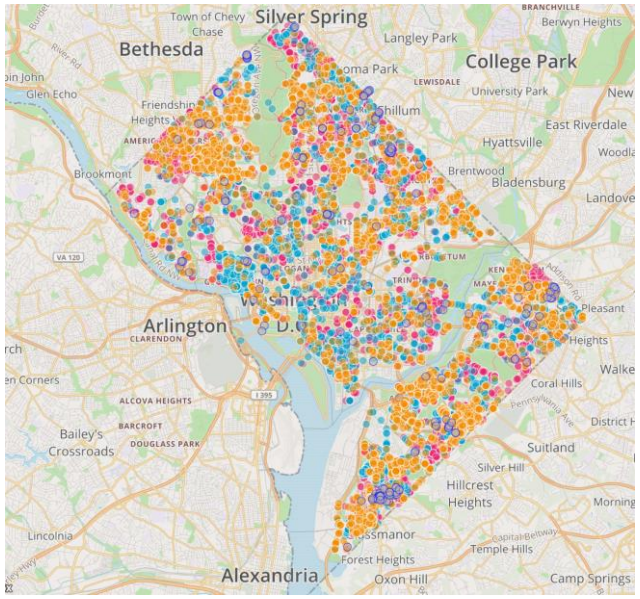
**800**

USERS




**819**

MILES AUDITED



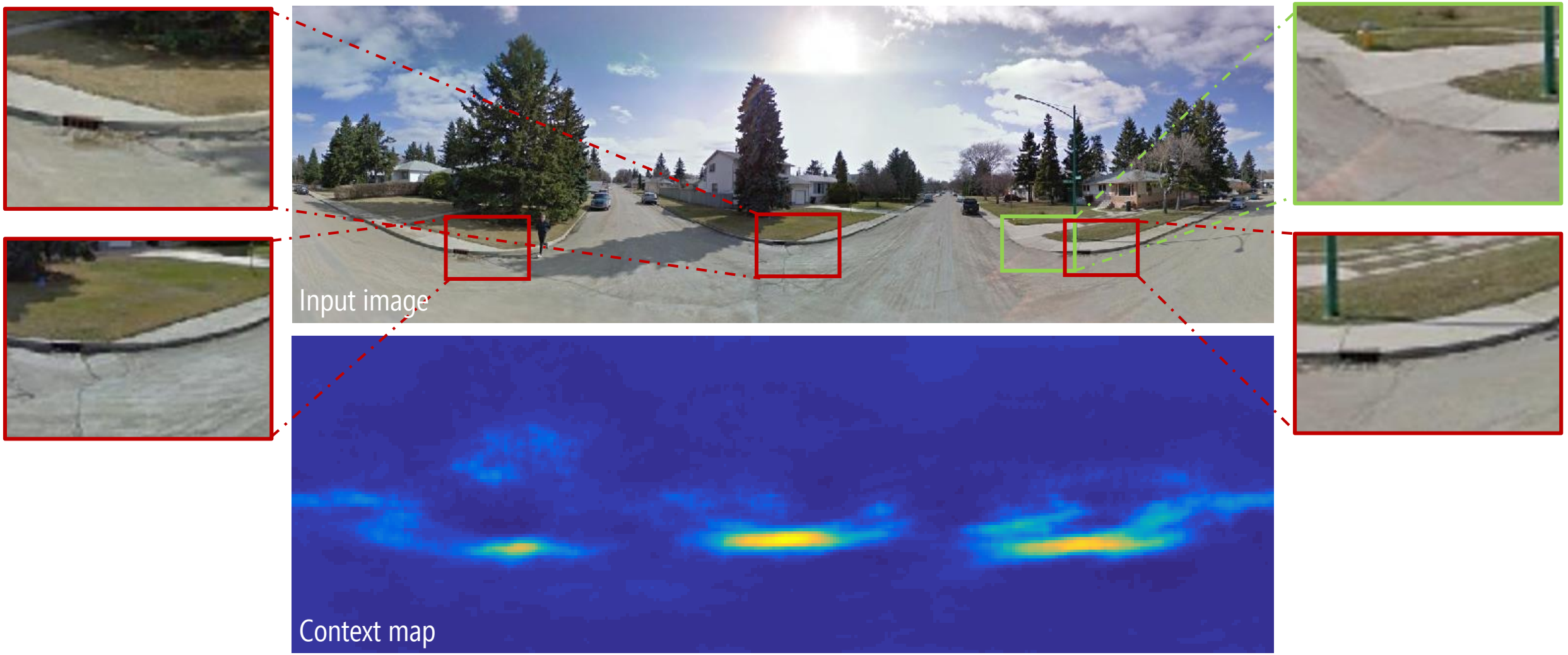

**105,000**

SIDEWALK LABELS

CURRENT & FUTURE WORK

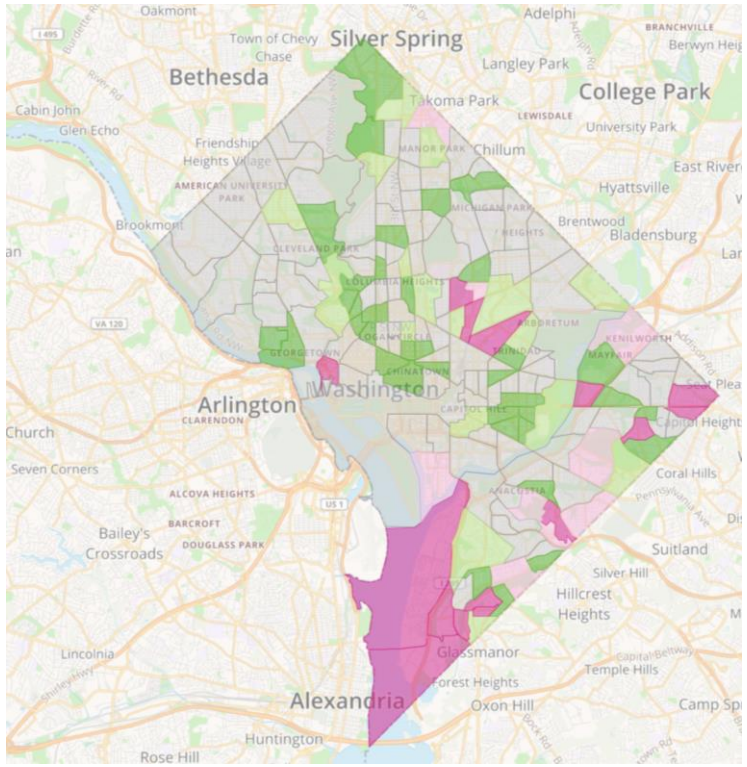
# APPLYING CONVOLUTIONAL NEURAL NETWORKS

Recently accepted to CVPR'17

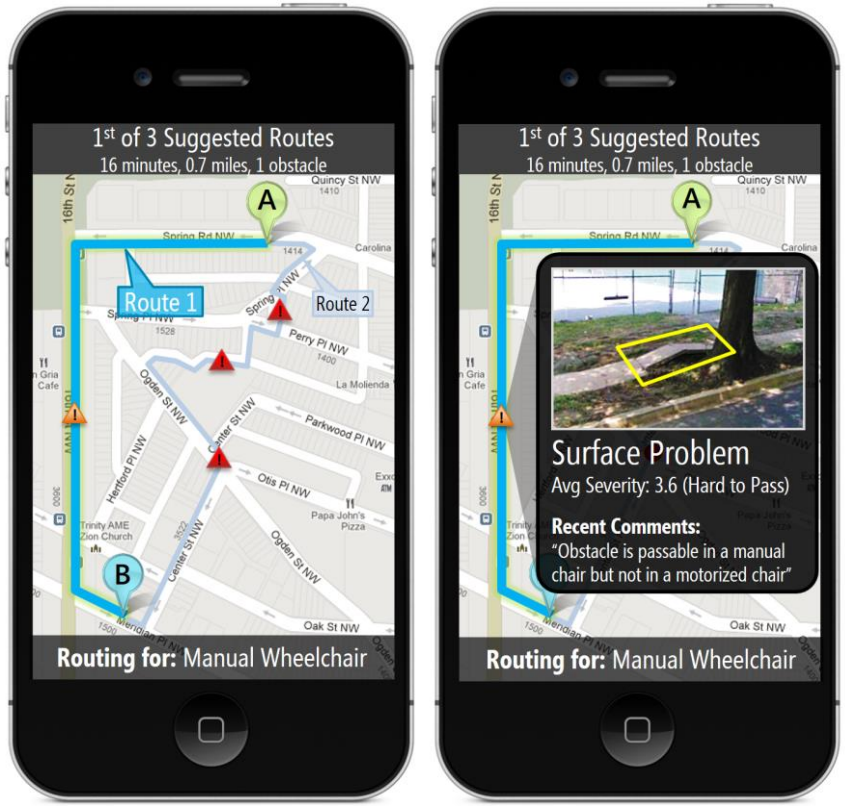


PROJECT SIDEWALK

# NOVEL ASSISTIVE TECHNOLOGY APPLICATIONS




New models & viz of city accessibility




Smart routing for people with impairments

**DC**

**vs**

**NYC**

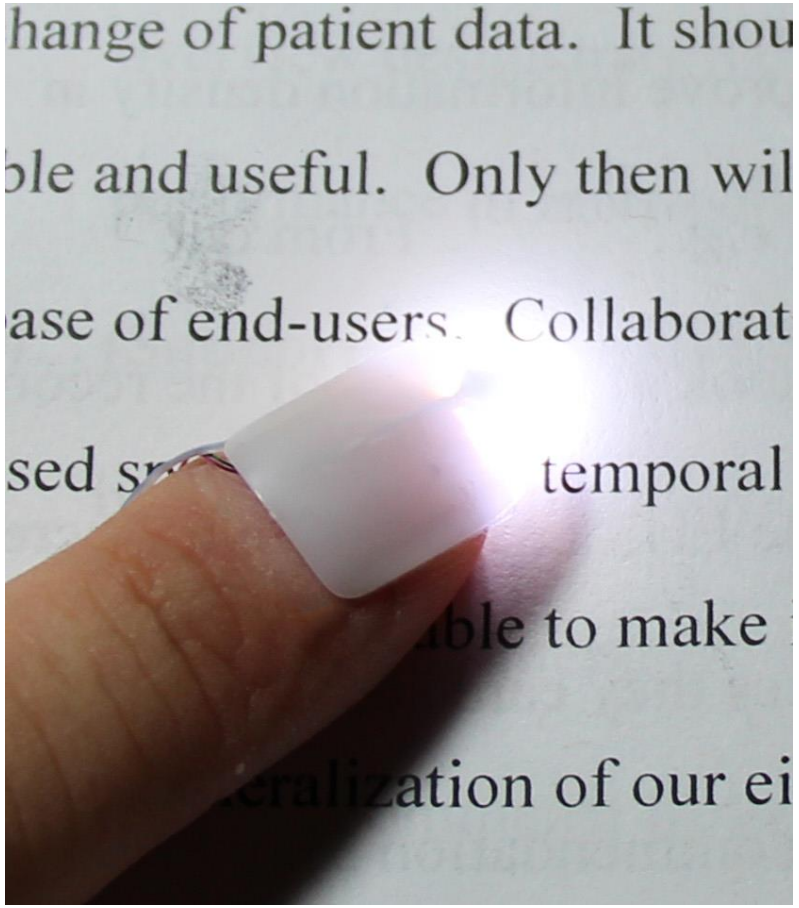
Cross-city comparison tools

THREAD 1: ACCESSIBILITY

# IMPROVING ACCESS TO THE PHYSICAL WORLD

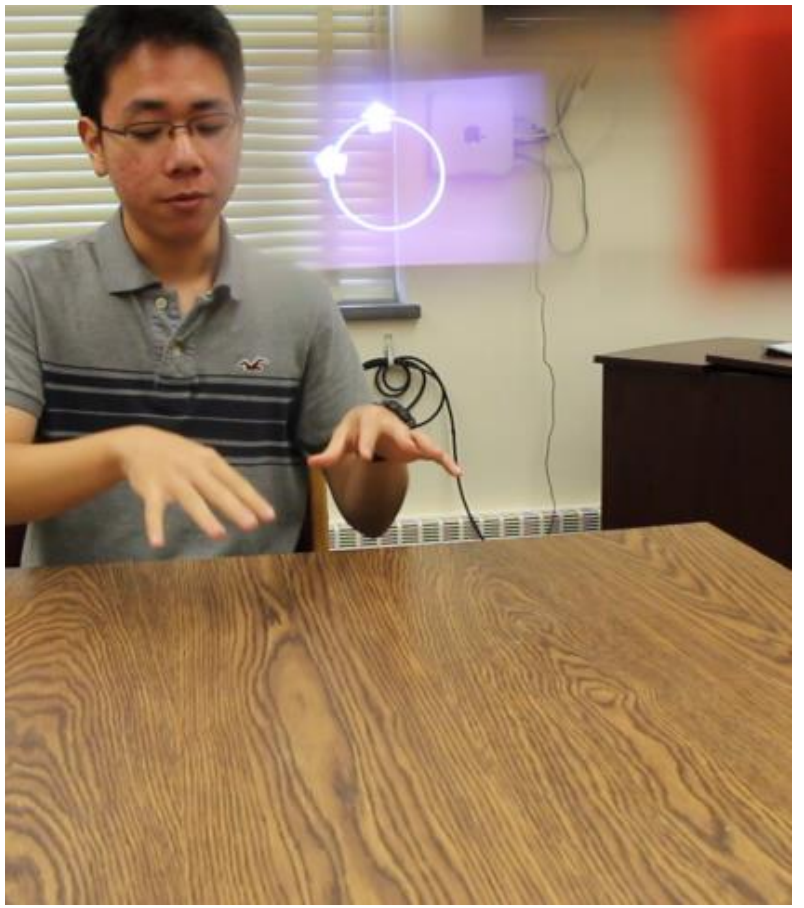
## PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16, ASSETS'17]




## HANDSIGHT

[ACVR'14, ASSETS'15, GI'16, TACCESS'16, ASSETS'17 x3, IMWUT'17]



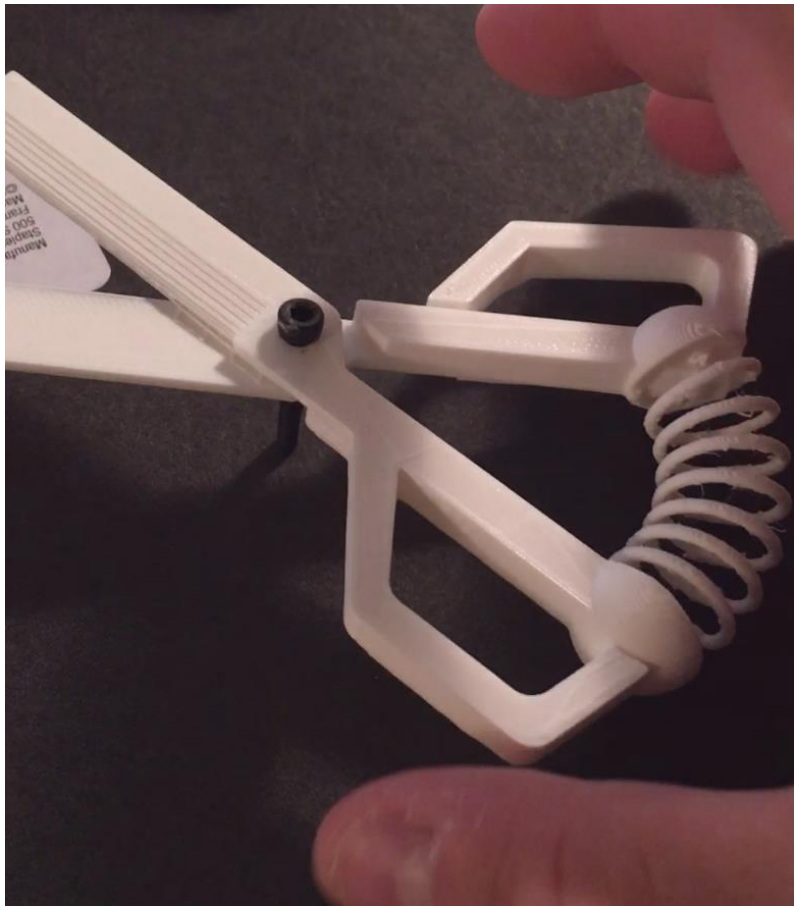
## GLASSEAR

[CHI'15]

THREAD 1: ACCESSIBILITY

# IMPROVING ACCESS TO THE PHYSICAL WORLD

With UW CSE PhD student Liang He



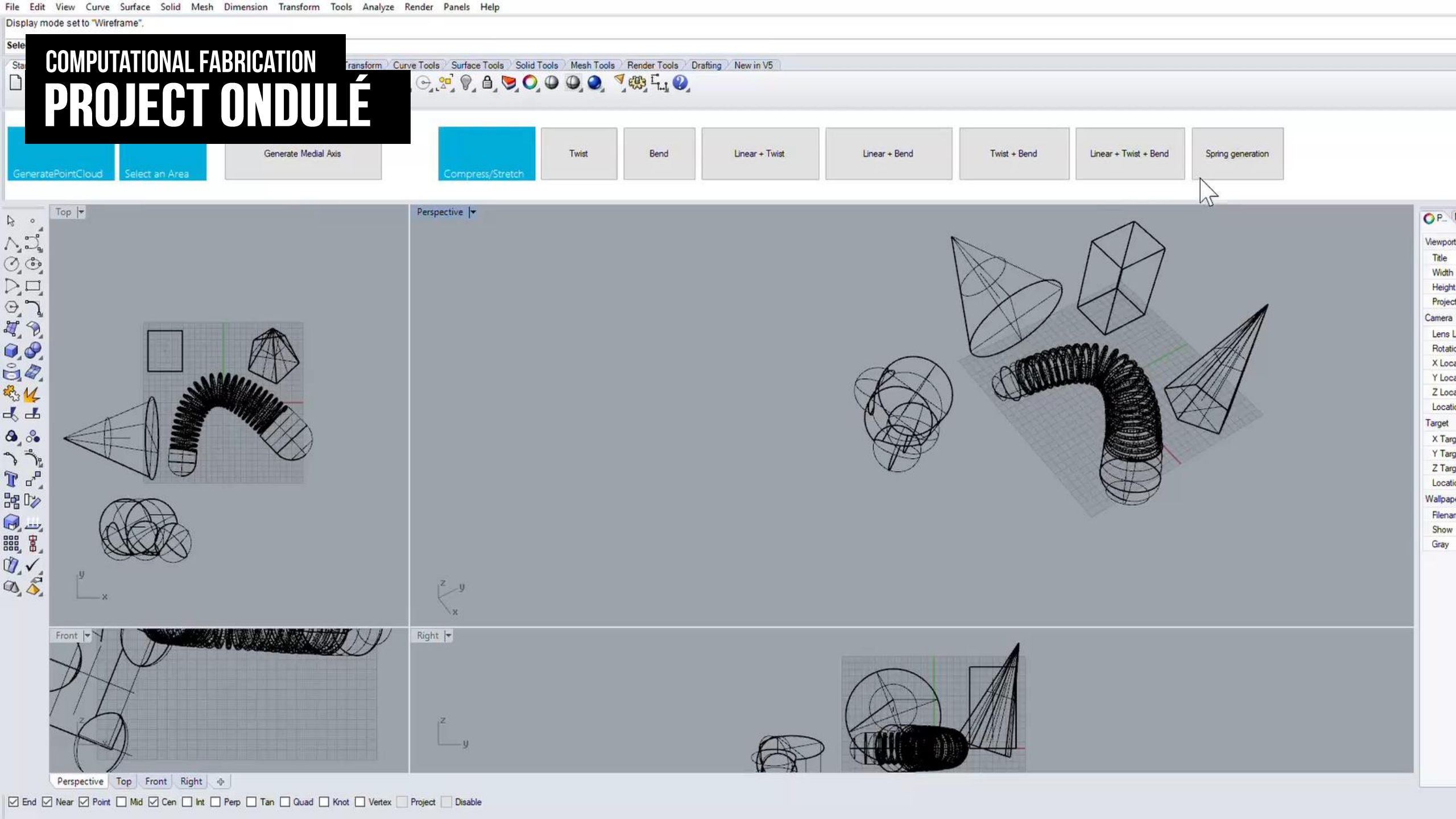
**ONDULÉ**

[CompFab'17, UIST'17 Poster]

*How can we...*

Enable designers to rapidly build, simulate, and fabricate 3D-printable objects with embedded mechanical springs?

# COMPUTATIONAL FABRICATION
# PROJECT ONDULÉ



PROJECT ONDULÉ

# EXAMPLE DEFORMATIONS

## ORIGINAL PRINT

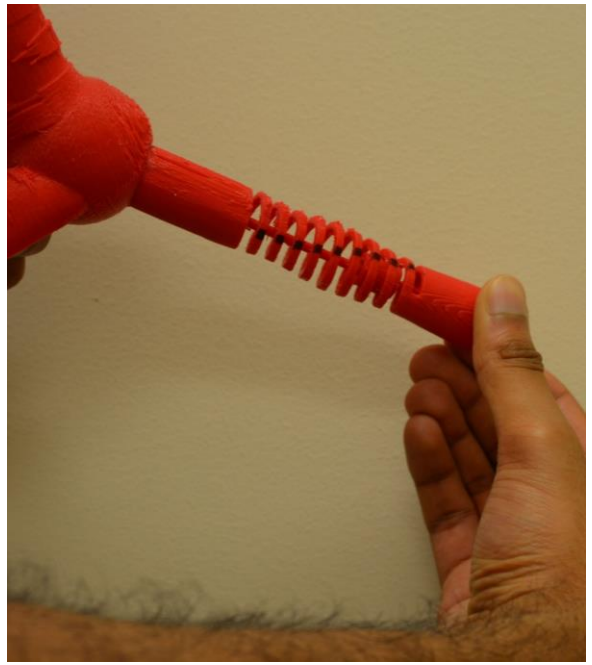
Tigger with traditional helical spring

## DESIGN #1: BEND ONLY

Helical spring with embedded flexible sawtooth backbone

## DESIGN #2: LINEAR ONLY

Helical spring with a prismatic joint



## DESIGN #3: TWIST ONLY

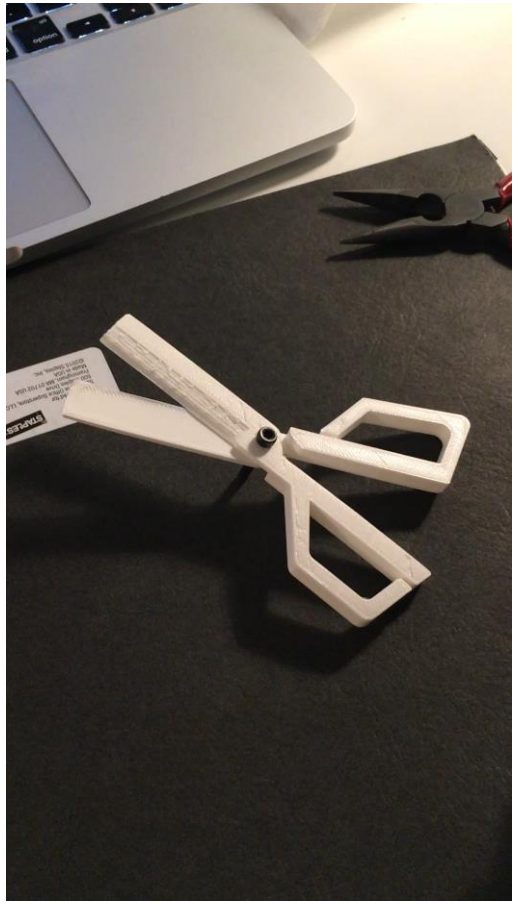
Helical spring with a ring bearing structure

PROJECT ONDULÉ

# ACCESSIBILITY APPLICATIONS

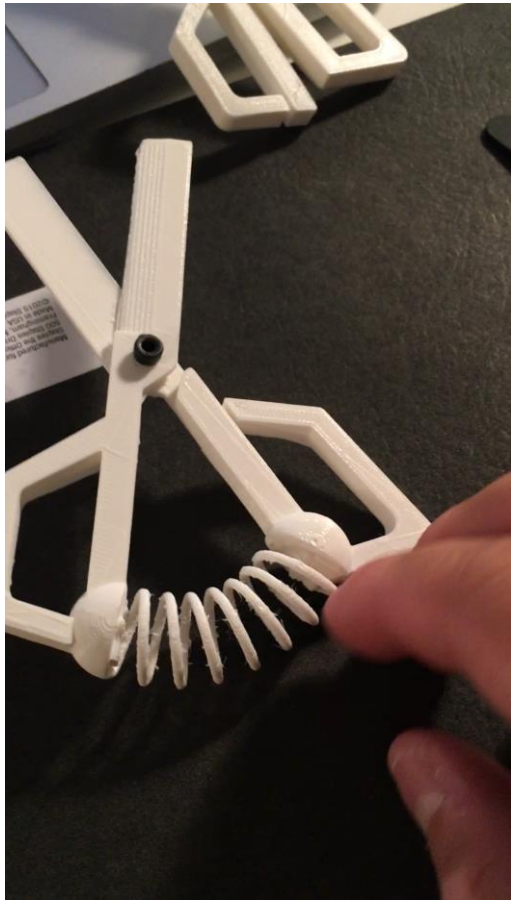
PROJECT ONDULÉ

# ACCESSIBILITY APPLICATIONS



## TRADITIONAL SCISSORS

Requires fine motor abilities

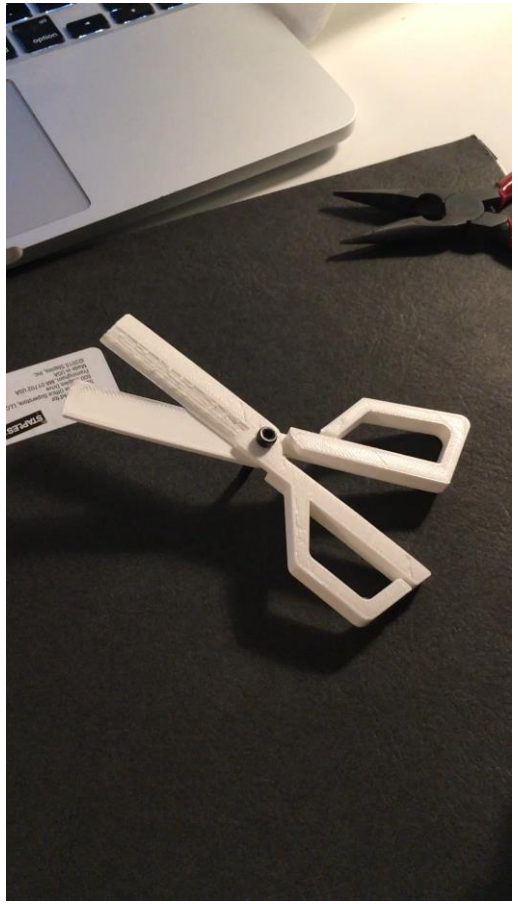


## SPRING SCISSORS

Spring automatically reopens scissors after a cut

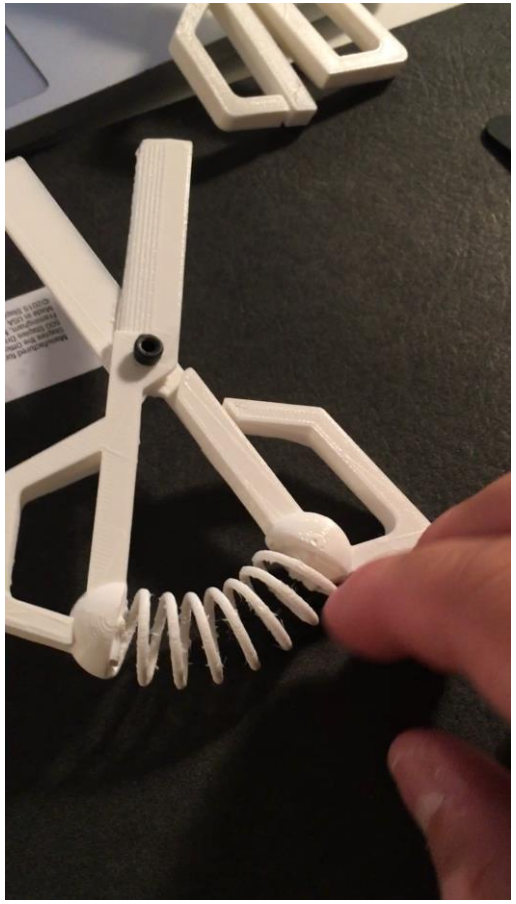
PROJECT ONDULÉ

# ACCESSIBILITY APPLICATIONS



## TRADITIONAL SCISSORS

Requires fine motor abilities



## SPRING SCISSORS

Spring automatically reopens scissors after a cut

YOUR IDEA HERE!

YOUR IDEA HERE!

YOUR IDEA

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



HEALTH & WELLNESS



ACCESSIBILITY

**STEM EDUCATION**

***How can we...***

design wearables that engage and scaffold children in life-relevant, personally meaningful STEM learning experiences.

THREAD 2: STEM EDUCATION

# ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

## BODYVIS

[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

## MAKERWEAR

[IDC'15, CHI'16 Best Poster, CHI'17 Best Paper]

THREAD 2: STEM EDUCATION

# ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

With UMD CS PhD student Seokbin Kang

## BODYVIS

[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

***How can we...***

design wearables that use the human body and physical activity as a platform for experimentation & scientific inquiry?

"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

## PROTOTYPE 1: MID-FI

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

## PROTOTYPE 2

Improved Anatomy
Heartrate, Breathing
LEDs
Lilypad Arduino

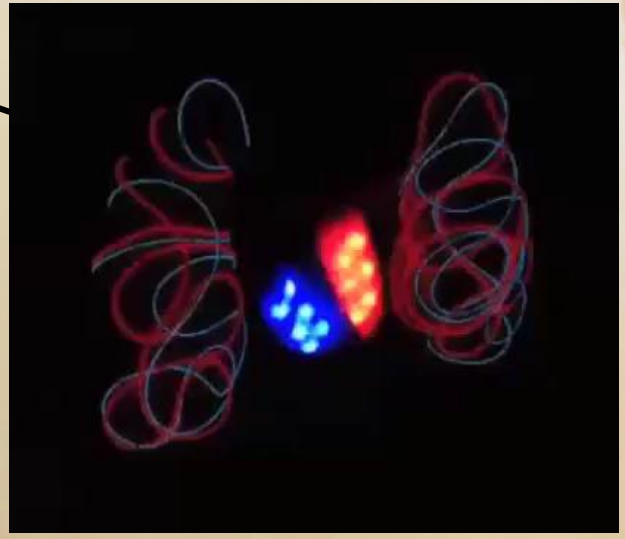

## PROTOTYPE 3

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


## PROTOTYPE 4: HI-FI

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

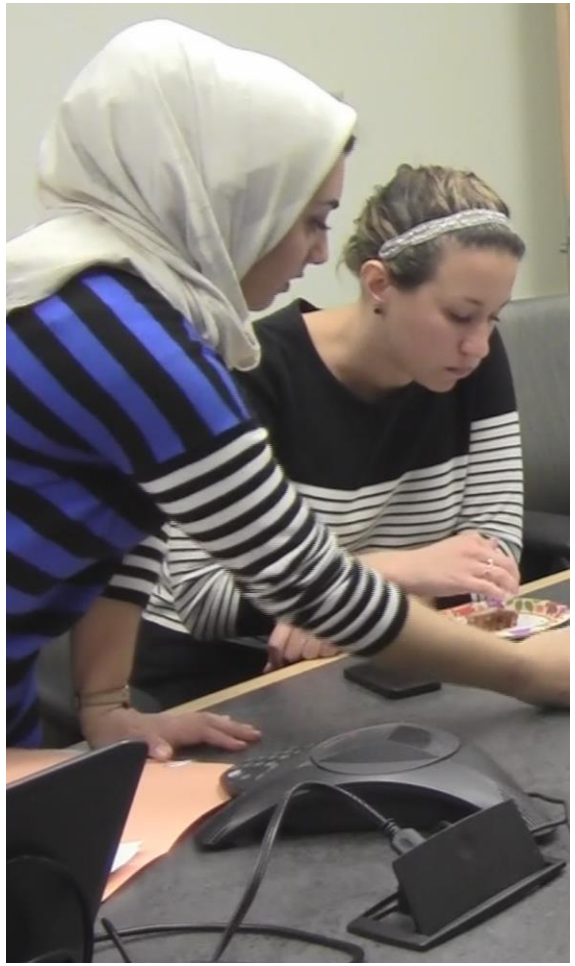
Optical heart rate sensor




The heart and lungs visualize wearers' live heart and breathing rate.

BODYVIS

# EVALUATIONS (N=200)



TEACHER INTERVIEWS

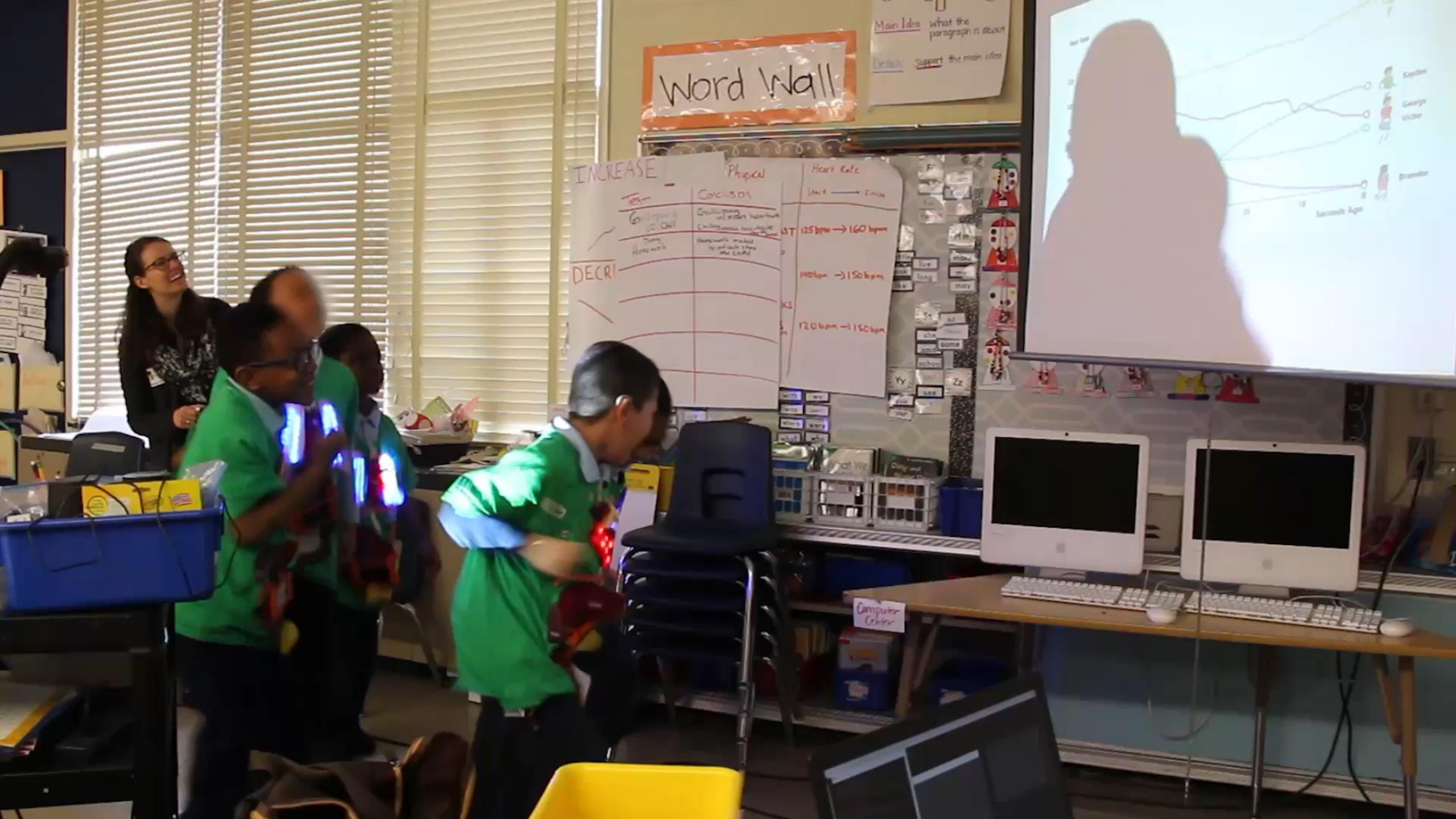
AFTER-SCHOOL PROGRAMS

SCIENCE CAMPS

ELEMENTARY SCHOOLS


OVERALL REACTIONS
High Engagement


OVERALL REACTIONS
High Engagement


Word Wall
Main Idea
what the paragraph is about
Details
support the main idea
INCREASE
Physical
Heart Rate
DECRI
Computer Center

# UNEXPECTED FINDING

## How Does It Work?


THREAD 2: STEM EDUCATION

# ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

## BODYVIS

[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

## MAKERWEAR

[IDC'15, CHI'16 Best Poster, CHI'17 Best Paper]

THREAD 2: STEM EDUCATION

# ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

## MAKERWEAR

[IDC'15, CHI'16 Best Poster, CHI'17 Best Paper]

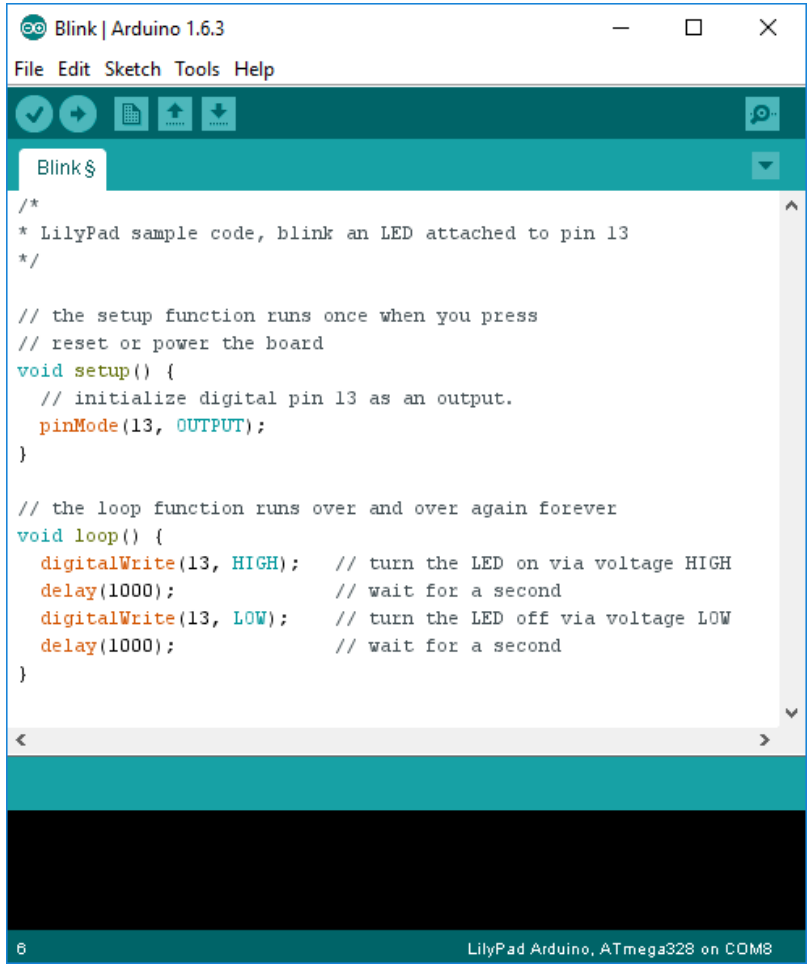
***How can we...***

enable young children to build their own interactive wearables?


LILYPAD ARDUINO

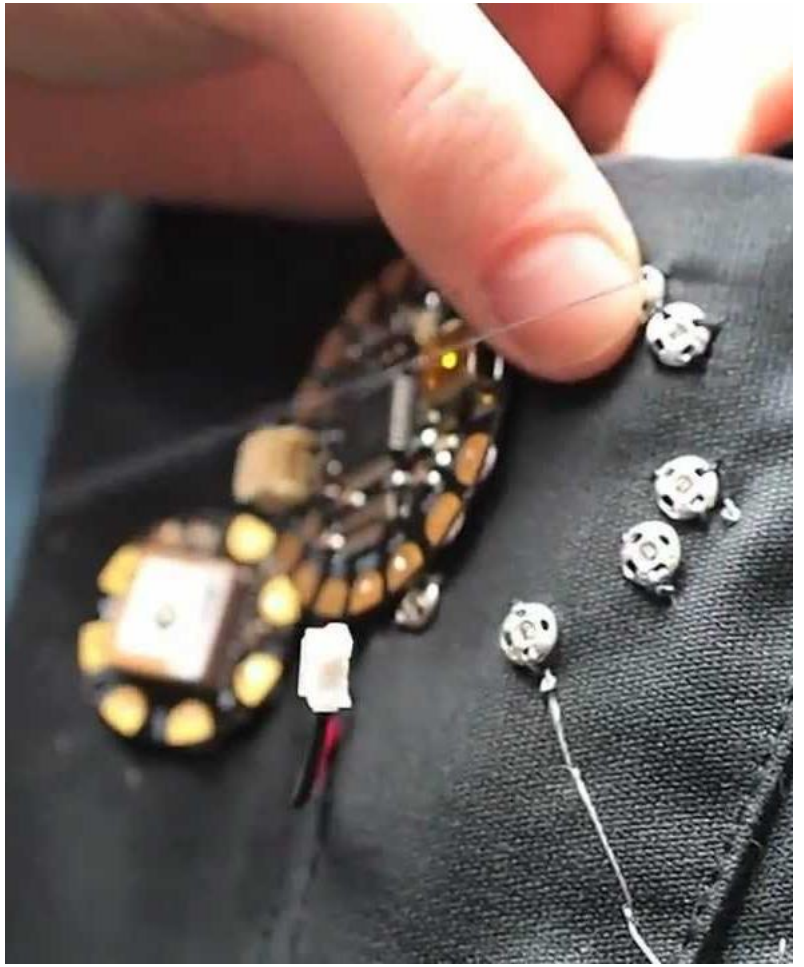
See: Buechley & Hill, 2010; Kafai, Lee, *et al.*, 2014; Kafai, Fields, & Searle, 2014

# CURRENT WEARABLE TOOLKITS




EMBEDDED PROGRAMMING

BASIC CIRCUIT & ELECTRONICS KNOWLEDGE

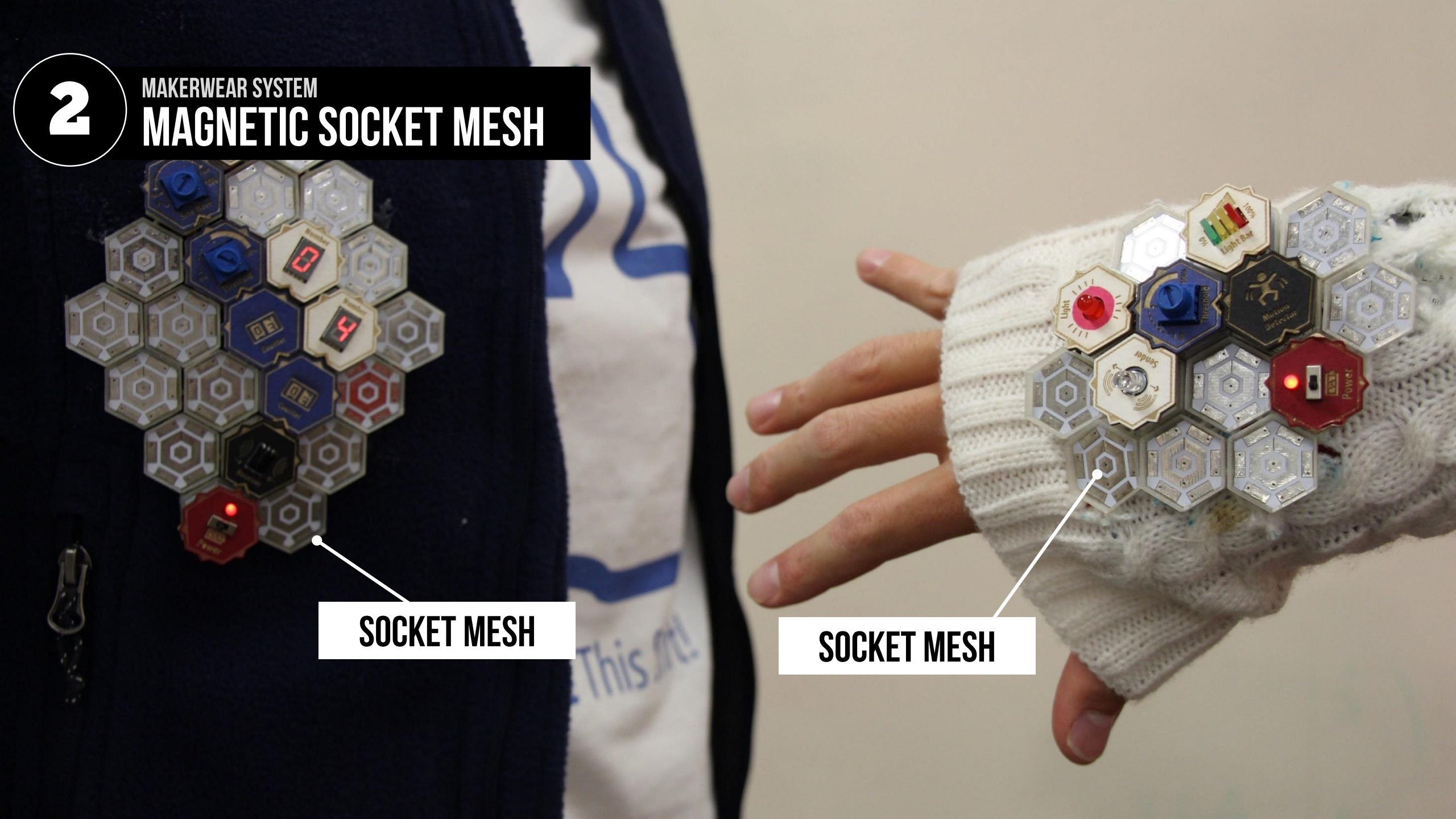


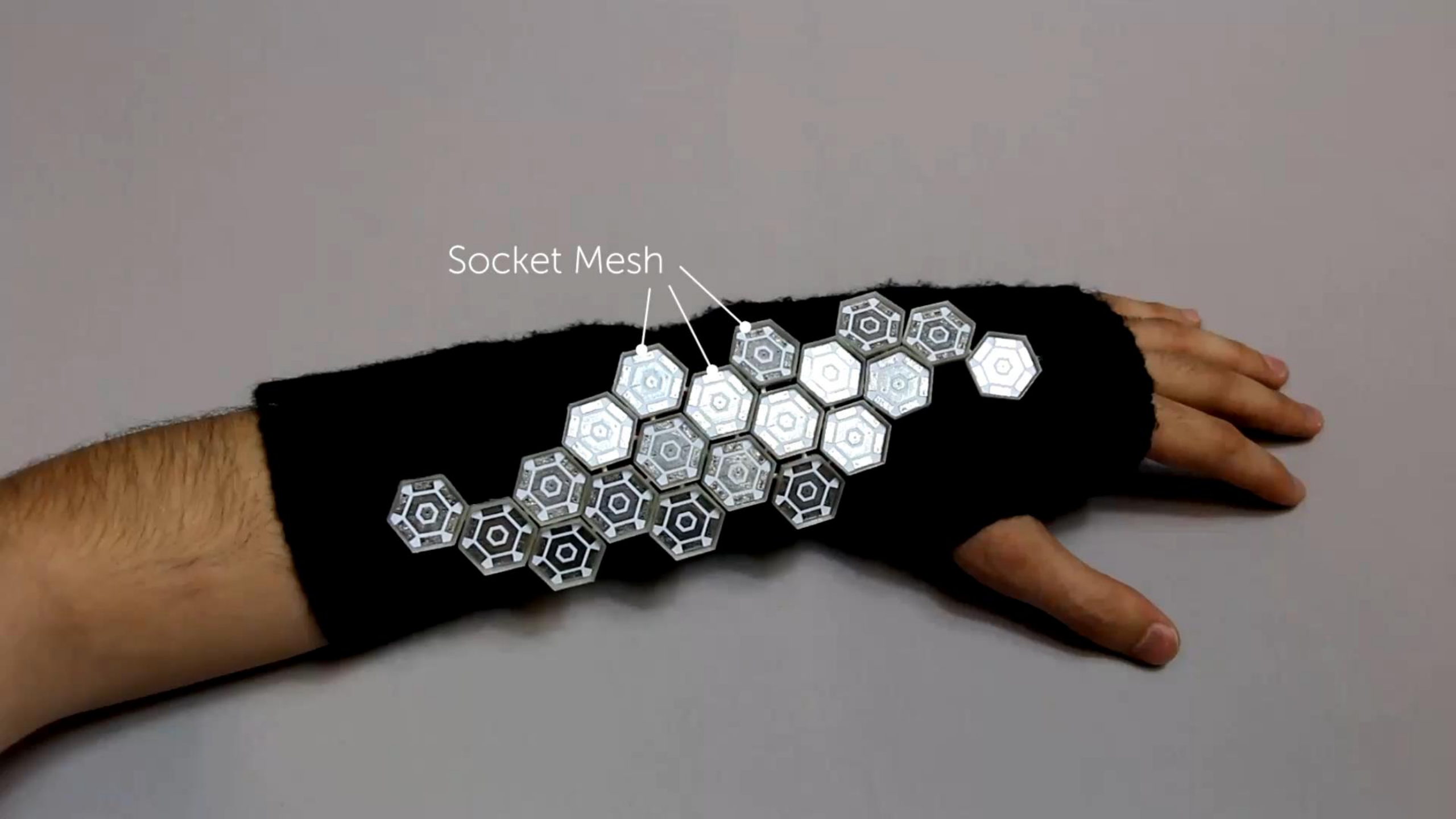
MANUAL SKILLS LIKE SEWING / SOLDERING

# THE MAKERWEAR SYSTEM

https://github.com/MakerWear


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


Socket Mesh


# 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;

MAKERWEAR FINDINGS

# FINAL PROJECTS


Omar, Age 6

Justin, Age 8


Tyrese, Age 5

LeShawn, Age 6

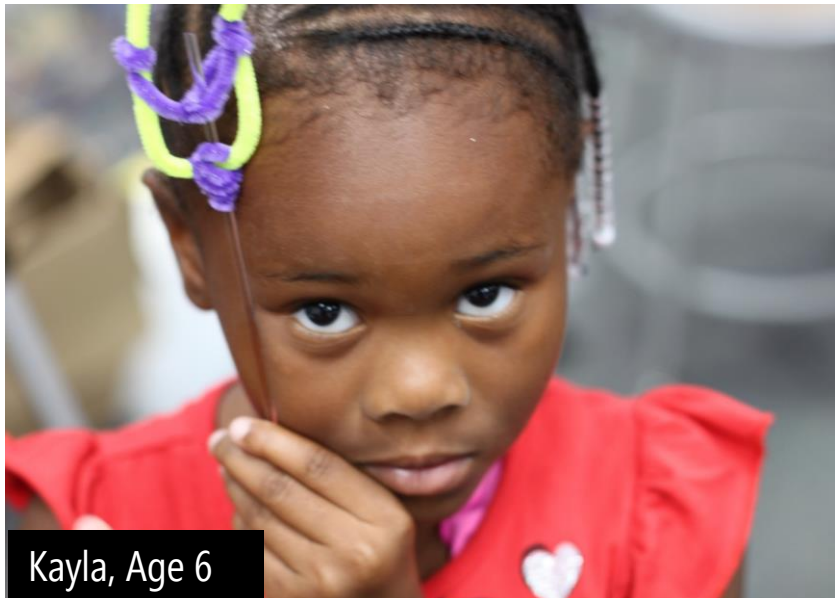

Sarah, Age 9


Keisha, Age 6


Austin, Age 9


Amelia, Age 10


Tina, Age 8


Kayla, Age 6

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?



SPORTS/FITNESS

38%



ROLE PLAY

31%

SOCIO-DRAMATIC PLAY

19%



OTHER

13%

MAKERWEAR FINAL PROJECT

# “MAGIC POKÉMON”

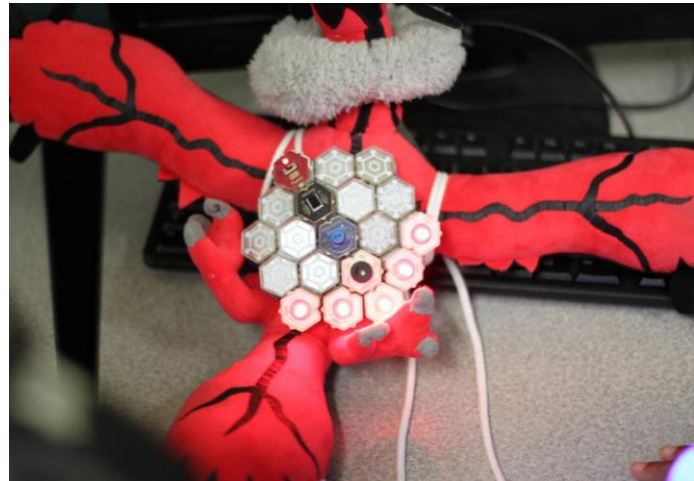
Austin, Age 9

# MAGIC YVELTAL POKÉMON

Maker: Austin, Age 9
14 modules: 9 actions, 2 sensors, 1 modifier
2 socket meshes
3 lo-fi pieces + pokemon

## VEST


## POKÉMON DOLL

MAKERWEAR FINAL PROJECTS

# WHAT DID CHILDREN MAKE?

SPORTS/FITNESS

**38%**



ROLE PLAY

**31%**



SOCIO-DRAMATIC PLAY

**19%**



OTHER

**13%**

MAKERWEAR FINAL PROJECT

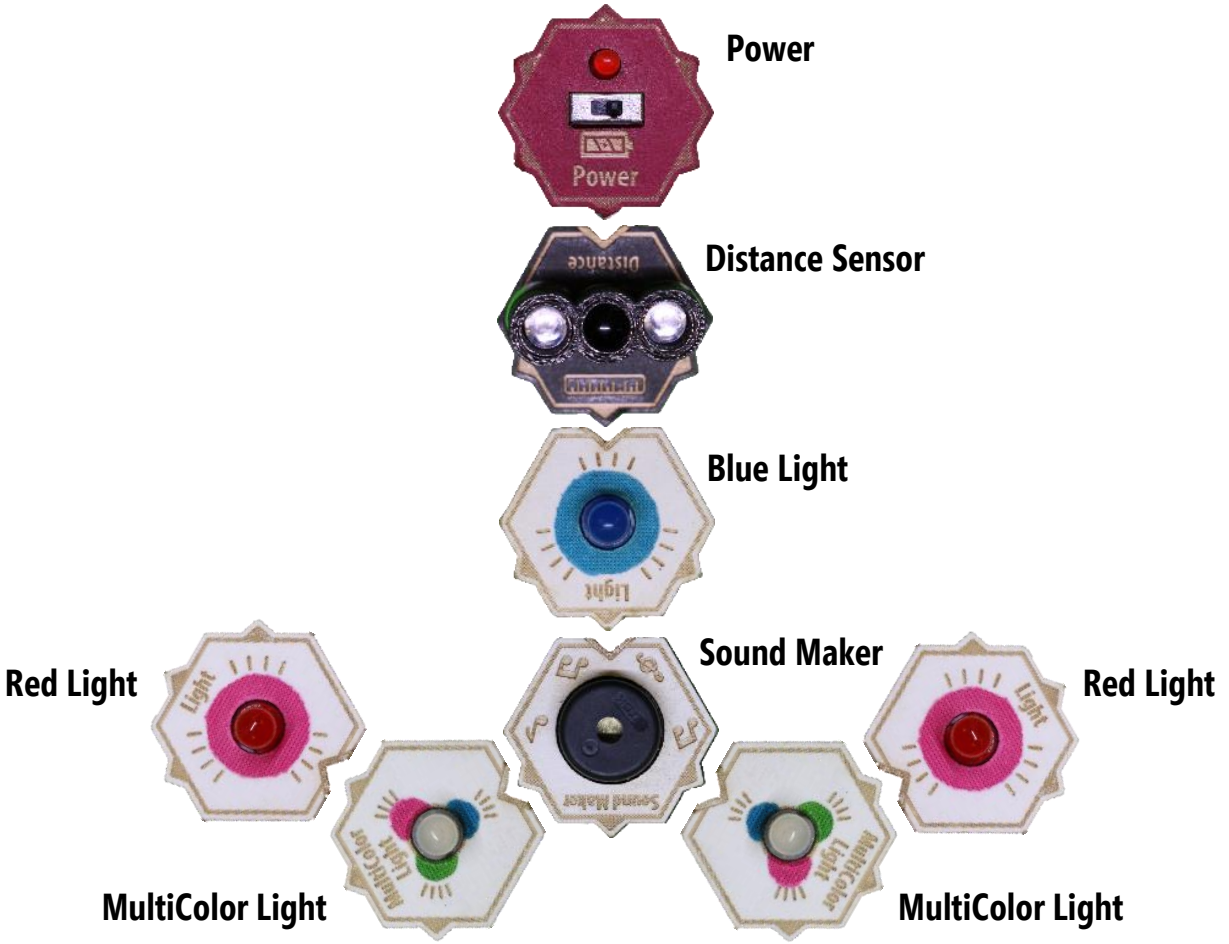
# “SMART LACROSSE STICK”


Sarah, Age 9


BAD
AD's
SUPERMAN
LOVES STEM
KEEP
GOING

# SMART LACROSSE STICK

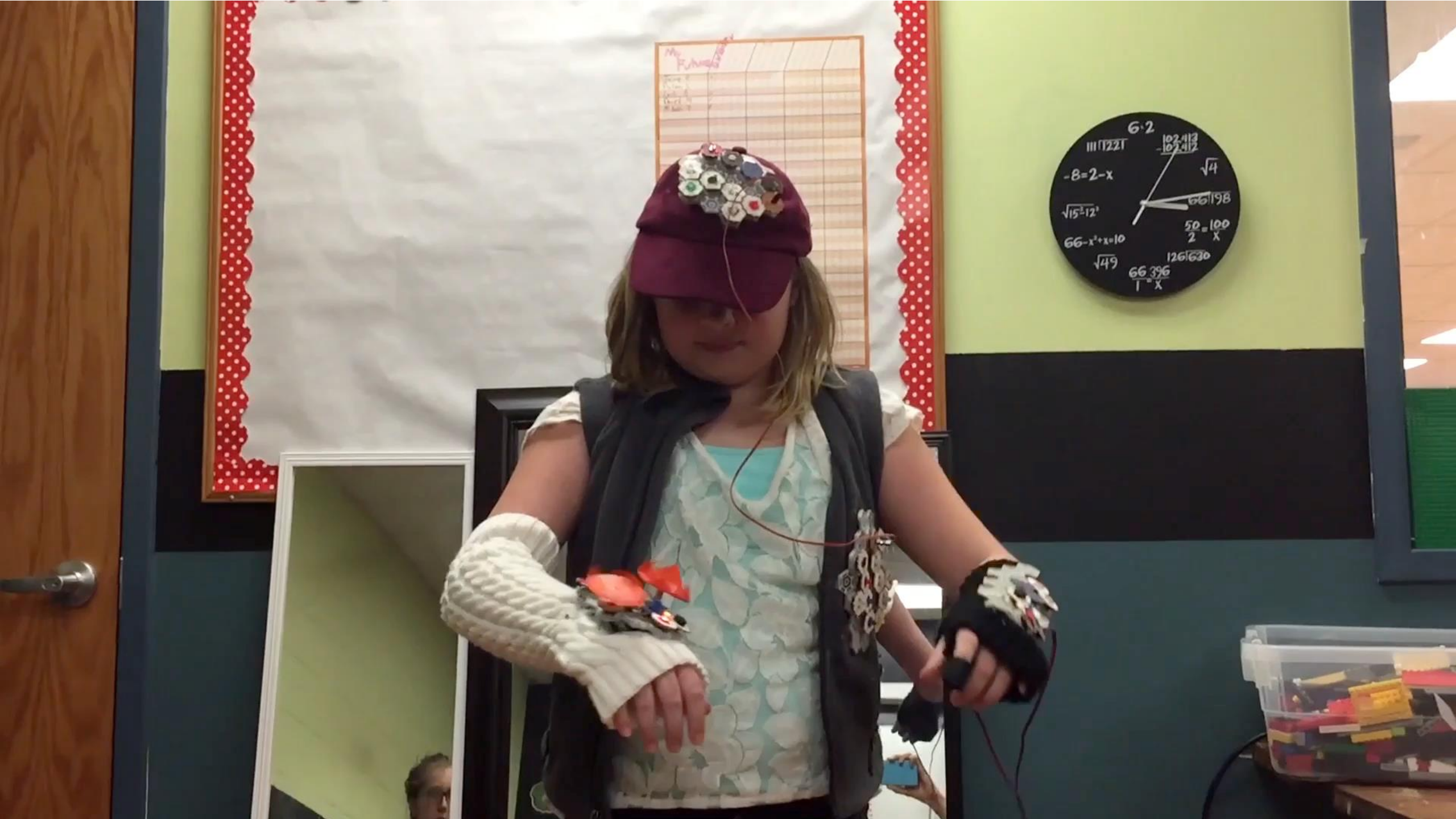
Maker: Sarah, Age 9
8 modules: 6 actions, 1 sensor
1 socket mesh
3 lo-fi pieces + lacrosse stick



MAKERWEAR FINAL PROJECT

# “NEXT GEN RUNNING CLOTHES”

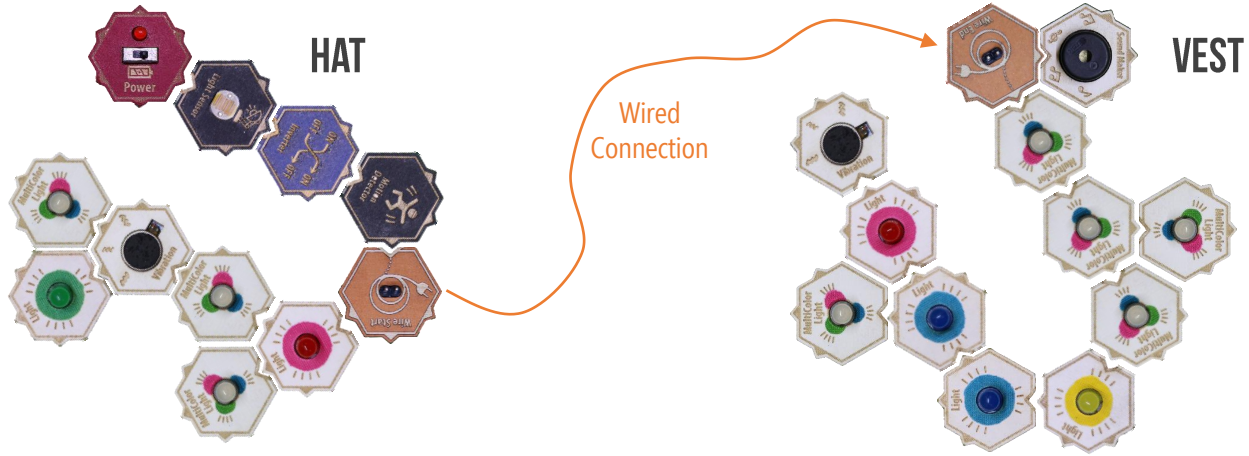
Amelia, Age 10


6·2
111221
-8=2-x
√4
66198
√15²-12²
66-x²+x=10
√49
126630
66 396
1 x

# NEXT GENERATION RUNNING CLOTHES

Maker: Amelia, Age 10
40 modules: 25 actions, 3 sensors, 5 modifiers
4 socket meshes; 2 lo-fi pieces

## MOTION-REACTIVE LIGHT-UP SAFETY HAT & VEST




## "AIR CONDITIONING" ARMBAND

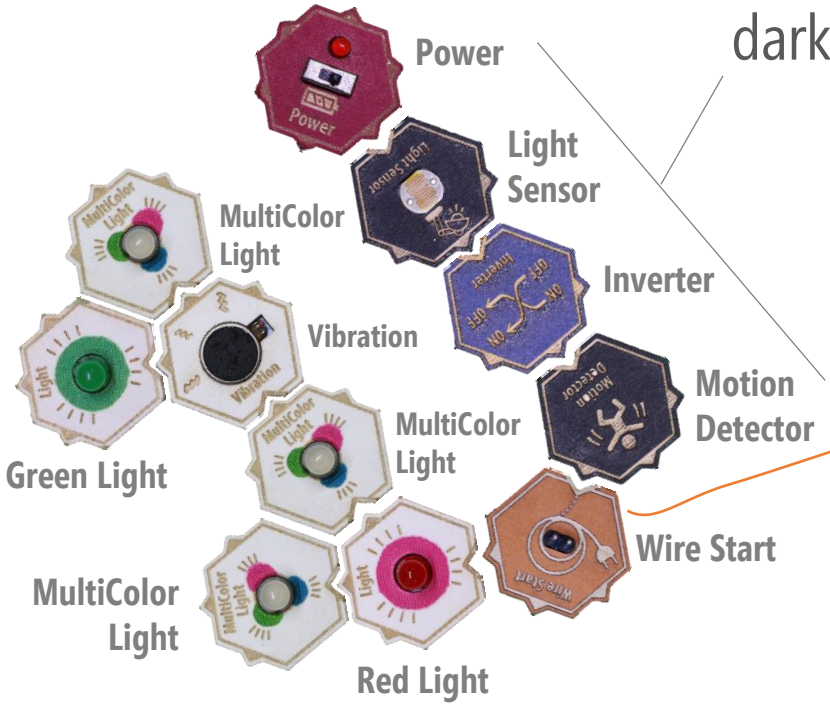
## "HEART TRACKER" ARMBAND

# NEXT GENERATION RUNNING CLOTHES

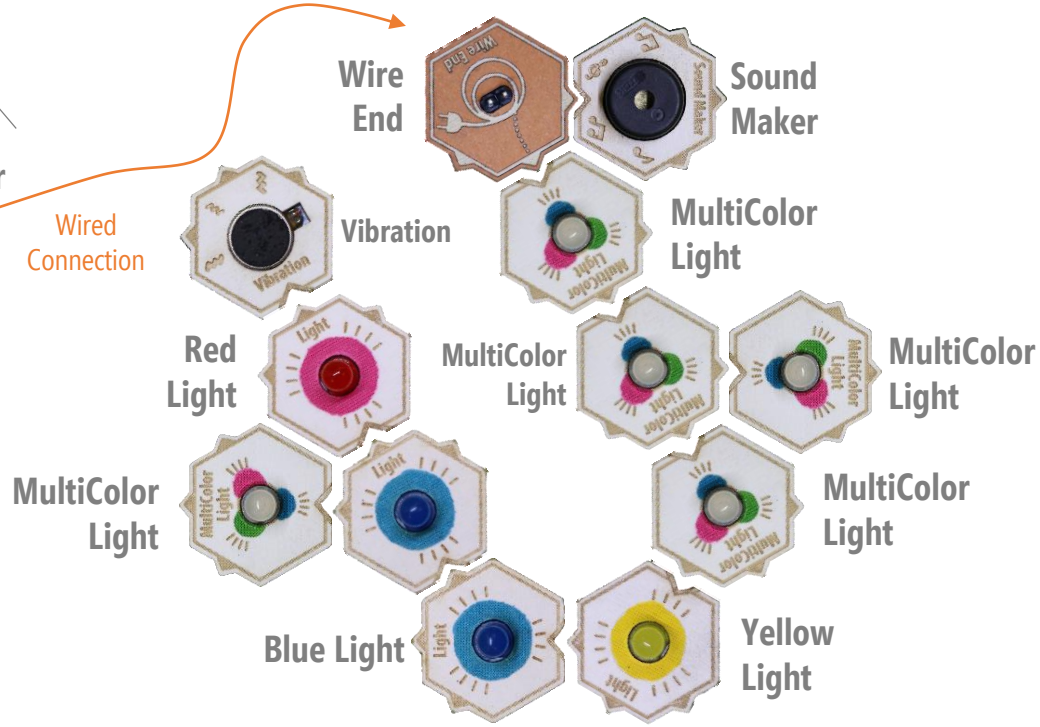
Maker: Amelia, Age 10
40 modules: 25 actions, 3 sensors, 5 modifiers
4 socket meshes; 2 lo-fi pieces

## MOTION-REACTIVE HAT

Activate hat & vest only when it's dark **AND** the wearer is moving



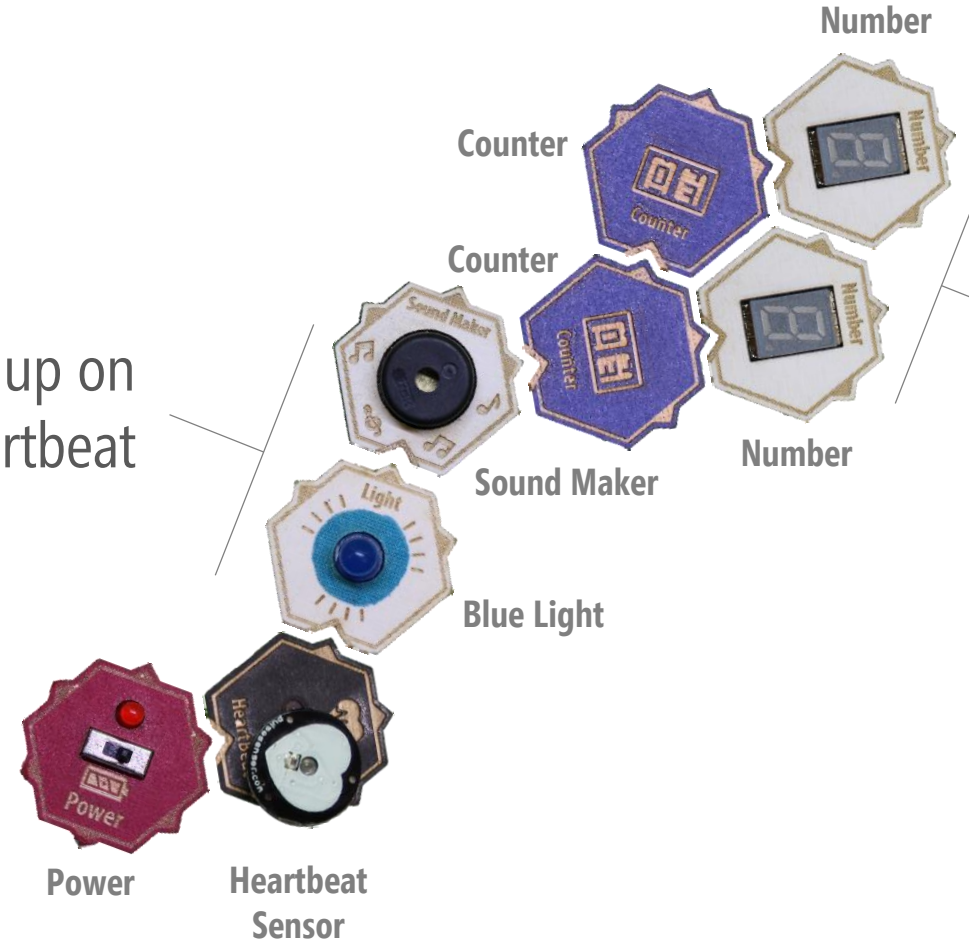

## MOTION-REACTIVE VEST



# NEXT GENERATION RUNNING CLOTHES

Maker: Amelia, Age 10
40 modules: 25 actions, 3 sensors, 5 modifiers
4 socket meshes; 2 lo-fi pieces

## "HEART TRACKER" ARMBAND



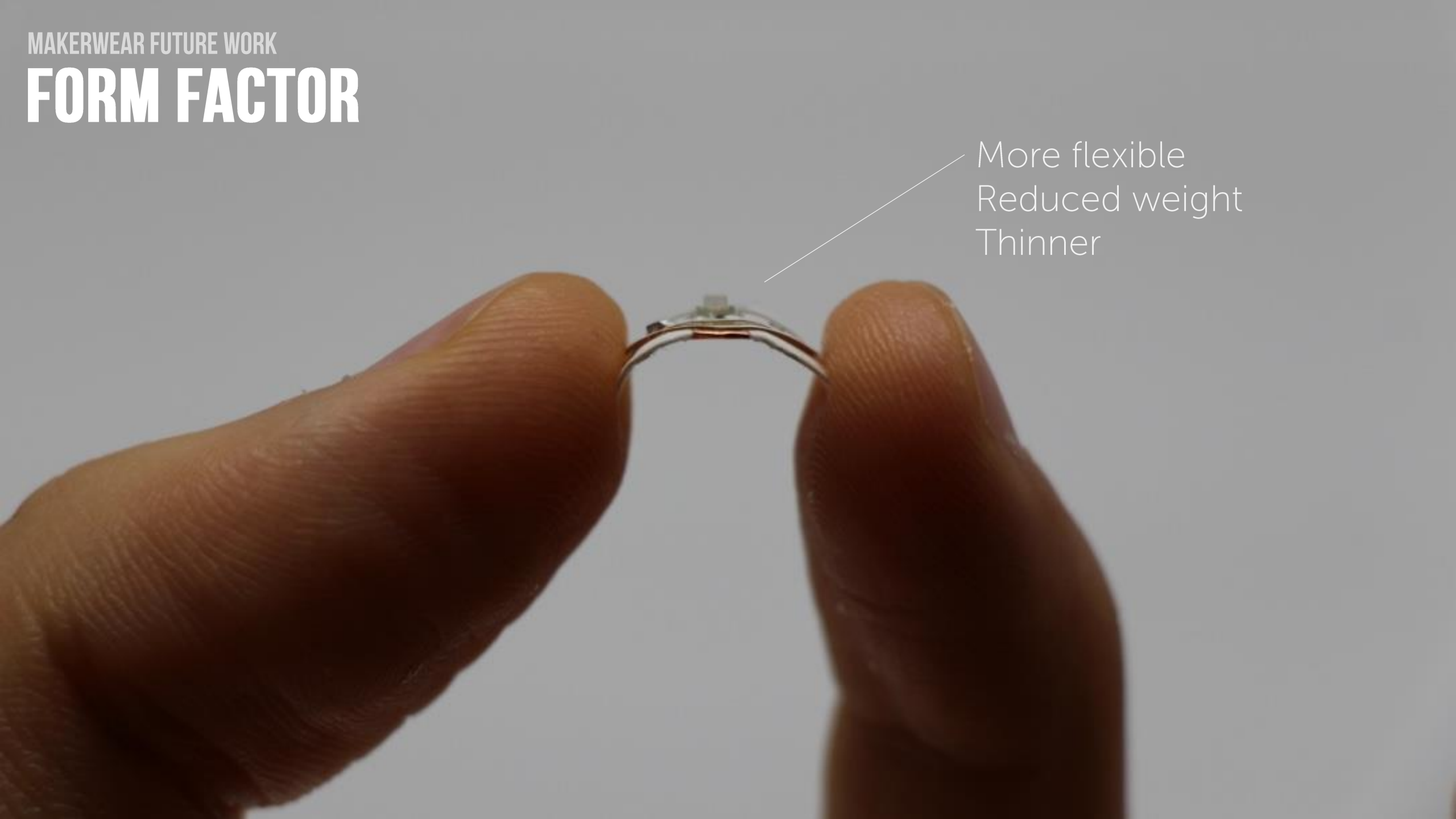

Beeps & lights up on each heartbeat

Counts heartbeats up to 99


MAKERWEAR FUTURE WORK

MAKERWEAR FUTURE WORK

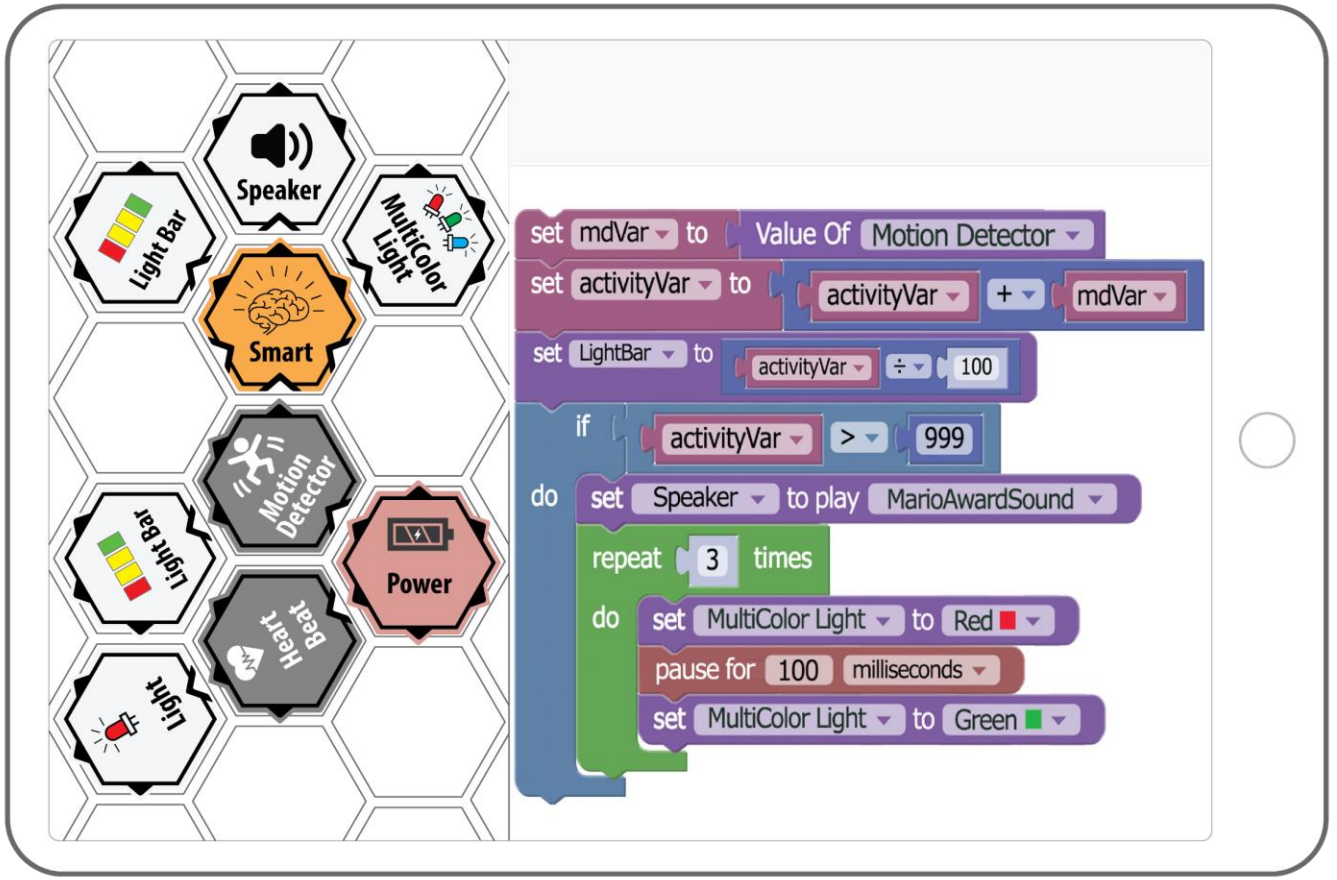
# FORM FACTOR



FUTURE WORK

# HYBRID TANGIBLE-GRAPHICAL PROGRAMMING INTERFACE

Modules will be wirelessly programmable via a custom tablet programming interface



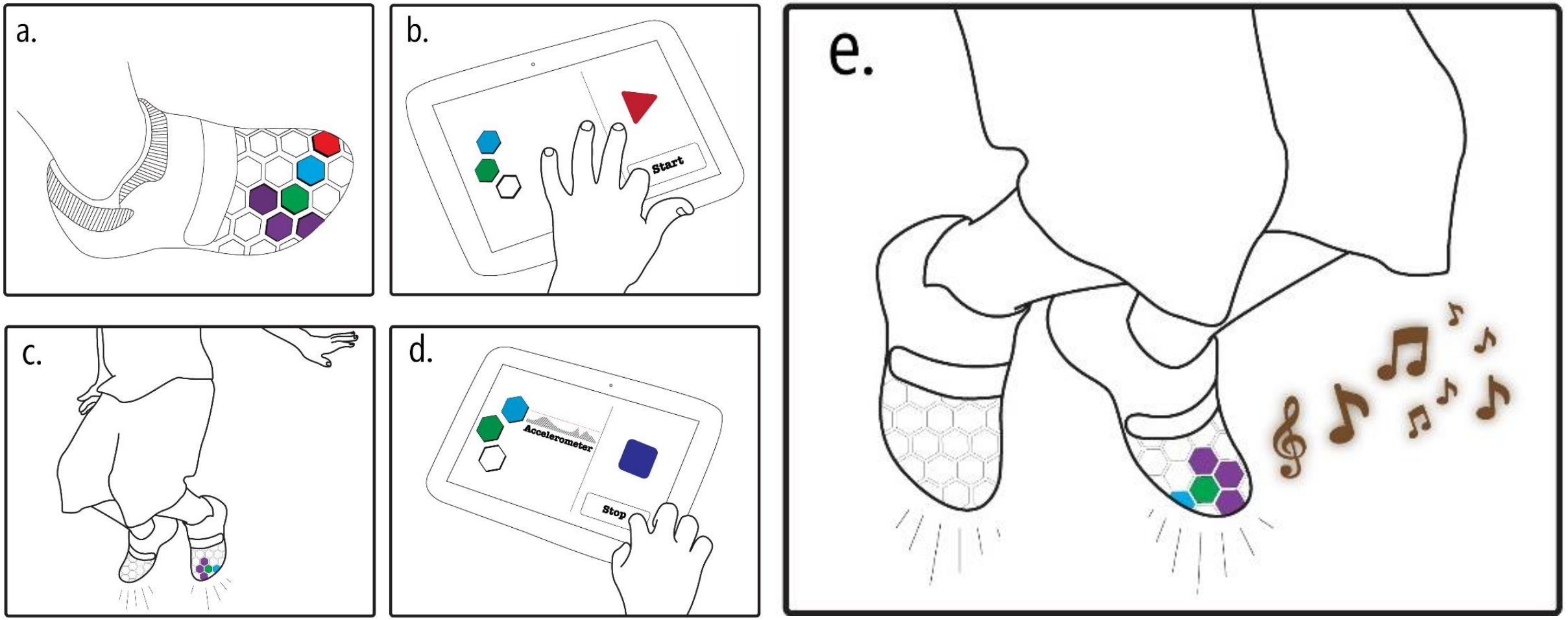

**Sample Application:**

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

FUTURE WORK

# INTERACTIVE MACHINE LEARNING

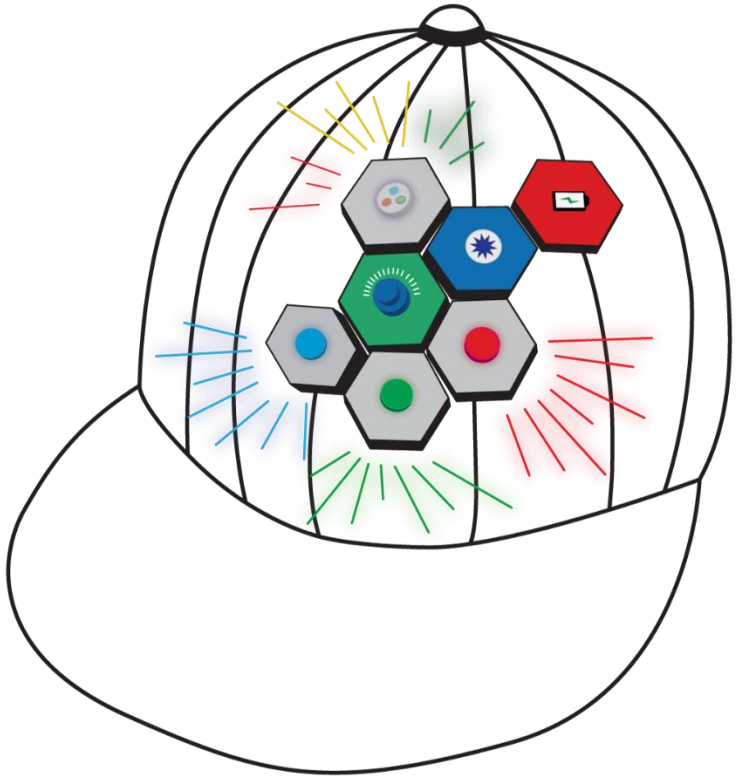
Children can program complex behavior via a novel machine learning interface



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.




JOIN US!
http://makeabilitylab.io

ACKNOWLEDGEMENTS

# FUNDING SOURCES





CDMRP
Congressionally Directed Medical Research

## MAPPING ACCESSIBILITY OF THE WORLD

NSF #1302338, Google, IBM

PI Froehlich, Co-PI David Jacobs

## HMD SOUND AWARENESS

Google Faculty Research Award

PI Leah Findlater, Co-PI Froehlich

## HANDSIGHT TOUCH VISION

Department of Defense CDMRP

PI Froehlich, Co-PIs Leah Findlater & Rama Chellappa

## BODYVIS & SHAREDPHYS

NSF #1441184

PI Froehlich, Co-PI Tamara Clegg

## MAKERWEAR

NSF CAREER #1652339

PI Froehlich

# MAKING WITH A SOCIAL PURPOSE

@jonfroehlich

DESIGN USE BUILD

MAKEABILITY LAB

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

UNIVERSITY of WASHINGTON