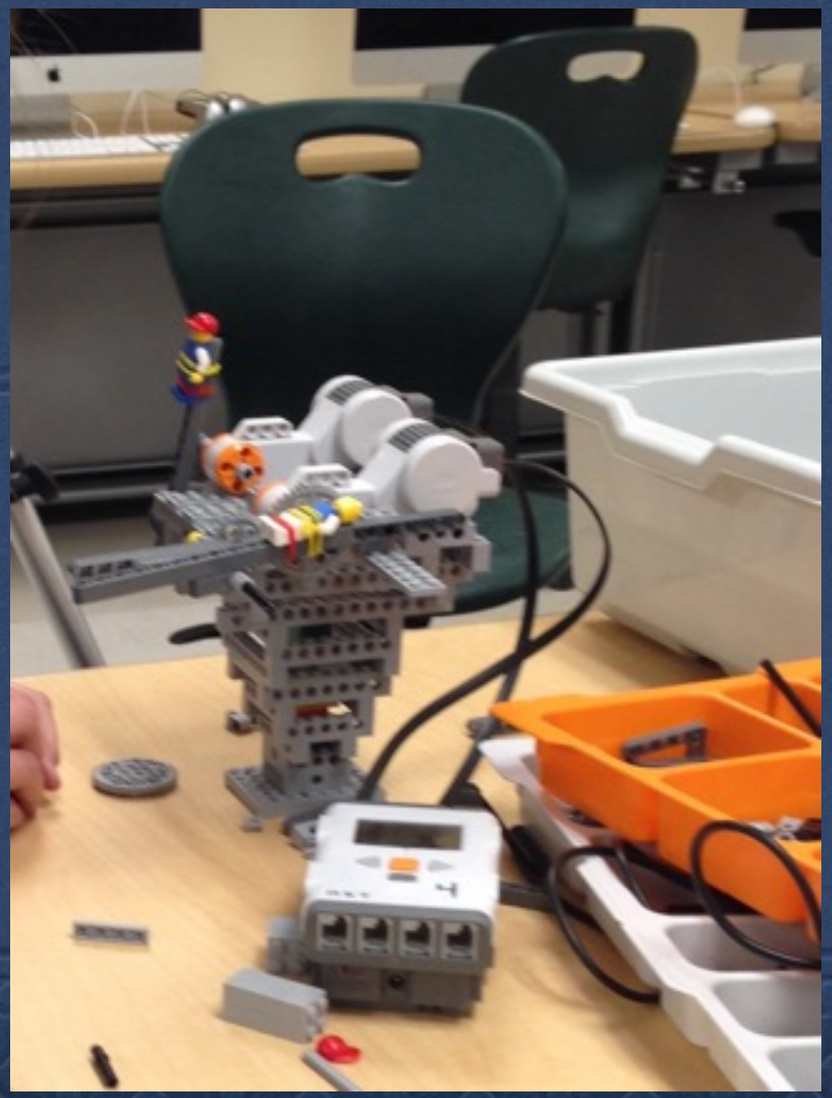
Cross Case Analysis of Elementary Engineering Task



John Heffernan - kidsengineer.com

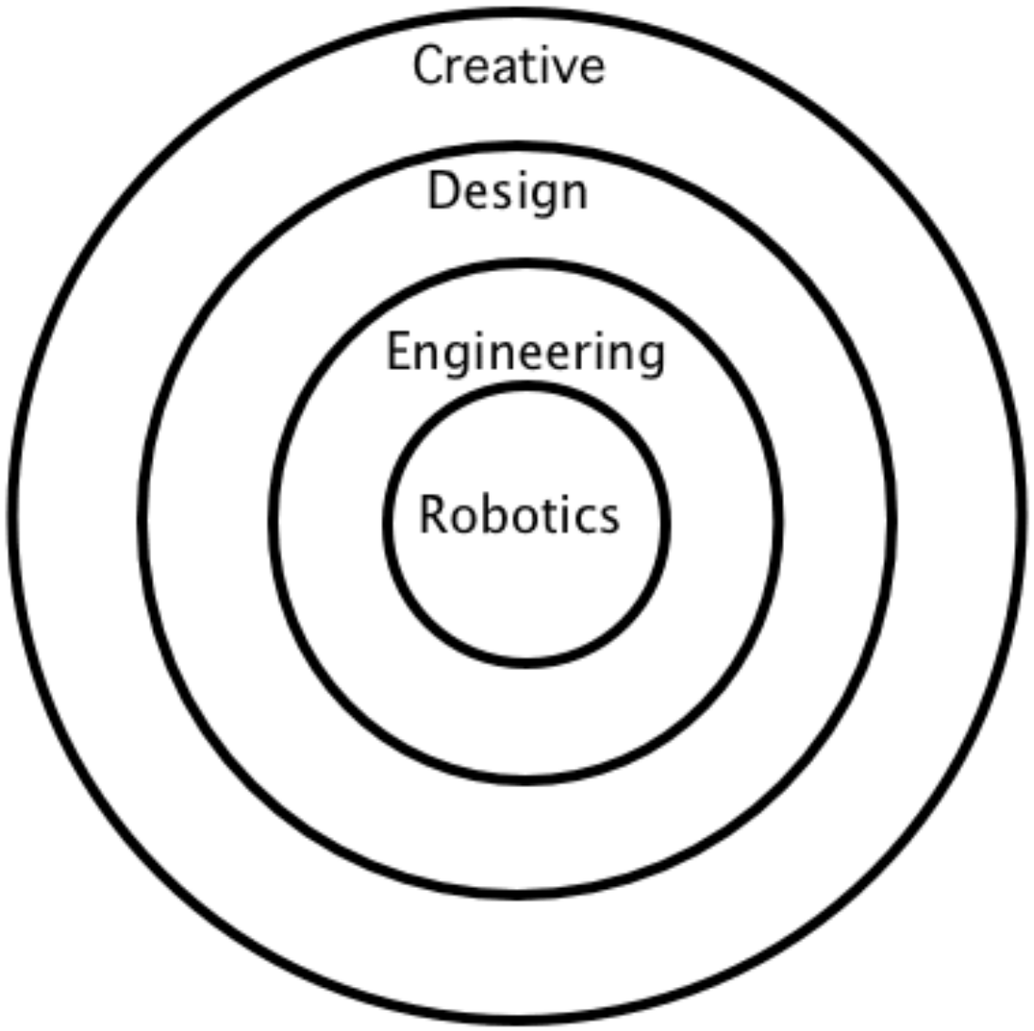
Problem Statement

- *Increasing academic focus resulting in loss of designerly play including engineering (Zhao, 2012).*
- *High need for diverse STEM workforce (Brophy, Portsmore, Klein, & Rogers, 2008).*
- *Start at elementary (Cunningham & Hester, 2007)*
  - *Children natural builders*
  - *Motivating, increase STEM pipeline*
  - *Integrate math and science*
  - *Problems solving, modeling, collaboration*

Research Questions

- *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?*
- *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?*

Literature Review

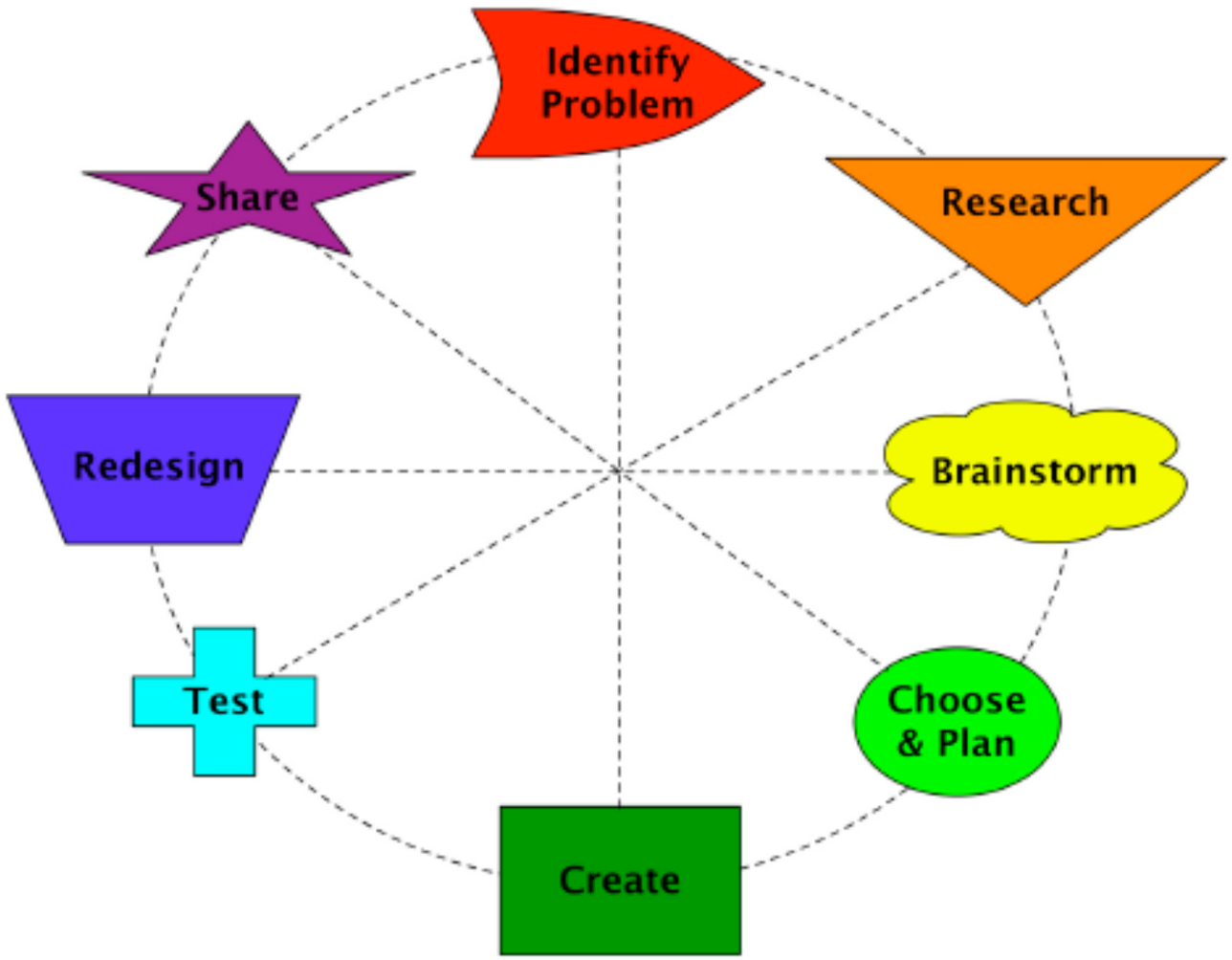


Existing EDP Research

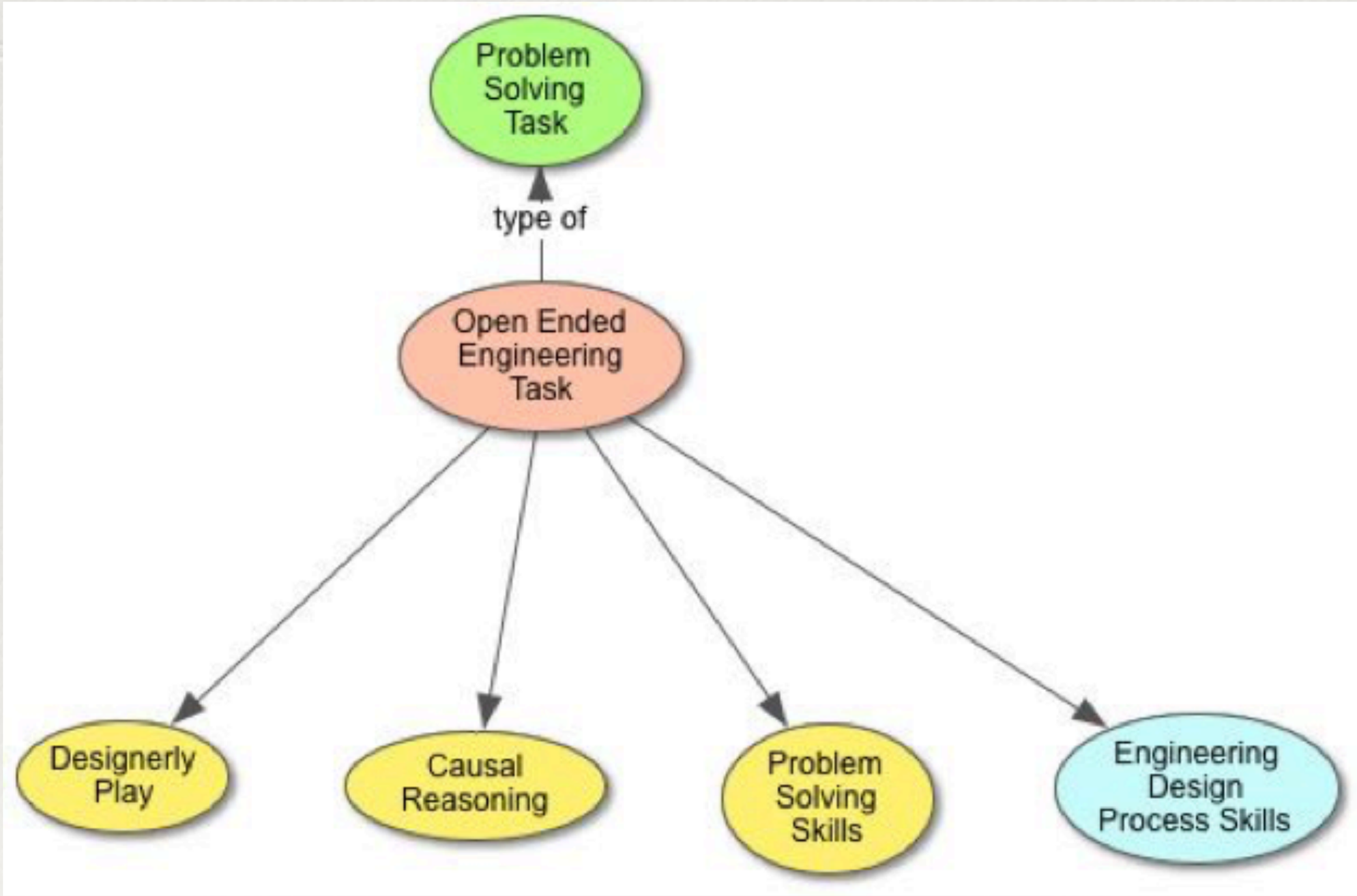
"While much is known about the design processes of older students and experts, there has not been a thorough and in-depth study of elementary student design processes and it is unknown if and how the conclusions and recommendations of these studies apply at the elementary level."

Portsmore (2011)

Engineering Design Process



Initial Conceptual Framework

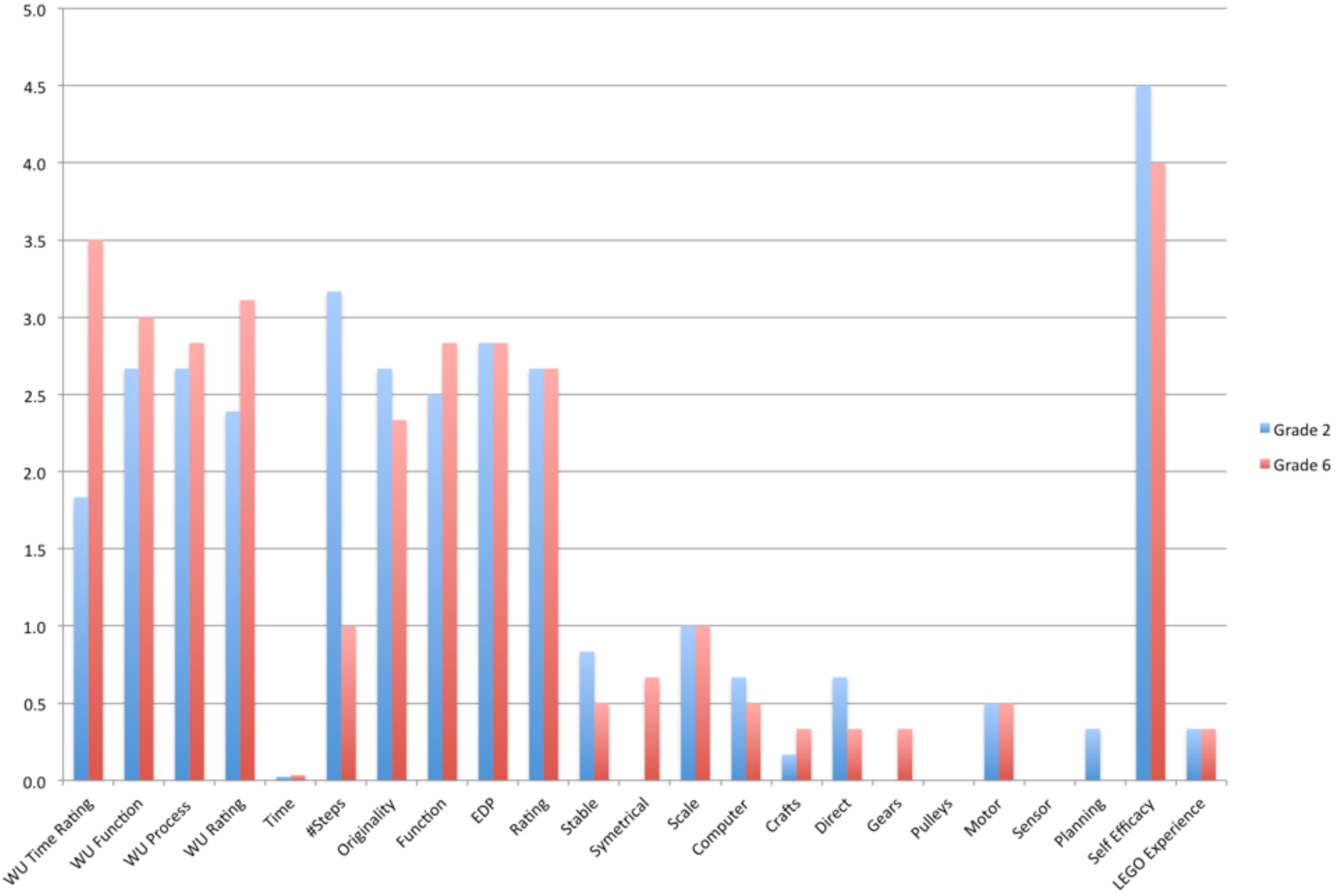


Methodology

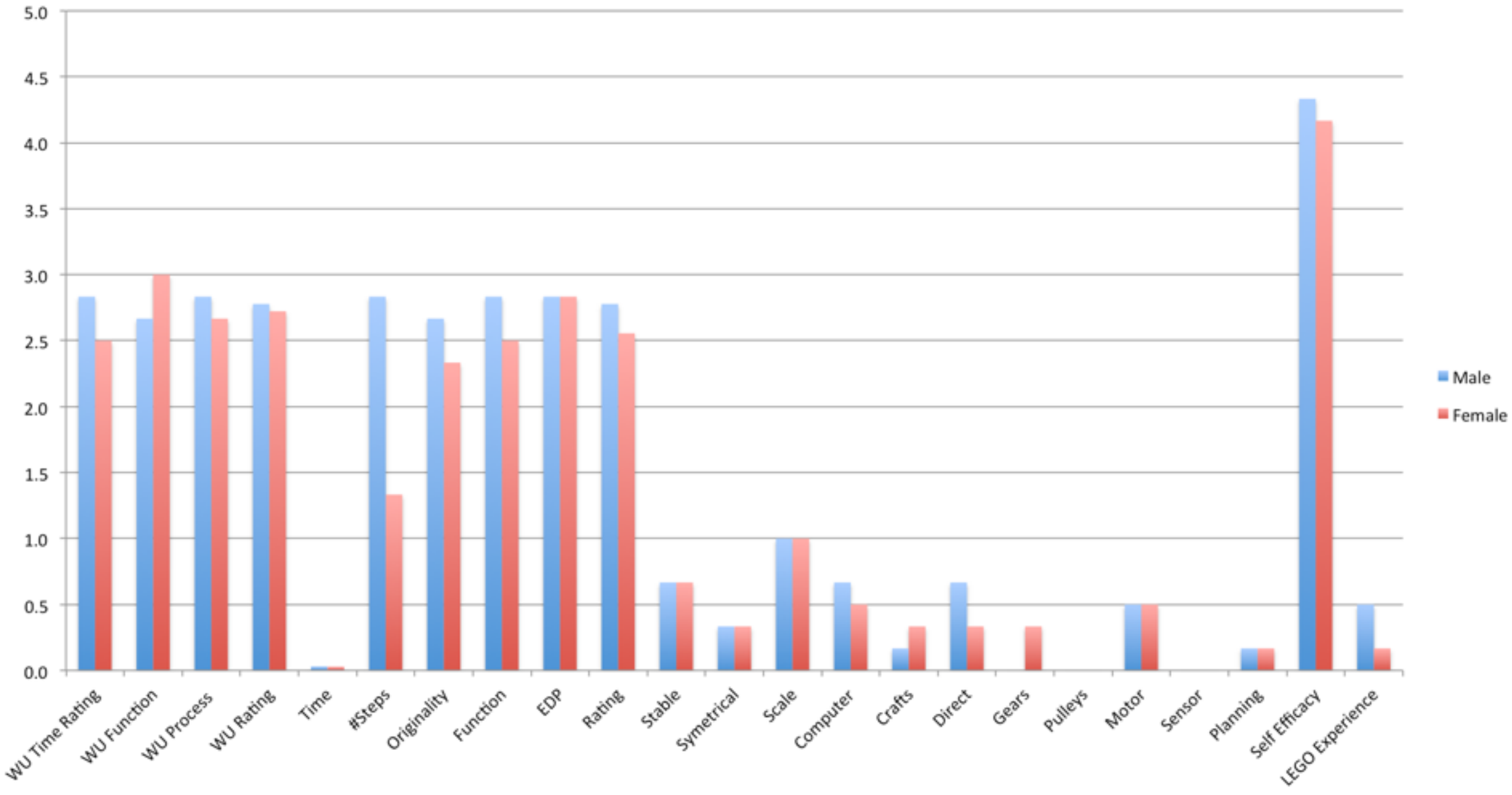
- *Qualitative, Cross Case, Cross-Sectional*
- *Semi-clinical video interview (Ginsburg, 1997)*
- *Talk aloud protocol (Ericsson & Simon, 1980)*

- *Filmed six second grade student and six grade six students doing same open-ended engineering task of amusement park ride with age-appropriate LEGO robotics materials and craft materials*
- *All students started with curriculum in K*
- *Qualitative analysis of EDP, finished rides, and EDP related codes and activity*

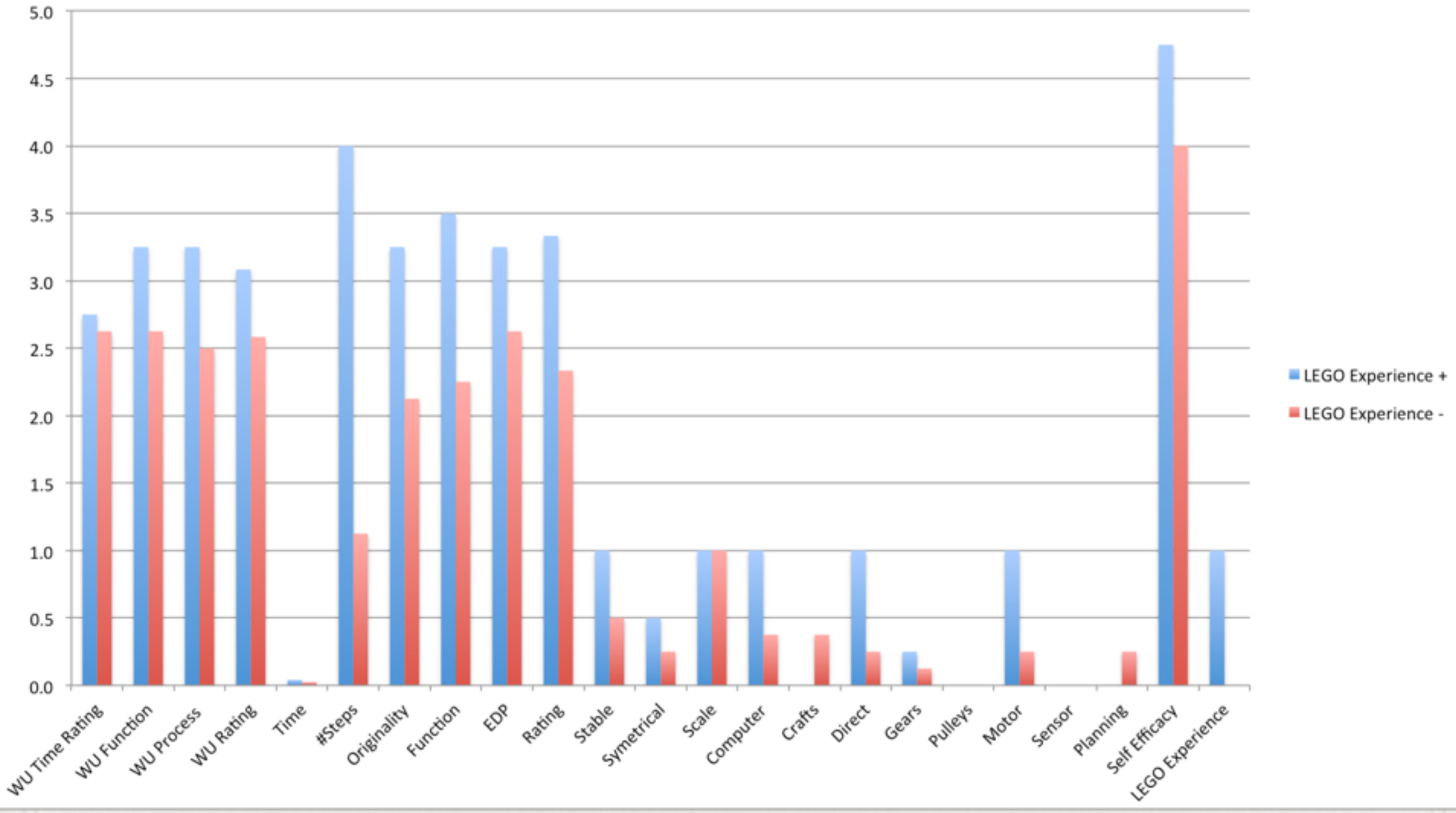
Finished Model Design Data by Grade Level



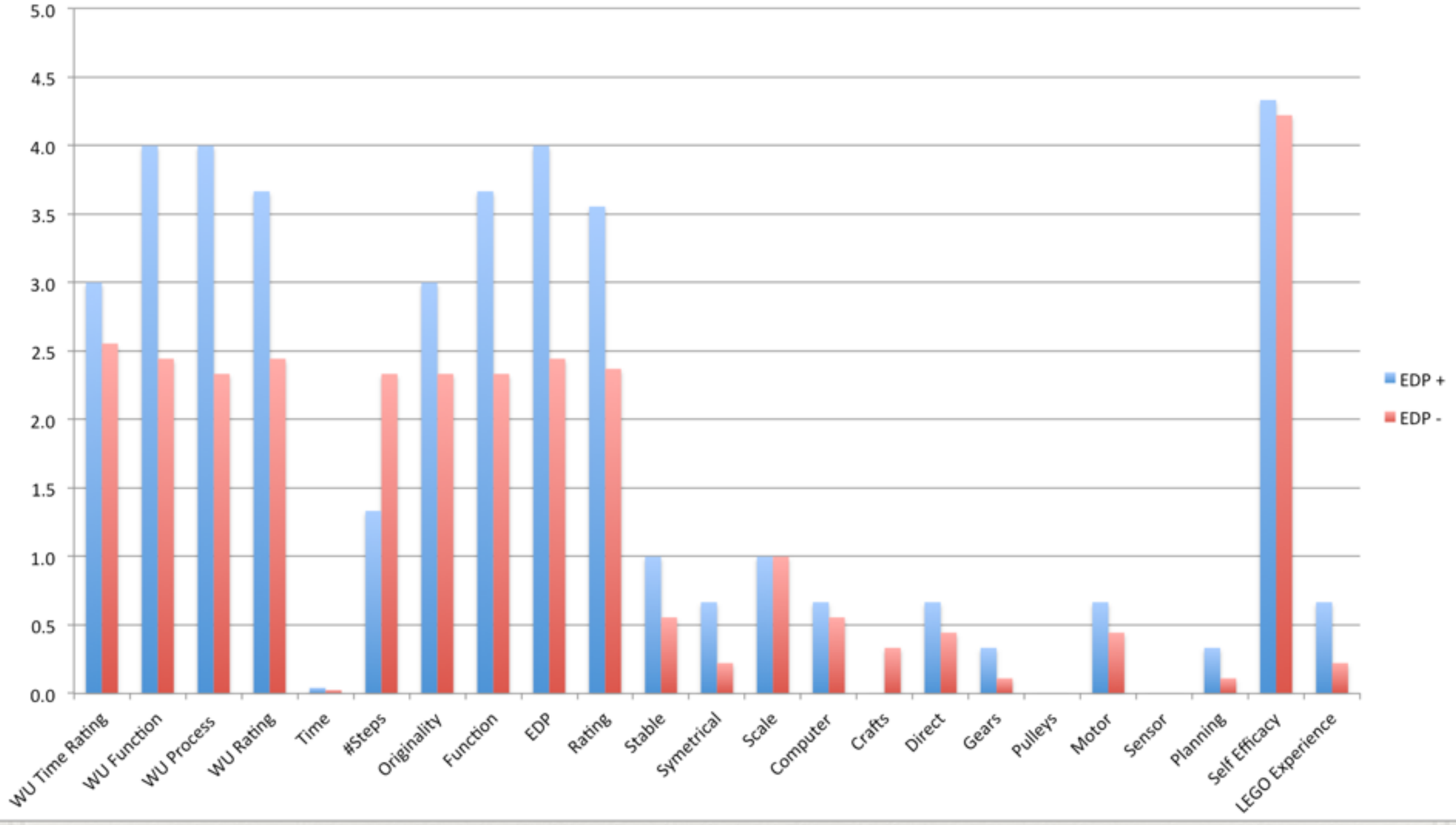
Finished Model Design Data by Gender



Finished Model Design Data by LEGO Experience



Finished Model Design Data by EDP+/-



Coded and Segmented Sample

Girl 5 Segmented Coded Example

[00:32:41] [EVALUATE] {moving}

[00:32:49] [PLAN] {no_activity}

Researcher: Yeah. There's always a challenge.

[00:32:51] [PLAN] {searching} Girl 05: Hmm. Trying to think about this.

[00:32:57] [RESEARCH] Girl 5: If I have this, that, that'll be upright. Yeah, that seems like it'll work. If I put one of these on each, I hope this will work. Put this on that, and that will run with ...

[00:32:53] {connecting}

[00:33:22] Girl 05: How am I going to connect that? It'll be like ...

[00:33:26] {moving}

[00:33:28] [BUILD] {connecting} Girl 05: Yeah, okay.

Researcher: Great idea.

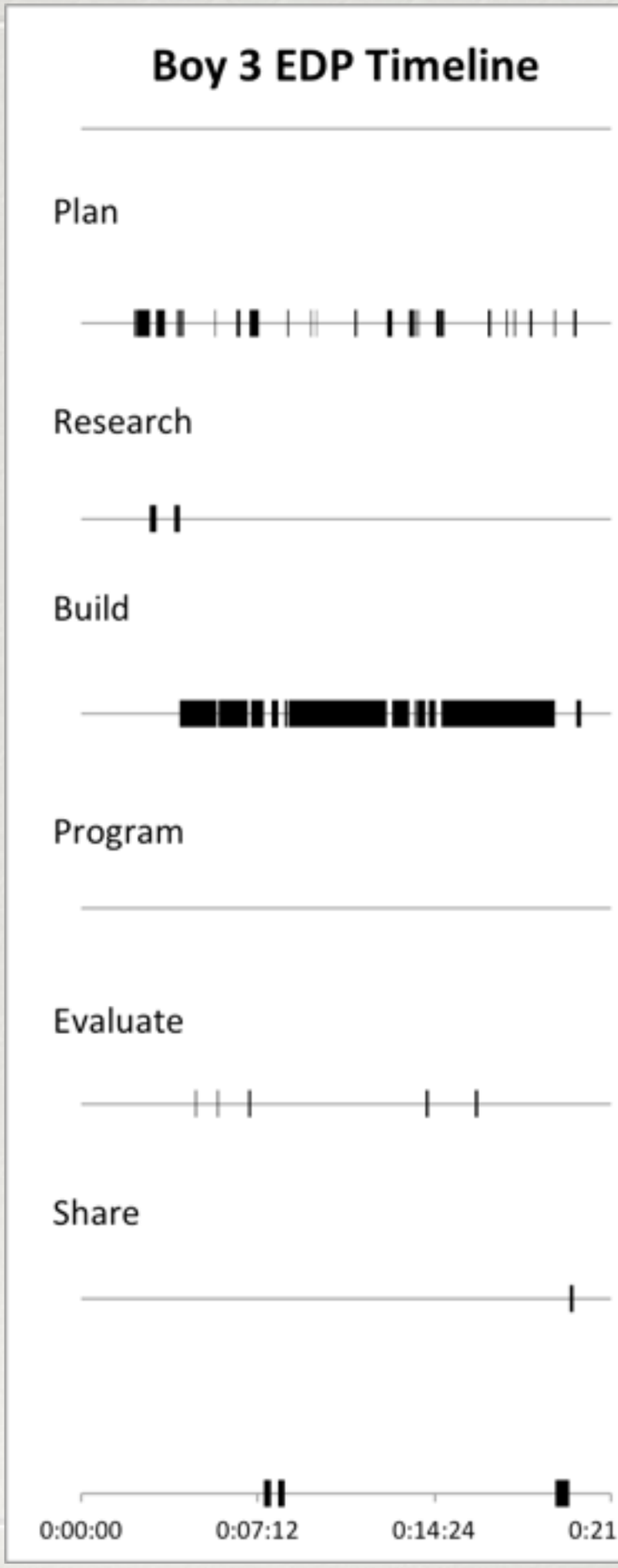
[00:33:33] {measuring} Girl 05: Okay, where did my middle ...

[00:33:37] Girl 05: Yeah. Then it'll ...

[00:33:38] {connecting}

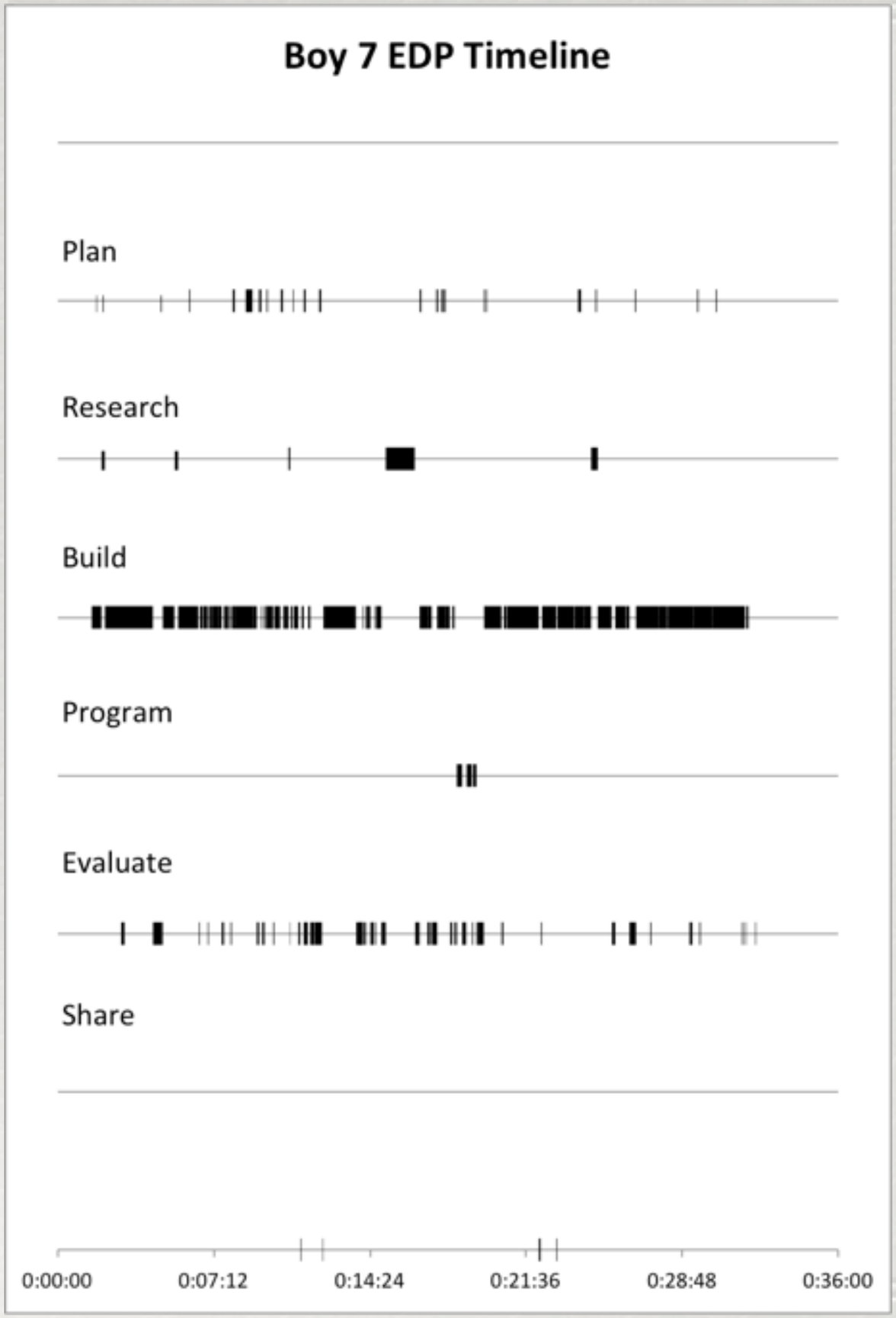
[00:33:40] [EVALUATE] {moving}

[00:33:42] Girl 05: Weird.

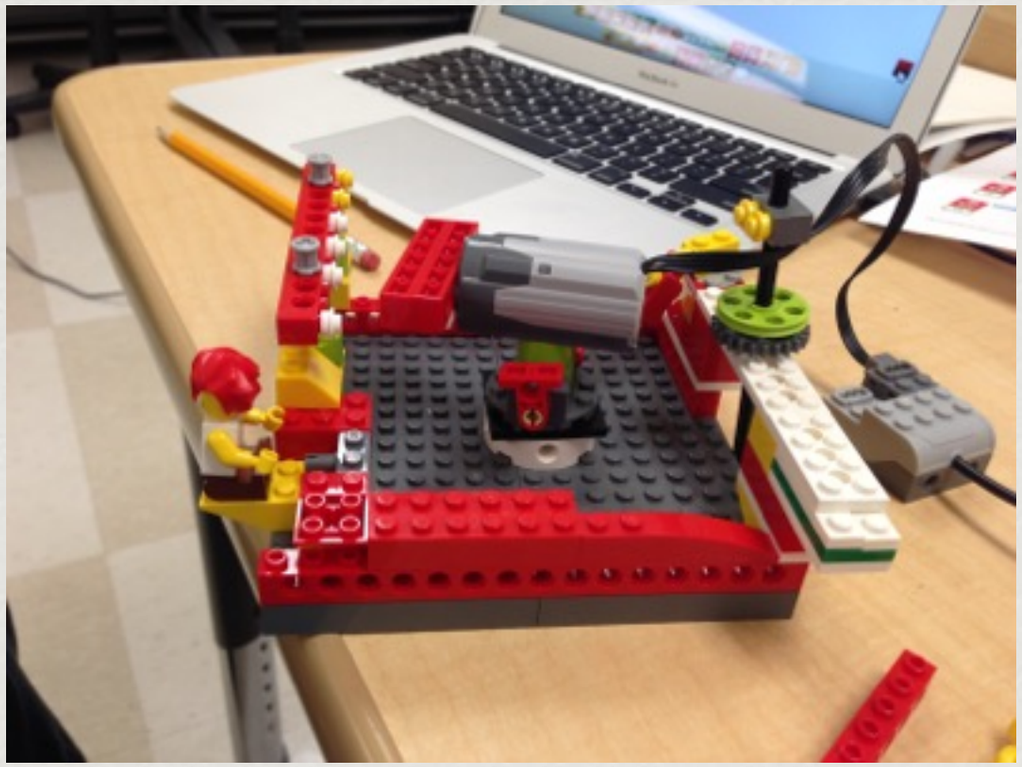


Low complexity, low tools

Gender Subject	Boy 3
Grade Level	6
Model Rating	2.0
Prelim EDP Rating	2
LEGO Experience	0
Motor	0
SK	Low
Math/Science	Low
Design Principles	Low
EDP Process	Low
CR	Medium
Plan-Ahead	Low
CF	Medium

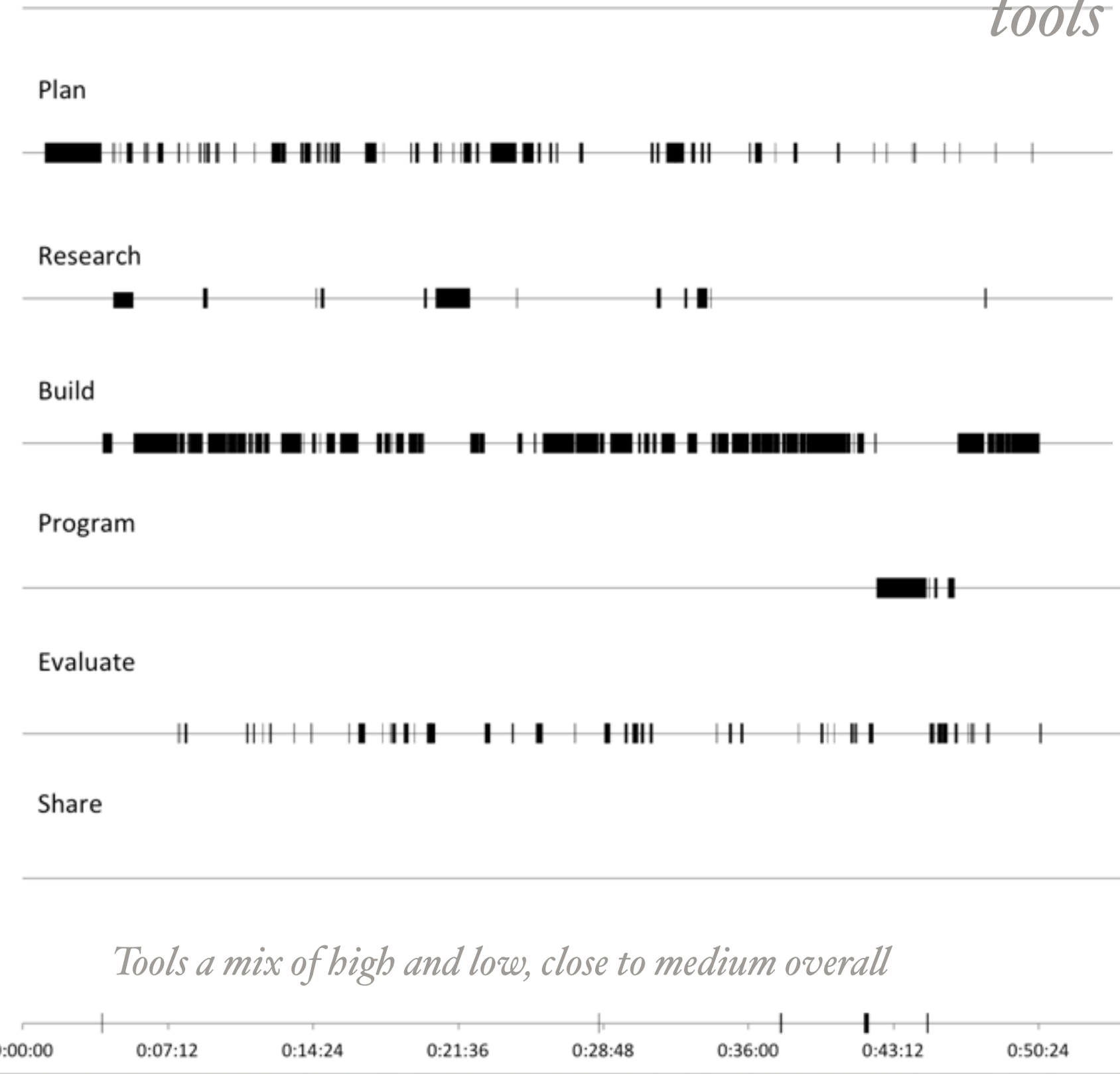


Medium complexity, medium tools

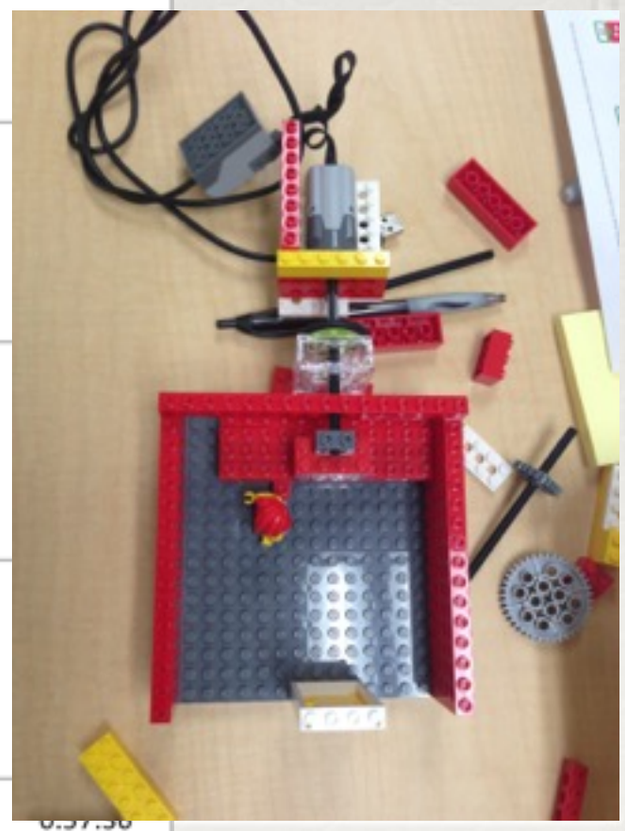


Gender Subject	Boy 7
Grade Level	2
Model Rating	3.0
Prelim EDP Rating	3
LEGO Experience	1
Motor	1
SK	Medium
Math/Science	Low
Design Principles	Medium
EDP Process	Medium
CR	Medium
Plan-Ahead	Low
CF	Low

Medium complexity, Low tools*

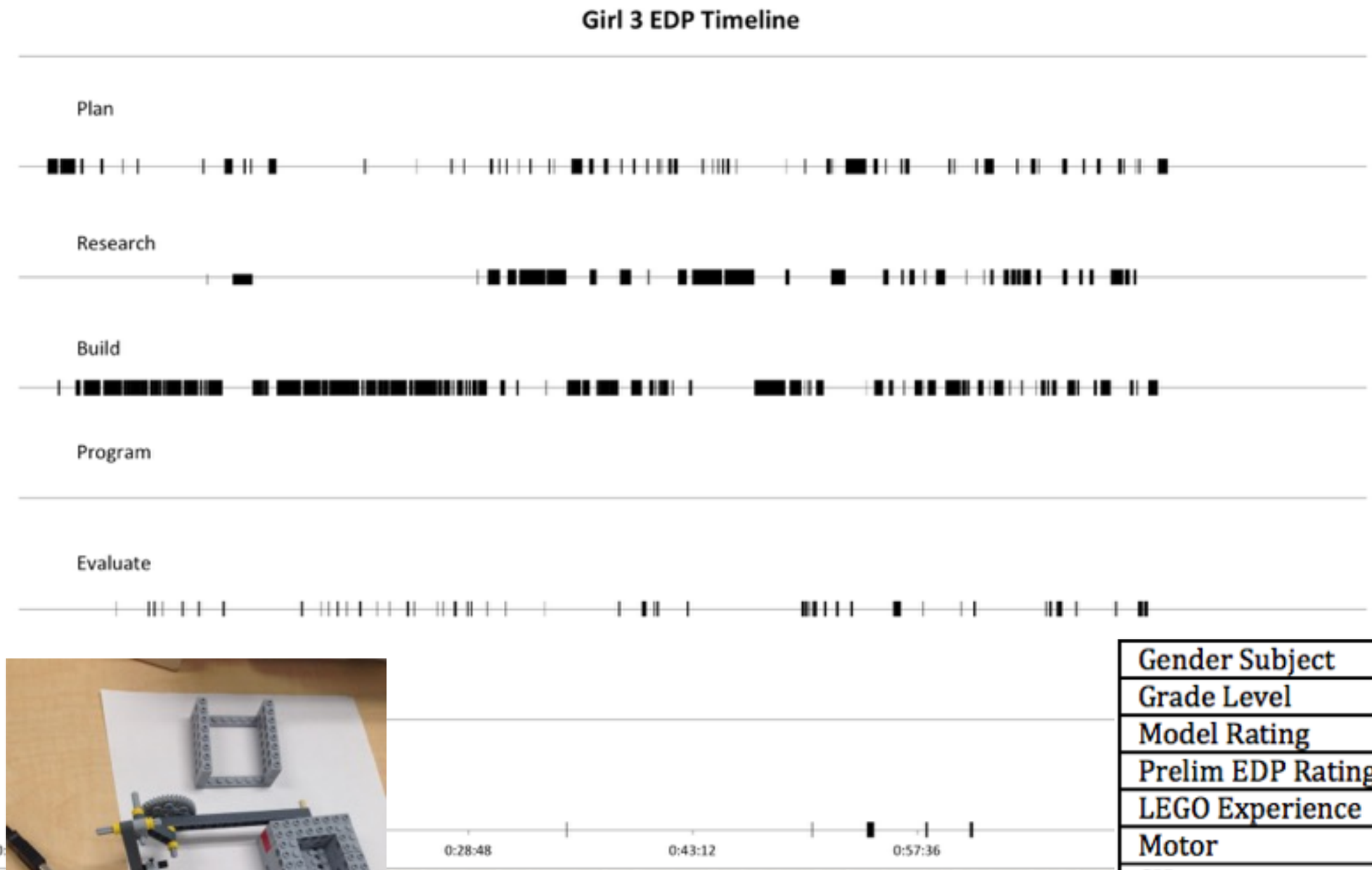


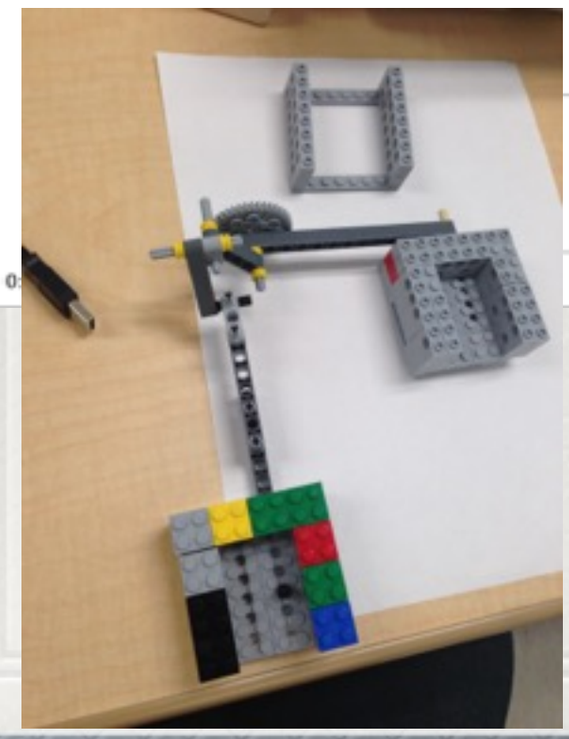
Gender Subject	Boy 8
Grade Level	2
Model Rating	2.3
Prelim EDP Rating	3
LEGO Experience	0
Motor	1
SK	Low
Math/Science	High
Design Principles	Low
EDP Process	High
CR	Low
Plan-Ahead	High
CF	Low



Tools a mix of high and low, close to medium overall

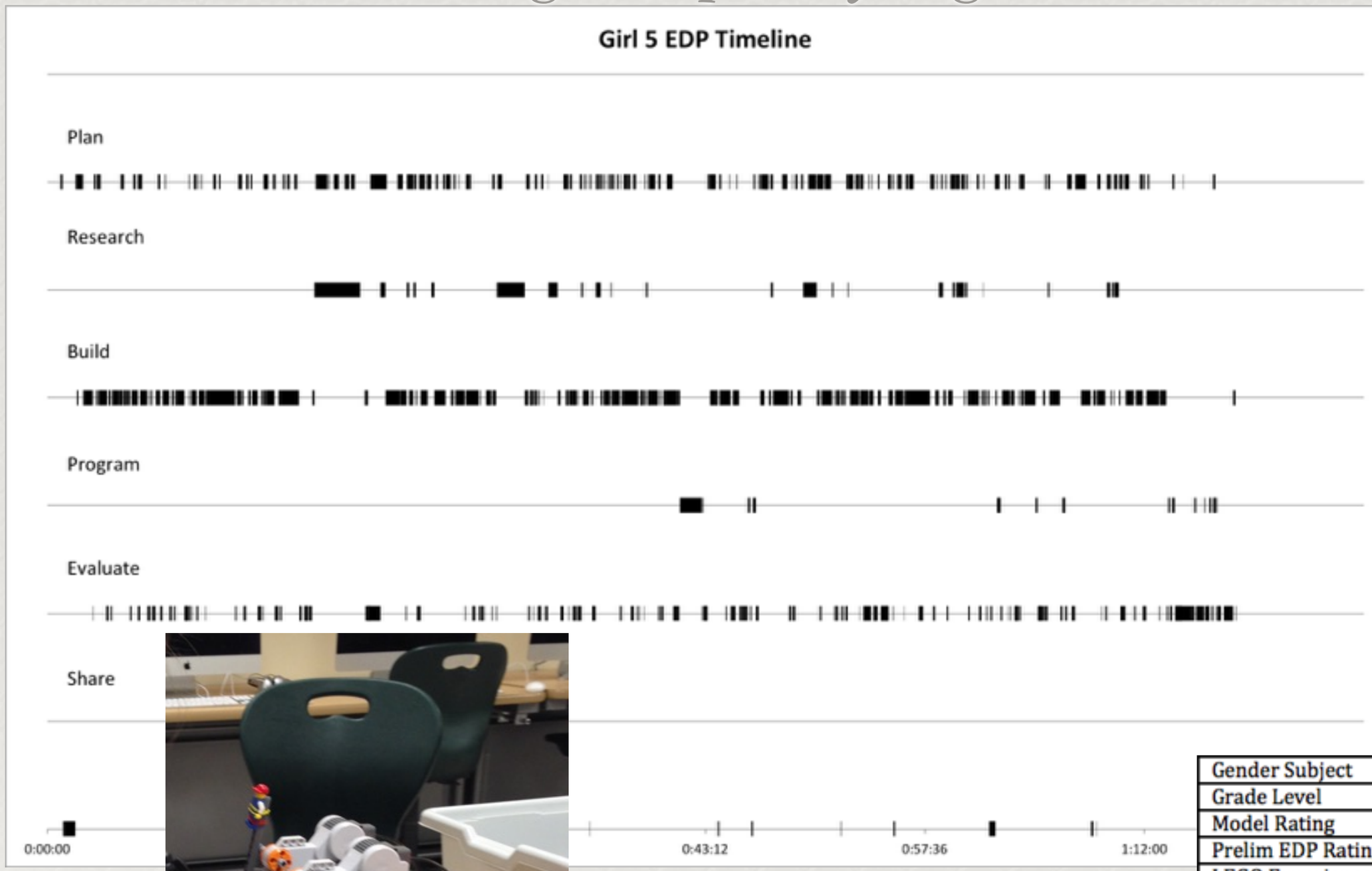
High complexity, low tools

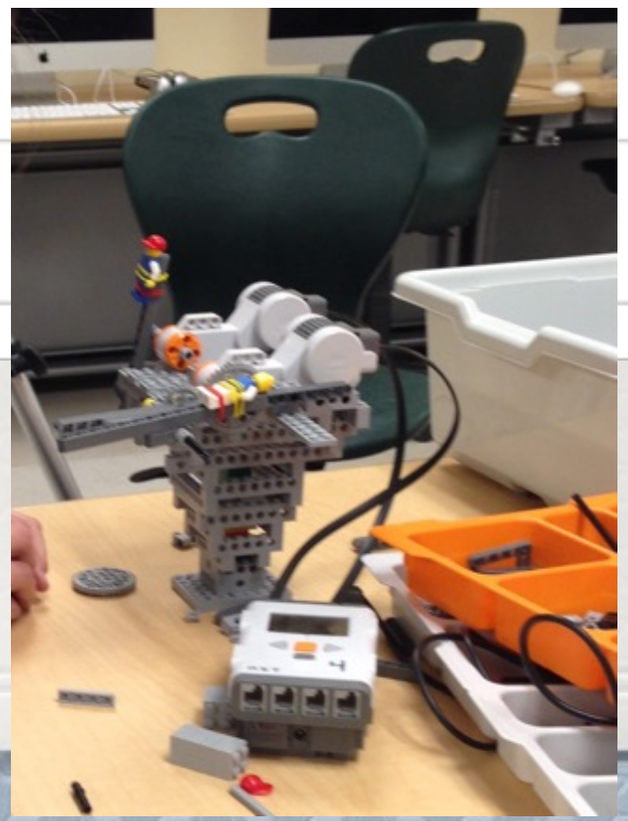




Gender Subject	Girl 3
Grade Level	6
Model Rating	1.3
Prelim EDP Rating	2
LEGO Experience	0
Motor	1 (Intended)
SK	Low
Math/Science	Low
Design Principles	Low
EDP Process	Medium
CR	Low
Plan-Ahead	Low
CF	Low

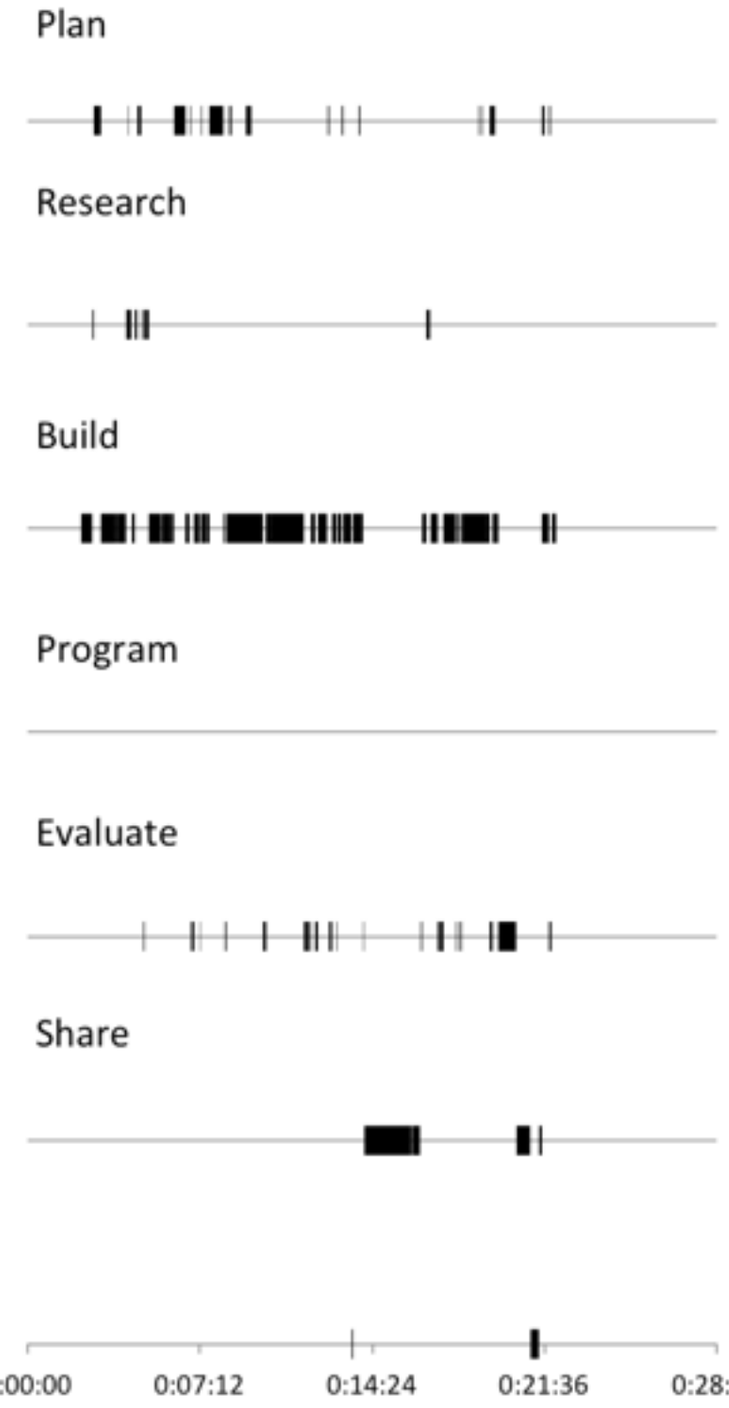
High complexity, high tools



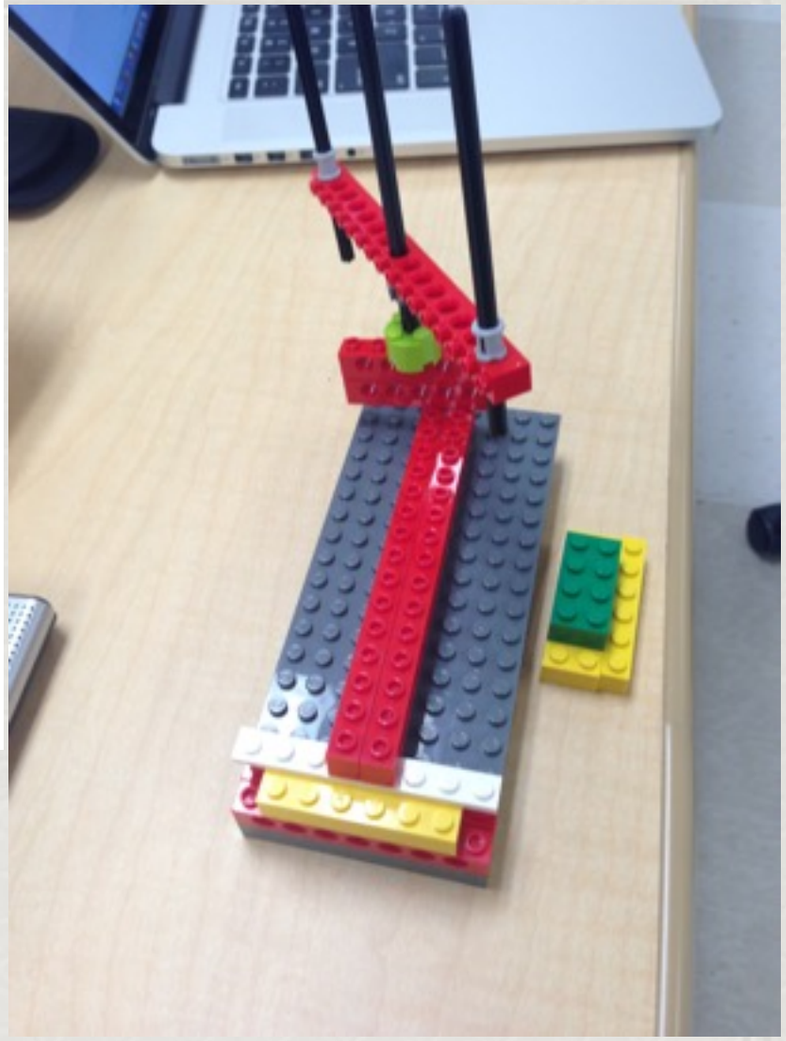


Gender Subject	Girl 5
Grade Level	6
Model Rating	3.7
Prelim EDP Rating	4
LEGO Experience	1
Motor	1
SK	High
Math/Science	High
Design Principles	High
EDP Process	High
CR	High
Plan-Ahead	High
CF	High

Girl 6 EDP Timeline



Gender Subject	Girl 6
Grade Level	2
Model Rating	2.0
Prelim EDP Rating	3
LEGO Experience	0
Motor	0
SK	Low
Math/Science	Low
Design Principles	Medium
EDP Process	Medium
CR	Low
Plan-Ahead	Low
CF	Medium



Low complexity, low tools

Girl 8 EDP Timeline

Plan

Research

Build

Program

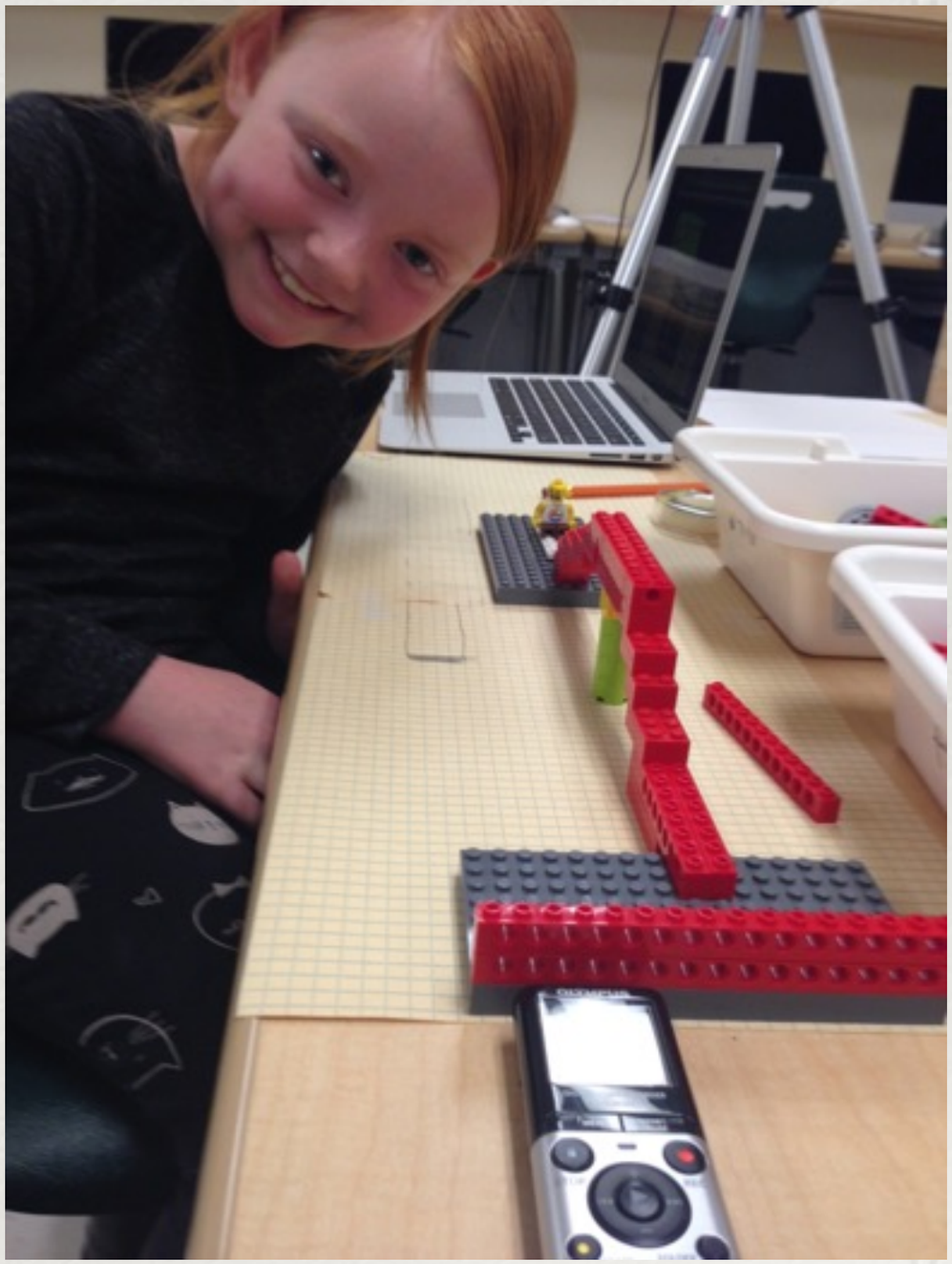
Evaluate

Share

0:00:00 0:07:12 0:14:24 0:21:36

Low complexity, high tools

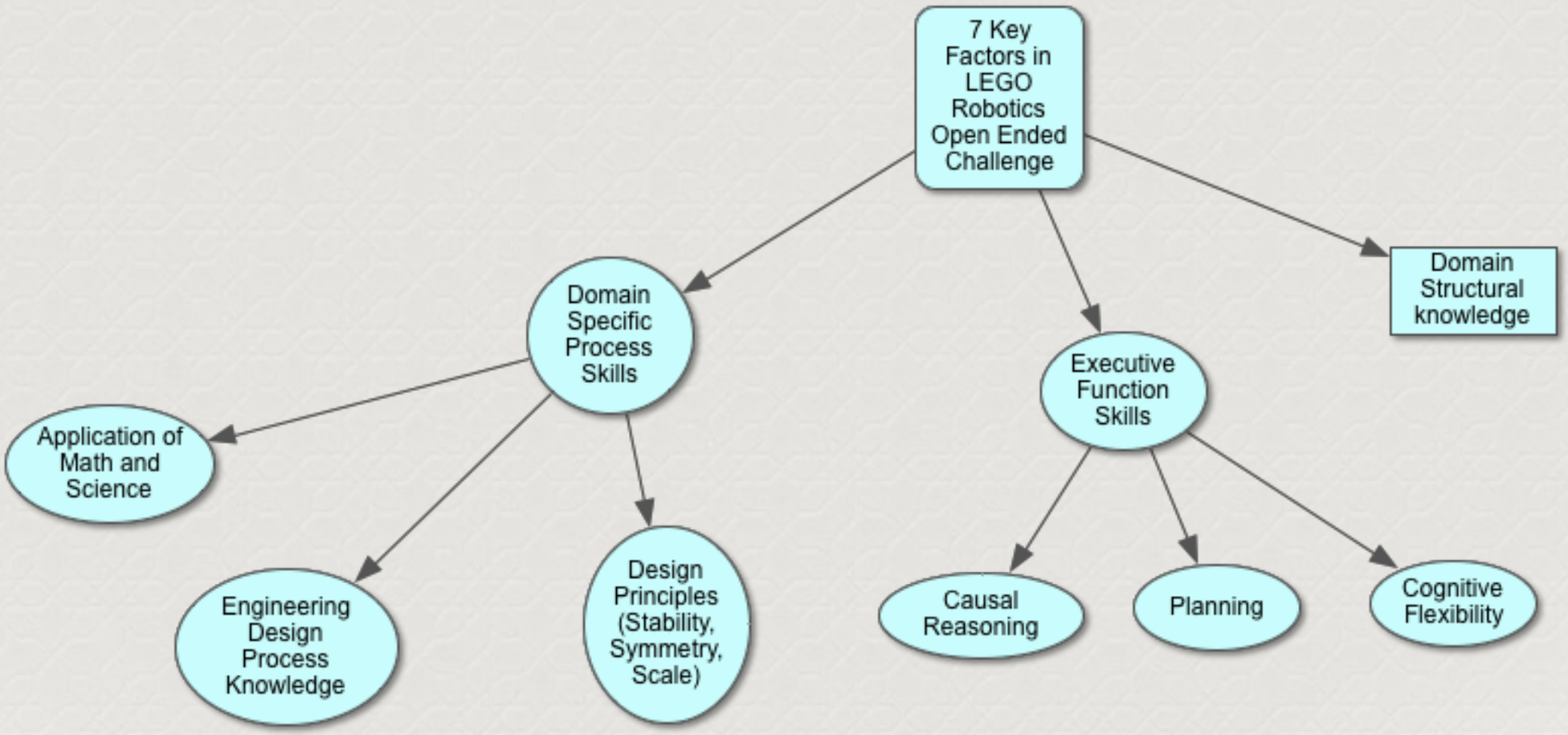
Gender Subject	Girl 8
Grade Level	2
Model Rating	3.3
Prelim EDP Rating	4
LEGO Experience	0
Motor	0
SK	High
Math/Science	High
Design Principles	High
EDP Process	High
CR	High
Plan-Ahead	High
CF	Medium



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:

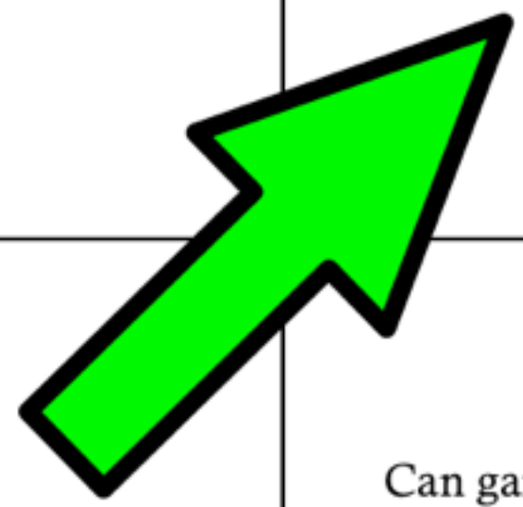
- *Girl 5, Boy 5 - dense, mix of phases throughout*
- *Boy 3, Girl 6 - build away!*
- *Girl 3 - DNF, ongoing research and planning, which never resolved issues, serial building did not work for her*
- *Girl 8 - "idealized" EDP - plan and build*


7 Key Factors in LEGO Robotics Open Ended Challenge
Domain Specific Process Skills
Application of Math and Science
Engineering Design Process Knowledge
Design Principles (Stability, Symmetry, Scale)
Domain Structural knowledge
Executive Function Skills
Causal Reasoning
Planning
Cognitive Flexibility

Structural Knowledge

Scaffold process and EF skills
May need medium complexity

Ideal
Make sure complexity
is sufficient to challenge
Need high complexity



Teach SK and process skills
May need lower complexity,
more time, or more scaffolding
Determine general EF or domain
specific process skills or both

Can gain structural knowledge
Scaffold as needed
May need medium complexity
Determine general EF or domain
specific process skills or both

Process Skills

Resources

- *johnheffernan@verizon.net*
- *Kids Engineer - http://www.kidsengineer.com/*
- *Elementary Engineering - Sustaining the Natural Engineering Instincts of Children*