Engineering Attitudes, Habits of Mind and Design Awareness in a Fab Lab Maker Space Summer Camp

C. Aaron Price
Bryn Pernot
Gloria A. Segovia
Katherine Gean

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"…despite our best efforts to plan [students'] education… to a large extent we simply wind them up, step back, and watch the amazing things they do."

– Charles M. Vest
President, National Academy of Engineering (2008)

Only 10% of students in the United States are formally taught engineering skills in school, making informal settings critical (National Academy of Engineering, 2010; Schnittka, et al. 2012)

Engineering concepts are best taught with inductive technique, which is more aligned with the freedom afforded informal learning experiences (Felder, 2002)

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Engineering Design: Building Bridges

Students become civil engineers challenged to design, build and test bridges using the principles of mechanical physics. They'll learn about compression, tension, shapes, materials, and more.

EiE Engineering is Elementary | Engineering Adventures

Developed by the Museum of Science, Boston

Recycled Racers

Go Green

3-5 Grades

Afterschool

Green Engineering

Invasive Species

Hop to It

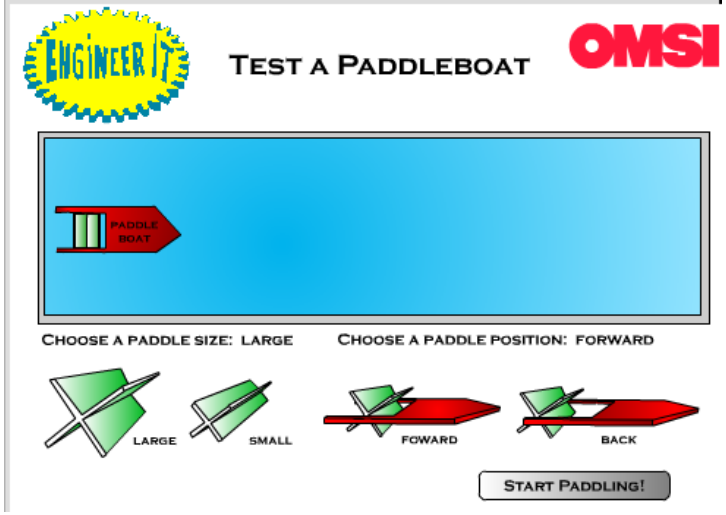
3-5 Grades

Afterschool

Mechanical Engineering

Think, Build, Test, Do It Again

Test a Paddleboat



Wanger Family **FAB**LAB
Museum of Science and Industry, Chicago

Monday	Tuesday	Wednesday	Thursday	Friday
Learning Equipment: Laser Cutting	Learning Equipment: Vinyl Cutting	Learning Equipment: ShopBot CNC Router	Learning Equipment: 3D printing	Free Project
Free Project	Free Project	Free Project	Free Project	

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"What impact does participation in a one-week summer camp program in a maker space have on middle school and high school children's attitudes towards engineering and awareness of engineering habits of mind and design aspects?"

- Pre-Survey
  - Demographics
  - DIY Background
  - Engineering Attitudes
  - Design and Daily Life
  - MCASS items
- Post-Survey
- Parental Survey
- 3 Summer Camps w/Control

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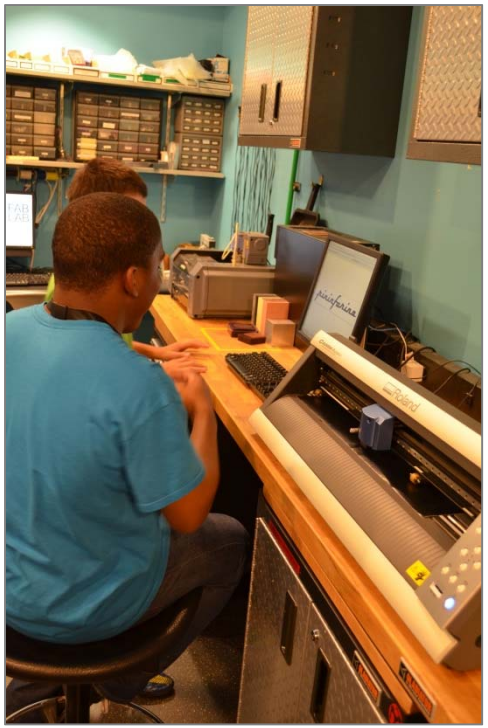
(very) Open Ended Questions

- What is engineering design?
- What skills are needed to be a good engineering designer?
- How can the field of engineering design improve your community?
- How can the field of engineering design improve your daily life?
- Do you think you could be an engineer or engineering designer? Why or why not?



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Section Three: Please answer the following questions by placing an "**X**" next to activities that you **have done** in the **past 12 months**. I have...

☐	...assembled something using instructions.
☐	...taken something apart to figure out how it works.
☐	...used tools or materials to fix something.
☐	...adapted something and used it in a way that it was not originally designed to be used.
☐	...invented something that can be used.
☐	...built or made something from scratch using raw materials.
☐	...used a computer program to design something.
☐	...used a computer program to create a physical object.

National Assessment of Educational Progress (NAEP, 2014)
Biographical Inventory of Creative Behaviors (Batey, 2007)

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Engineering is Elementary
Developed by the Museum of Science, Boston

Engineering helps me to understand today's world.
Girls are better at engineering than boys.
I would like to work with engineers to solve engineer problems.
Engineering is fun.
Engineering has nothing to do with real life.
Engineers help make people's lives better.
Engineering is boring.
I know what engineers do for their jobs.
Boys are better at engineering than girls.
Engineering is easy for me.
I would like to learn more about engineering.
Engineering is really hard to understand.
Engineers cause problems in the world.
It is important for me to understand engineering.

Lachapelle, Hertel, San Antonio-Tunis & Cunningham, 2014
(α = .82)

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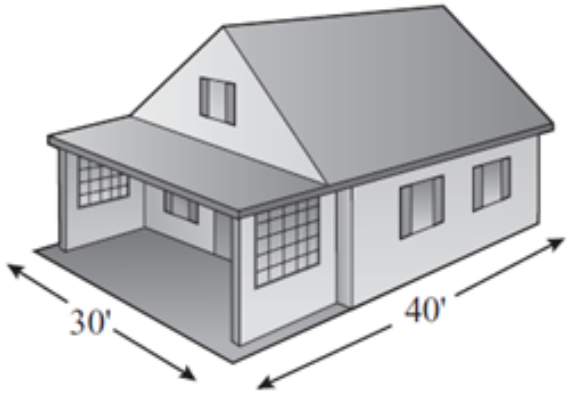
5. Juan is going to design a kite for mass production. After doing research, Juan creates several different designs and selects the one he wants to use. What are the next two steps Juan should do in the design process?

A. Build and finish full-size kites.
B. Redesign the kite and evaluate it.
C. Build a prototype of the kite and test it.
D. Patent the kite design and sell it to others.

6. The diagram below represents a house.



An architect needs to produce a scale drawing of the first-floor plan of this house on a sheet of $8\frac{1}{2}$" X 11" paper. Which of the following scales will allow the architect to make the largest drawing possible on one sheet of paper?

A. 1" = 1'
B. $\frac{1}{2}$" = 1'
C. $\frac{1}{4}$" = 1'
D. $\frac{1}{8}$" = 1'

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Treatment Participant Data

N = 18

Average Age: 13.5 (*SD* = 1.8)

44% female / 56% male

64% White / 21% African-American / 17% Hispanic / 7% Other Ethnicity

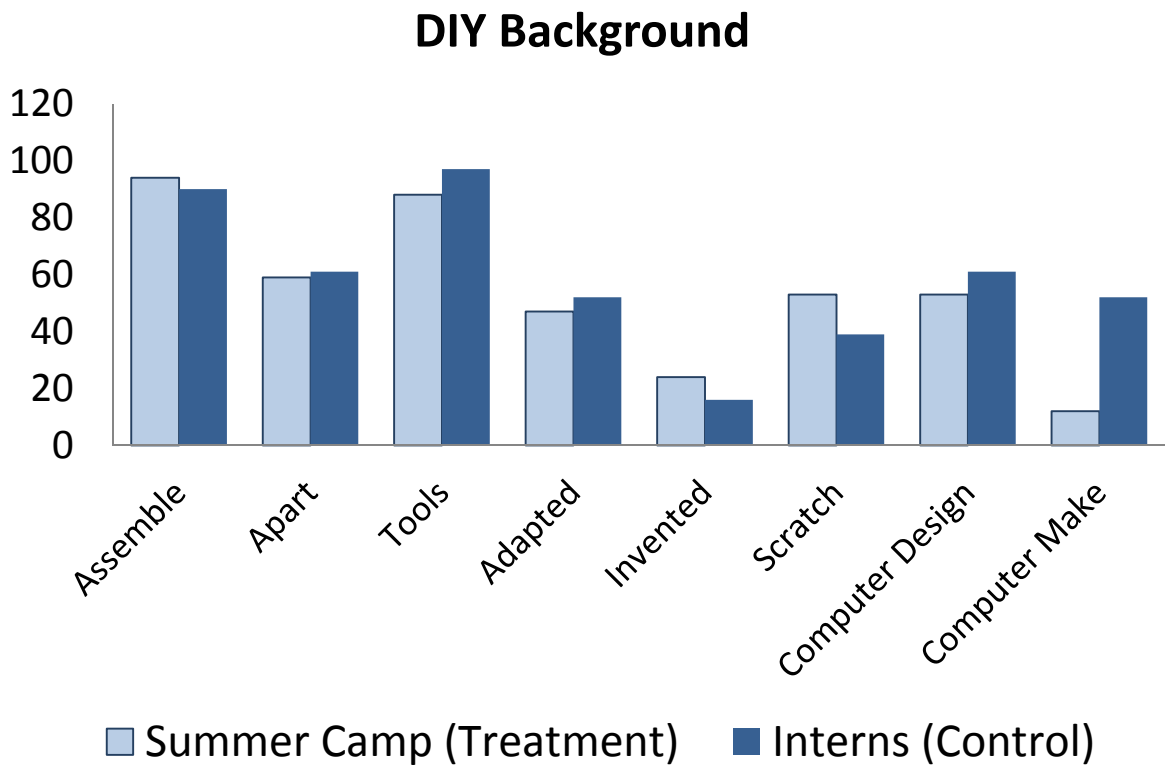
Control Participant Data

N = 31

Average Age: 18 (*SD* = 2; unreliable)

48% female / 52% male

52% African-American / 23% White / 13% Hispanic / 20% Other Ethnicity



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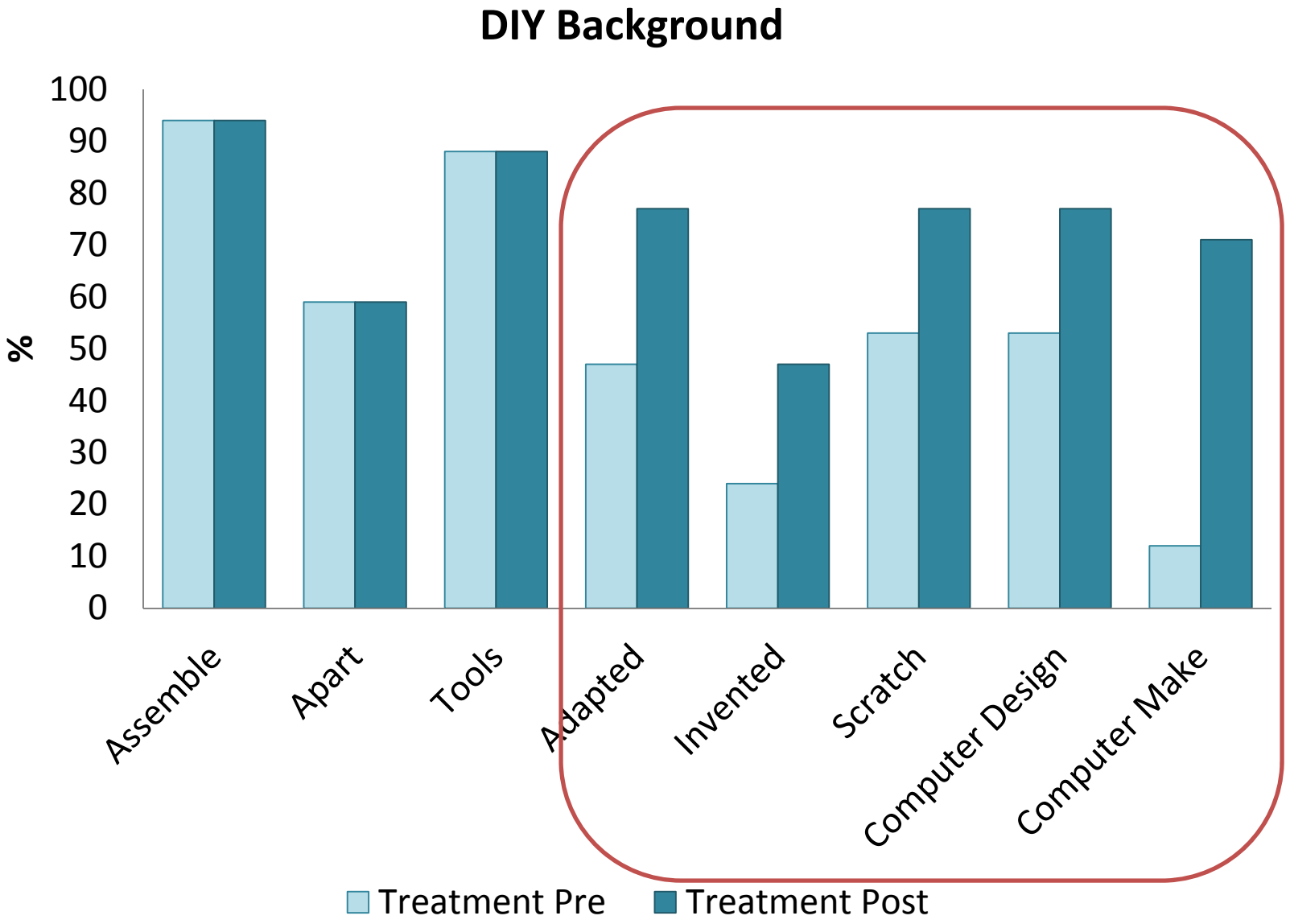


Open-Ended Items

		Pre-Survey (references)	Post-Survey (references)
NRC Engineering Habits of Mind (Katehi, et al. 2009)	Systems Thinking	4	5
	Creativity	9	8
	Optimism	7	4
	Collaboration	2	4
	Communication	1	2
	Attn. to Ethical Considerations	7	5
NGSS' engineering design component ideas	Define	11	11
	Develop	5	4
	Optimize	7	6

MCAS Mean Correct Scores

	Pre-Test	Post-Test
Summer Camp (T)	.40	.42
Interns (C)	.49	.50
MA State Average	.60	

EIA Mean Composite

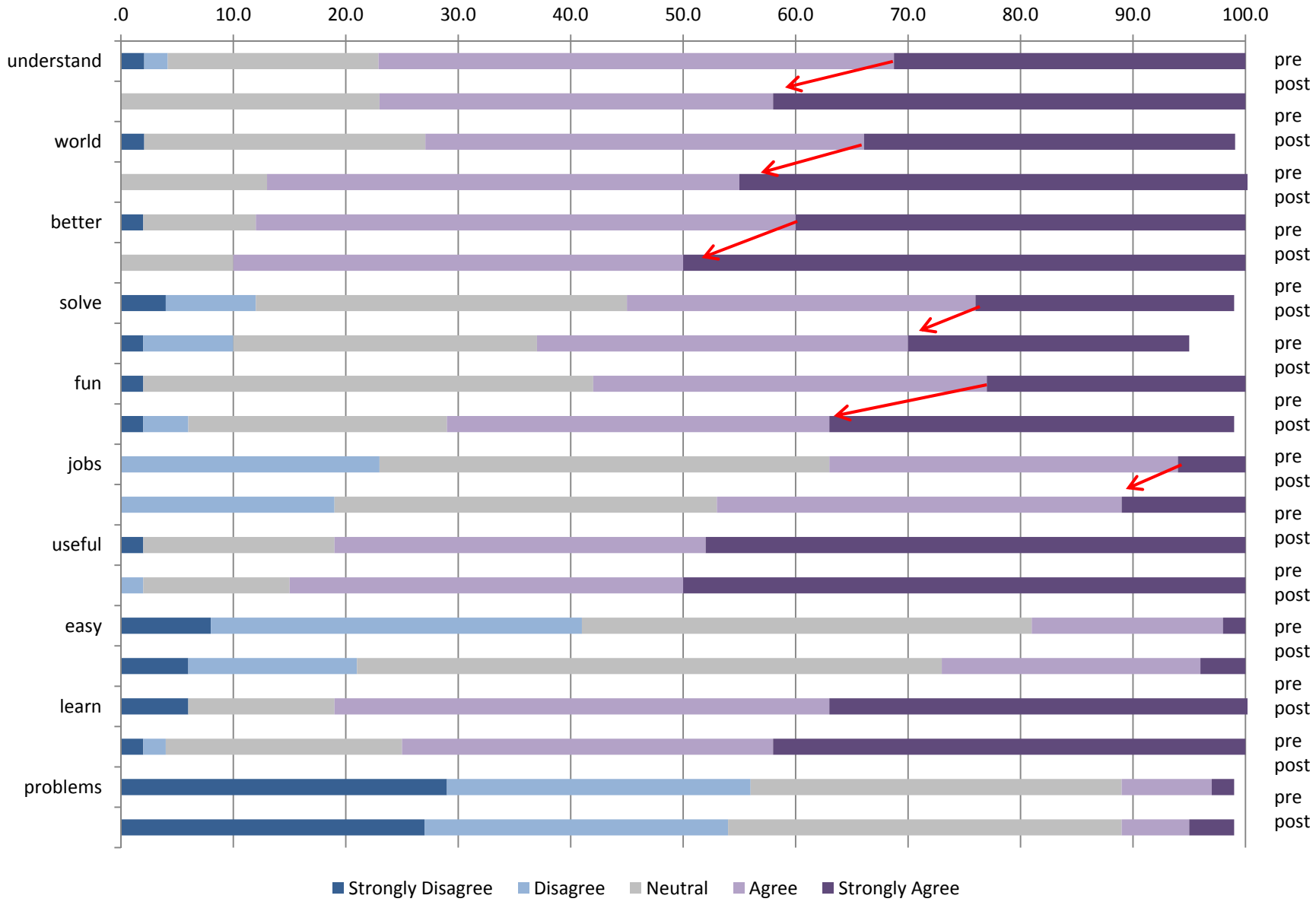
(0=Strongly Disagree, 5=Strongly Agree)

	Pre-Test	Post-Test
Summer Camp (T)*	3.22 (.28)	3.33 (.28)
Interns (C)	3.05 (.45)	3.15 (.35)

* $p < .05$, $r = .28$, $SE = .07$

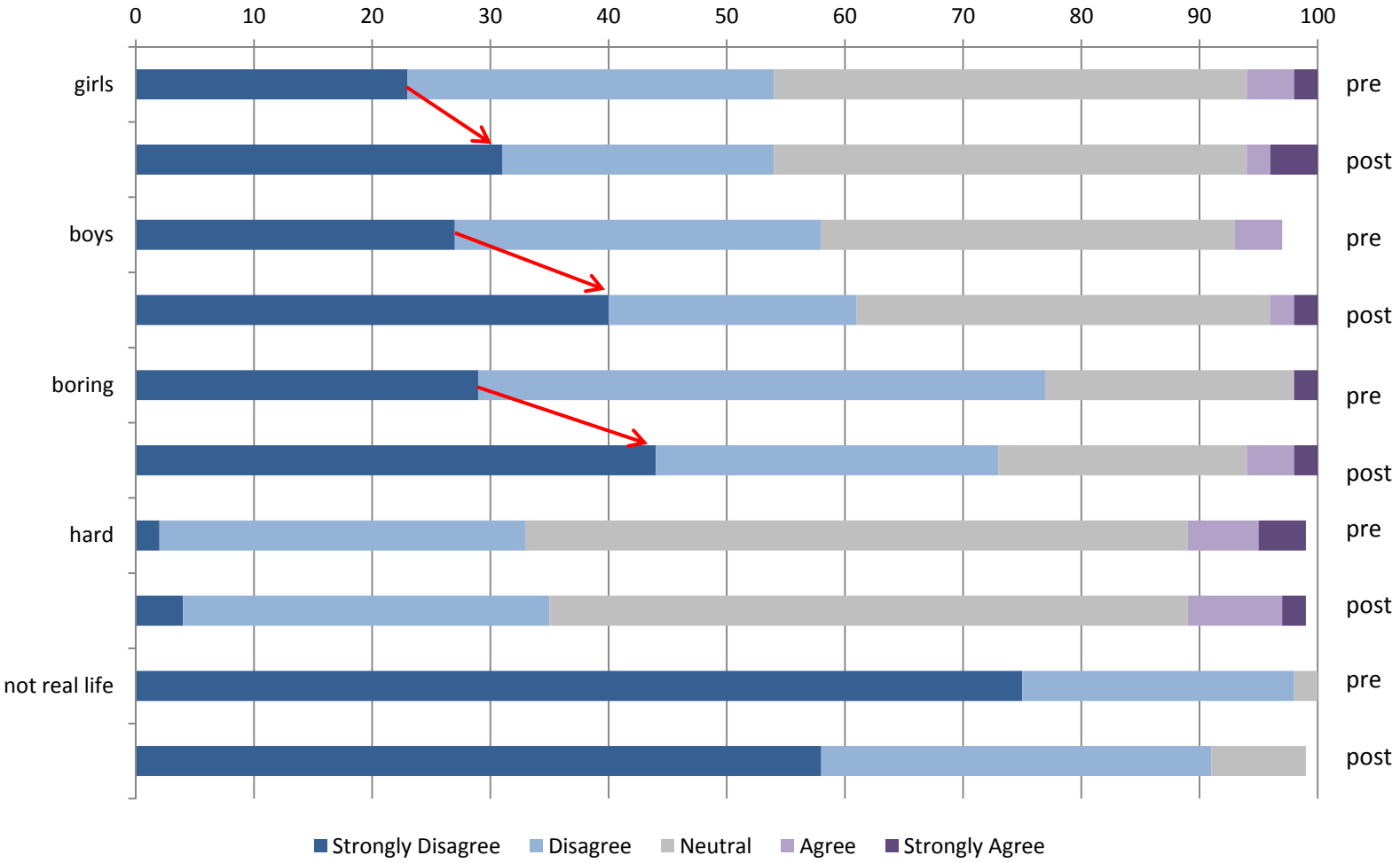
EIA Items

Positively Worded



EIA Items

Negatively Worded



Results

- Habits of mind/design references did not change
- Increased DIY experiences
  - Especially with creative and digital experiences
- Slight increase in engineering attitudes and interests
  - Especially in practical subscale and gender roles
- Nothing definitive, but hints as to what to explore deeper…

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- 2015 Summer Camps
  - Four camps and 15 total participants
  - DIY Identity
    - Engineering habits of mind framework
  - Continue and extend EIA
- Spring, 2015 ethnographic study of longer duration programming
  - Hybrid spaces/identity through unique aspects of a Fab Lab community of practice
- Thanks to the EIA team for sharing their instrument