ELEMENTARY ENGINEERING

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GOALS

- Deepen understanding of what engineering is, of elementary engineering processes, and of success factors for elementary students with the goal of improving teaching of engineering at the elementary level.
- Move understanding of teachers whether just starting the teaching of engineering or experienced engineering teachers.

LOGISTICS

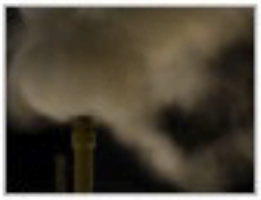
- Slides at kidsengineer.com under Resources-> Presentations
- SCHEDULE 8:30 to 12:00
  - Introduction and Setup
  - Activity
  - EDP Processes
  - Reflections and Summary
- FOOD (bring your own lunch, coffee and snacks anytime)


ENGINEERING is applying understanding of the world in the PURSUIT of solutions to problems.

If we want the next generation of children to be innovators, we need to give them practice innovating

Make solar energy economical

Provide energy from fusion



Develop carbon sequestration methods

Manage the nitrogen cycle

Provide access to clean water

Restore and improve urban infrastructure

Advance health informatics

Engineer better medicines

Reverse-engineer the brain

Prevent nuclear terror

Secure cyberspace

Enhance virtual reality

Advance personalized learning

Engineer the tools of scientific discovery

GRAND CHALLENGES FOR ENGINEERING

http://www.engineeringchallenges.org

Celia & Isabel & Andrew

- Entering First Grade (6 & 7 years old)
- 3 day camp (3 hours per day) at Tufts
- Pirate's Gold Challenge
- Hold 15 pieces of gold
- Stay together when dropped

I: Okay Now try it (try the drop test
C: No, we already did the crash test. We don't have to do it again. We made it thicker that means its stronger so we don't have to do it
I: but
A: If you make it thicker it will fall down. It will break easier.
C: Yeah, the layers will break but not the real part. These are just layers.
A: If you make it taller and thicker it will break easier.
C: Well, we're just doing what we think.
I: I put a little layers. You put a lot.

TAP CREATIVE PLAY

- Who is tapping into creative play? Are we?


Bell

TAP CREATIVE PLAY

It's more fun to actually be building something. If you took a class in robots and just learned about things, if the teacher just drilled information into your head, it would not be as fun as building and experiencing it to learn.

Grade 6 Girl 2

ENGINEERING DEFINITION

Engineering requires applying content knowledge and cognitive processes to design, analyze, and troubleshoot complex systems to meet society's needs." (Brophy et al., 2008, p. 371) Implicit in that definition is creating models and predicting performance, which is what separates true engineering from trial and error methods.

DRAW (OR DIAGRAM) THE ENGINEERING DESIGN PROCESS

- What things do you need to do to go from problem to solution?

KIDS CAN……

ENGINEER

Informal test

Customer: I'll take two coconuts (at Cr$ 40.00 each. Pays with a Cr$ 500.00 bill). What do I get back?

Child: (Before reaching for customer's change) 80, 90, 100. 420.

Formal test

Test item: 420 + 80.

The child writes 420 plus 80 and claims that 130 is the result. [The procedure used was not explained but it seems that the child applied a step of a multiplication routine to an addition problem by successively adding 8 to 2 and then to 4, carrying the 1; that is, 8 + 2 = 10, carry the one, 1 + 4 + 8 = 13. The zeros in 420 and 80 were not written. Reaction times were obtained from tape recordings and the whole process took 53 seconds.]

Examiner: How did you do this one, 420 plus 80?

Child: Plus?

Examiner: Plus 80.

Child: 100, 200.

Examiner: (After a 5 second pause, interrupts the child's response treating it as final) Hum, OK.

Child: Wait a minute. That was wrong. 500. [The child had apparently added 80 and 20, obtaining one hundred, and then started adding the hundreds. The experimenter interpreted 200 as the final answer after a brief pause but the child completed the computation and gave the correct answer when solving the addition problem by a manipulation-with-quantities approach.]

Carraher, T. N., Carraher, D. W. and Schliemann, A. D. (1985)

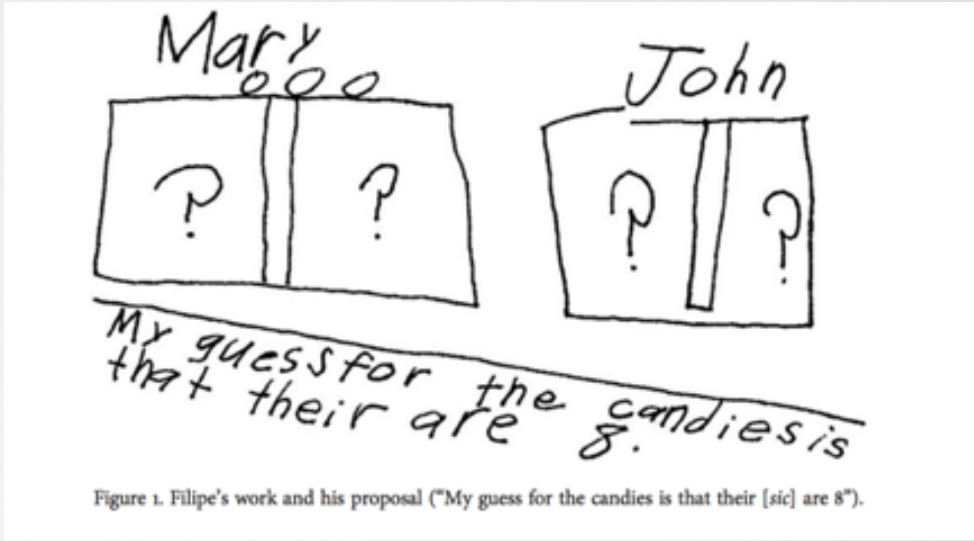
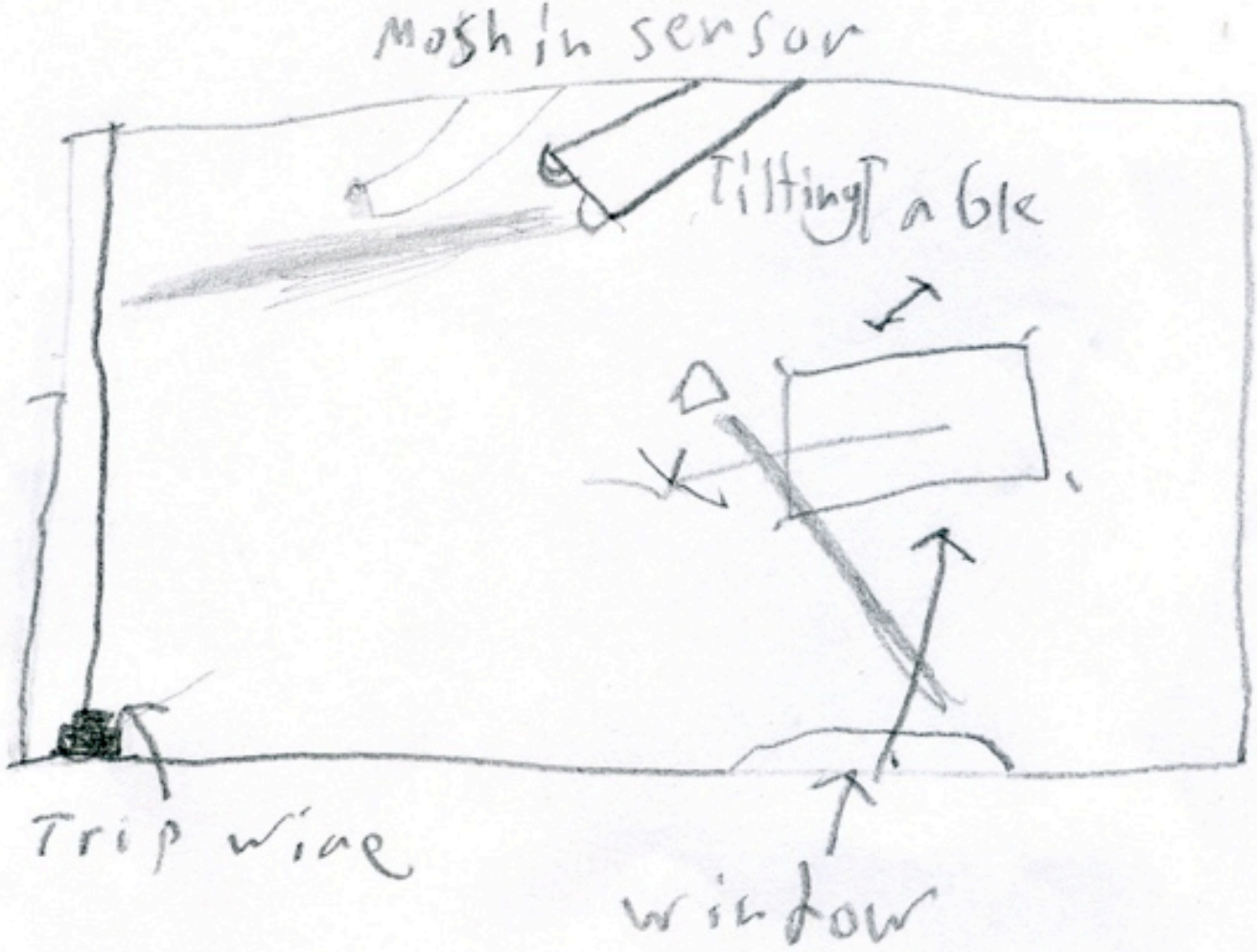


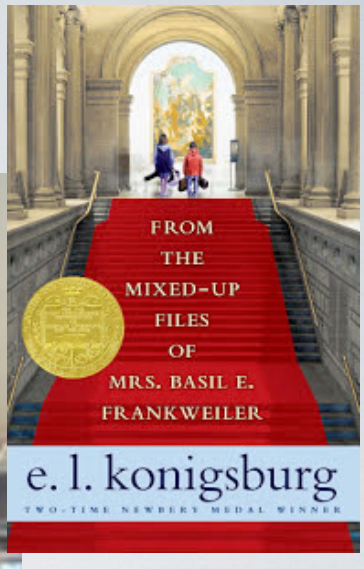
Figure 1. Filipe's work and his proposal ("My guess for the candies is that their [*sic*] are 8").

Brizuela, B. (2016)

ENGINEERING


Mosh in sensor
Tilting table
Trip wire
window

Novel Engineering



- novelengineering.org

Time	TRANSCRIPT
00:00.0	So we would have them and do you wanna make this out of wood?
00:05.1	hmm wood would be more artificial but it would take longer
00:09.1	It would take longer but it would be stronger and um
00:16.0	But how would um they would how would they get the wood?
00:21.0	Do they have to?
00:23.1	Yeah but if they if when they but remember Jamie's really cheap
00:28.2	Yeah he is.
00:30.1	So if they wouldn't probably get the wood the would probably get cardboard cause
00:37.1	Yeah
00:37.3	I see what you're saying. I see what you're saying.
00:40.2	Cause Jamie's cheap and that would probably cost like a lot more than cardboard
00:45.2	But then cardboard is wouldn't be as sturdy and um you know how flimsy cardboard is
00:53.2	Yeah I mean
00:58.1	But then they once the get the wood they'd have the card
01:02.2	They'd have to get glue. They'd have to get all those stuff.
01:05.2	They could use nails.
01:06.2	Yeah but nails cost more than glue.

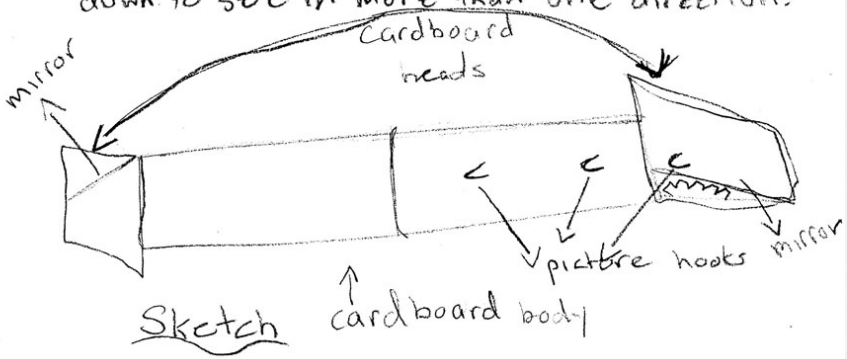
14 April, 2011

Dear Tufts Engineers,

Hello, our names are

We are reading the book, From the Mixed-Up Files of Mrs. Basil E. Frankweiler by E.L Konigsburg and we noticed a problem that we might be able to solve as engineers! The problem we chose is how to see the statue Angel better. We chose this problem because Jamie and Claudia need to get a better look at Angel to see who sculpted her.

My partner and I plan to solve the problem by building a periscope-like device to see above the heads of adults and around obstacles. Unlike a regular periscope the mirror in the head can move up and down to see in more than one direction.



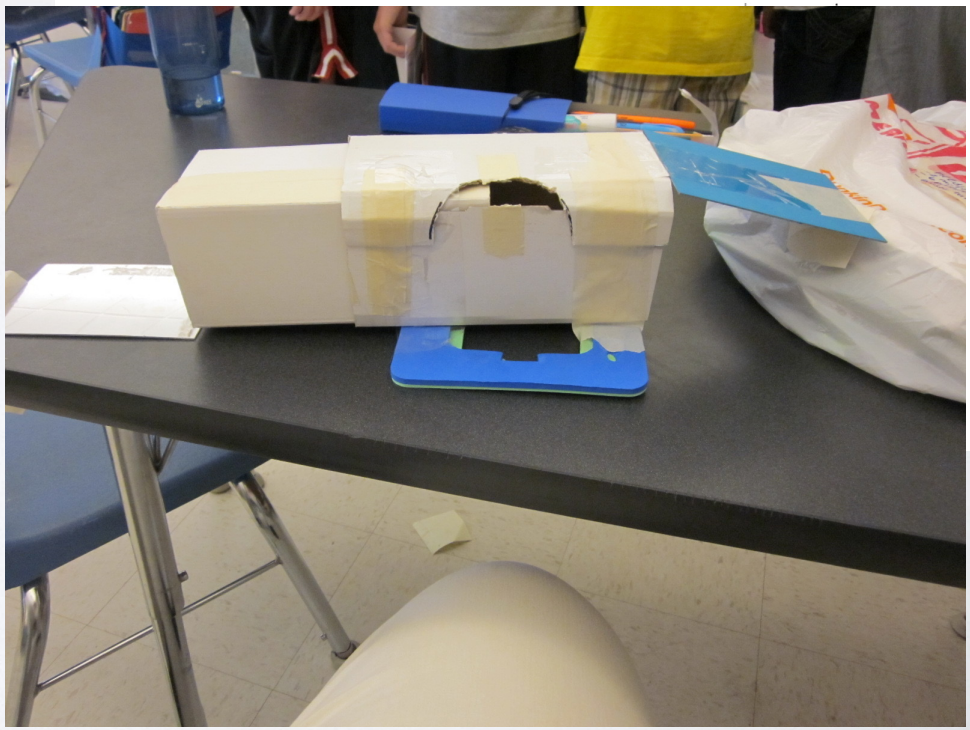
Sketch

The materials we think we will need are:

- 5 medium cardboard packing boxes for the body and the heads.
- 2 6 by 6 cm mirrors for seeing out of the periscope.
- 6 picture hooks for locking the head.
- 5 cm of stiff plastic tubing to lock the gear.
- 2 rolls of red duct tape for reenforcing the body and heads.
- 4 thick rubber bands for locking the head.

We hope we can successfully build our contraption!

Sincerely,



BURGLAR ALARMS

MOTIVATING

YEAR 1 CLEVER SOLUTION

Open Ended Challenges

STARTER TASK

- Cooling Fan - Walk Thru Quick

TASK

- Design a safe and fun amusement park ride
- See student checklist (use)

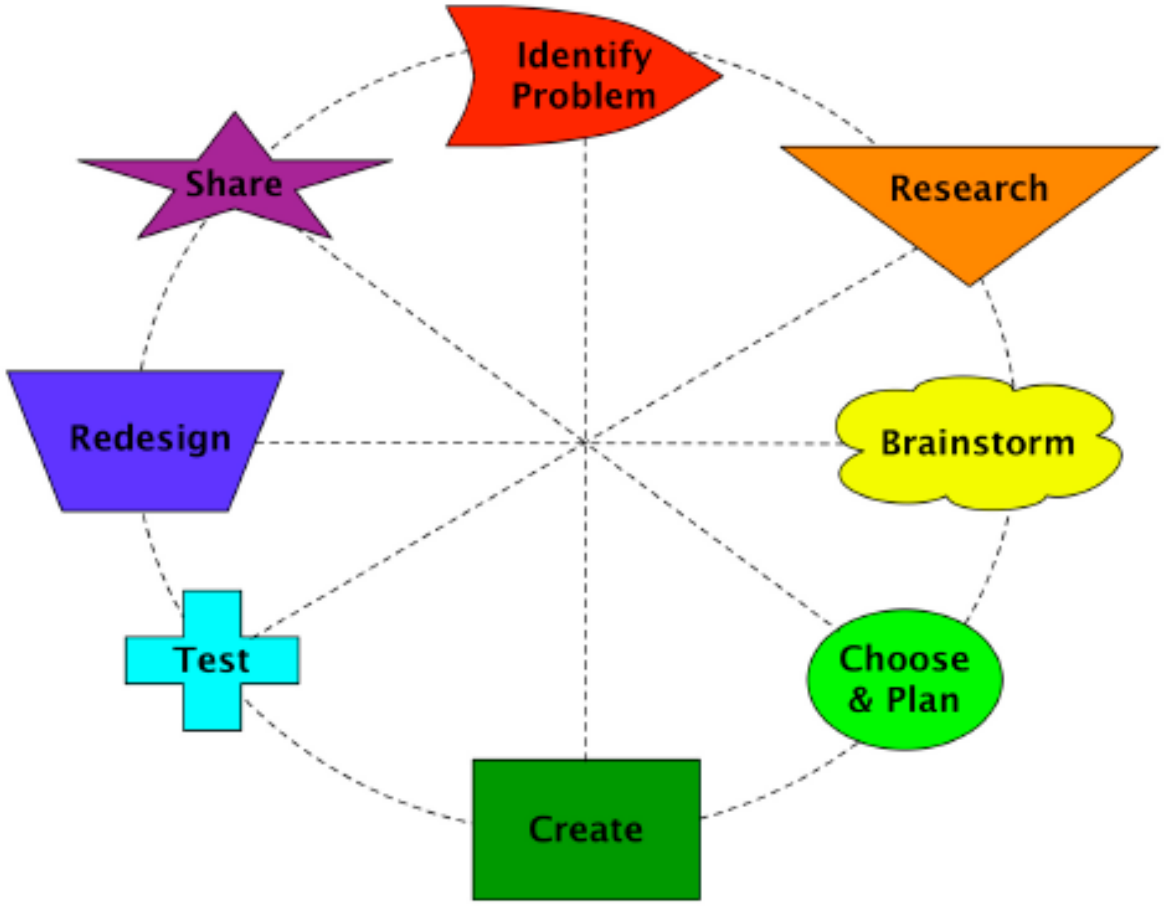
RIDE FAIR

- Take turns with partner pitching and switching

REFLECT ON YOUR DESIGN PROCESS

- How did the work you did creating the ride compare to your initial representation of the design process?
- Where was it the same ? Where was it different?

Engineering Design Process

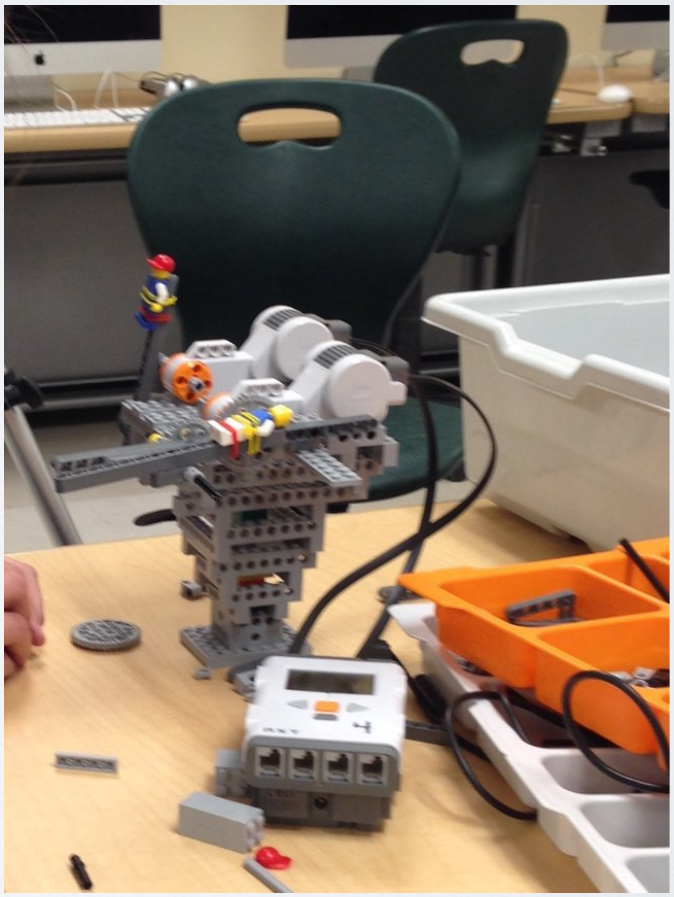


Courtesy - Dr Merredith Portsmore, Tufts CEEO

WE WANT STUDENTS TO **DO** ENGINEERING

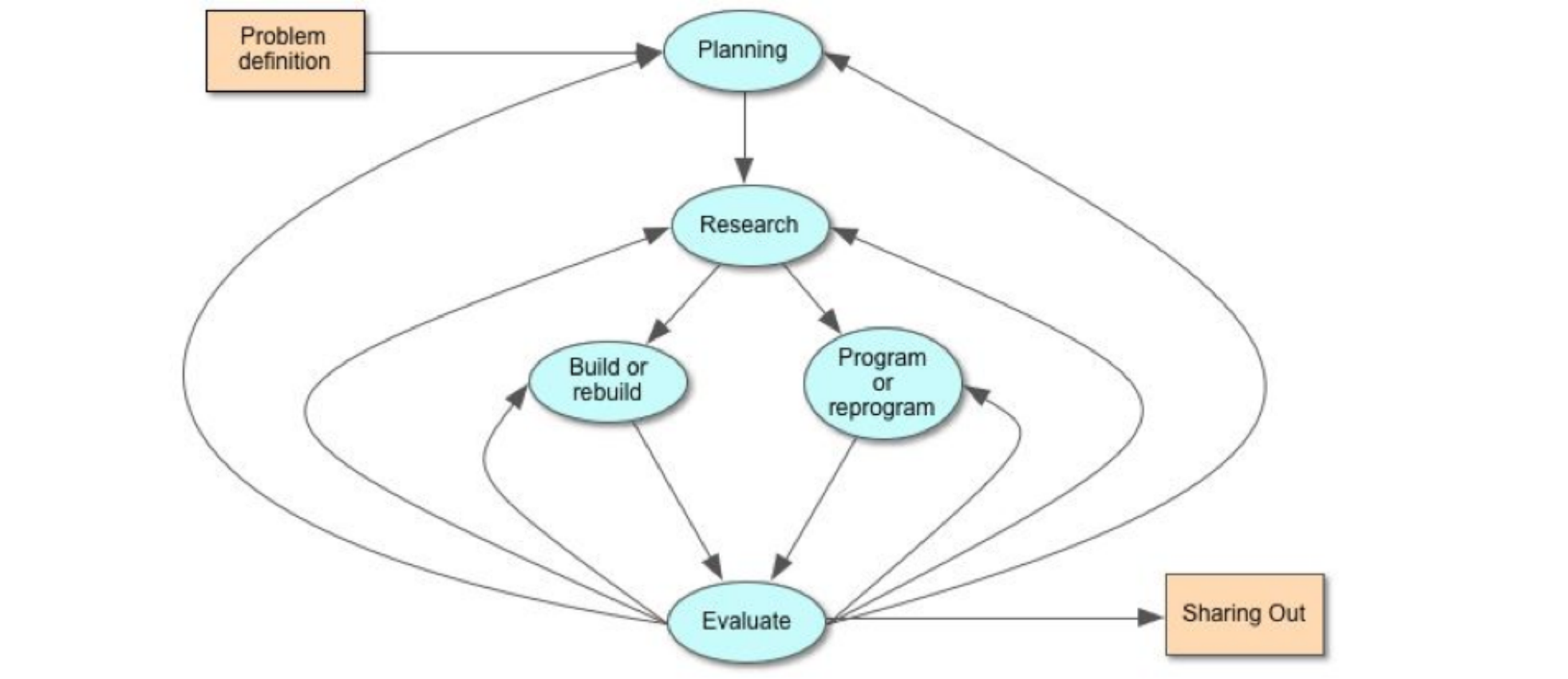
- We don't want students to memorize steps
- We want them to be good at practices that support finding solutions
  - Leveraging their knowledge in math, science, ELA
  - Know when to persist and when to start over

CROSS CASE STUDY OF ELEMENTARY ENGINEERING TASK

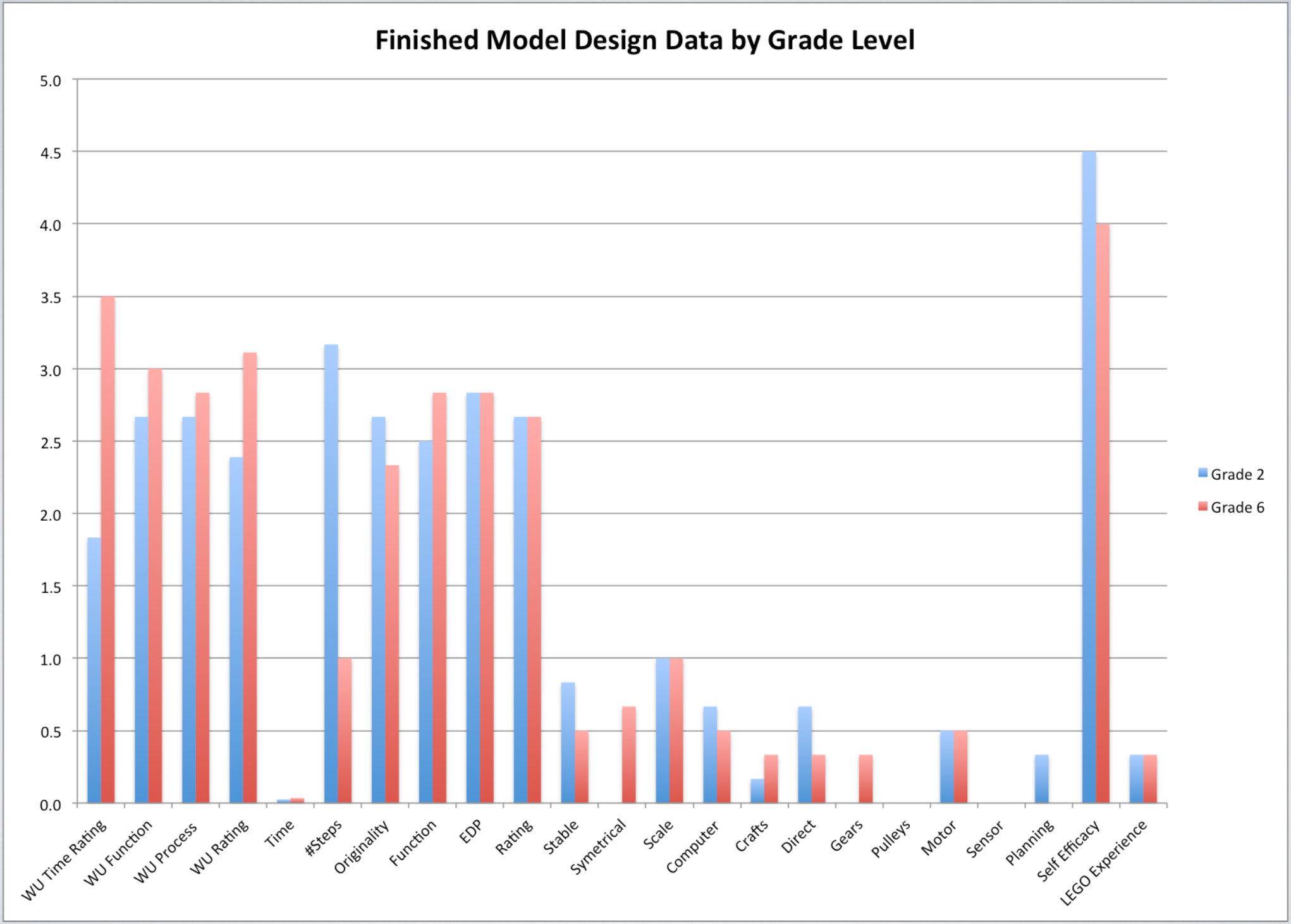


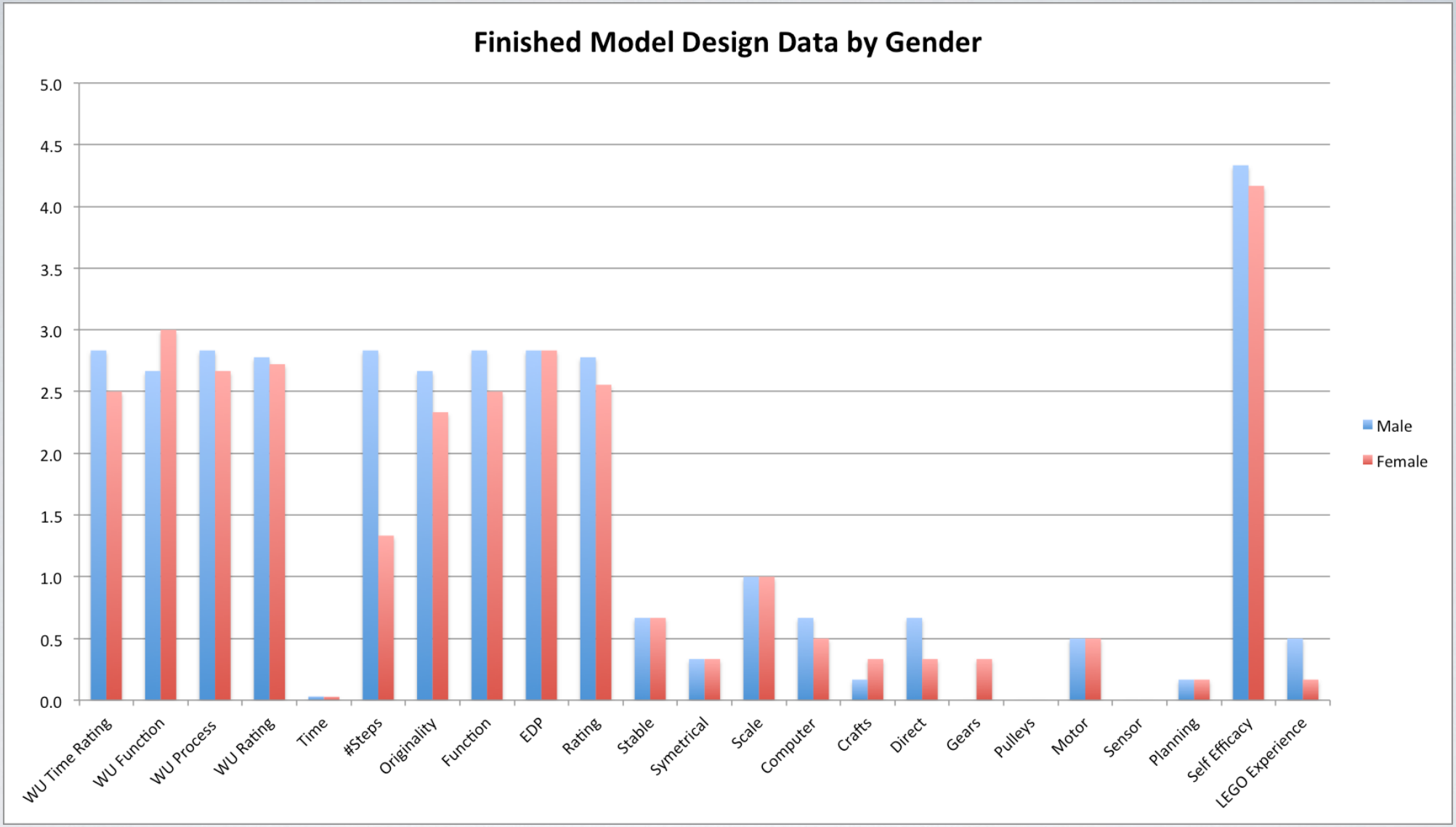
RESEARCH QUESTION

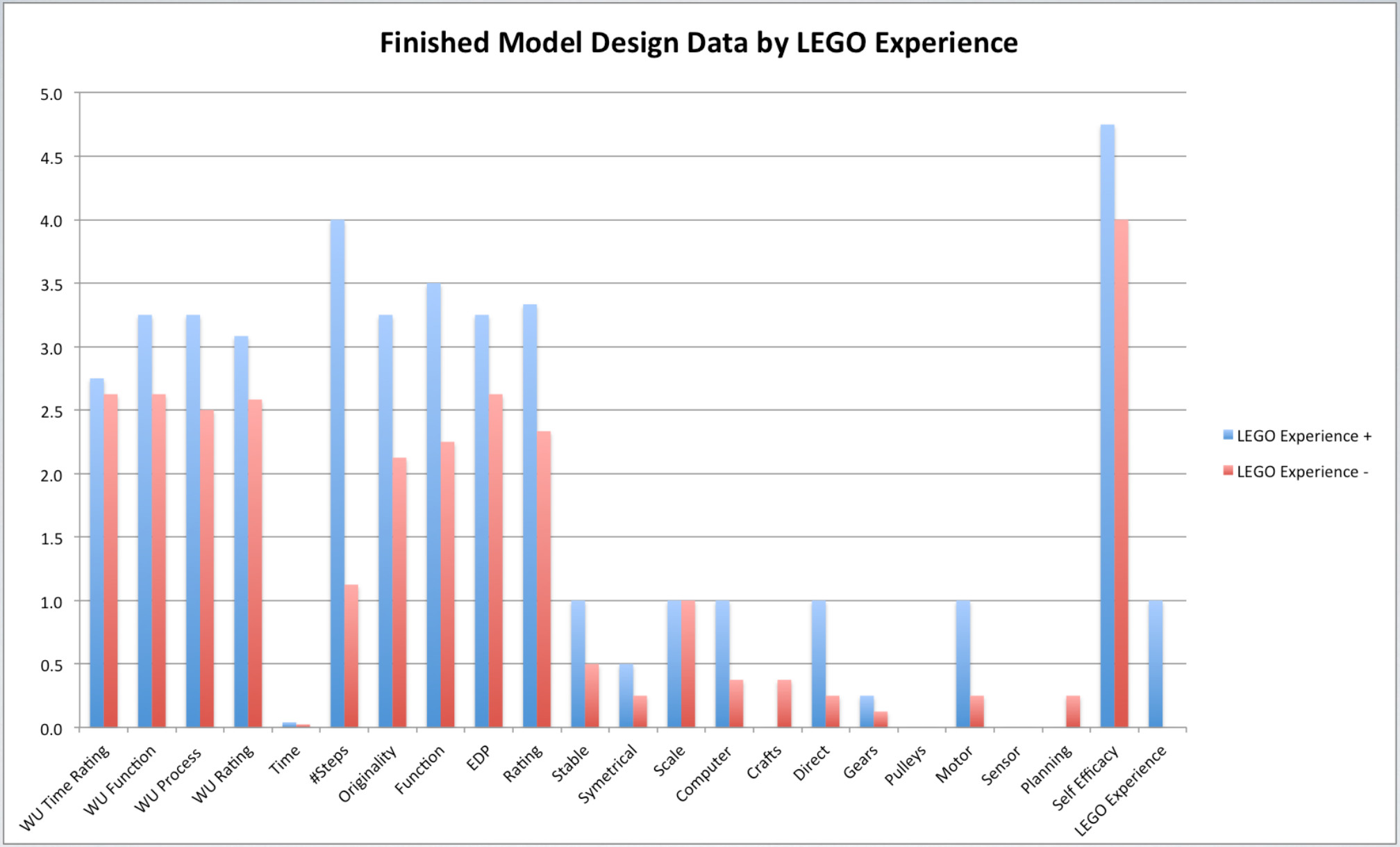
- Do grade 2 and grade 6 students' engineering design processes and final products differ? If so, what are the specific differences?
- Do male and female students' engineering design processes and final products differ? If so, what are the specific differences?
- Added: if differences are not seen by gender and grade level, what relationships do explain the differing final products and engineering design processes of elementary students?
- First, need an EDP model for this study

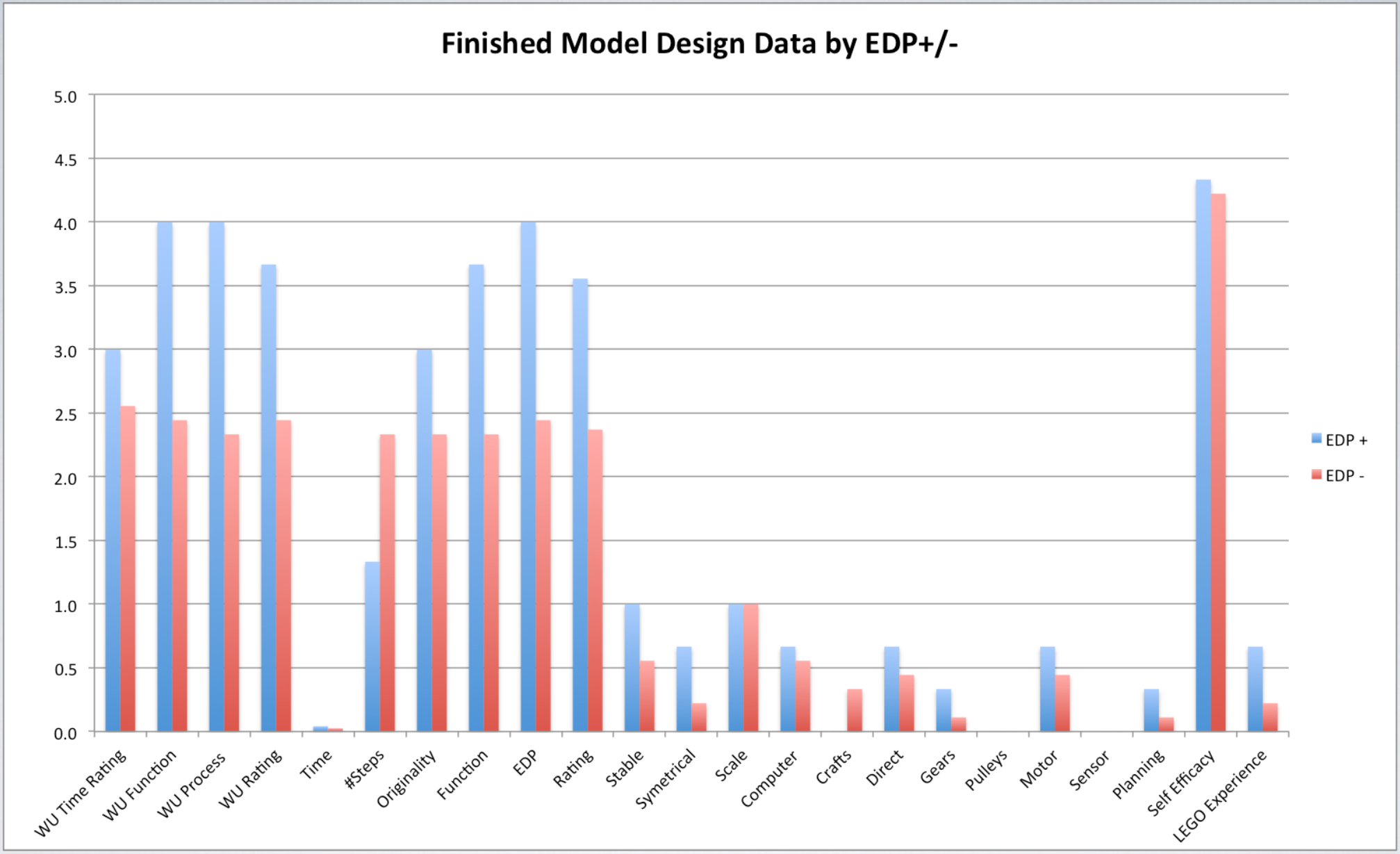


Engineering design process model for this study


Finished Model Design Data by Grade Level
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
WU Time Rating
WU Function
WU Process
WU Rating
Time
#Steps
Originality
Function
EDP
Rating
Stable
Symetrical
Scale
Computer
Crafts
Direct
Gears
Pulleys
Motor
Sensor
Planning
Self Efficacy
LEGO Experience
Grade 2
Grade 6

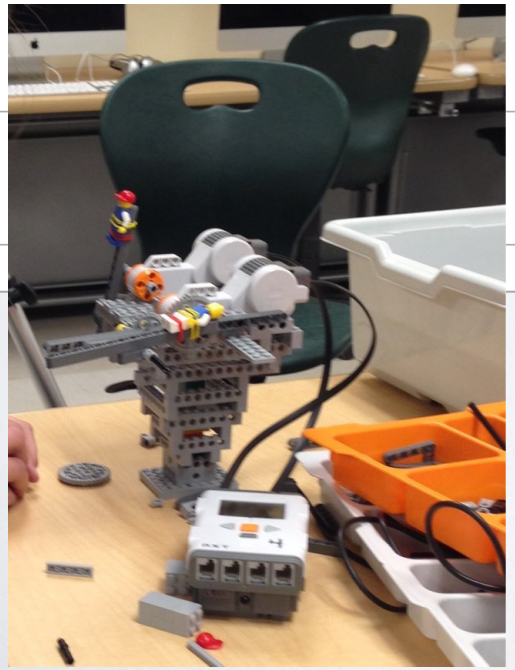

Finished Model Design Data by Gender
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
WU Time Rating
WU Function
WU Process
WU Rating
Time
#Steps
Originality
Function
EDP
Rating
Stable
Symetrical
Scale
Computer
Crafts
Direct
Gears
Pulleys
Motor
Sensor
Planning
Self Efficacy
LEGO Experience
Male
Female


Finished Model Design Data by LEGO Experience
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
WU Time Rating
WU Function
WU Process
WU Rating
Time
#Steps
Originality
Function
EDP
Rating
Stable
Symetrical
Scale
Computer
Crafts
Direct
Gears
Pulleys
Motor
Sensor
Planning
Self Efficacy
LEGO Experience
LEGO Experience +
LEGO Experience -


Finished Model Design Data by EDP+/-
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
WU Time Rating
WU Function
WU Process
WU Rating
Time
#Steps
Originality
Function
EDP
Rating
Stable
Symetrical
Scale
Computer
Crafts
Direct
Gears
Pulleys
Motor
Sensor
Planning
Self Efficacy
LEGO Experience
EDP +
EDP -

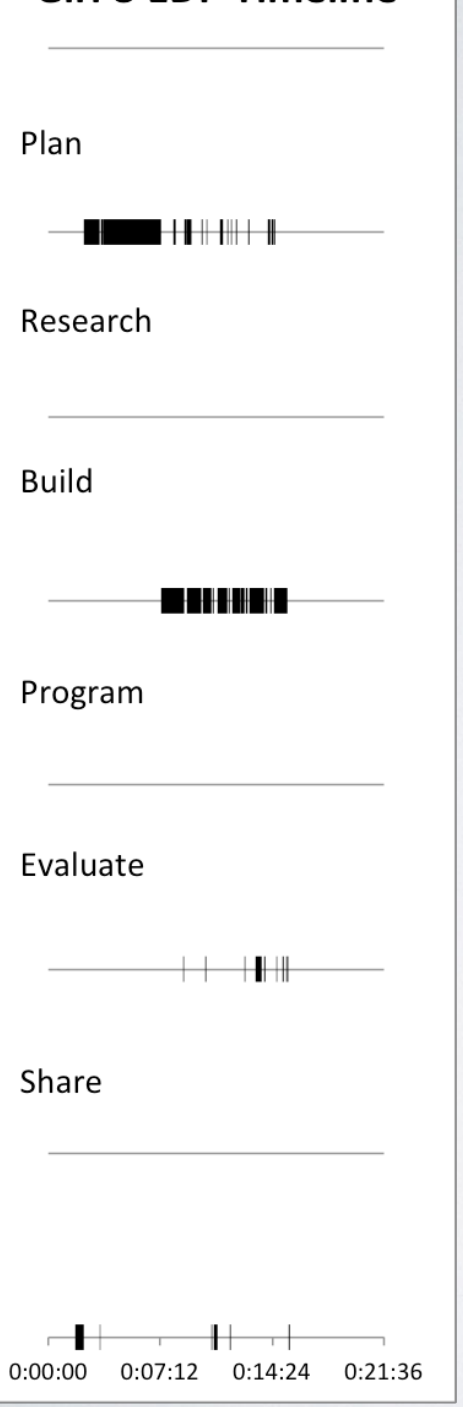
Subject	Structural Knowledge	Math/ Science	Design Principles	EDP Process	CR	Planning	CF	Overall Knowledge and Process Rating (Tools)	Build Complexity
Boy 06	Medium	Low	Low	High	High	Low	High	Medium	High
Boy 07	Medium	Low	Medium	Medium	Medium	Low	Low	Medium	Medium
Boy 08	Low	High	Low	High	Low	High	Low	Low*	Medium
Girl 06	Low	Low	Medium	Medium	Low	Low	Medium	Low	Low
Girl 08	High	High	High	High	High	High	Medium	High	Low
Girl 09	Low	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium
Boy 03	Low	Low	Low	Low	Medium	Low	Medium	Low	Low
Boy 04	High	Medium	High	Medium	High	Low	Medium	Medium	Low
Boy 05	High	Medium	High	Medium	High	High	Medium	High	High
Girl 03	Low	Low	Low	Medium	Low	Low	Low	Low	High
Girl 04	Low	Low	Medium	Medium	High	Medium	Medium	Medium	Medium
Girl 05	High	High	High	High	High	High	High	High	High

High complexity, high tools



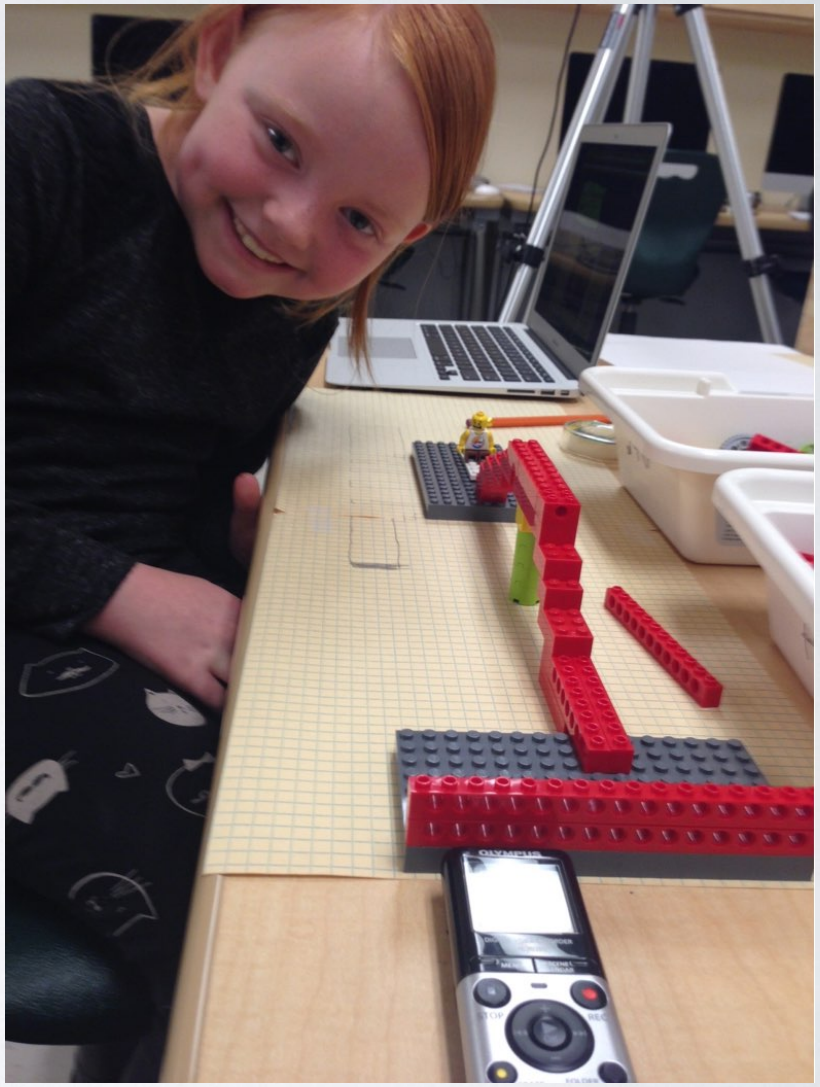
Gender Subject	Girl 5
Grade Level	6
Model Rating	3.7
Prelim EDP Rating	4
LEGO Experience	1
Motor	1
SK	High
Math/Science	High
Design Principles	High
EDP Process	High
CR	High
Plan-Ahead	High
CF	High

Girl 8 EDP Timeline

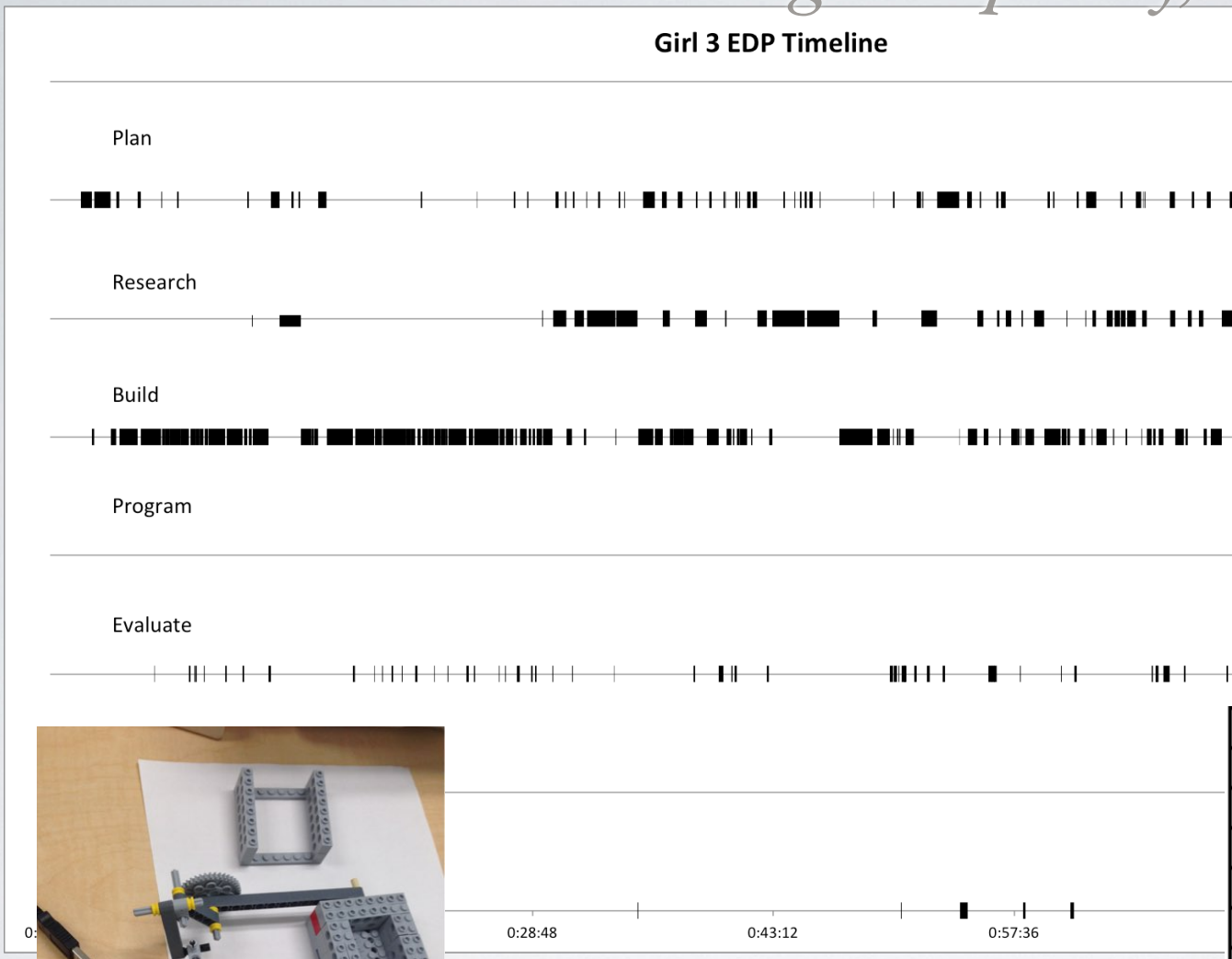


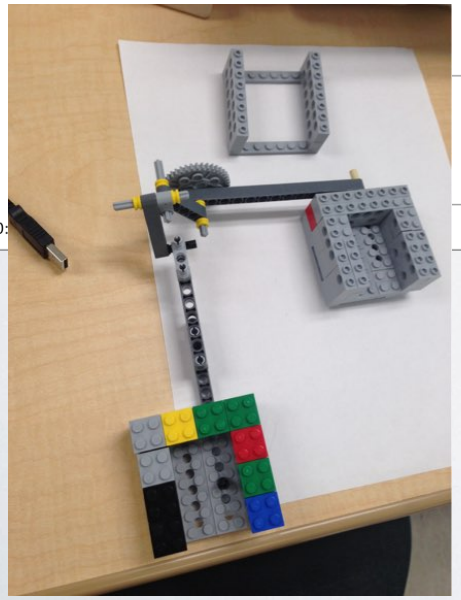
Low complexity, high tools

Gender Subject	Girl 8
Grade Level	2
Model Rating	3.3
Prelim EDP Rating	4
LEGO Experience	0
Motor	0
SK	High
Math/Science	High
Design Principles	High
EDP Process	High
CR	High
Plan-Ahead	High
CF	Medium



High complexity, low tools





Gender Subject	Girl 3
Grade Level	6
Model Rating	1.3
Prelim EDP Rating	2
LEGO Experience	0
Motor	1 (Intended)
SK	Low
Math/Science	Low
Design Principles	Low
EDP Process	Medium
CR	Low
Plan-Ahead	Low
CF	Low

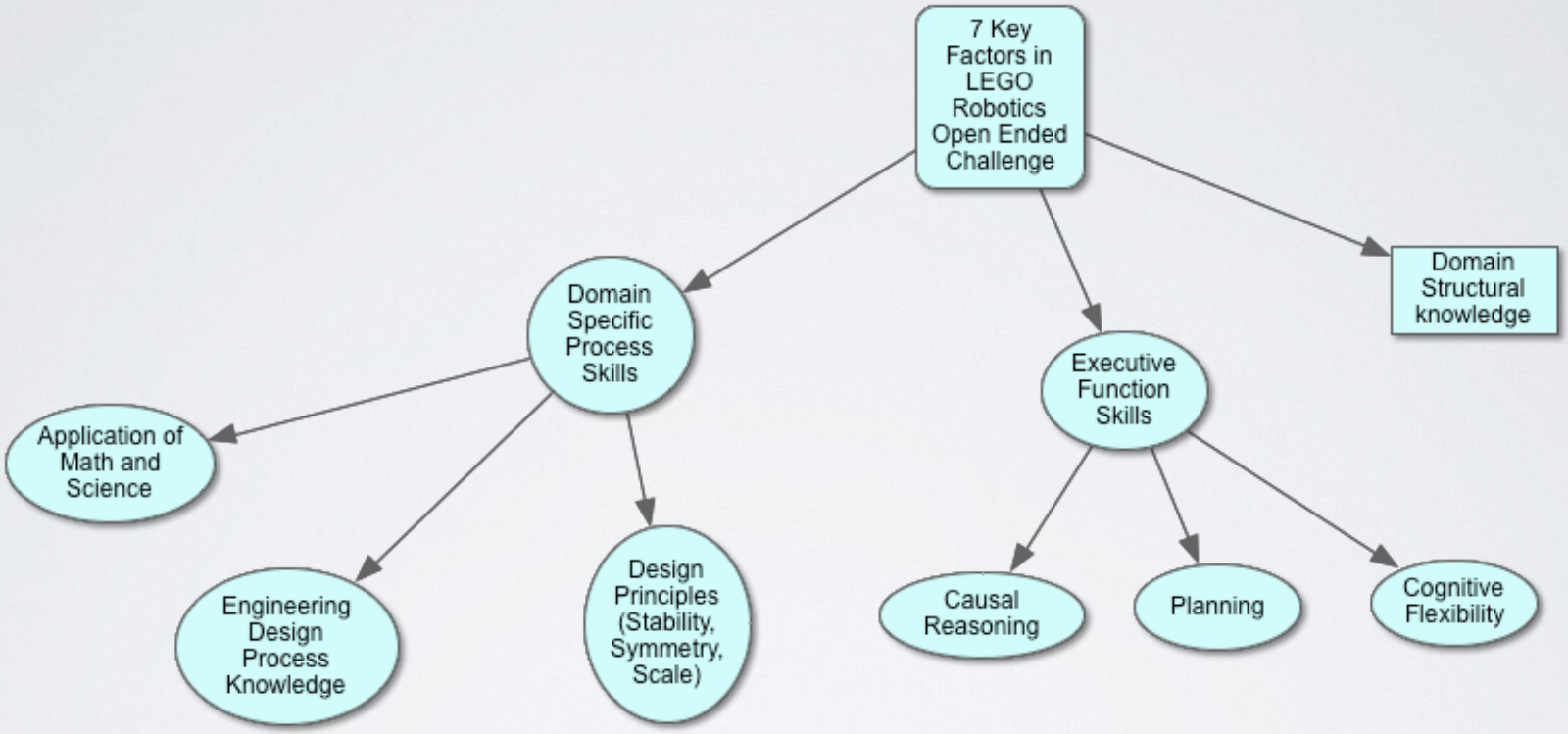
Never finished

Complexity / Tools	Low	Medium	High
Low	Boy 3, Girl 6	Boy 8	Girl 3
Medium	Boy 4	Girl 4, Boy 7, Girl 9, Boy 6	
High	Girl 8		Girl 5, Boy 5

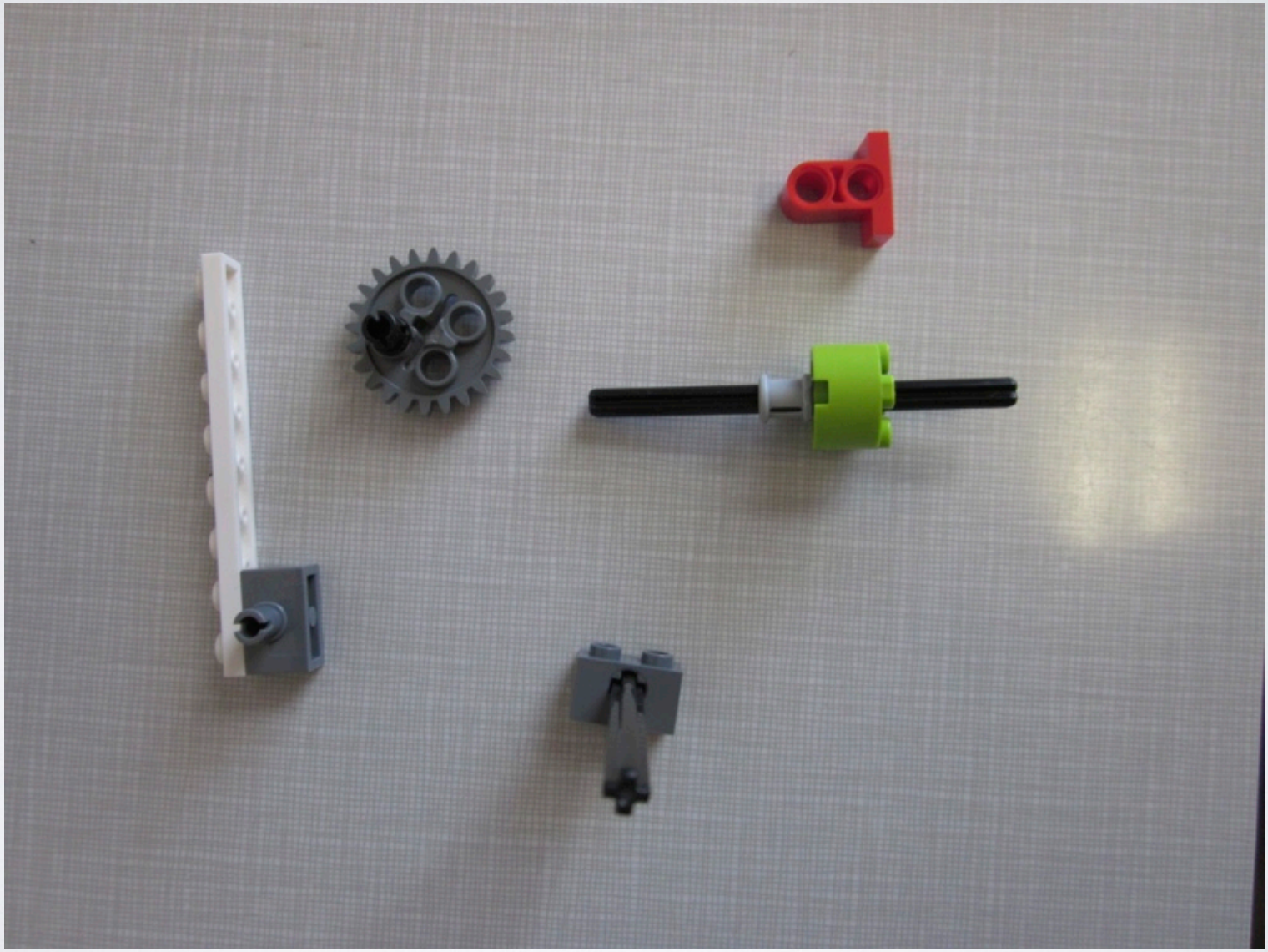
Look at graphs especially outliers:

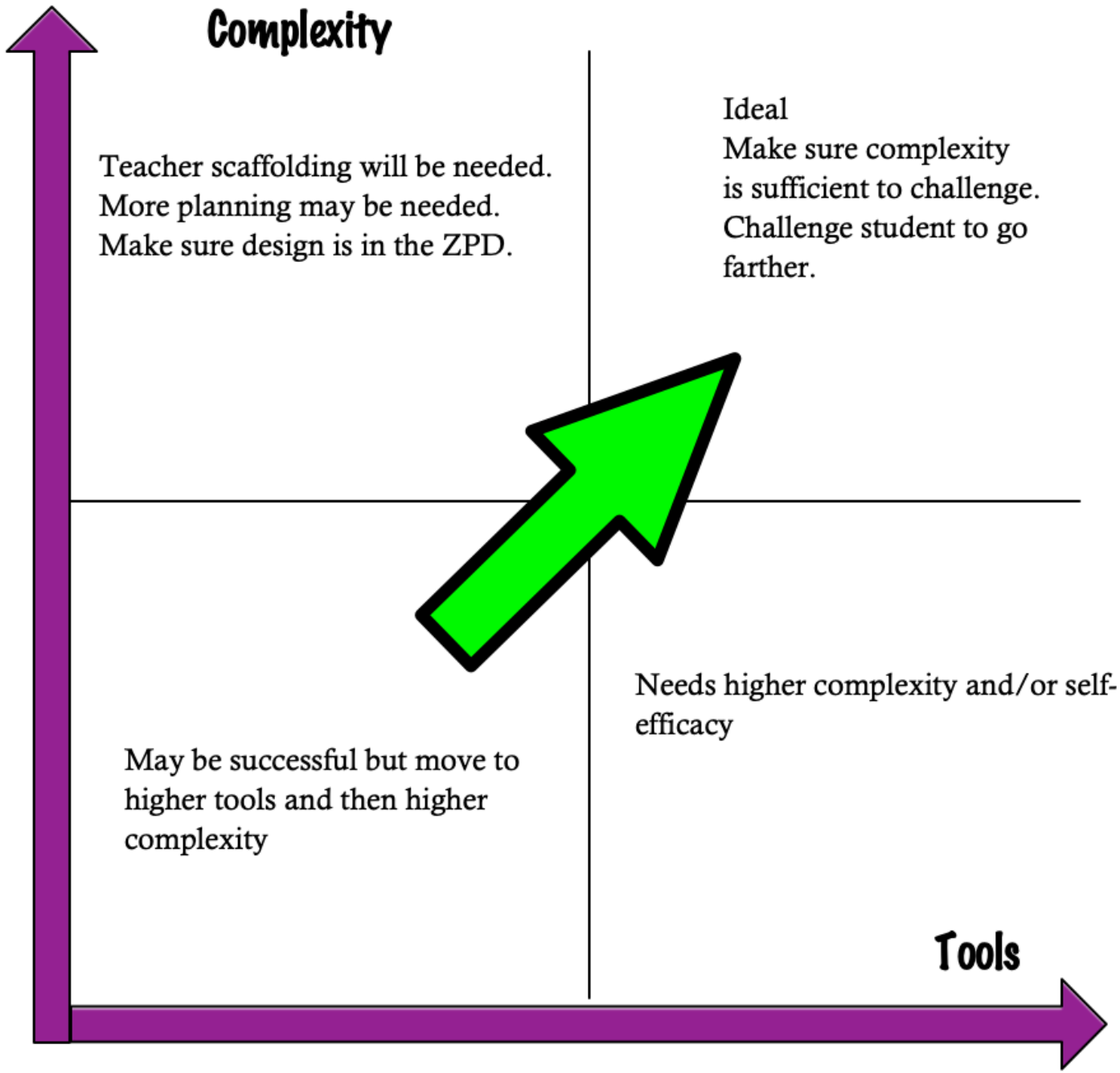
- *Girl 5, Boy 5 - dense, mix of phases throughout*
- *Boy 3, Girl 6 - build away!*
- *Girl 3 - DNF, ongoing research and planning, which never resolved issues, serial building did not work for her*
- *Girl 8 - "idealized" EDP - plan and build*

SEVEN FACTORS



KEY WEDO | CONNECTORS




Complexity
Teacher scaffolding will be needed.
More planning may be needed.
Make sure design is in the ZPD.
Ideal
Make sure complexity
is sufficient to challenge.
Challenge student to go
farther.
May be successful but move to
higher tools and then higher
complexity
Needs higher complexity and/or self-
efficacy
Tools

REFLECTION

- What was it like?
- What was new for you?
- What was challenging

TEACHER INTERVIEW

TO DO

- Add slides - MP
- Get materials (kits, devices, food, coffee, sign in sheet)
- Post presentation on kidsengineer.com
- Numbers (WCS=4, BES=11, NES=10, CO=1, SPED?) Say 30 so 15 kits and iPads
- Get art supplies for posters
- Setup room including screen and A/V