Creating an interdisciplinary learning environment using engineering design and thinking skills

MassCue
10/28/2010

Bill Wolfson

We focus on PreK- grade 5 teachers and students.

Using design thinking to engage students in STEM subjects.

EngineeringLens

Background

- We are losing out to other nations in educating Students in STEM.

- Our education system still often operates in “Silos” versus interdisciplinary learning, making our students unable to see the relevance of what they are studying.

- Elementary teachers are often more comfortable with Language Arts than with STEM subjects.

The core idea of the approach is that engineering need not “stand alone” in the curriculum, but can and should leverage other curricular elements, in particular literature.

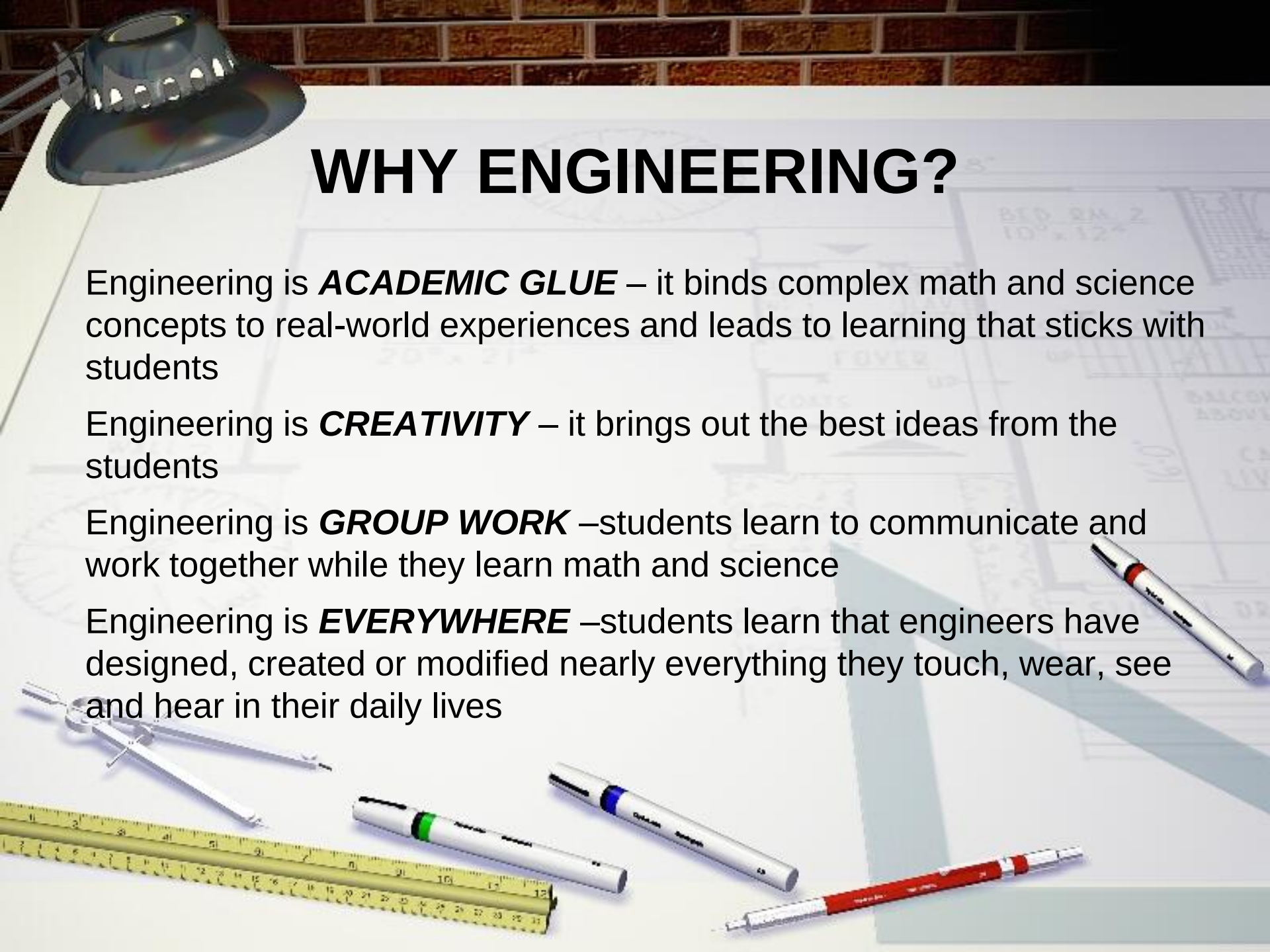
WHY ENGINEERING?

Engineering is ***ACADEMIC GLUE*** – it binds complex math and science concepts to real-world experiences and leads to learning that sticks with students

Engineering is ***CREATIVITY*** – it brings out the best ideas from the students

Engineering is ***GROUP WORK*** –students learn to communicate and work together while they learn math and science

Engineering is ***EVERYWHERE*** –students learn that engineers have designed, created or modified nearly everything they touch, wear, see and hear in their daily lives



Objectives for the teachers:

1. Increase familiarity with Strand Four of the MA Science Framework
2. Utilize Design Thinking process across all disciplines.
3. Use of Thinking Skills in the learning process.
4. Understanding of what engineers, mathematicians, and scientists do.
5. Connect literacy with engineering, math, and science instruction.
6. Creating an interdisciplinary learning environment.

We start with the definition of an engineer:

… Designs useful products and processes for society based on all disciplines but mainly science and math.

Also discuss:

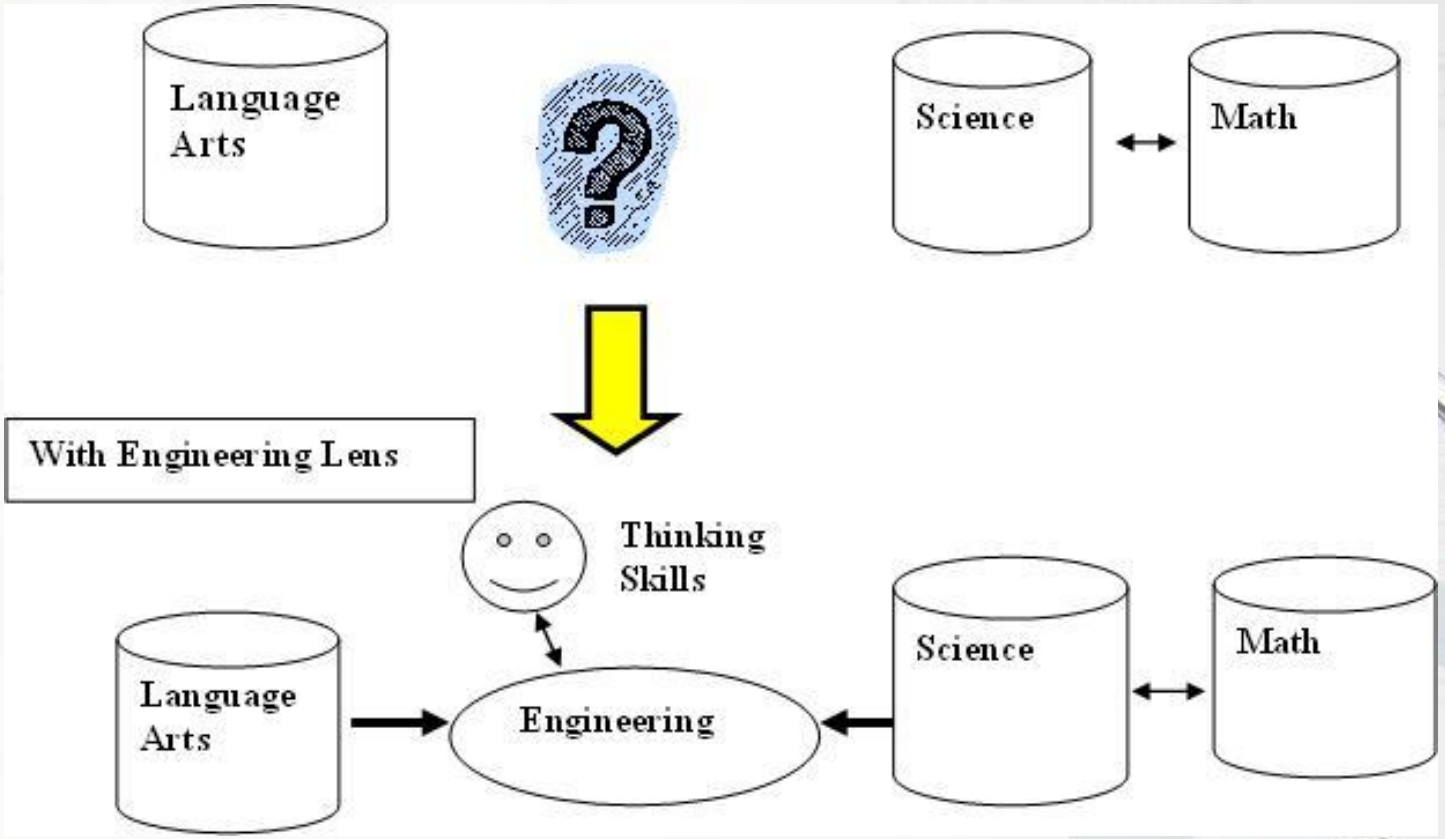
- ❑Scientists
- ❑Mathematicians
- ❑Artists
- ❑Entrepreneurs
- ❑Technologists

Engineering is everywhere

Show how we can find how engineering connects to Science and Mathematics using simple household items

- Water Nozzles
- Brushes
- Flashlights
- Ice Cream Scoopers

Building the connection



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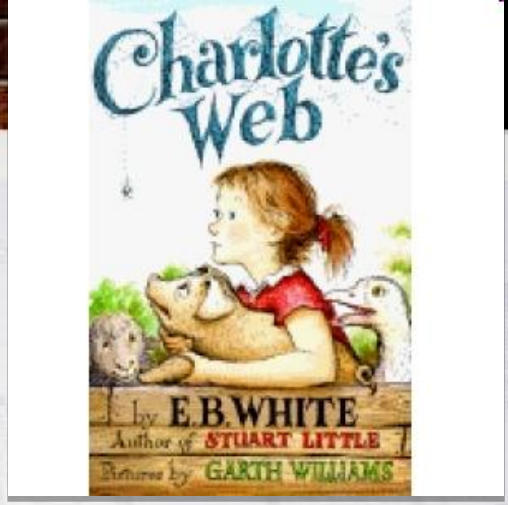
Example

- Needs of the characters
- Solving a known problem in the story

Engineering designs useful products or processes using all disciplines' but mainly science and math.

Charlotte's Web by E.B. White



Design Challenges:

- Killing of the runt P1
- Keeping warm at night in the yard. P9
- Mr. Zuckerman knew that a manure pile is a good place to keep a young pig P14
- Wilber was lonely, he wanted love P27
- Have you ever tried to sleep while sitting on eight eggs asked the goose. P33
- "I happen to be a trapper", says Charlotte P39

Note: just thru pg 39 out of 184

Charlottes Web

Challenge	Math	Life	Earth & Space	Physics & Chemistry	Simple Machines	????
Keeping warm at night						

Use manure

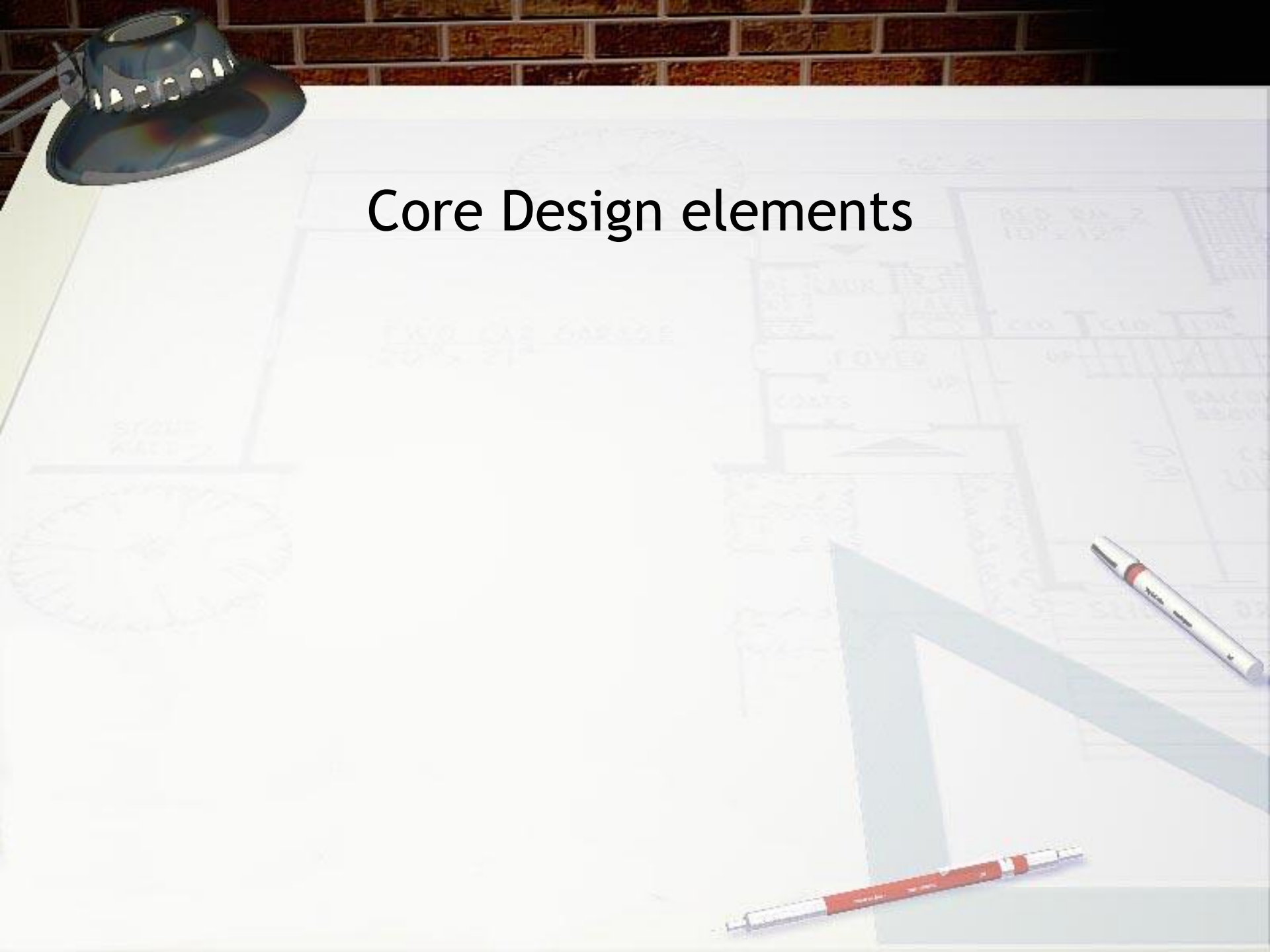
Build a house

Use a fire

Use a ramp to lift him off the ground

Give him more food to eat

Core Design elements

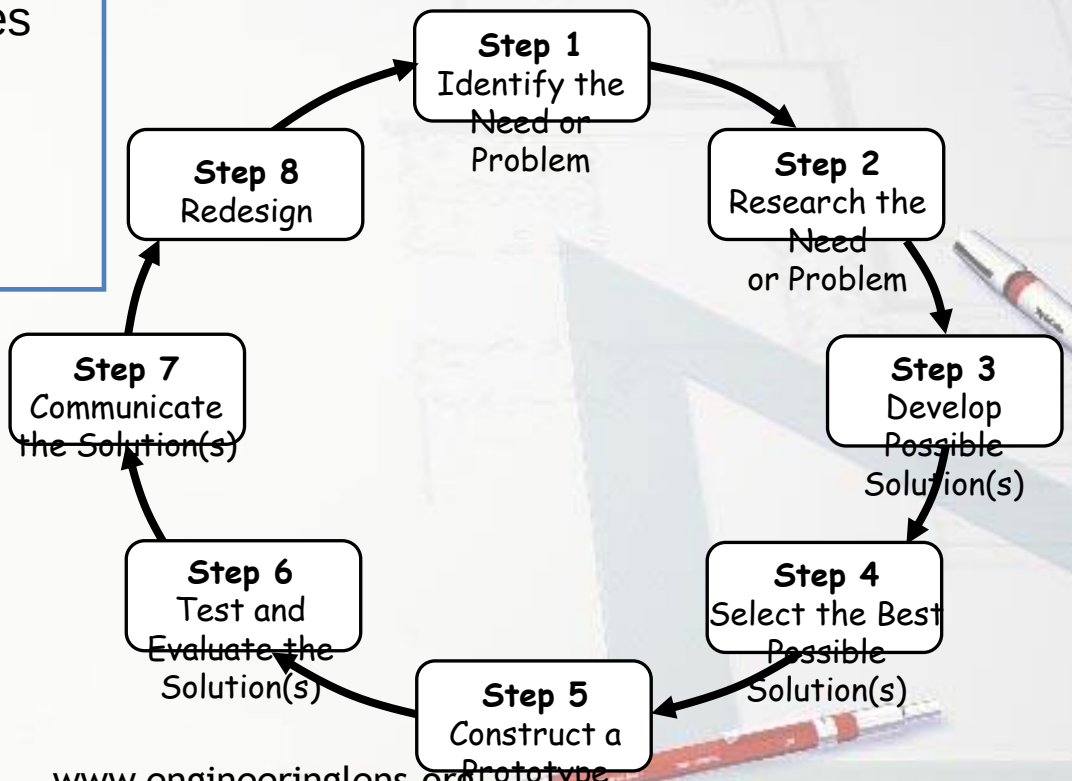


MA Framework

Strand 4 Engineering & Technology

Science Framework Principles
- Design process
- Tools
- Materials
- Simple machines

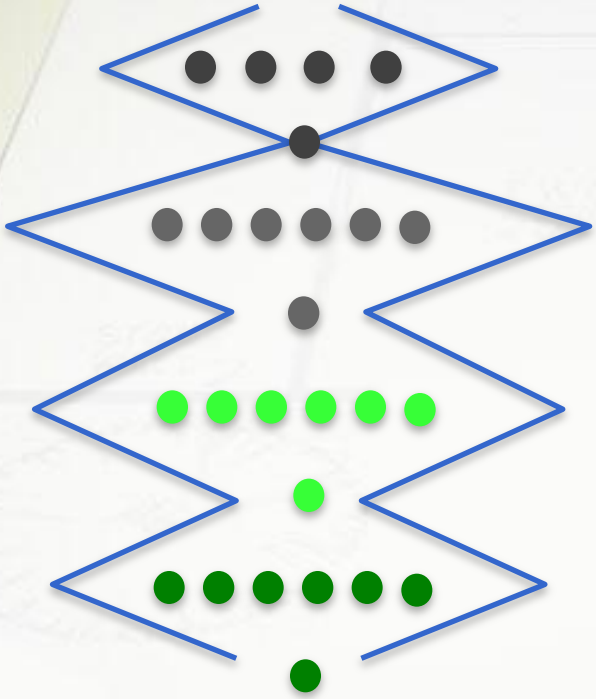
Missing:
- People
- Iterative process
- Divergent/Convergent thinking



Framework Oct. 2006

www.engineeringlens.org

Connecting literature



Divergent/Convergent thinking

- Story/Characters
- Design Challenge
- Specification
- Designs
- Product
- Testing/ Feedback

Reporting

Iterative process

Mark Somerville, Olin College

"It bugs me when my coffee gets cold."

- Needs
- Requirements
- Specification

Divergent:
Generate raw ideas

Use solar power!

Drink Tea!

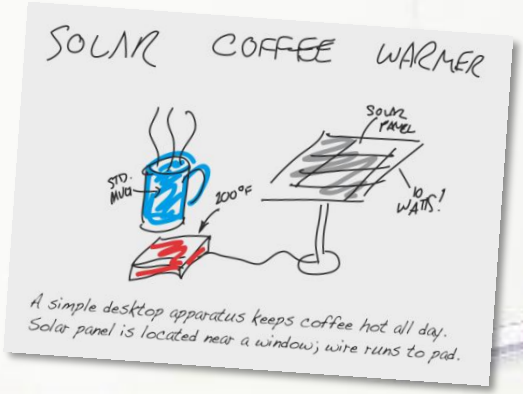
Convergent:
Define requirements

Coffee Warmer
REQUIREMENTS

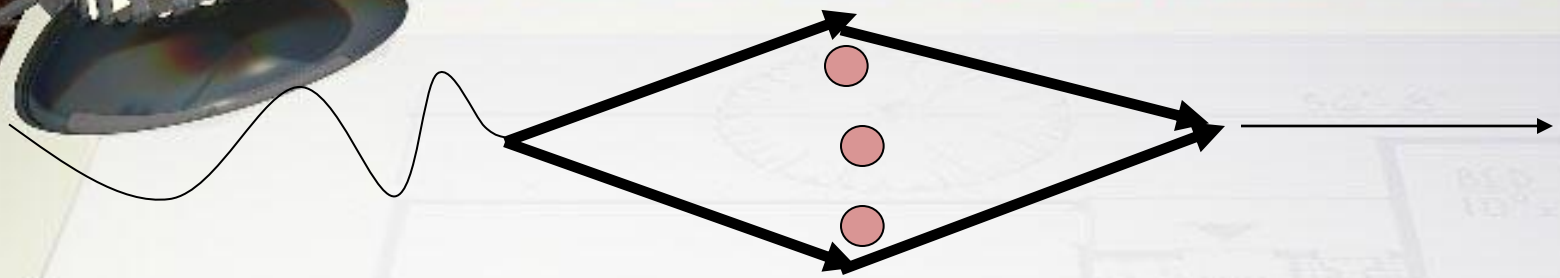
The design should…
Be no larger than…
Cost no more than…
Keep coffee at…

Divergent:
Generate alternatives

Convergent:
Select an approach



Summary Process



Priming	Generative	Convergent	Defining
History	Brain Writing	Discussion of Pro/Con	Gallery Sketches
Needs	Morphological Analysis	Shaping	Modeling/Building
Problem Framing	Shaping	Requirements	Posters
Values	Brain Storming	Decision Matrix	Presentation
OTHERS			

Listen to the needs and values of the customers

- **Generate raw ideas for a given challenge**
- **Select an idea that is particularly interesting**
- **Identify the requirements for that concept**
- **Come up with multiple solutions that meet the requirements**
- **Select a solution, based on the requirements**

Thinking Skills are the Tools of Engineering

Design Thinking

- Generate raw ideas for a given challenge
- Select an idea that is particularly interesting
- Identify the requirements for that concept
- Come up with multiple solutions that meet the requirements
- Select a solution, based on the requirements.

Creative thinking	Critical Thinking
Meta-cognitive reflection	Questioning

6 Hats by Ed DeBono

Dialogue versus Argument

De Bono's Six Hats

Red Hat - Emotions and Feelings, Intuitions 	White Hat - Facts, Figures, Information and Data 	Black Hat - Caution and Judgement, Problems 
Yellow Hat - Positives, Advantages and Benefits 	Green Hat - Creativeness, Imagination and Possibilities 	Blue Hat - Managing the Thinking, Big picture 

Reflects and questions own assumptions

Tying Science into the design

Science Framework

Earth/ Space

Life

Physic/ Chemistry

Engineering/ Technology

Strand 4

The *Purpose and Nature of Science and Technology/Engineering section describes how science and technology/engineering interrelate.*

Specifics:
http://www.doe.mass.edu/frameworks/current.html
Latest version Oct 2006
Status: In update mode

Use at least one science constraint when generating your design solutions

Design challenges	Sciences	Filters	Results
	Earth & Space	Energy in the Earth System Materials and Energy Resources Earth process and Cycles Structure of the Earth Earth in the Solar System	
	Life science	Characteristics of Living Things Systems in living Things Heredity Evolution and Biodiversity Living things and their environment	
	Physic & Chemistry	State of Matter Position and motion of objects Electricity & sound	
	Engineering	Tools Materials Engineering Design	

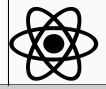
Life Science
Design challenges
Science
Earth and Space
Design challenges
Science

As an Example

Life Science →

Design challenges ↓	Characteristics of Living Things	Systems in living Things	Heredity	Evolution and Biodiversity	Living things and their environment

"Example" Science matrix

Science Themes/Units			
Grade	Physical Science	Earth Science	Life Science
K	 **Position and Motion**	 **Day and Night**	 **Plant or Animal**
1	 **Solid, Liquid, and Gas**	 **Weather**	 **Animals Classifications and Life Cycles**
2	 **Force and Motion**	 **Earth**	 **Animals Habitats/ Adaptations**
3	**None**	 **Solar System**  **Water**	 **Plants**
4	 **Energy**	 **Planet Earth**	**None**
5	 **Matter**	 **Meteorology**	 **Animal Kingdom**
MCAS Test			
6	 **Magnets and Motors**	 **Measuring Time**  **Space**	 **Ecology**

Mathematic outcomes

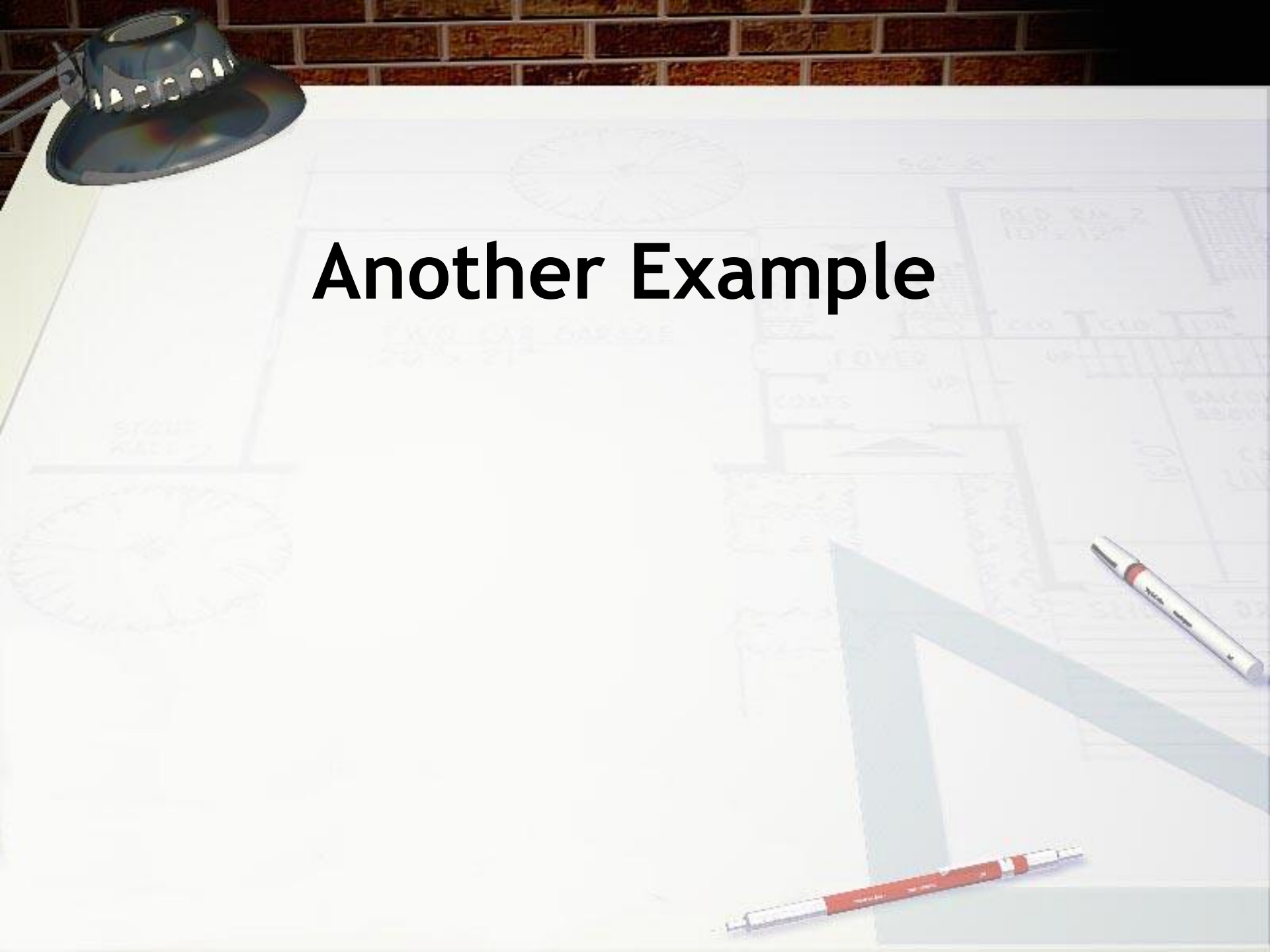
Mathematical reasoning is fundamental to the design and construction process.

In the lessons, we have the opportunity to ask mathematical thinking questions such as:

- How would I draw a diagram that shows the area, dimensions, etc. of what we are doing?
- How am I going to collect data to evaluate the design during the testing phase?
- How would I calculate _____?
- How would I calculate the cost of the material we need.
- In general we can ask questions that gets the students thinking and probing about the following:
  - Dimensions, Shapes, Patterns, Number sense, Colors, Functions Area Grouping/Comparing, Measurements.

Number Sense	Patterns, relationships Algebra	Geometry	Measurements	Data Analysis Statistics, Probability

Another Example



Goldilocks

Design Challenges :

- Breaks into the house
- Finds the food cold or too hot
- Breaks a chair
- Finds the beds not comfortable
- Escapes by jumping from the house.

Did not find a room for the bears to hibernate.

Design challenges in the story " Goldilocks"

Goldilocks

Habitate

Design a Room

Bears hibernate

Signs, art & math

Security system

tunnels, mechanical locks

Entering the house

Design food warmer

Eating the porridge

insulation, energy transfer

Found sleeping

Design a bed

Materials, structure

Running out

Sitting on the chair

Design a chair

3 leg chair?

Materials

Excape from upstairs

Slide, friction

Trampoline, springs

9/17/09

Benefits

- Meets all the learning principles of the Massachusetts Science Framework
- Promotes higher-order thinking skills using design learning.
- Invites the incorporation of instructional technology into the curriculum. Engineering is differentiated
- Rich cross-curricular possibilities.
- Integration with science and math is an important way to show students how and why both are relevant and useful in the world.
- Directly connected with improvement of living conditions/safety/health and welfare of people.

Diana Mason, Missy Taft,

EngineeringLens

Leadership must embrace innovation and set the environment for making it happen!!!

21st Century Skills

Collaboration
Communication
Creative Thinking
Critical Thinking

Risk Taking
Learning from failure

Trust
Respect

Curiosity

About Us

Our method; Uniqueness

- Not another Silo.; Interdisciplinary
- Uses design to support learning.
- Students make decisions versus learning through highly scripted program.
- Integrates the learning of thinking skills, system thinking and self assessment.
- Open source for educators.

Call to Action

1. Started as a life goal to get children excited about engineering careers.
2. Team of academics, school teachers and a few retired engineers.
3. Goal is to create curriculum for PD for educators with assessment in urban, suburban and rural school districts.
4. Sustainability model is:
   - taught as supplemental curriculum in teachers colleges.
   - interactive web site for collaboration.
   - ownership by major NP education corp.

Activities www.engineeringlens.org

- Created Syllabus for 3 credit course (FSU)
- One-credit on-line course FSU
- First major implementation in Millis Public Schools (9/2009 to 1/2010), completed second & third group, June, August, 2010 .
- Created on-line learning site in Moodle learning software(The Learning Curve)
- Tufts CEEO has received an NSF research grant(DRK-12) based on this concept.

Can we work with your district ?

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End
Thank you