The Development and Validation of an Engineering Assessment

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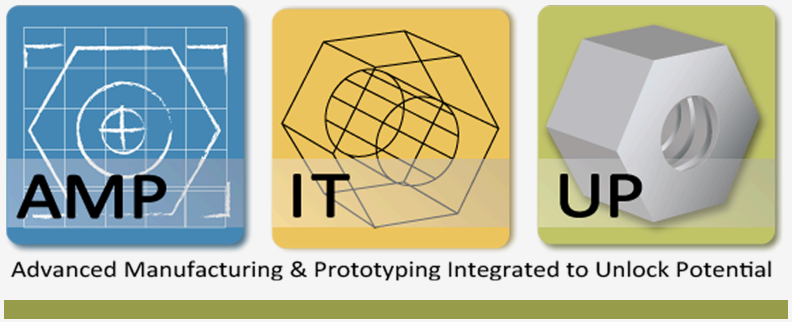

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Background

Advanced Manufacturing & Prototyping Integrated to Unlock Potential (AMP-IT-UP)

- Five year NSF Math and Science Partnership between Georgia Tech and the Griffin-Spalding School District
- STEM curriculum for middle-grades students (6^{th}-8^{th} grade) & 9^{th} grade students.
- **Engineering design courses (STEM Innovation & Design)**
- **Math & Science Modules**
- ***https://ampitup.gatech.edu***

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Overarching Purpose

- Contribute to the limited body of research on K-12 engineering assessment
- **Conceptualize the instrument as a measure of science and engineering practices**
- Provide some validation results of an instrument measuring student understanding of engineering practices

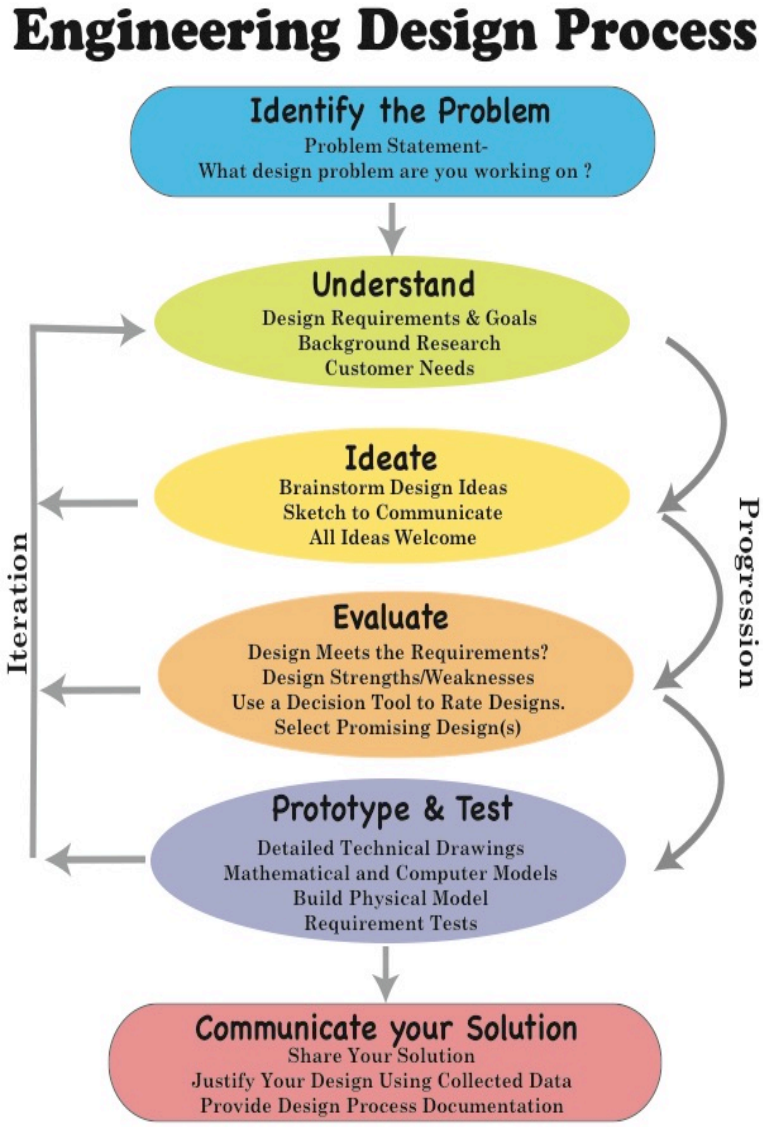
Next Generation Science Standards (2013)

- Engaging in the practices of engineering helps students understand:
  - the links between engineering and science
  - the crosscutting concepts and disciplinary ideas of science and engineering
  - makes students' knowledge more meaningful and embeds it more deeply into their worldview.

Background

NGSS Engineering Practices

1) Asking questions (for science) and defining problems (for engineering)
2) Developing and using models
3) Planning and carrying out investigations
4) Analyzing and interpreting data
5) Using mathematics and computational thinking
6) Constructing explanations (for science) and designing solutions (for engineering)
7) Engaging in argument from evidence
8) Obtaining, evaluating, and communicating information



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Designing an Assessment of the Engineering Design Process

- 40 multiple choice, scenario-based items differentiated per grade-level (6th through 8th grades).
- Each item is aligned to one or more engineering concepts
- Most items were developed by a team of curriculum experts in engineering education, educational research, and psychometrics
- A few items adapted from School of Engineering Education at Purdue University (Moore & Guzey, 2013)

Methods

- Sample:
  - Two Middle Schools
  - 6th Grade = 63; 7th Grade = 41; 8th Grade = 92
- Framework:
  - Evidence Centered Design (Almond, Steinberg, & Mislevy, 2002)
  - Mixed Methods to strengthen validity argument
- Data Analysis:
  - Many-Facet Rasch Model
    - Item difficulty & student achievement
  - Qualitative Analysis of Cognitive interviews
    - Are items eliciting the intended skills?
- Time Frame:
  - First Pilot in Spring 2014
  - Second Pilot in Spring 2015

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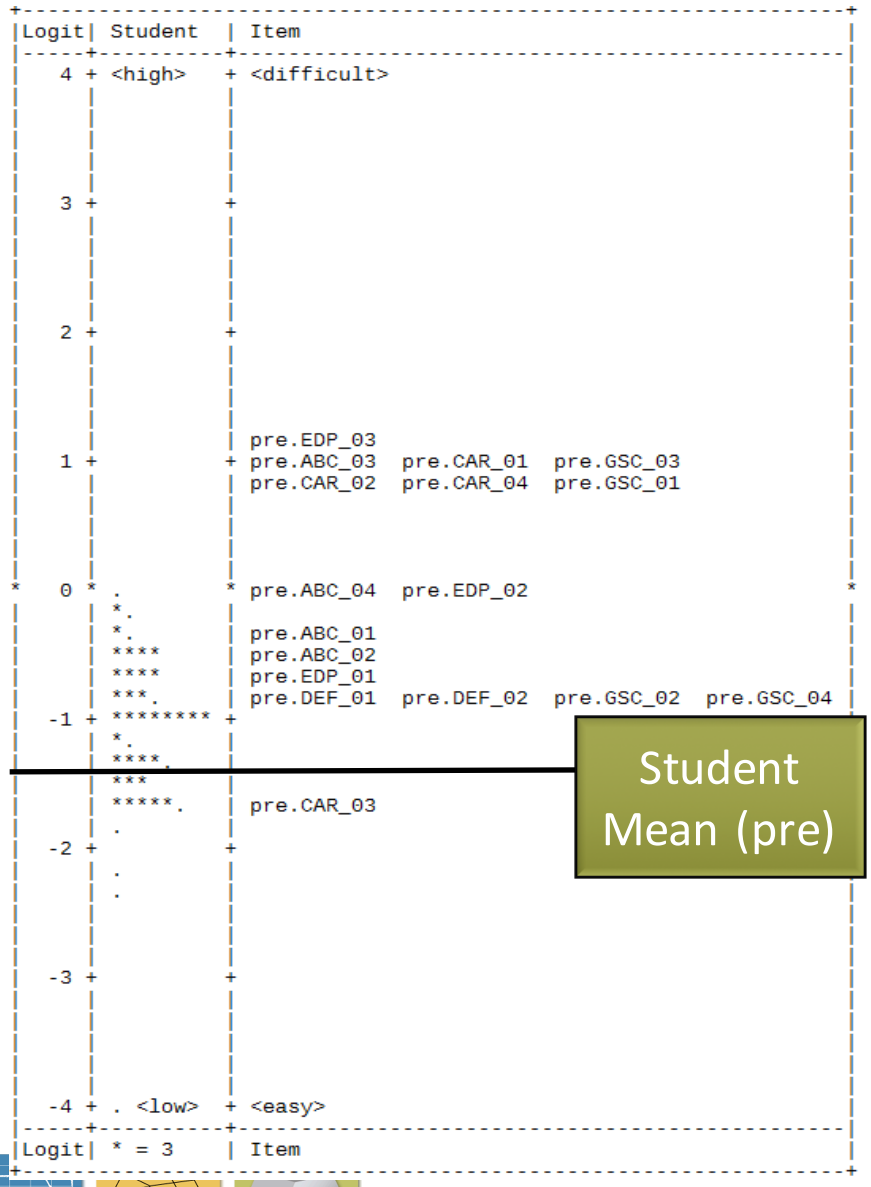
Fit Statistics

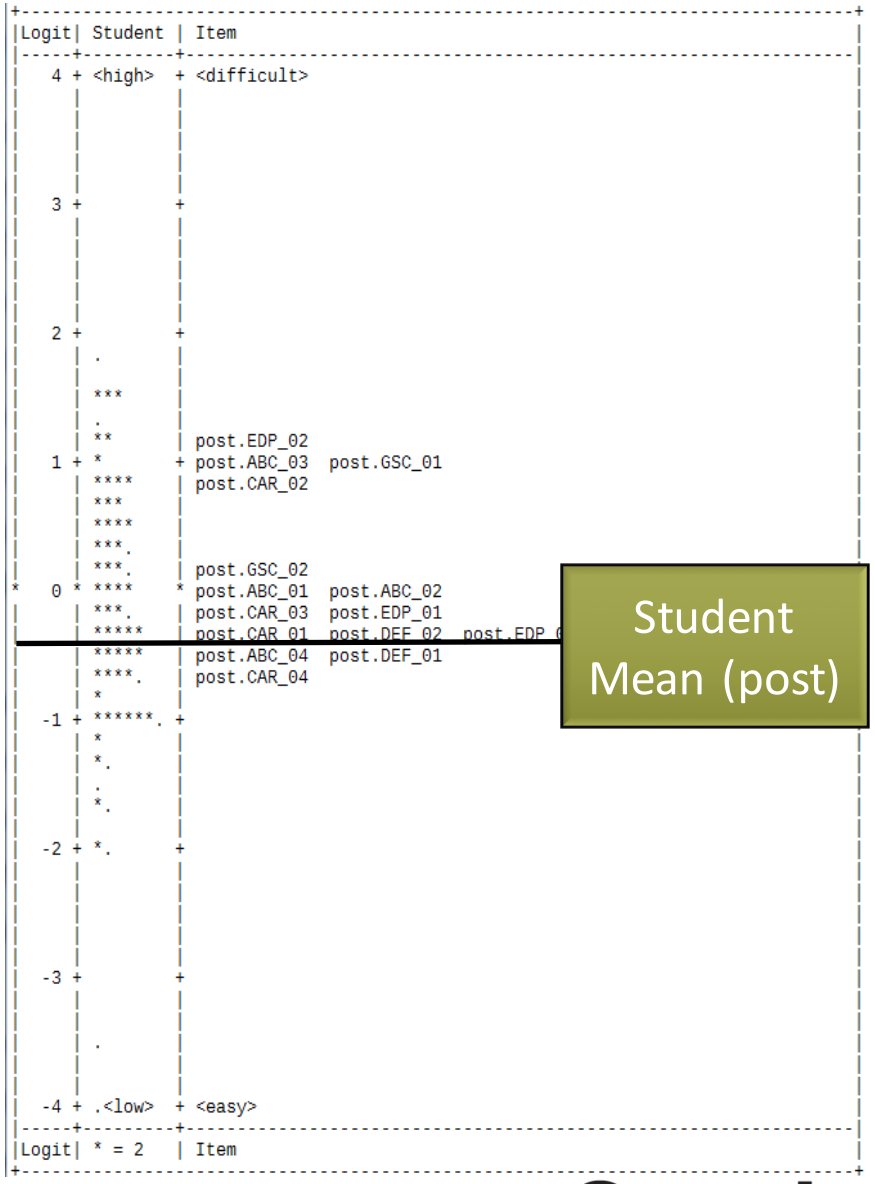
- Items functioned as expected based on indicators of model-data fit, reliability, and item-achievement level targeting.
  - Item difficulty estimates for the post-test range from $\delta = 1.35$ (*SE* = 0.27; proportion correct = 0.21) to $\delta = -2.04$; proportion correct = 0.87).
  - Model-data fit statistics suggest that, in general, the Infit and Outfit *MSE* statistics fall within the expected range of 0.80 to 1.30.

Pre/Post-Test Analyses

- Item difficulty decreased and student achievement increased during Spring 2015.
- Student achievement indicate positive changes between pre- and post-assessments for the overall sample.

Results





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Example

Engineering & Science Practices Alignment

A camping supply company asked you to design a water bottle. You did some background research to understand customer needs. Based on your research, you made a list of requirements. The water bottle must:

1. Include a clip to attach the bottle to a backpack
2. Hold at least 8 ounces of liquid
3. Be dishwasher safe (not be damaged in the dishwasher)

When you test your water bottle design, you discover some unexpected results. The clip is not strong enough to stay attached when the water bottle is full, and the plastic on the bottle becomes warped in the dishwasher. What should you do next?

a. Start over and begin working on a new water bottle design
b. Use a new type of plastic to make the water bottle more dishwasher-safe
c. **Update your requirements and brainstorm changes to improve the design**
d. Use new materials to make the water bottle plastic thicker and the clip stronger

Example

Engineering & Science Practices Alignment

Engineering Design Process	State Engineering Standard	NGSS Science Practice
Ideate: Brainstorm design ideas, Sketch to communicate, All ideas welcome **Evaluate**: Design meets the requirements? Select promising designs.	The students will develop an understanding of how the design process is used to develop a technological system.	**Practice 6**: Constructing Explanations and Designing Solutions

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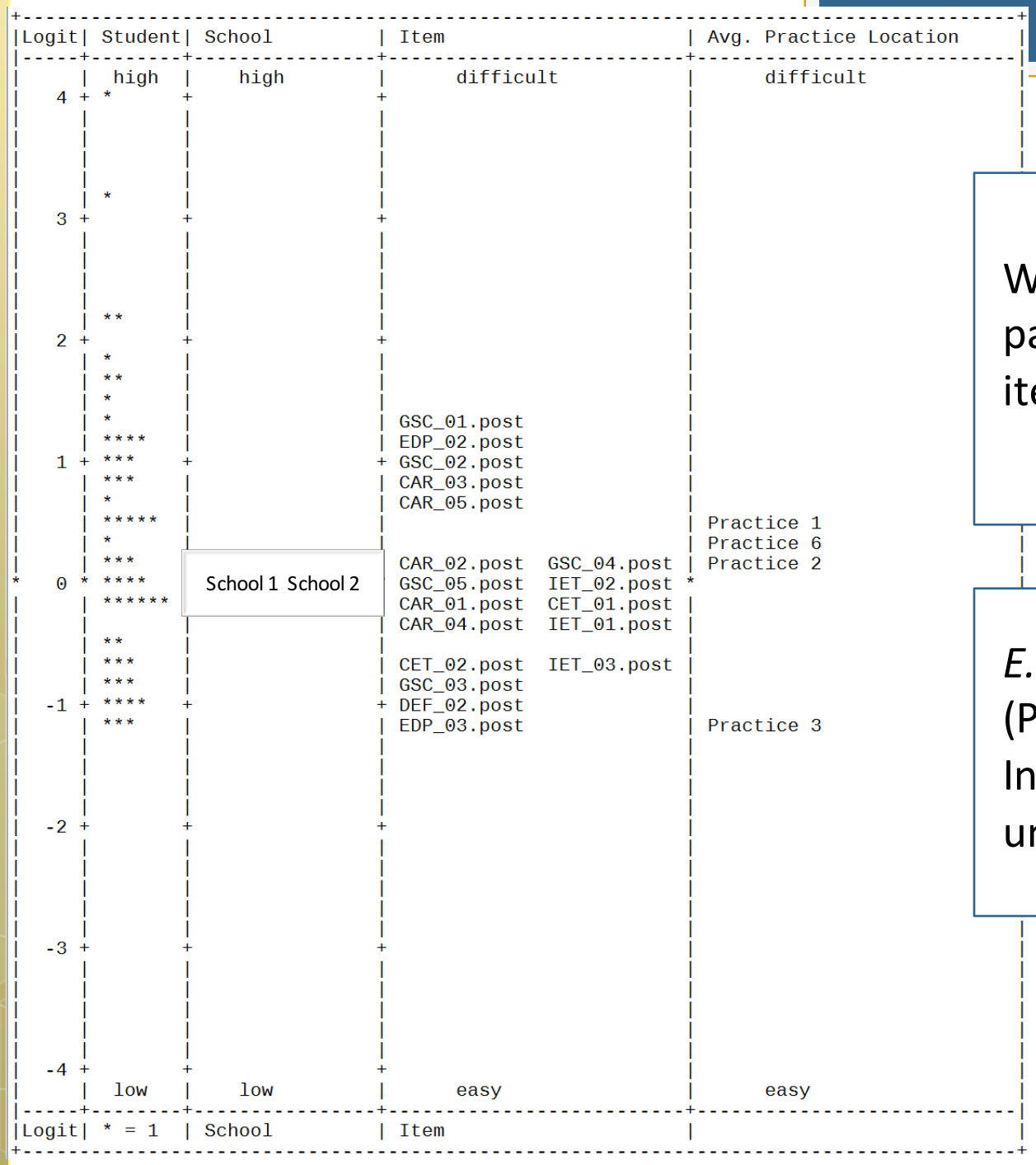
Example



We can begin to look at the patterns in the difficulty of the items per practice.

E.g., Hypothesis: Practice 3 (Planning & Carrying Out Investigations) is more easily understood by 6th graders.

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Thank you!

AMP-IT-UP Website

https://ampitup.gatech.edu

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