MakerWear:
A Tangible Approach to Interactive Wearable Creation For Children

Majeed Kazemitabaar, Jason McPeak, Alexander Jiao, Liang He, Thomas Outing, Jon Froehlich
“…to be makers of things, not just consumers of things.”

Former President, Barack Obama
Remarks to the National Academy of Sciences, 2009

A new construction kit aimed at enabling children to design and build their own interactive wearables.

With only a few components, children can build a wide range of designs...
MakerWear

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With only a few components, children can build a wide range of designs...
MakerWear Examples
All built without the creation of code!
Research Questions

How can we support young children and a wide-age span (ages 5-10) in the creative design of interactive wearables?

What do children want to build if given the opportunity?

Can MakerWear be an introductory pathway to STEAM-related activities like engineering, design, and computational thinking?

How can we design MakerWear to allow children to build designs that integrate into their everyday life (e.g., soccer, theatre)?
Constructionism

Our research is rooted in Papert’s theory of constructionism, which suggests a strong connection between design and learning.

Seymour Papert
MIT Professor
Pioneer of AI & new learning theories
Constructionism

Our research is rooted in Papert’s theory of constructionism, which suggests a strong connection between design and learning. ‘Remarkable Learning’ occurs when children are working with materials to design, create, and invent external and shareable artifacts.

Seymour Papert
MIT Professor
Pioneer of AI & new learning theories
Design Inspirations
Light-Up Shoes

Children love light-up shoes
Interactive
Responsive
Expressive
Fun

Not modifiable
Not extensible
Not programmable
Fashion Customization

Children enjoy customizing their clothing, & collecting and sharing designs

Not interactive
Not programmable
**LilyPad Arduino**

Incredibly successful e-textile microcontroller platform.

Open-ended
Programmable
Wearable

Not designed for children
Requires sewing
Requires programming
Requires basic electronics

Source: Buechley et al., CHI'08, DIS'10
BodyVis

E-textile shirt for visualizing live physiological data

New platform for health and science learning

Fully responsive and interactive

Source: Norooz et al., IDC'13, CHI'15
BodyVis Provoked Curiosity

Children constantly asked “how does it work” and wanted to explore the “insides” of the BodyVis shirt. This was unexpected!
Construction Kits
Construction Kits

Construction Kit Definition

“Construction kits—like LEGO or Erector Sets—are **creative platforms** that enable users to **design and create things through** interworking components.”

Based on definition by: Resnick, M., & Silverman, B. Some reflections on designing construction kits for kids, *IDC*’05
Construction Kit History

Source: Resnick, M. Behavior Construction Kits. Commun. ACM '93
Construction Kits

1st Generation Kits
Allowed children to build structures (e.g., towers, buildings)

2nd Generation Kits
Allowed children to build mechanisms (e.g., pulleys, working ferris wheels, cars with gears)

3rd Generation Kits
So-called digital-physical kits allow children to build interactive behaviors (e.g., a car that follows a light)

Source: Resnick, M. Behavior Construction Kits. Commun. ACM '93
Digital-Physical Construction Kits

Robotics (e.g., Cubelets)
Electronics (e.g., littleBits, SAM)
Circuits (e.g., LightUp)

Often programmable
Modular
Snappable (typically magnetic)
CONSTRUCTION KITS

Digital-Physical Construction Kits

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Circuits (e.g., LightUp)

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Modular
Snappable (typically magnetic)
Modular Robotics Cubelets

**SENSORS**
- Light Sensor
- Distance Sensor
- Temperature Sensor

**ACTIONS**
- Rotating Wheels
- Flashlight
- Speaker

**“THINK”**
- Inverse
- Maximum
- Threshold

**OTHER**
- Battery
- Pass Through
- Blocker

**CONSTRUCTION KITS**
CUBELETS

Modular
Snappable
Emergent behavior
Rapid prototyping
Highly iterative
CONSTRUCTION KITS

Digital-Physical Construction Kits

Designed & used in static spaces
Not wearable
Not intrinsically shareable
Children not designing for the self, their changing contexts
Why Clothing?

Clothing is a Unique Design Context

Constructions are wearable & thus, inherently social, mobile, & always available
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Why Clothing?

Constructions are wearable & thus, inherently social, mobile, & always available

Changing environments  Social Interactions  Daily Life
MakerWear Design Process
What do children want to make? and how do they want to make them?
Cooperative Inquiry

A participatory design method for collaboration between adults and children to:

Brainstorm
Design
Develop
Test
technology for children!
What do children want to make? and how do they want to make them?
1st Co-design session

A ‘blue sky’ open-ended method to elicit unbounded ideas for interactive wearables.

Shoes
adhesive cardboard
large post-it pads
markers
1st Co-design session

Themes and Design ideas:

Personalization
Gestures
Achievements
Communication
Programming
What do children want to make? and how do they want to make them?
2nd Co-design session

Rapid prototyping session with:
littleBits
Velcro
Shoes
Sticky Notes

5 children + 5 adults
Morse Code Shoes

2nd Co-Design Session: Rapid Prototyping
2nd Co-design session Outcomes

Shoes that would:

- Make noise when walk
- Shoelaces that light-up in the dark
- Sound Activated Foot-massage
- Air-Conditioner Shoes

Major Problems: **power, connections, attachment, ...**
MakerWear Design
Module Layers

Layer One
Magnet, Spring Contacts

Layer Two
Electronics, Connection to bottom layer.

Layer Three
Laser cut cover: Module icon & label

Sensor
Module Layer Two

Custom PCB with pre-programmed electronics for given module
Module Layer Three

Laser cut top shows iconography & label representing module behavior
Example Module: MultiColor Light
Example Module: Inverter
Example Module: Distance Sensor
5 Module Types

- Modifier
- Sensor
- Power
- Action
- Misc

Design Overview
Module Library
Module Library

- Button
- Tilt Sensor
- Impact Sensor
- Distance
- Motion Detector
- Color Detector
- Light Sensor
- Sound Sensor
- Temperature
- Receiver
- Heartbeat
- Sunlight Detector
Module Library

Design Overview
Module Library

Modifier
Module Library
Socket Meshes
Design Overview

Socket Meshes

Vest

Scarf

Hat
Demo!
Evaluations
## Evaluation

### MakerWear Studies

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Preliminary Studies
Custom Light Oscillator
Male child maker (~8 yrs old)
Custom Light Oscillator
Male child maker (~8 yrs old)
Custom Light Oscillator
Male child maker (~8 yrs old)
CUSTOM LIGHT OSCILLATOR
Male child maker (~8 yrs old)
Movement-Based Instrument w/Lights

2 brothers
Movement-Based Instrument w/Lights

2 brothers
Outcomes

Explicit support for lo-fi integration: Rotator / LEGO

Increased number of sockets

Created 12 additional modules
Final Workshops
Final Workshops

two single-session (1.5 hour) workshops divided into two different age groups: 5-7 and 8+

Three four-session workshops divided into three age groups: 5-7, 8-9, 10+
EVALUATION

**Final Workshops**

Pre questionnaires
Building/Play time
Design challenges
Post questionnaire

Artifact-based interviews
MakerWear Creations
Workshop Designing Challenges
DANCE FREEZE
Day 2: 11 yr old male maker
Dance Freeze
Day 2: 11 yr old male maker
Dance Freeze
Buzz Lightyear
Day 2: 11 yr old male maker
Buzz Lightyear
Day 2: 11 yr old male maker
Buzz Lightyear
Laser Tag
Day 3: 6 yr & 7 yr male makers
Laser Tag
Day 3: 6 yr & 7 yr male makers
Laser Tag
MakerWear Creations
Workshop Final Projects
Wrecking Ball Armband
6 yr old male maker
Wrecking Ball Armband
6 yr old male maker
SMART LACROSSE STICK

9 yr old female maker
Smart Lacrosse Stick

9 yr old female maker
Pokémon Doppelgänger
9 yr old male maker
Pokémon Doppelgänger
9 yr old male maker
Jogging Clothes

10 yr old female maker
Jogging Clothes
10 yr old female maker
Light-Up Socks
7 yr old male maker
Light-Up Socks
7 yr old male maker
Fitness Tracker
11 yr old male maker
Future Work
Future Work

Form Factor

- More flexible
- Reduced weight
- Thinner
Expand Module Library
Expand Module Library

Greater emphasis on unique aspects of wearability: social, environmental, movement
Future Work

Wireless Programming Interface

Modules will be wirelessly programmable via a custom tablet programming interface.

Tickle
https://tickleapp.com/

SAM Labs
https://samlabs.com
Wireless 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

Programming by Demonstration
Children can program complex behavior via a novel interaction machine learning interface
Interactive Machine Learning

Children can program complex behavior via a novel interaction machine learning interface.
MakerWear

A new construction kit aimed at enabling children to design and build their own interactive wearables.

A compelling pathway to engage children in STEAM-related activities

A new way for children to think about and develop electronics/code
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Media Acknowledgements

Dancer
By James Keuning
https://thenounproject.com/term/dancer/373924/

House
By Paulo Volkova
https://thenounproject.com/term/house/3966/

School
By Mike Wirth
https://thenounproject.com/term/school/23692

Bus Stop
By Iconathon
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Friends
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Boy
By Carlos Gonzalez
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Painting
Juan Pablo Bravo
https://thenounproject.com/term/painting/17015

Trampoline
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Children
OCHA Visual Information Unit
https://thenounproject.com/term/children/4283/

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uizin
https://thenounproject.com/term/arduino/34403