Cross Case Analysis of Elementary Engineering Task - Preliminary Results





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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

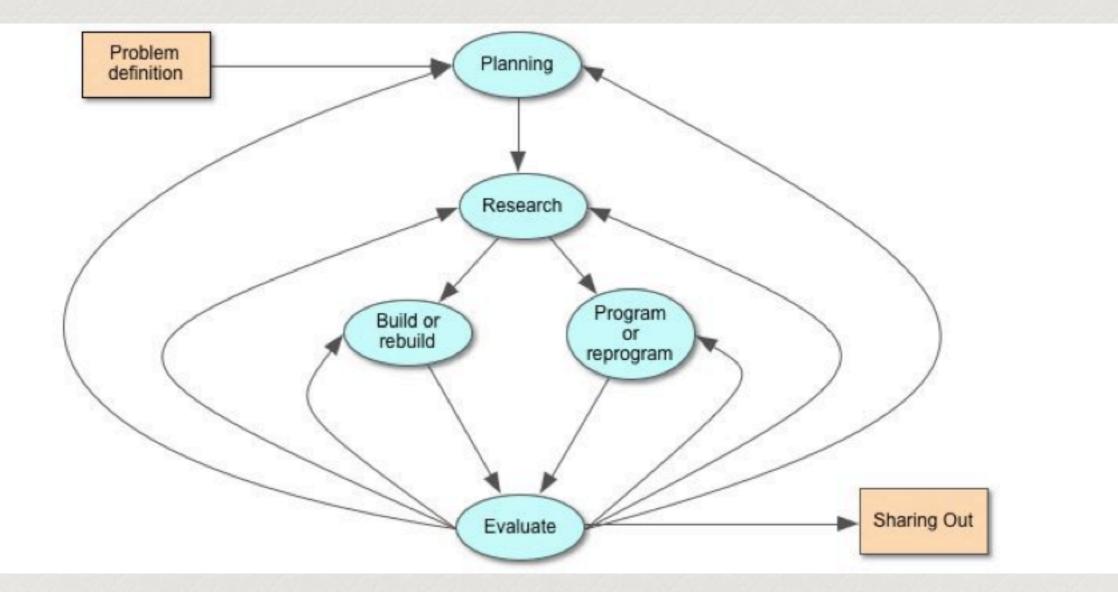


EDP Research

While much is known about the design processes of older students and experts, there has not been a thorough and indepth 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

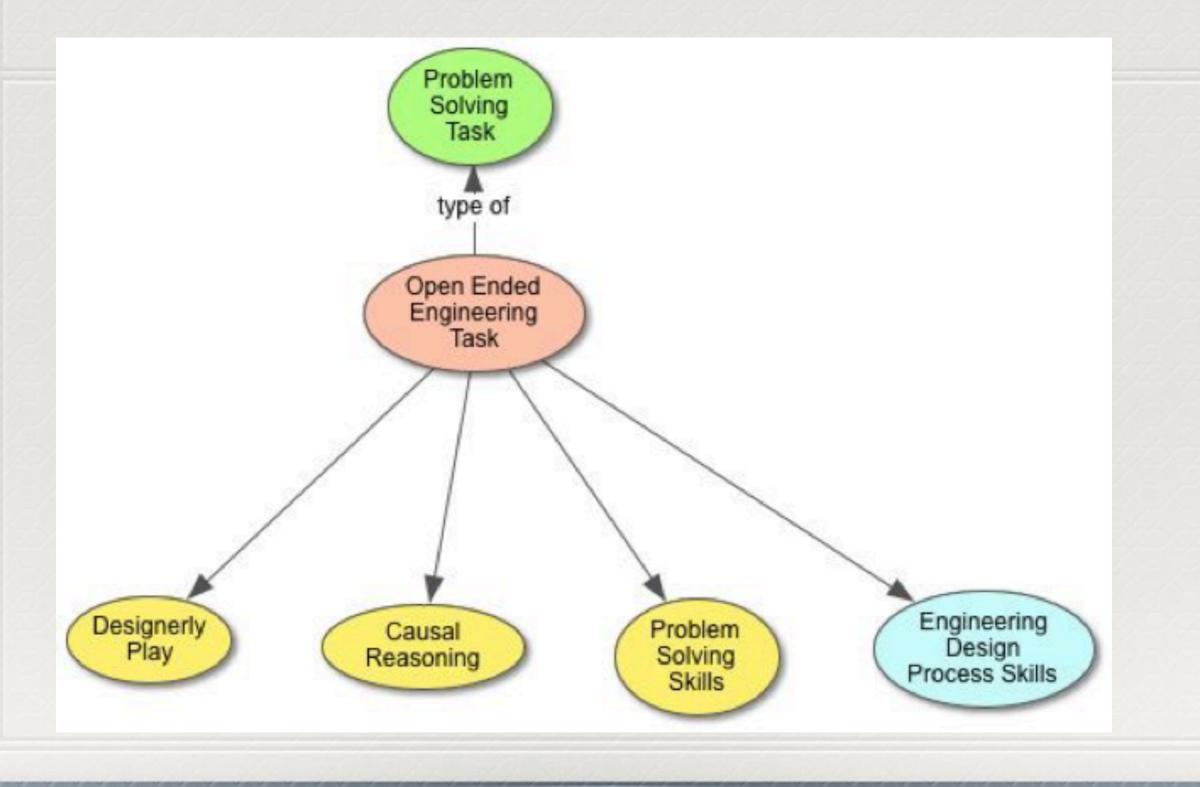
Research Questions

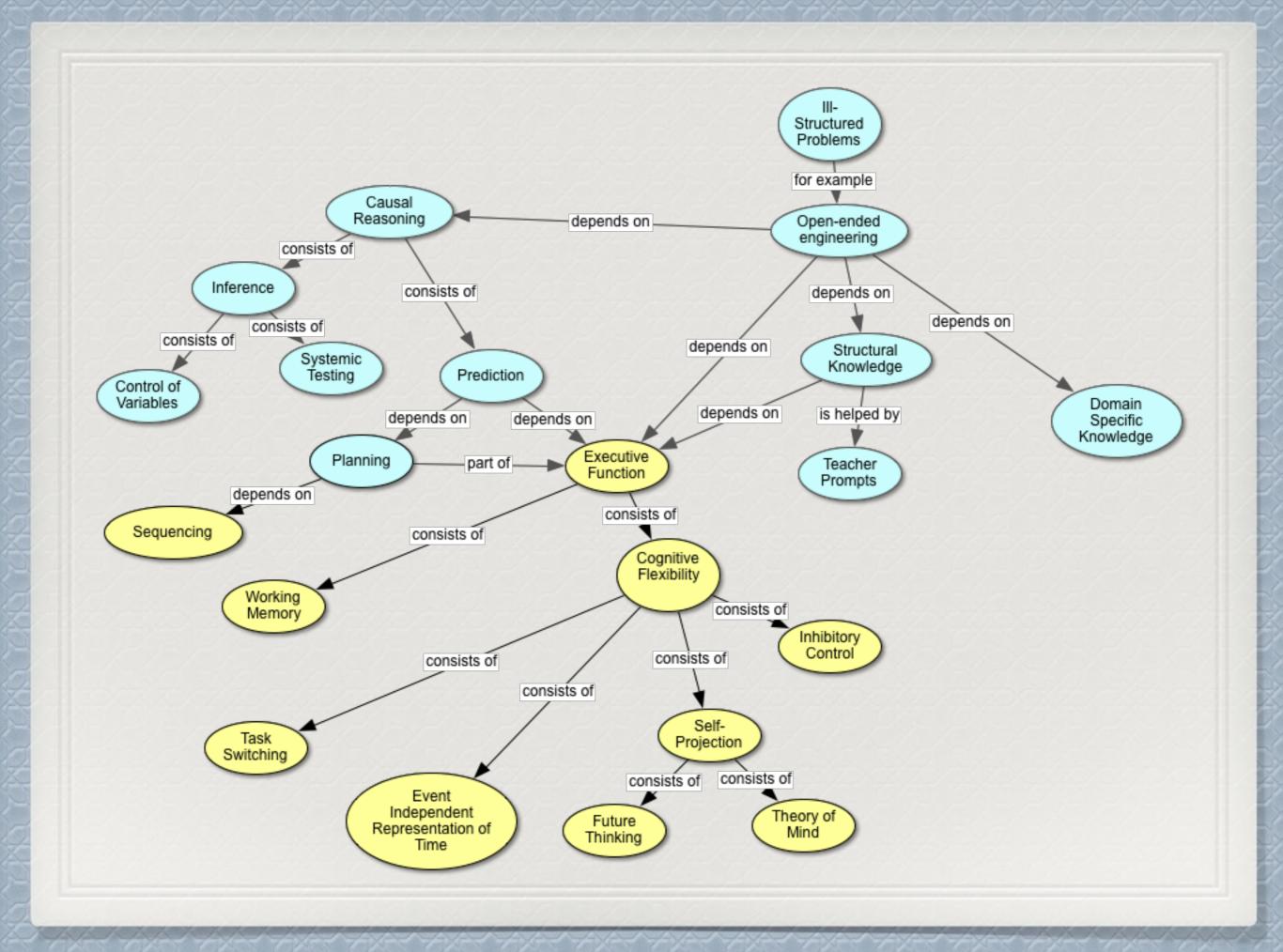
- What do grade 2 student engineering design processes look like? Grade 6 students?
- How do grade 2 and grade 6 students' engineering design processes differ? Are there specific design cycle pattern differences?
- What specific differences can be seen in the planning and drawing between grade 2 and grade 6 students?
- How does causal reasoning differ between grade 2 and grade 6 students?
- For all these questions, are there differences that can be seen by gender at each grade level? LEGO Experience? Engineering design proficiency?



Engineering design process model for this study

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 ageappropriate LEGO robotics materials and craft materials
- Qualitative and quantitive analysis of EDP and non-EDP codes and activity

Setting and Participants

Rural PK-6 school

6 typical boys and 6 typical girls

Students started in K with robotics curriculum (Heffernan, 2013)

Data Collection

Warm up task (roof) - rubric

Programs

Photos of prototype

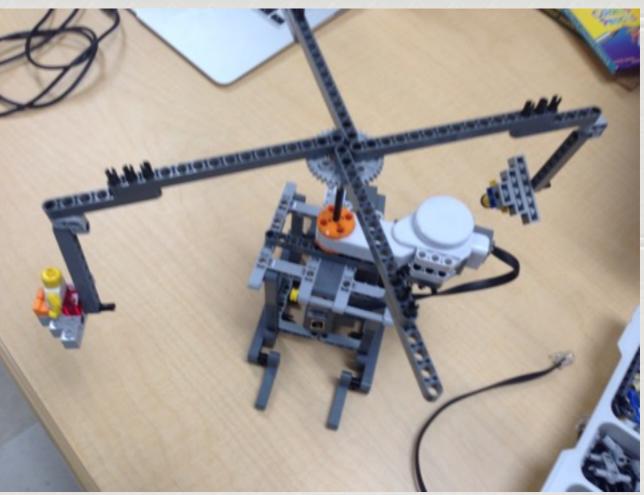
Design data for each prototype - today

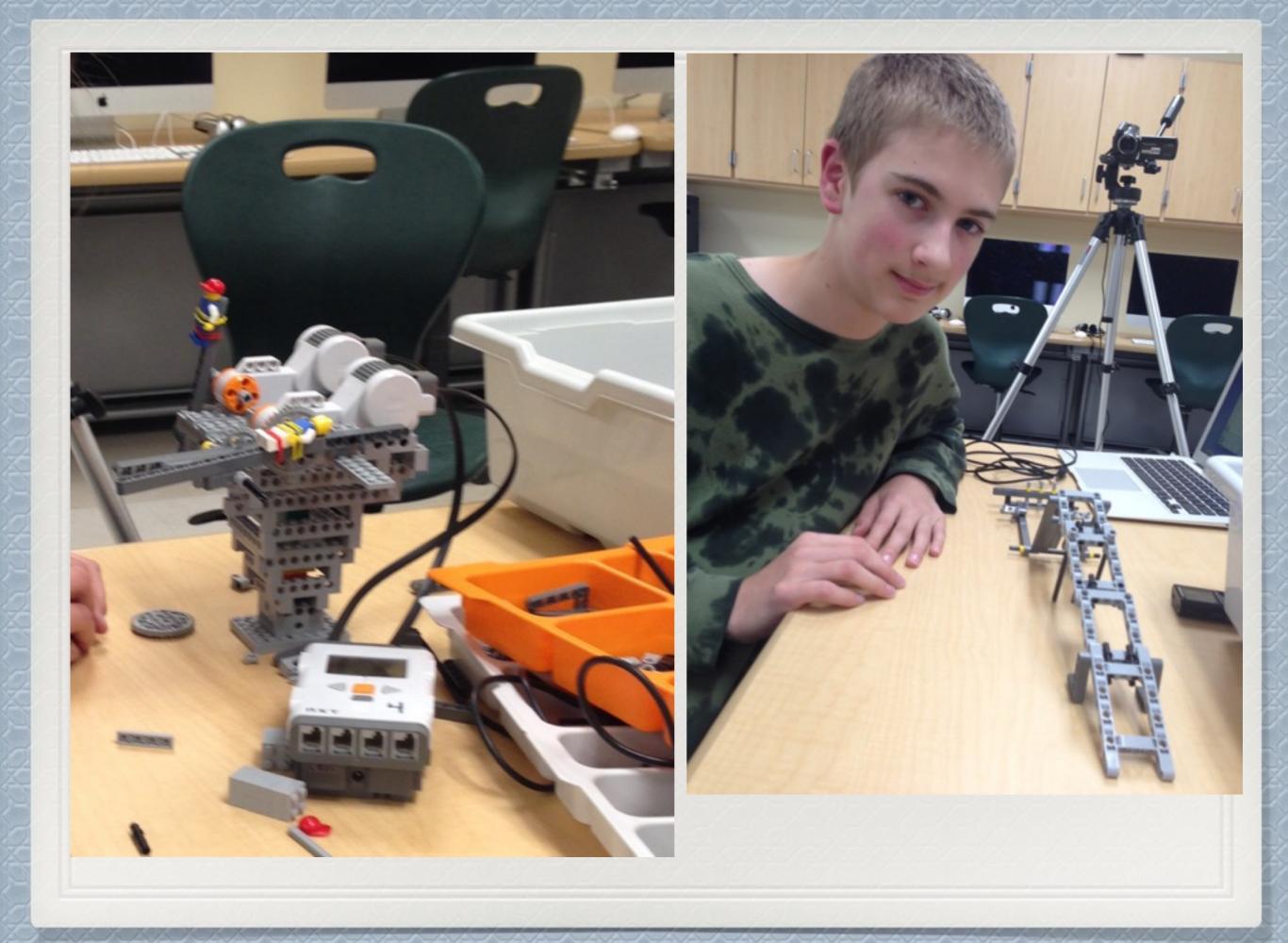
Video tape of sessions - will yield EDP and CR data - future

Data Collection Results

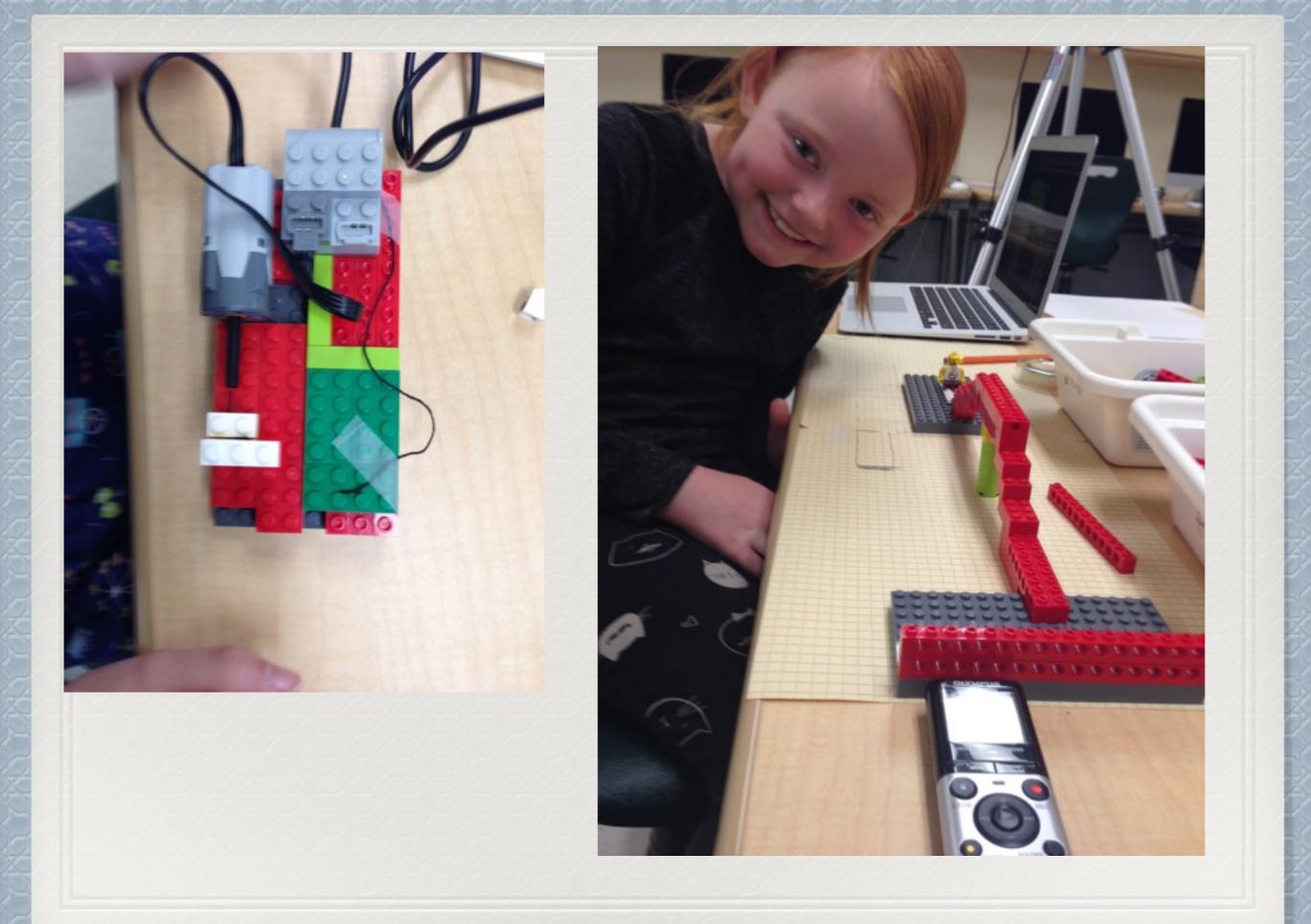
2 hours of warm task and 8.5 hours of main task some challenges with subjects and videotaping completed November-December multiple "track" issues with building and talking transcription, segmenting and time-stamping - pass I underway

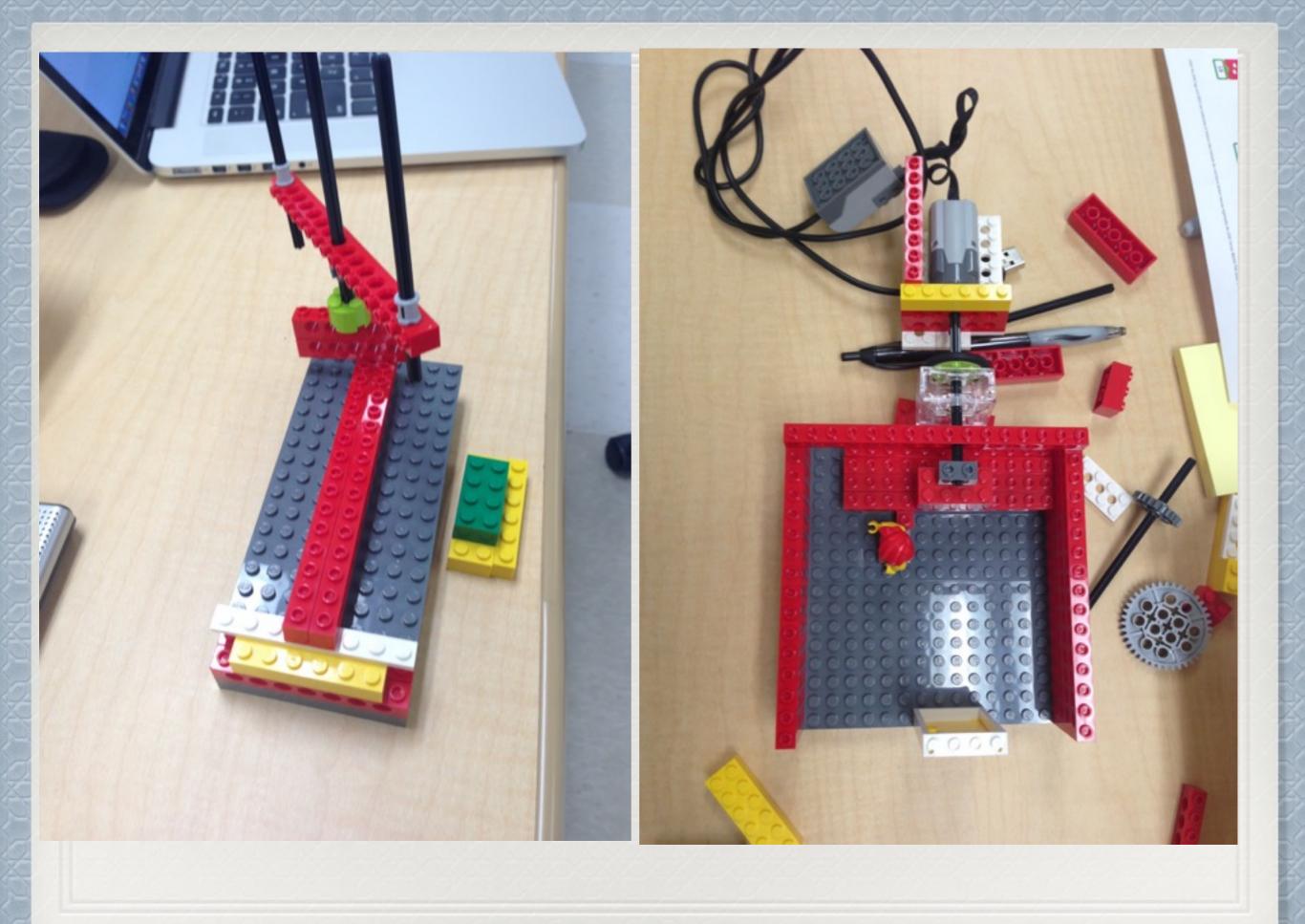


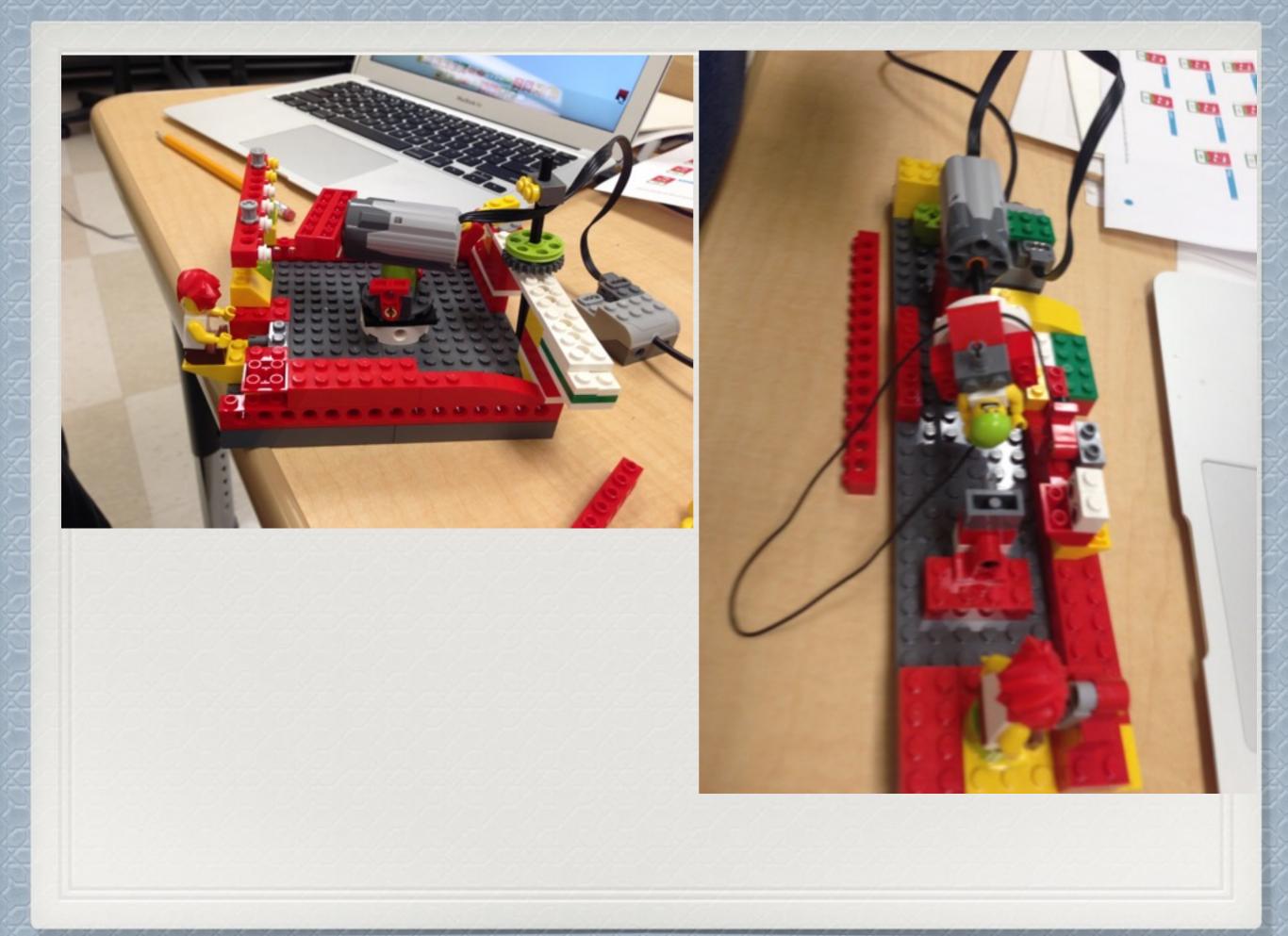


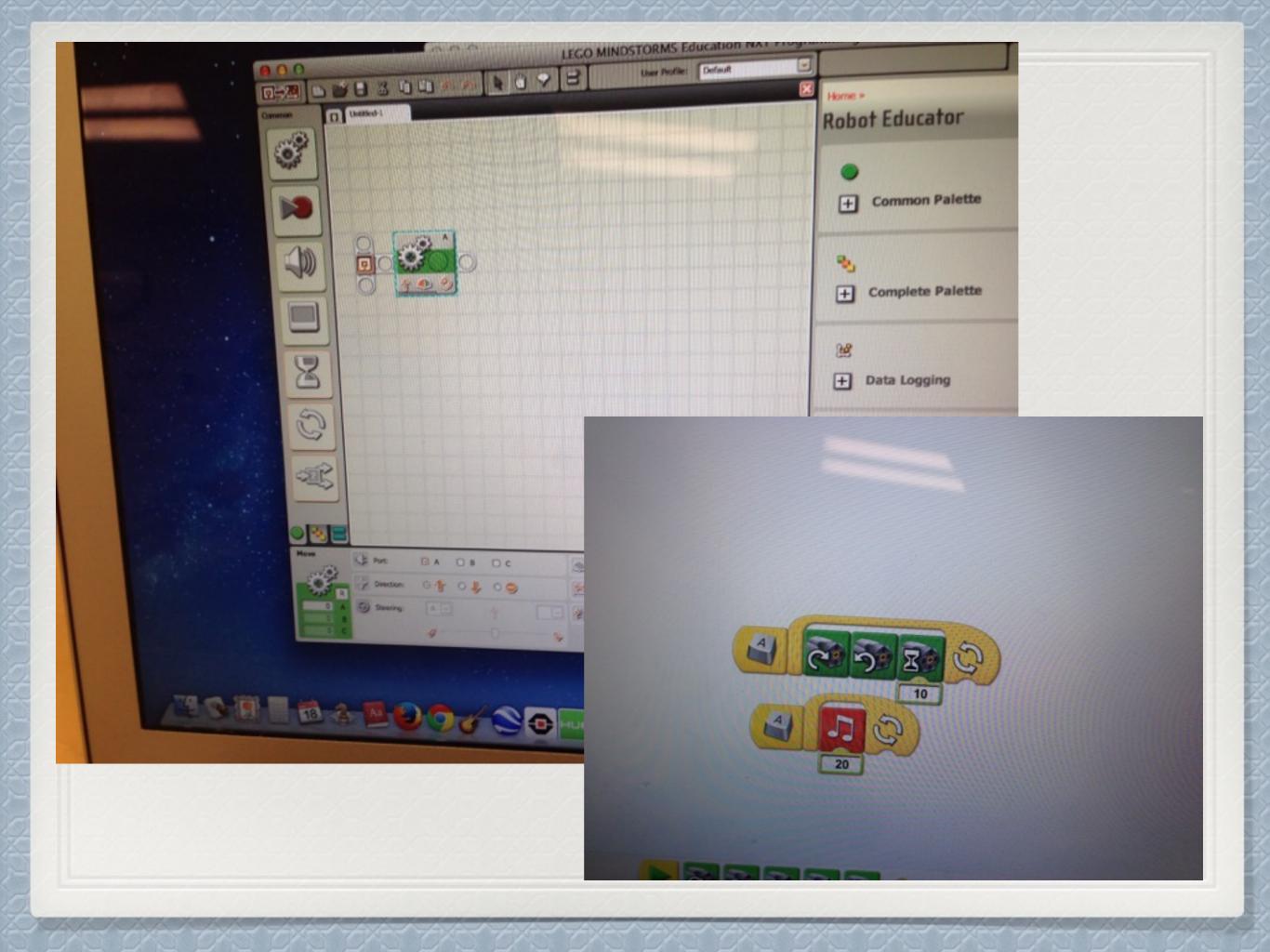












Design Data Analysis - Independent

Warm Up Task - time, function, process (rubric)
 Ride task - creativity, function, process (rubric)
 Design Data - #parts, time, use of different parts (motors, computer, crafts, sensors, gears, etc), stability, symmetry, scale

Self Efficacy

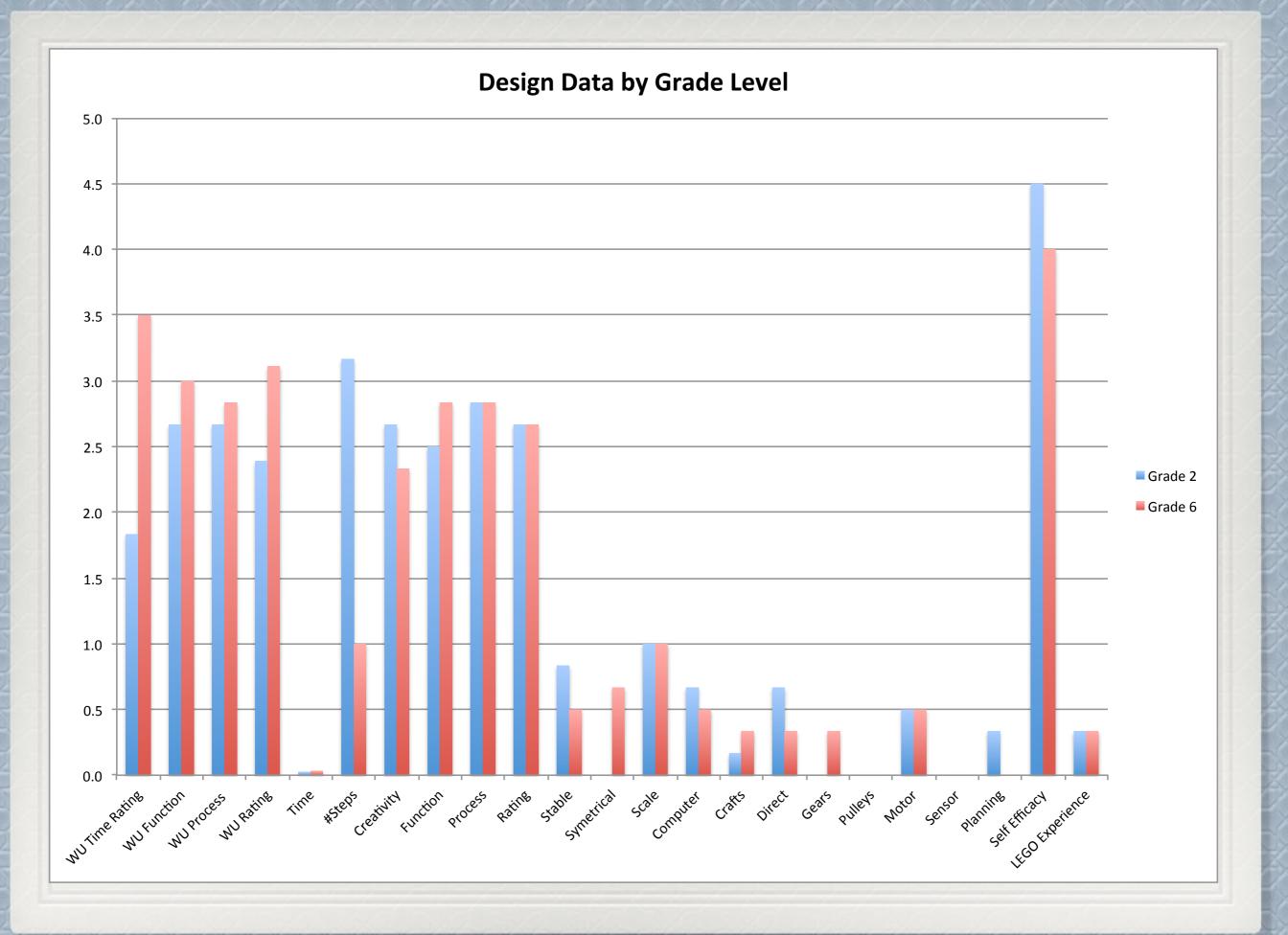
Design Data - Dependent

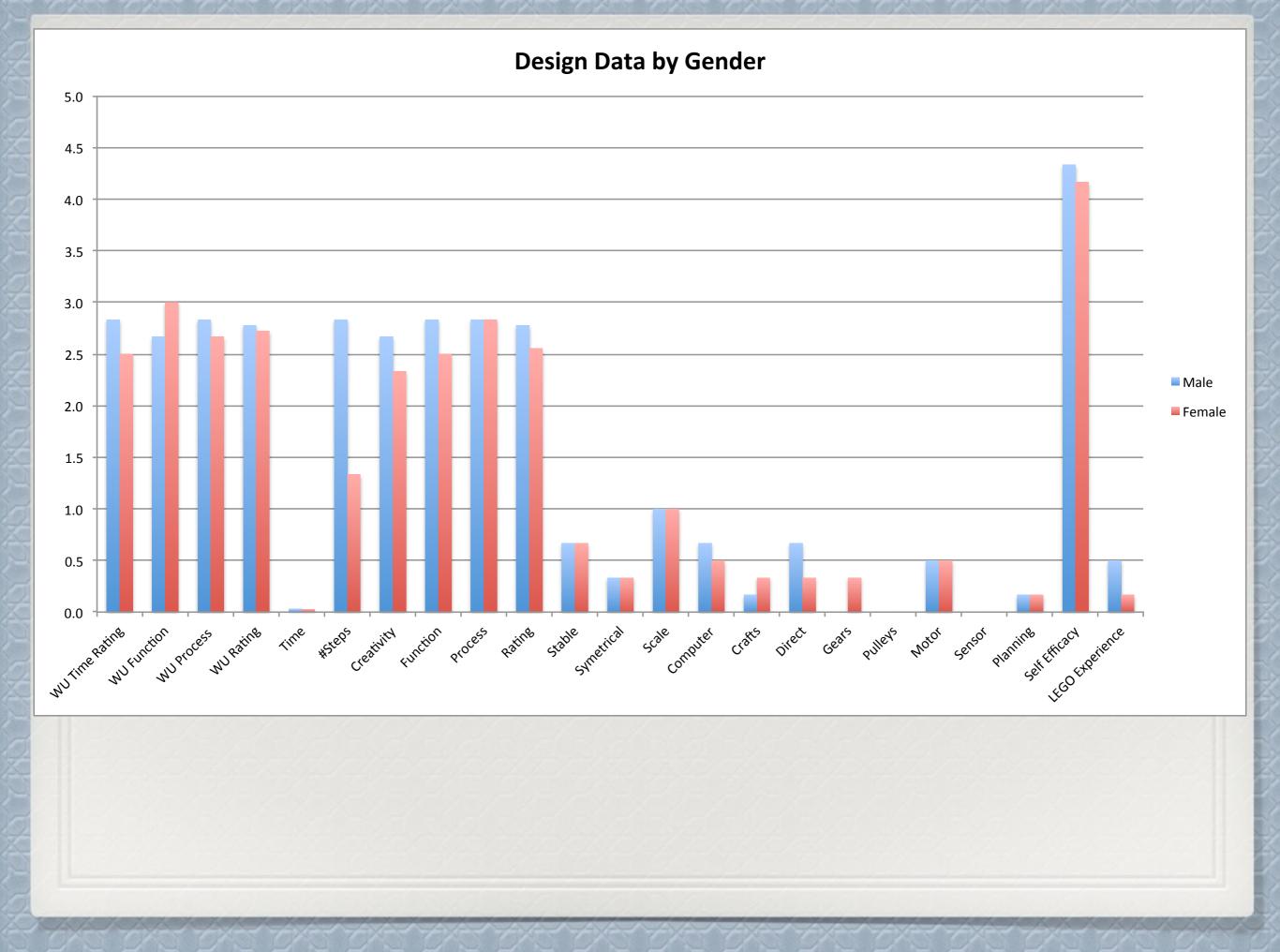


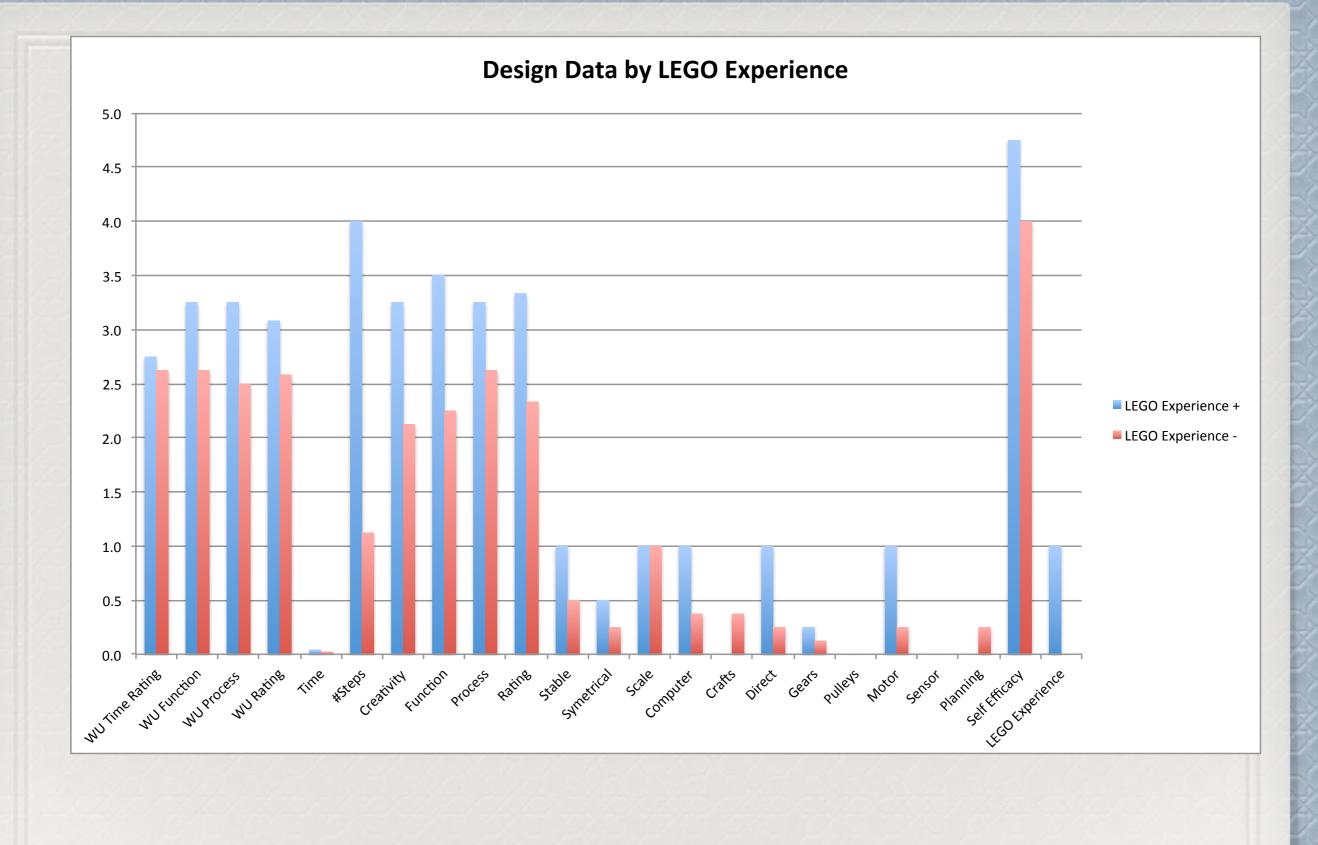
Grade Level

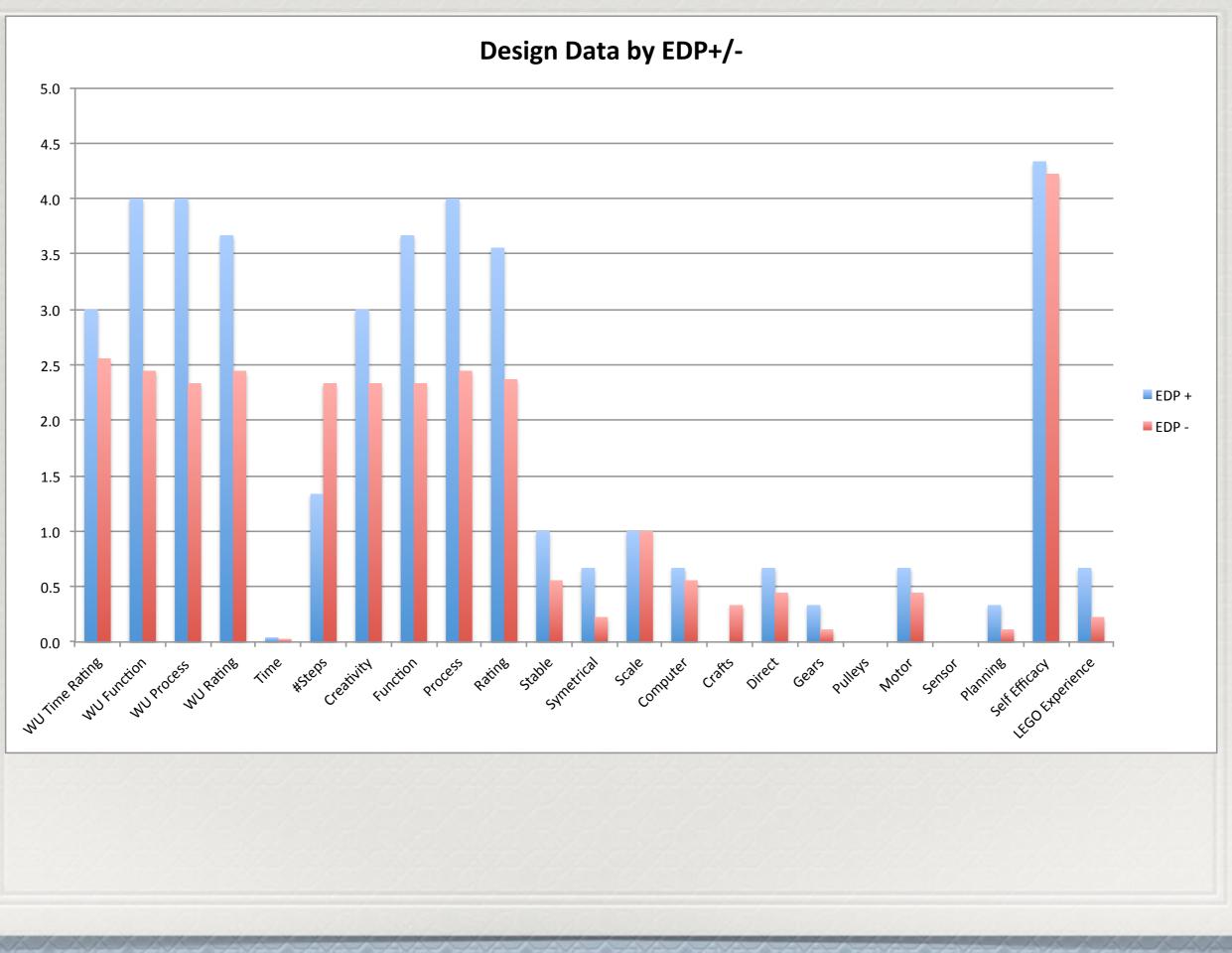
LEGO Experience

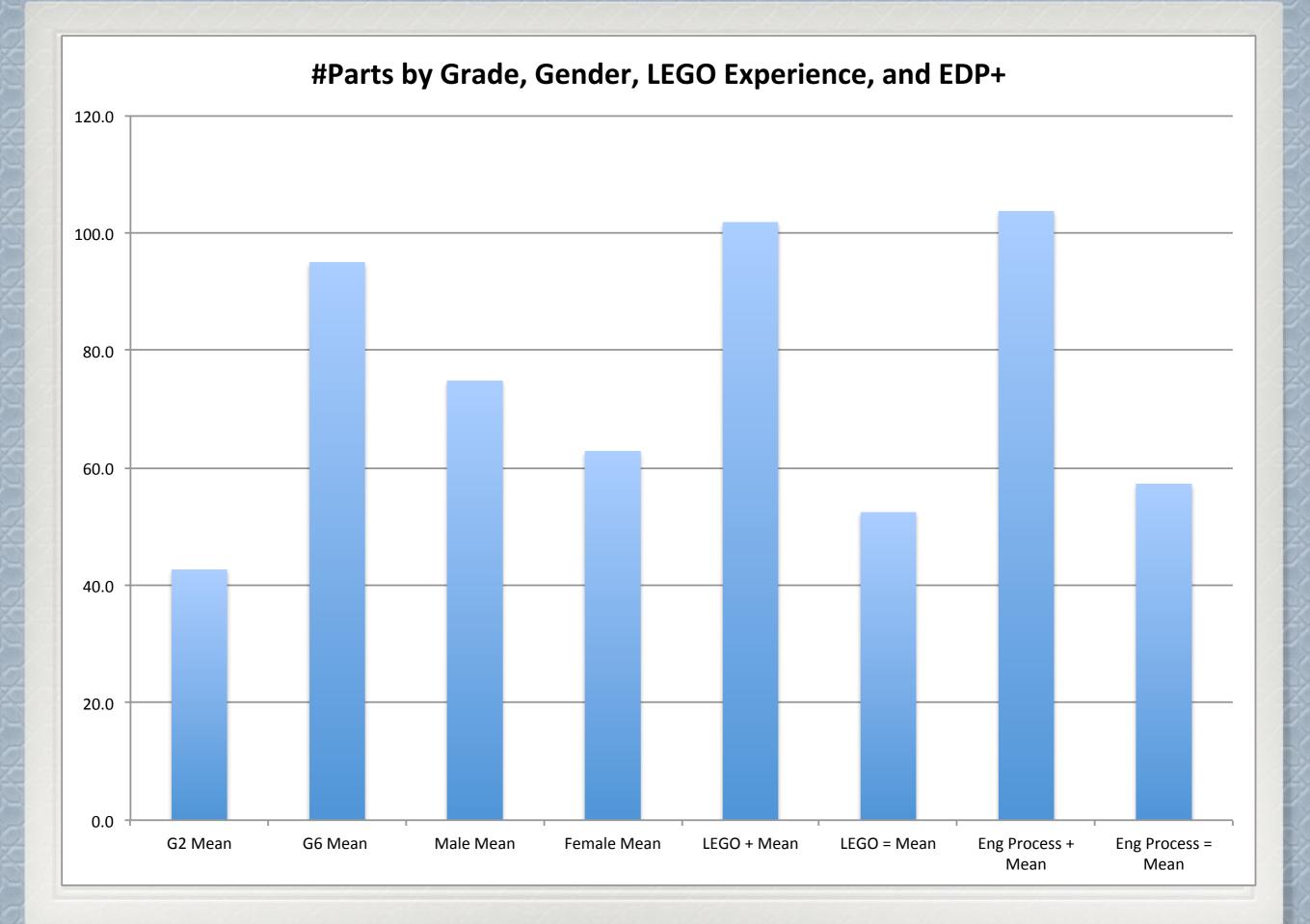
Engineering Design Process

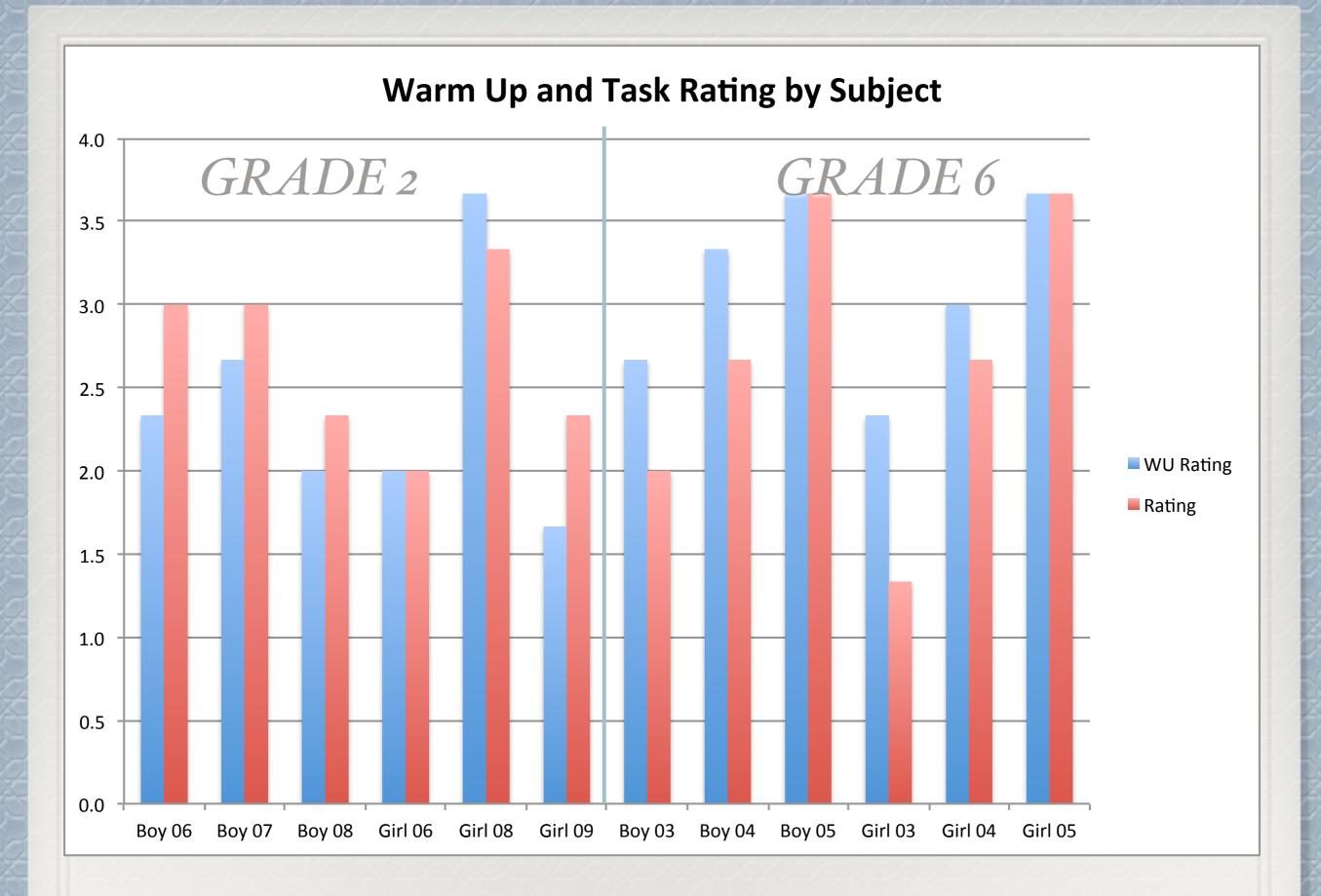


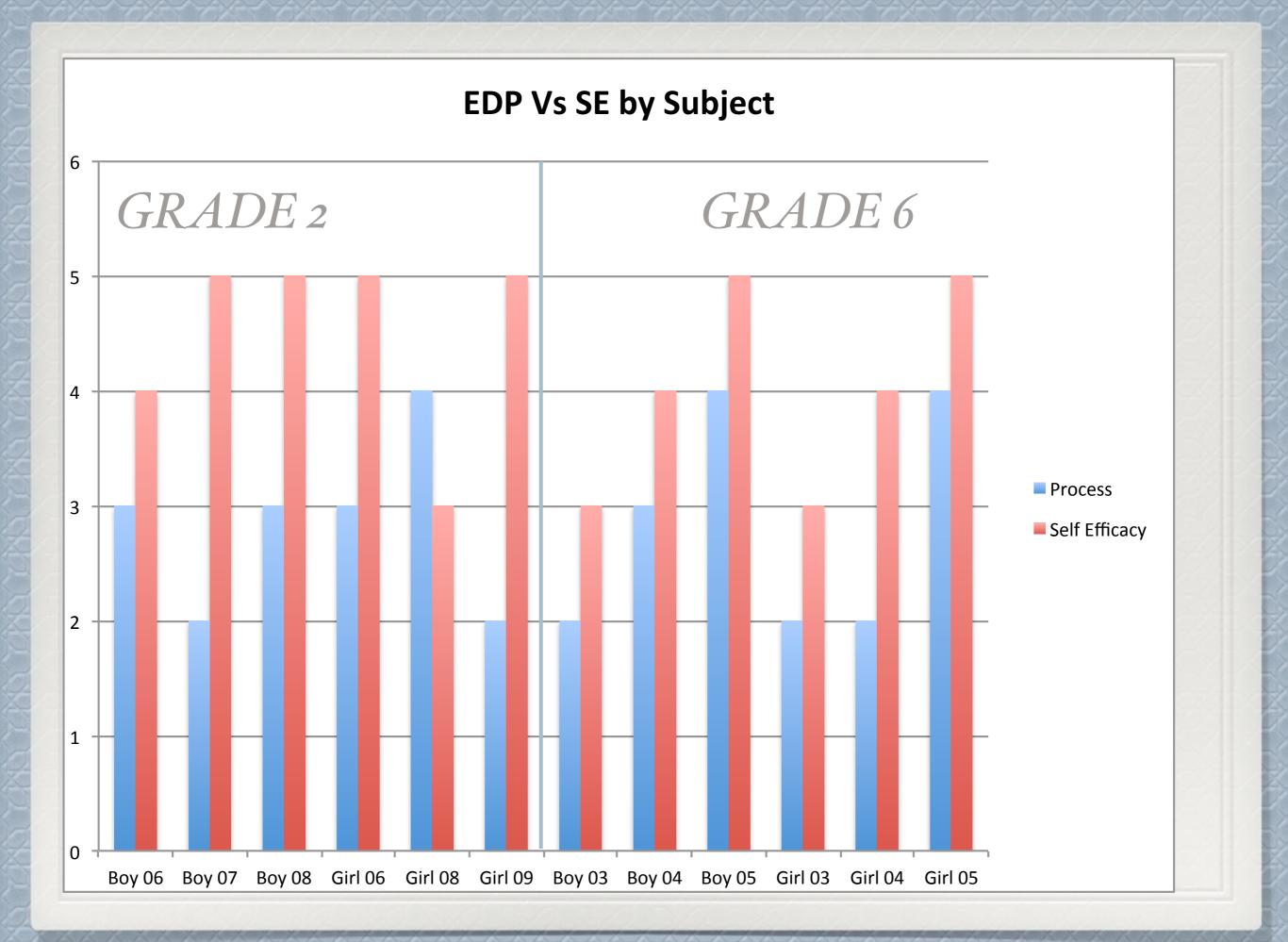


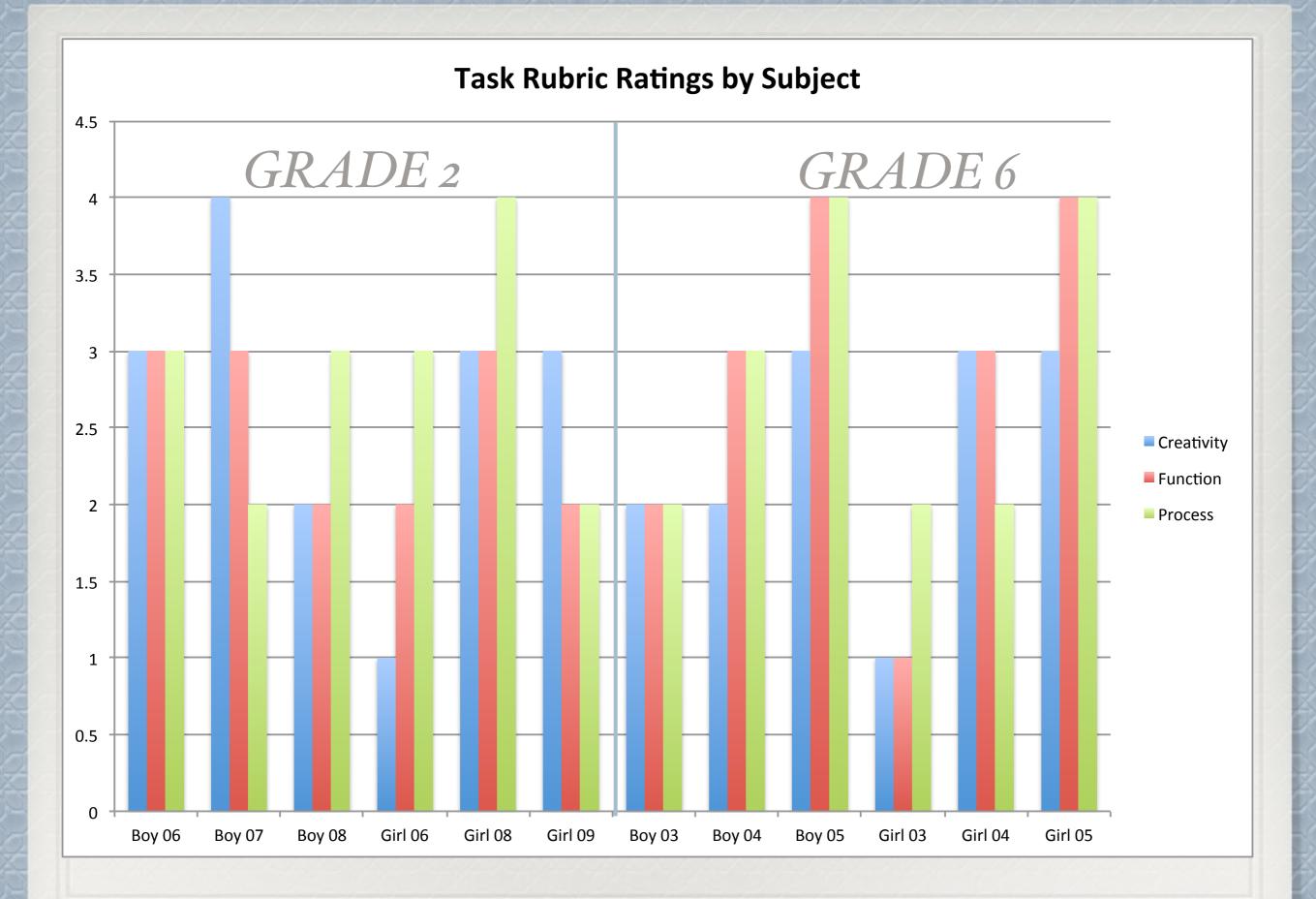


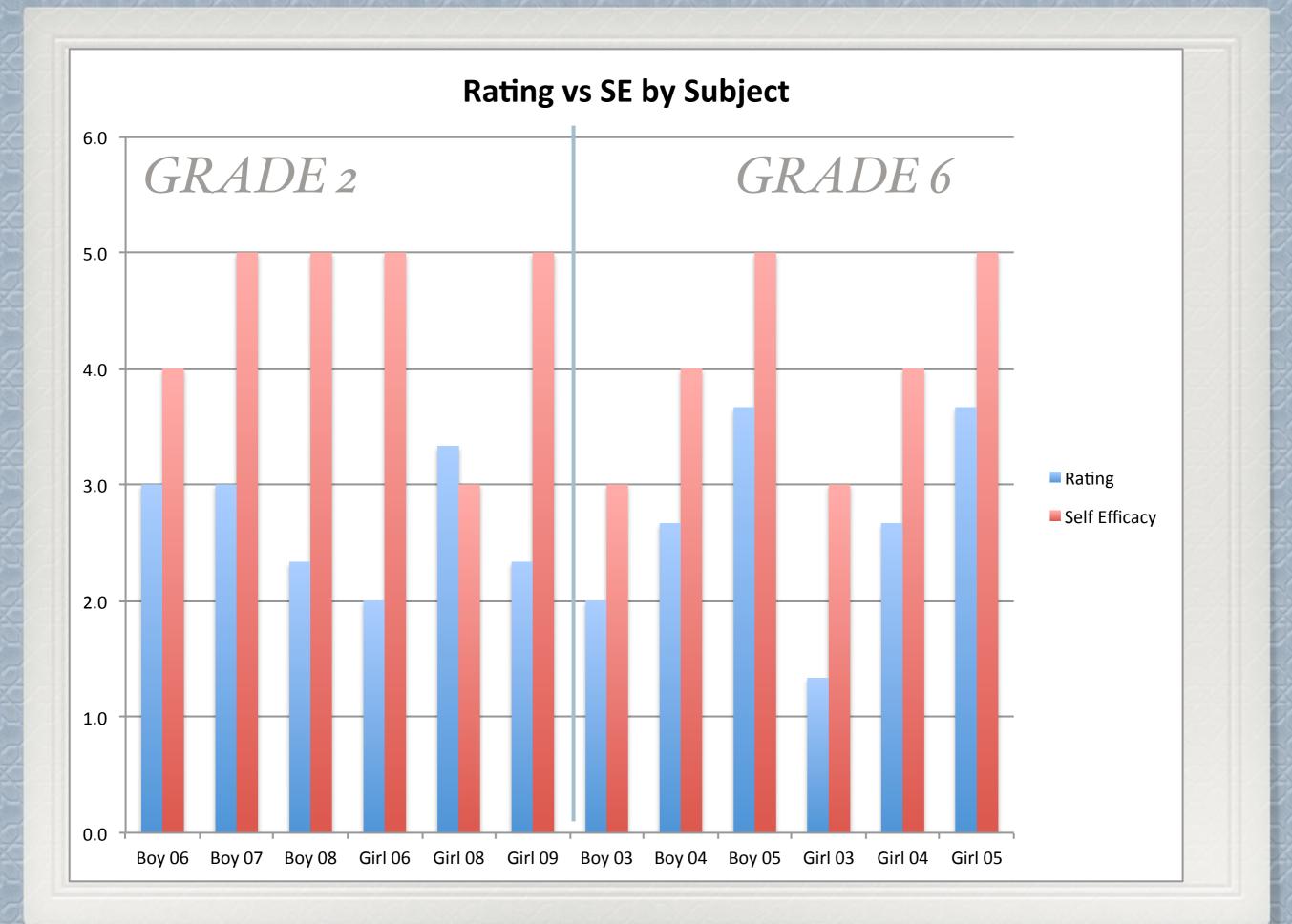






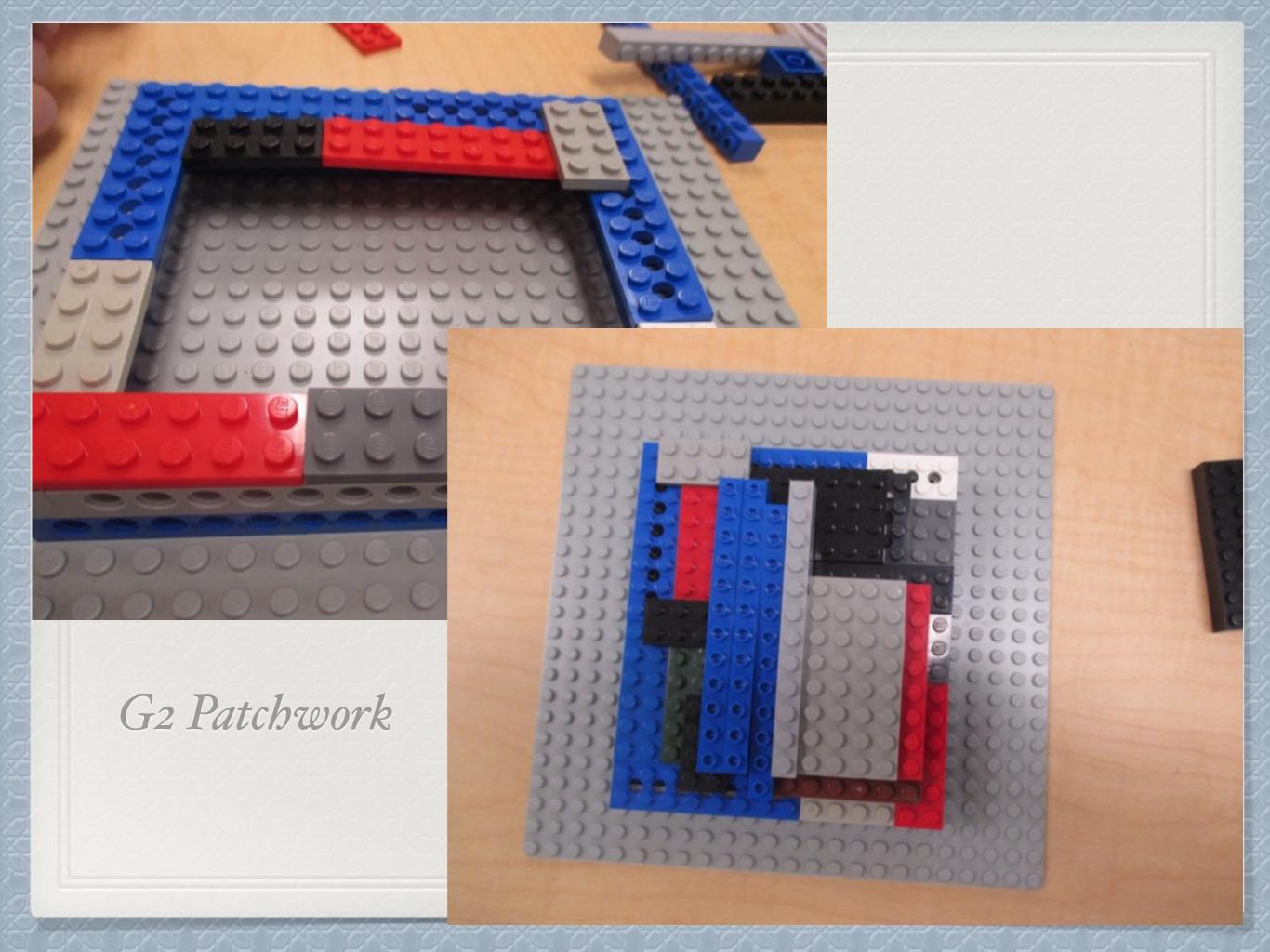


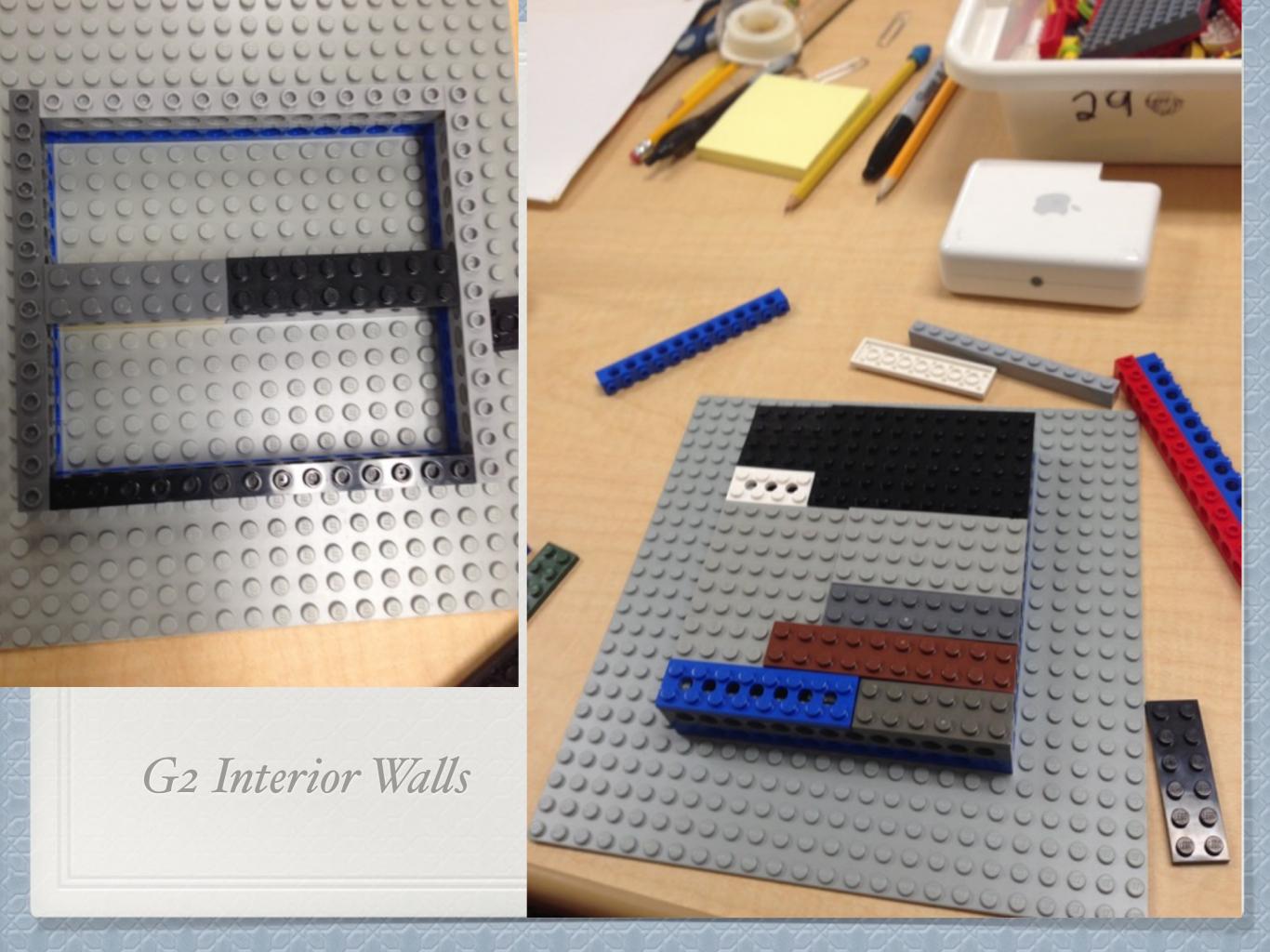


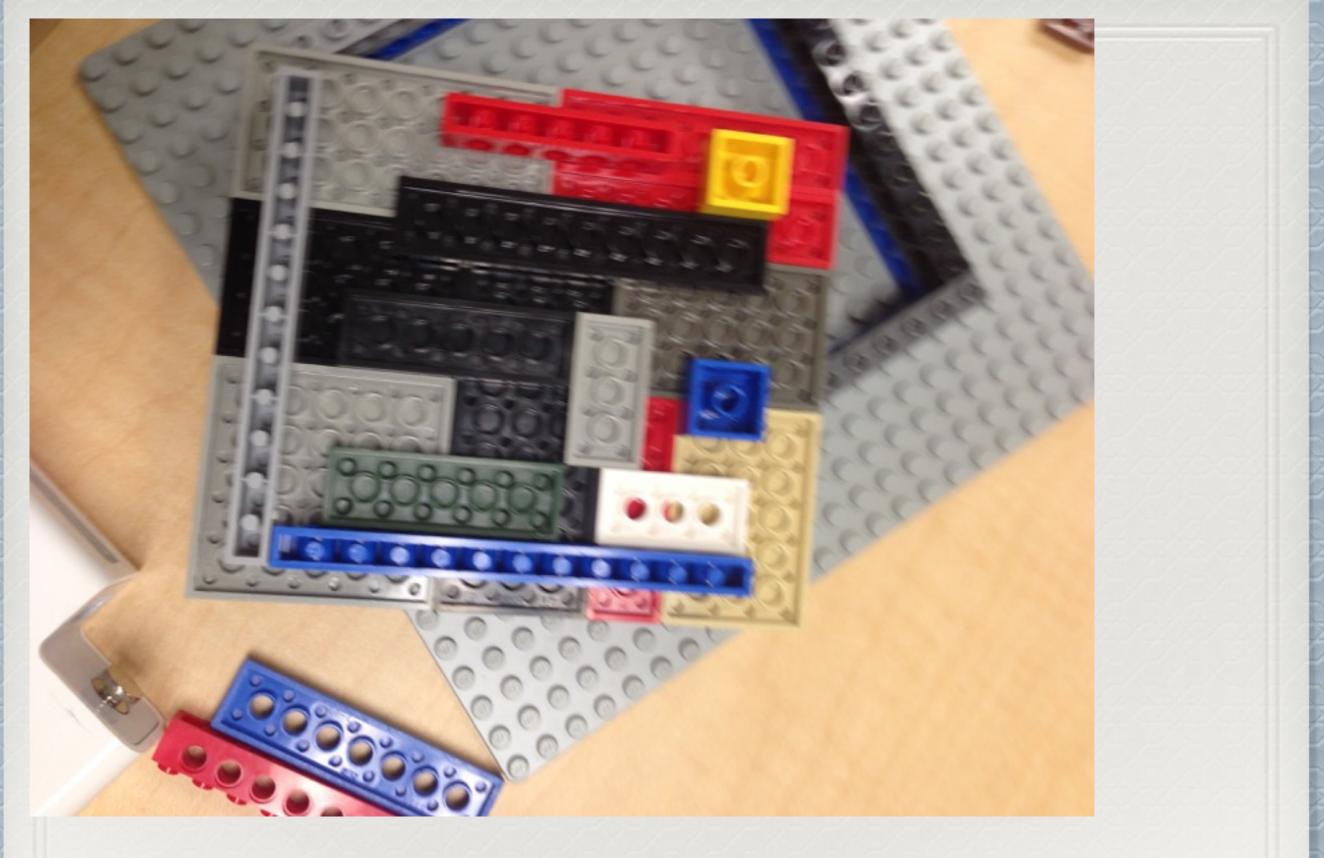


Big Ideas - Warm Up Task

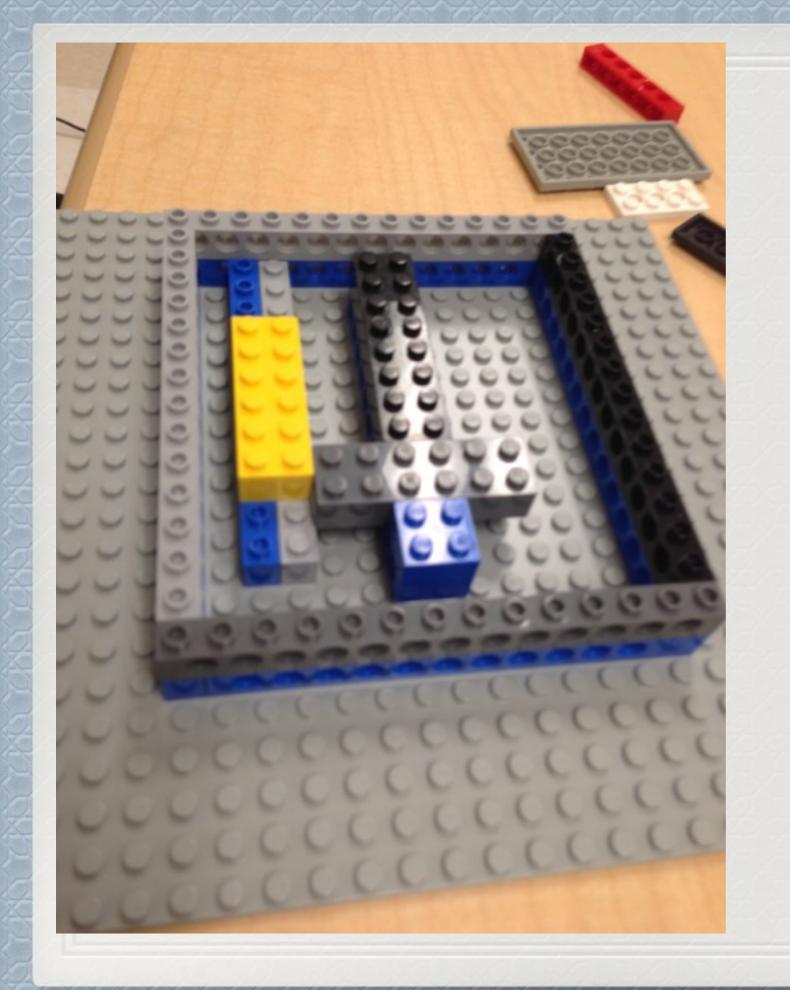
- Correlated with main task
- Some found it hard to attend to both constraints
- Structural knowledge of structures important



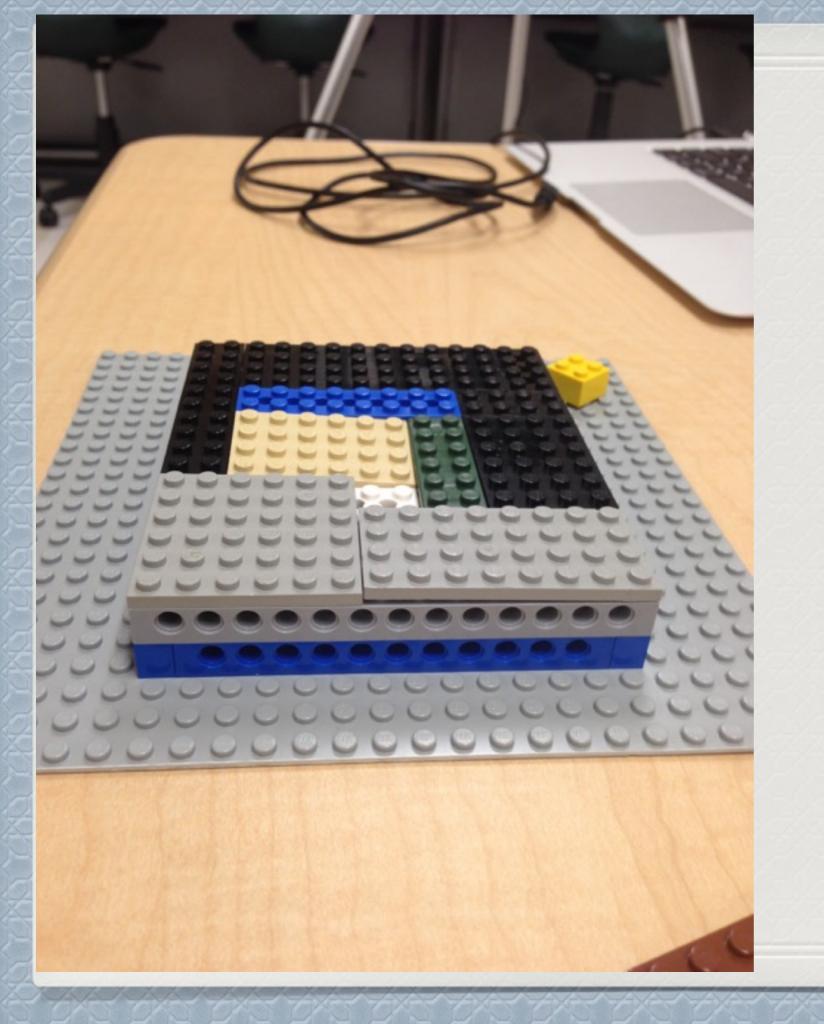




G6 Removable Roof



G6 Interior Walls



G6 Underneath Composite Pieces

Big Ideas - Main Task

For overall design results (not in-depth EDP and CR):

EDP and LEGO experience important

- Gender and grade level not significant
- Seems to be some significant differences in CR that correlates to advanced and EDP and results
- Programming not key
- Crafts not used much

Symmetry and stability important differentiators; scale concerns seen especially with roof

Big Ideas - EDP

Serial versus hierarchical building processes

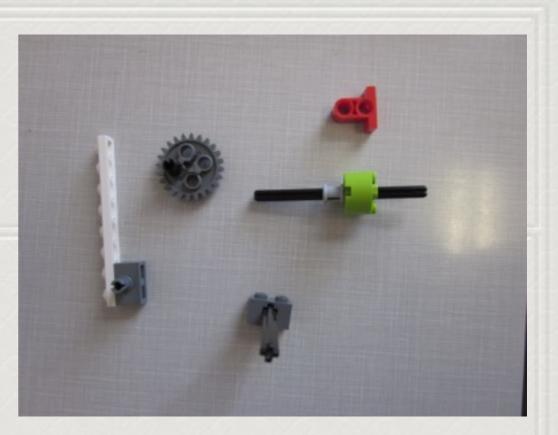
Students ideas of ride different; students could fill in hard to build parts mentally (non-computerized rides and coasters, for example)

Parts first and idea first

Relationship between domain specific knowledge and CR

Students do not generally choose to use separate planning materials

Big Ideas - LEGO



- Structural knowledge of LEGO key connector pieces
- Differences with LEGO engineering from paper and pencil non-building tasks

Big Ideas - Methodology

Talk aloud and clinical at the same time has some tradeoffs (richness of data, questions influence building)

Sharing out caused reflection and changes

Girl 05

- Could easily build and plan at the same time; others struggled to build and talk simultaneously
- Seemed to use COV
- Figured out some math and science transfer issues, in one case, with teacher prompting
- A Microgenetic learning moments (math and science application)

Microgenetic Learning Moments (3)

Gearing up vs gearing down

Odd number of holes in beam, where to center it

• 01:14:55 (Number of rotations of geared up side)

Transcript Example

[00:02:25] [RESEARCH] {no_activity}

[00:03:08][PLAN] Boy 05: I have to first build the structure of it. [IMPORTANT]

[00:03:12] [RESEARCH] {Searching}

Researcher: By structure, do you mean the part that holds up the moving parts?

[00:03:24] Boy 05: Yeah.

Researcher: What are you thinking? You picked out some parts.

[00:03:45] [PLAN] Boy 05: {no_activity}

[00:04:10] Boy 05: I think I'm going to have the base like this, and then have these holding this up.

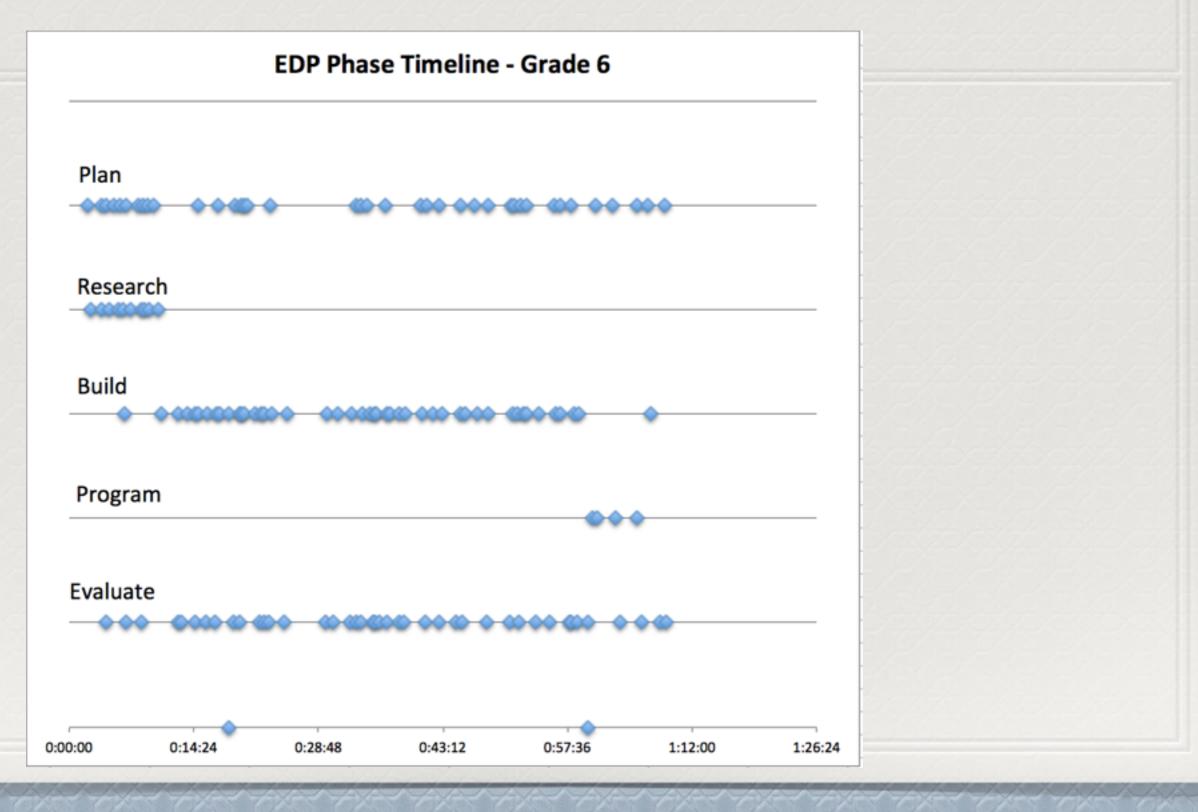
Actually, I think I might have it work like this, holding this up so this doesn't move back and forth.

[00:04:44] [BUILD-NORMAL] {connecting}

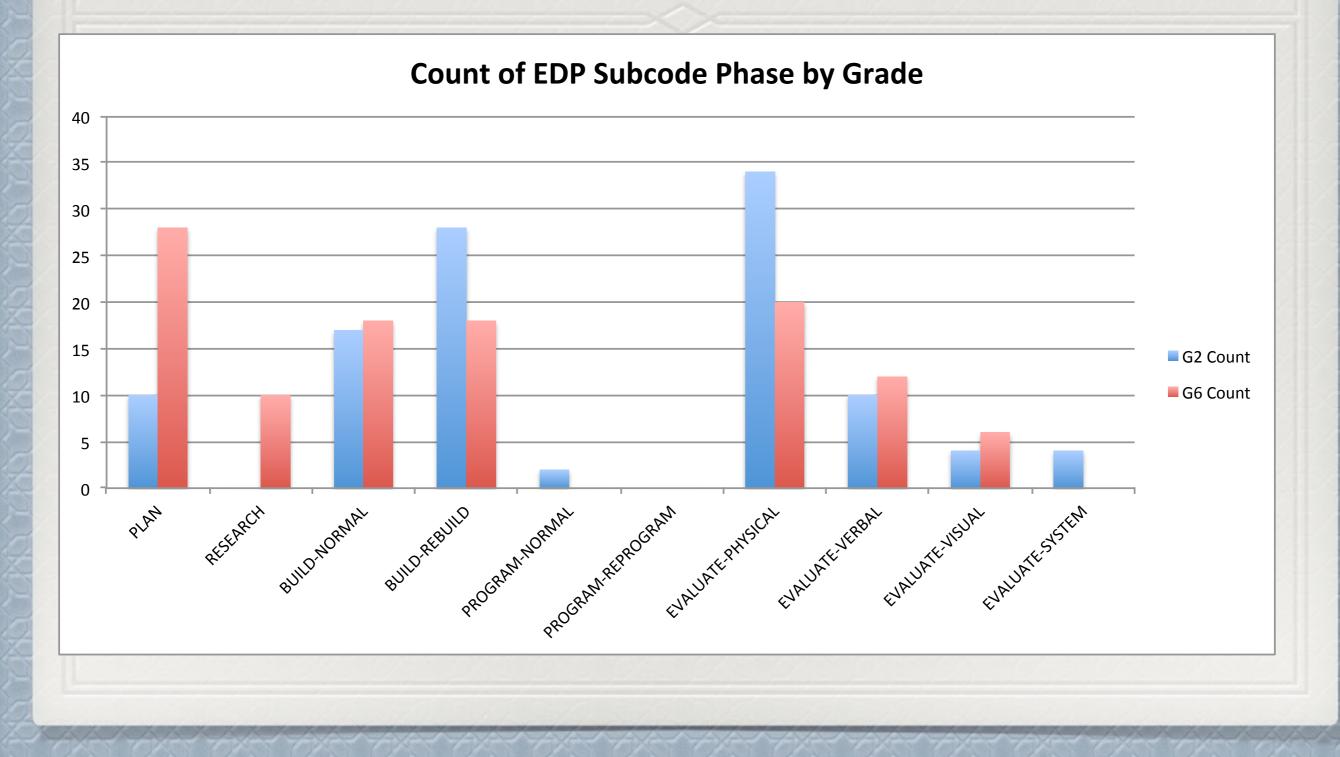
[00:05:01] [PLAN] {no_activity} Boy 05: I'm going to add these so they can connect.

[00:05:11] [EVALUATE-PHYSICAL] {moving} Boy 05: They don't fit properly.

EDP Timeline (Pilot)



EDP Frequency Chart (Pilot)



Non-EDP Codes

These will be tabulated and graphed by frequency and dependent variables

Next Steps

Time-stamping and segmenting - pass 2

Coding

Update extraction programs

Analyze EDP data

Analyze non-EDP data

Write results, discussion, summary



- Working full time as tech teacher
- Started courses in summer 2012
- Came in with research questions and teacher action research and clear desire and persistence to really understand elementary robotic
- Now have frameworks, previous research, and methodology to inform research
- Geared coursework and projects, when possible, to core questions
- Balance committee feedback with your own knowledge
- Kept reading and following lines of research, keep organized

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Resources

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 Kids Engineer - <u>http://www.kidsengineer.com/</u>
 Elementary Engineering - Sustaining the Natural Engineering Instincts of Children