Engineering as the STEM Integration Connection for All Learners

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Background

- Two projects on curriculum development
  - EngrTEAMS: Teacher-created curriculum study with strong coaching component (grades 4-8)
  - PictureSTEM: Researcher-created curriculum study with literacy component (grades K-5)
- Findings from design-based research evolved into STEM Integration Framework

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The STEM Integration Framework

High-Quality STEM Integration Learning Experiences for Students:

- Have a personally meaningful, motivating, and engaging **CONTEXT**
- Have learners participate in an **ENGINEERING DESIGN** task for a compelling purpose that involves problem-solving skills and ties to context
- Allow learners to **LEARN FROM FAILURE** and then have the opportunity to **RE-DESIGN**
- Include appropriate, standards-based science and/or mathematics **CONTENT**
- Teach content with **STUDENT-CENTERED** pedagogies
- Engage students in **EVIDENCE-BASED REASONING** to integrate the subjects.
- Promote **COMMUNICATION** skills and **TEAMWORK**
- Thread the **ENGINEERING THROUGHOUT** the experience, not just at the end.

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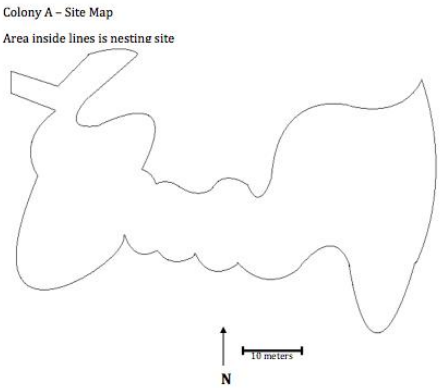
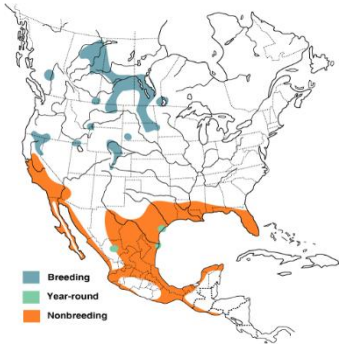
CONTEXT

EngrTEAMS: Saving Pelicans





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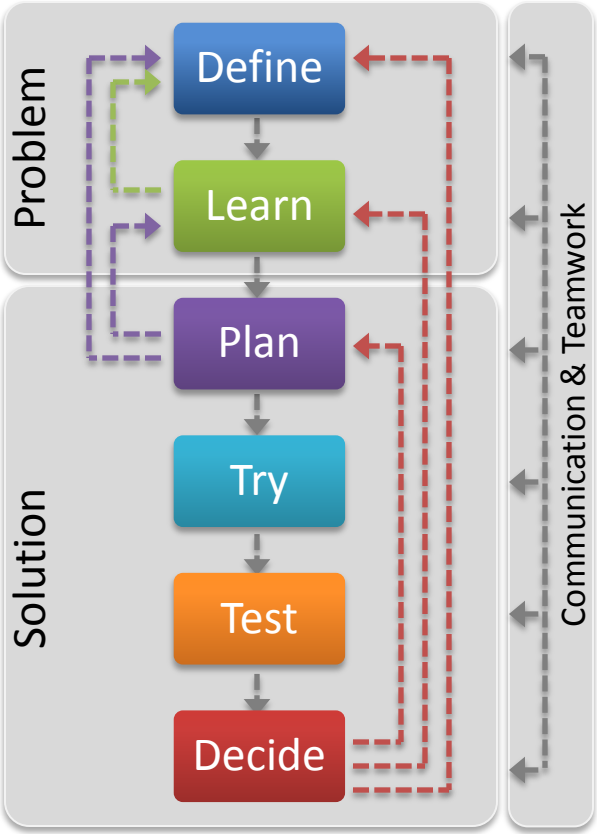
Engineering Design Process

A way to improve



ENGINEERING DESIGN, FAILURE, & REDESIGN

CONTENT PEDAGOGIES

Student-Centered – Minds-On/Hands-On

- Inquiry
- Discovery
- Argumentation
- Evidence-Based Reasoning

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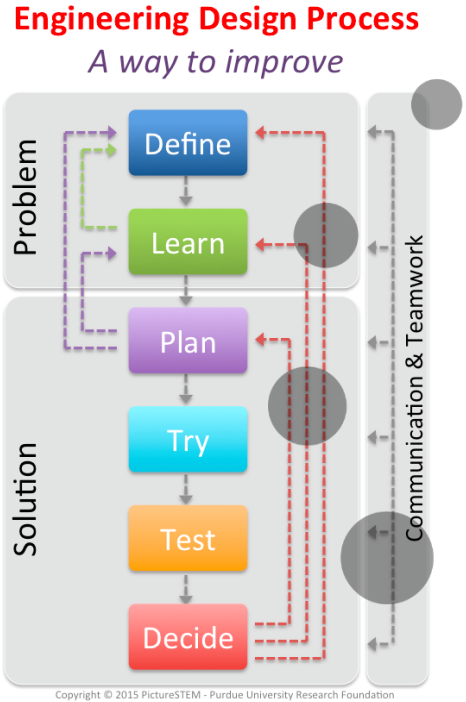
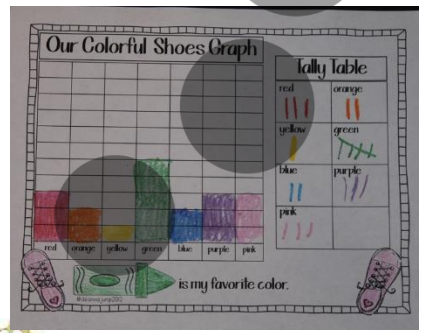
Evidence-Based Reasoning in STEM Integration





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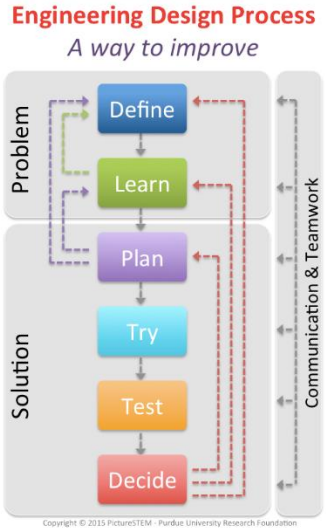
Evidence-Based Reasoning



Problem including Constraints & Criteria	
Simplifying Assumptions (if any)	
Ideas/Solutions	**Data/Evidence**
Explanation, Justification, Reasoning	

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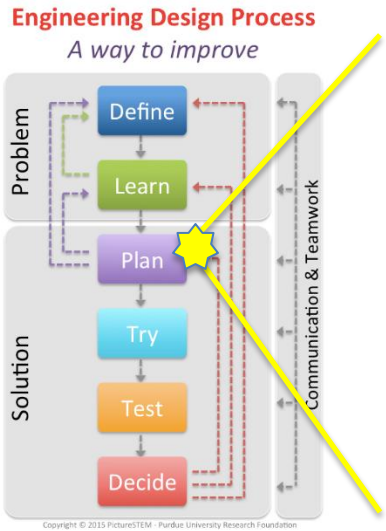
Evidence-Based Reasoning
As a part of the planning…



Problem including Constraints & Criteria

Problem scoping information

Simplifying Assumptions (if any)

Something that makes the design process more manageable but does not affect the essential character of the solution that needs to be implemented

Idea #1	**Data/Evidence**
Sketch or describe idea here. Include as much detail as possible.	Add detail about what you learned in researching about the problem that is relevant to your design.

Explanation, Justification, Reasoning

Give reasons why you think your design idea will exploit the scientific/mathematical principles in a way that will solve the problem .

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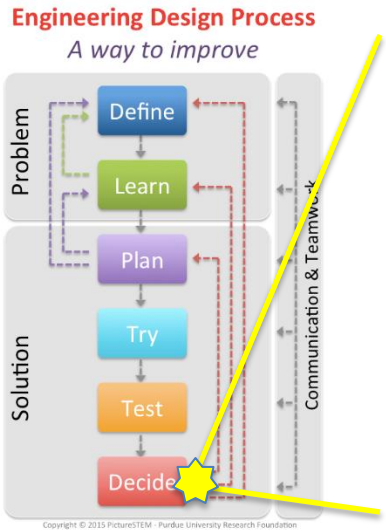
Evidence-Based Reasoning
As a part of the evaluation …



Problem including Constraints & Criteria	
Simplifying Assumptions (if any)	
Solution Include representations of your design solution here. Include as much detail as possible.	**Data/Evidence** Add detail about the evidence you collected to evaluate whether or not the solution meets criteria & stays within constraints.
Explanation, Justification, Reasoning Explain how your evidence, including scientific /mathematical evidence, was used to decide on relevant aspects of your design. Address how the criteria and constraints were or were not met and why your design choices were made based on the evidence. Justify how your design solves the client's problem & identify possible issues with your design.	

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Chair-ity Example

Problem including Constraints & Criteria

Design a cardboard chair for a charity dinner and auction

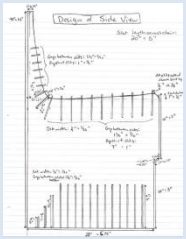
Criteria: cost, aesthetics, comfort, stability, support adult, repeatability of use

Constraints: cost, materials, time, function as chair

Simplifying Assumptions (if any)

We may neglect: manufacturability, longevity

Solution



Data/Evidence

- Our design uses inspirations from Jackson Pollock and Koi Fish.
- Load test and repeatability results - held 10 adults of up to 300 lbs for 20 minutes each
- Comfort test results – average comfort score 6.5/10.
- Stability test results – only fell over when we pushed it with the high force (not low or medium)
- Cost breakdown – 5 glue sticks = \$0.75; 5700 in^2 of recycled cardboard = \$18.53; Total = \$19.28

Explanation/Justification/Reasoning

Our chair demonstrated that it met the repeatability of use and exceeded the load capacity. While the comfort score could have been higher, we feel that higher comfort on cardboard chairs may be unreasonable due to material limitations. Our comfort score was based on several issues, the most important being how the chair lined up with the proportions of the human body. This chair does a good job at fitting the *greater trochanter of femur to the lateral epicondyle* (hip to knee) for all 10 of our test subjects. However, the seat height has been shown not to fit the *lateral epicondyle of femur to the base of the foot* (knee to base of foot) for 6 of 10 of our test subjects - their feet didn't touch the floor when sitting in our chair. Our stability test was designed to show that normal side force (such as would be expected from regular sitting) does not cause tipping. Our chair cost is a little high but meets the constraint. We feel that our artistic interpretation of chair design and the additional load capacity will make it worth more to the customer, and so the initial cost is worth the investment.

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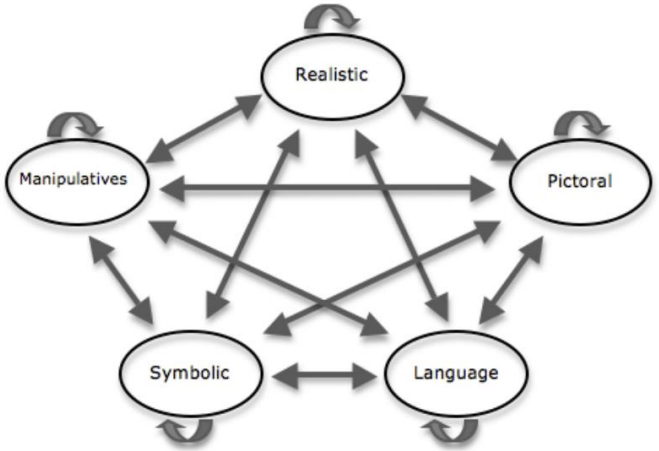
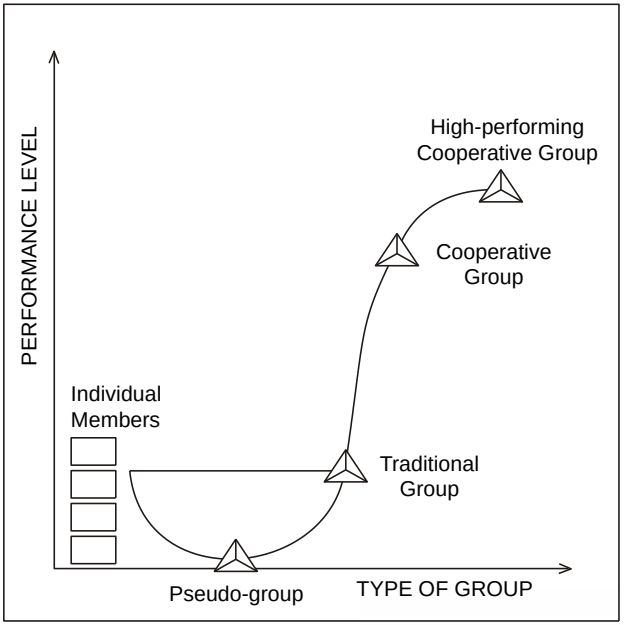
COMMUNICATION & TEAMWORK



Lesh & Doerr (2003)



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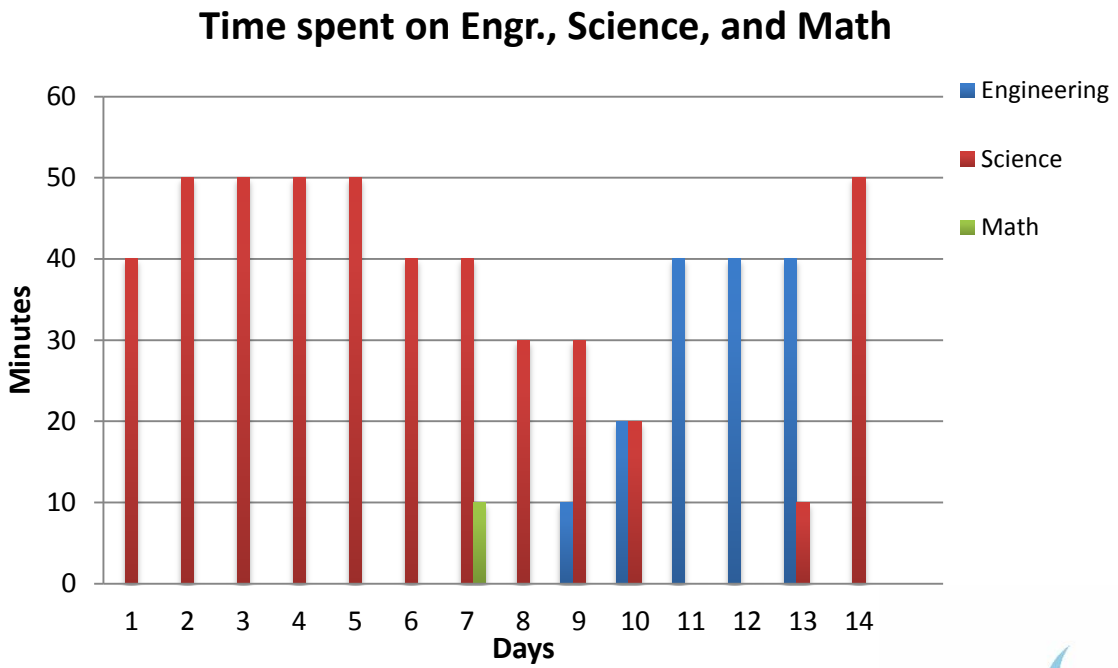
Less Effective Practice



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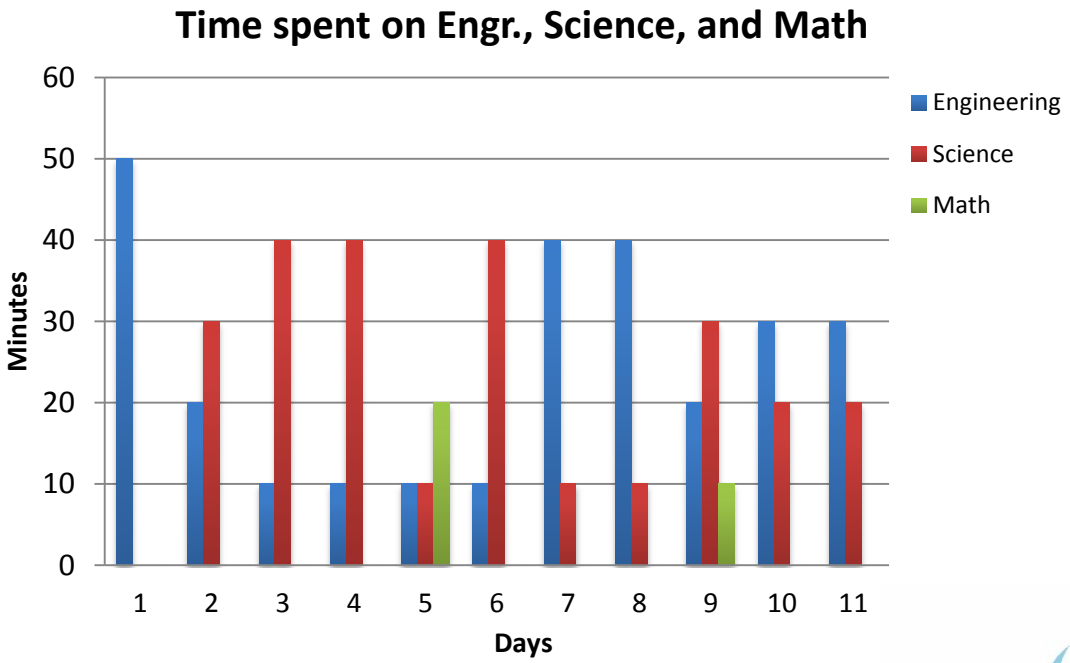
ENGINEERING THOURHGOUT
More Effective Practice



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Conclusion

Group	Item #1 Context					Item #2 Engineering					Item #3 Science					Item #4 Mathematics					Item #5 Pedagogies					Item #6 Teamwork					Item #7 Communication					Item #8 Assessment					Item #9 Organization				
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