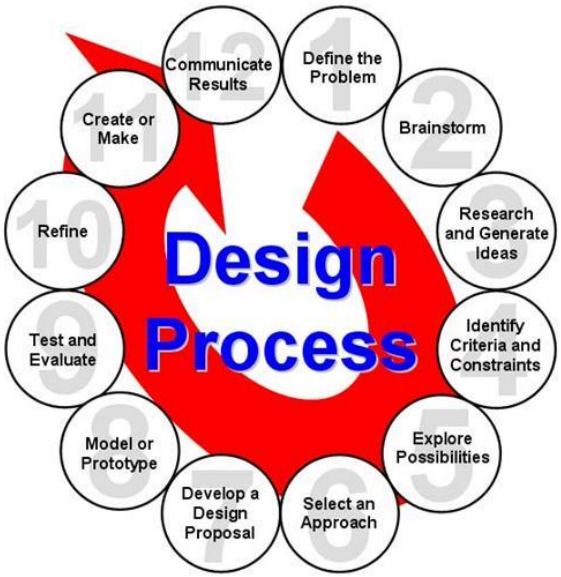
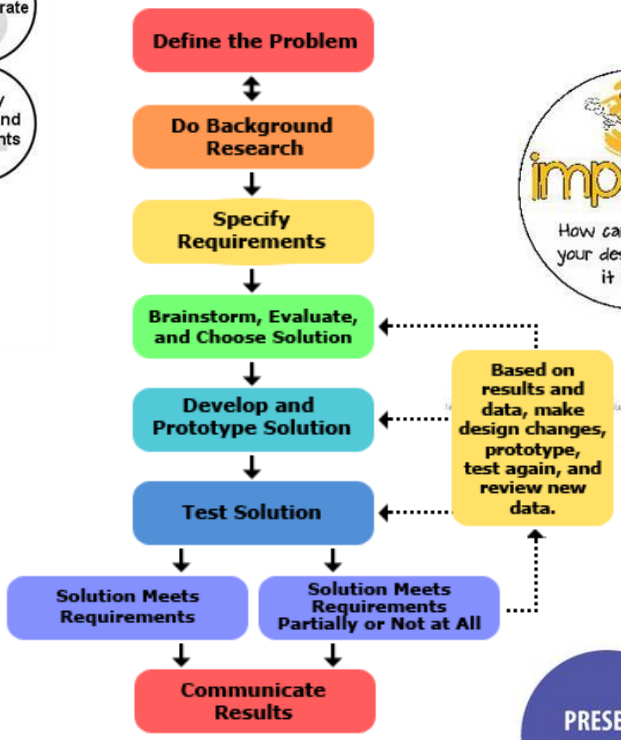
Experiencing the Engineering Design Process through a Math Lens

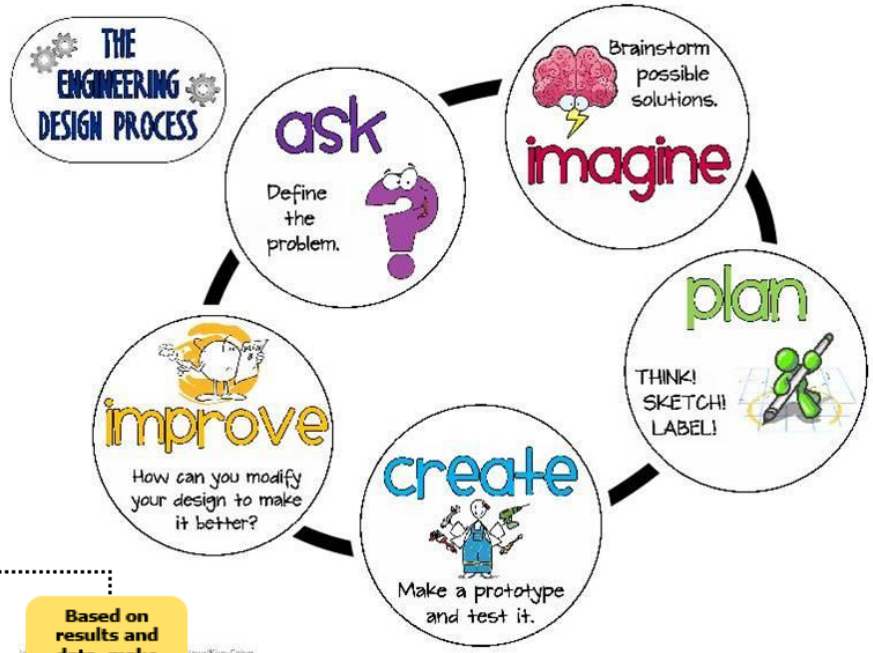
Heather Kohn
Marlborough High School, MA

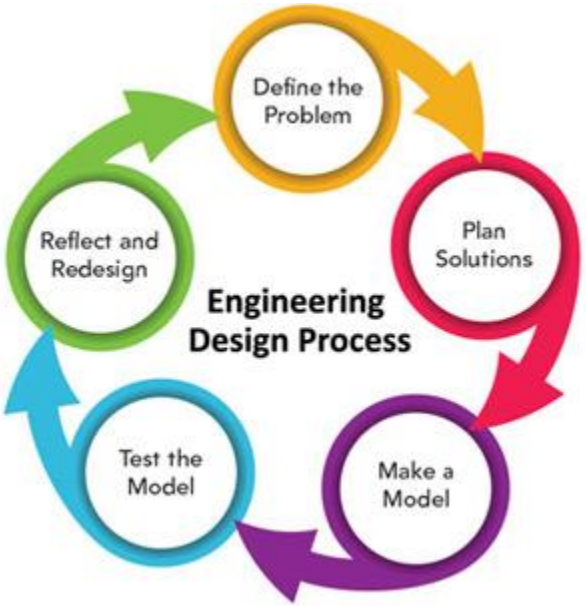
@heather_kohn
heather.m.kohn@gmail.com
growingexponentially.wordpress.com

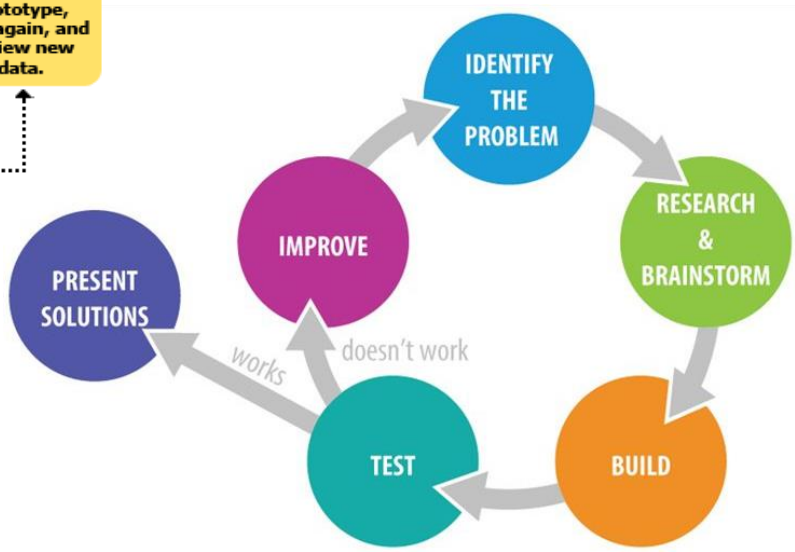
Engineering Design Process



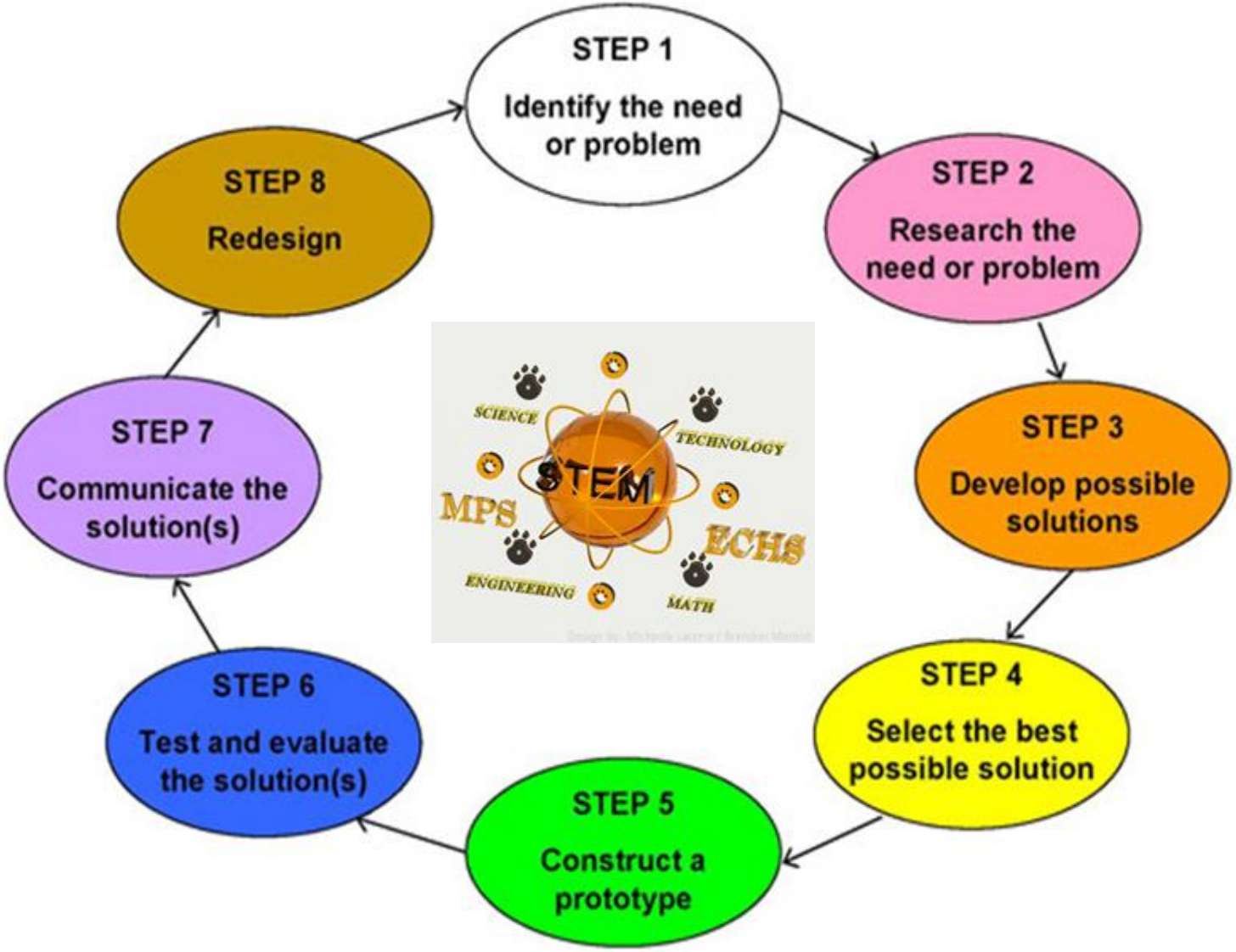








Engineering Design Process



Mindset

We're not doing engineering projects in math class.

We're doing math tasks with an engineering framework.

Why?

"Design involves both the use of existing information and knowledge and the generation of new information and knowledge.

Design requires leaps of the imagination, intuitive insight, the synthesis of different ideas, and empathy with people who come in contact with any new product, system, or process that is designed.

Design is learned by doing and reflecting."

(Radcliffe, 2014)

Why?

Math involves both the use of existing information and knowledge and the generation of new information and knowledge.

Math requires leaps of the imagination, intuitive insight, the synthesis of different ideas, and empathy with people who come in contact with any new product, system, or process that is designed.

Math is learned by doing and reflecting.

Processes

Table 1 The engineering design process and the mathematical thinking process follow similar paths.

Engineering Design Process	Mathematical Thinking Process
1. Define a problem.	1. What are you being asked to find?
2. Do background research.	2. What do we need to know?
3. Specify requirements.	3. List the given information or collect data.
4. Create various solutions, choose one, and develop it.	4. Select a strategy to solve the problem or analyze the data.
5. Build a prototype.	5. Solve the problem or make a conclusion after analyzing the data.
6. Test and redesign.	6. Does your answer make sense?
7. Communicate results.	7. Communicate results.

Source: The Engineering Process in Construction and Design. (2013). *Mathematics Teaching in the Middle School*,*18*(6), 332-338.

Barbie Bungee Example

Step 1: Identify the Challenge

Design a bungee cord for Barbie that gives her the safest, but biggest thrill of a drop.

Step 2: Research

What do you need to know to solve this problem?

Step 3: Develop Possible Solutions

How many rubber bands do you think you should use? Why?

Barbie Bungee Example

Step 4: Select the Best Solution

What does the group think? Why? What materials will you need?

Step 5: Construct a Prototype

What is the procedure for building it?

Step 6: Test and Evaluate the Solution

How did Barbie's bungee perform?

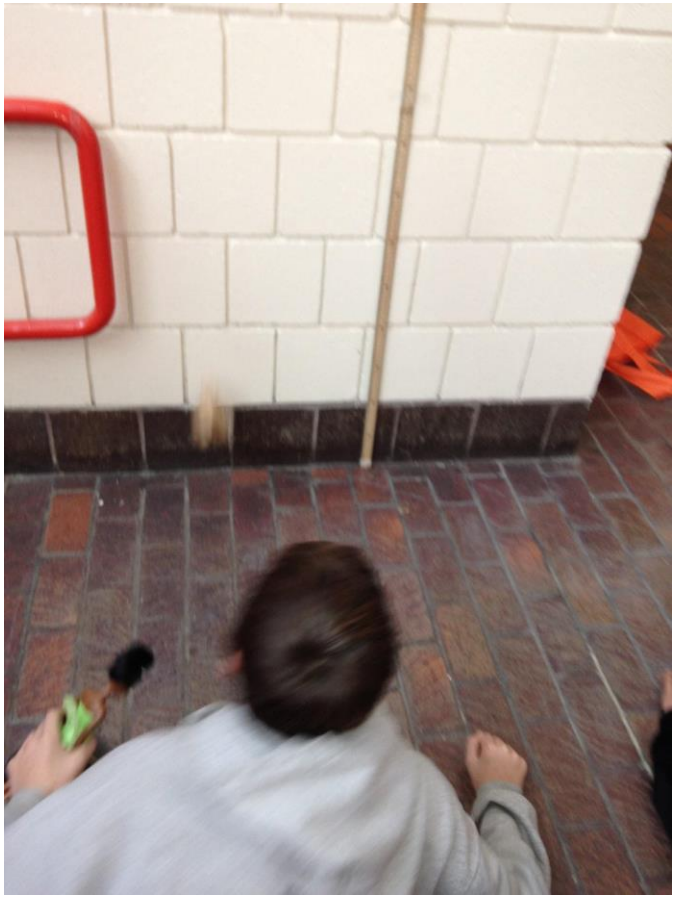
Barbie Bungee Example

Step 7: Communicate the Solution

How will you share your results?

Step 8: Redesign

How could you improve Barbie's bungee?



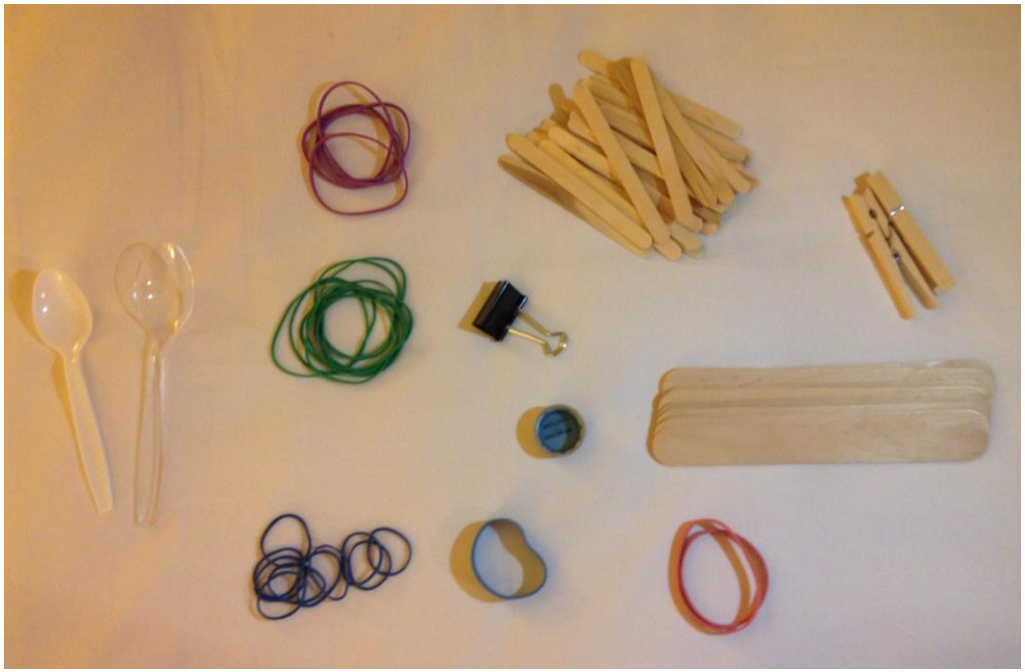
Engineering Design Plan
aka the “other” EDP

Catapult Launchers - Step 1

Challenge: Design a catapult that accurately launches an M&M so it hits the target

Constraints:

- Time
- Materials
- "Budget"
- Wifi



Catapult Launchers – Step 2

Research: What do you already know about this problem? What do you need to know? What *math* do you need to know?

At your table, you have *3 minutes* to review the research cards, or do your own internet research on catapult design.

Record any valuable information in your EDP.

Catapult Launchers - Steps 3 & 4

You have *5 minutes* for these steps!

Possible Solution:
Sketch your own catapult design

The BEST Solution: Chat with your group and select the best design. What materials will you need?

[In addition to the supplies in your bag, there is:
Gorilla Glue, duct tape, scissors]

Catapult Launchers - Steps 5 & 6

It's building and testing time!

You will have approximately *35 minutes* to build, AND start testing your catapult.

2 parts to testing:

1st = from ground
2nd = from tabletop

Catapult Launchers – Step 6

a) Let's say my averages are: Distance – 1.45 m
Time – .813 sec

b) .813/2 = 0.41

c) $d = \frac{1}{2}(9.8)(0.41)^2$ = 0.823 m

d) 1.45/2 = 0.725 m

e) $0 = a(0 - 0.725)^2 + 0.823$

$a = -1.56$

$y = -1.56(x - 0.725)^2 + 0.823$

f) $y = -1.56(x - 0.725)^2 + 1.55$

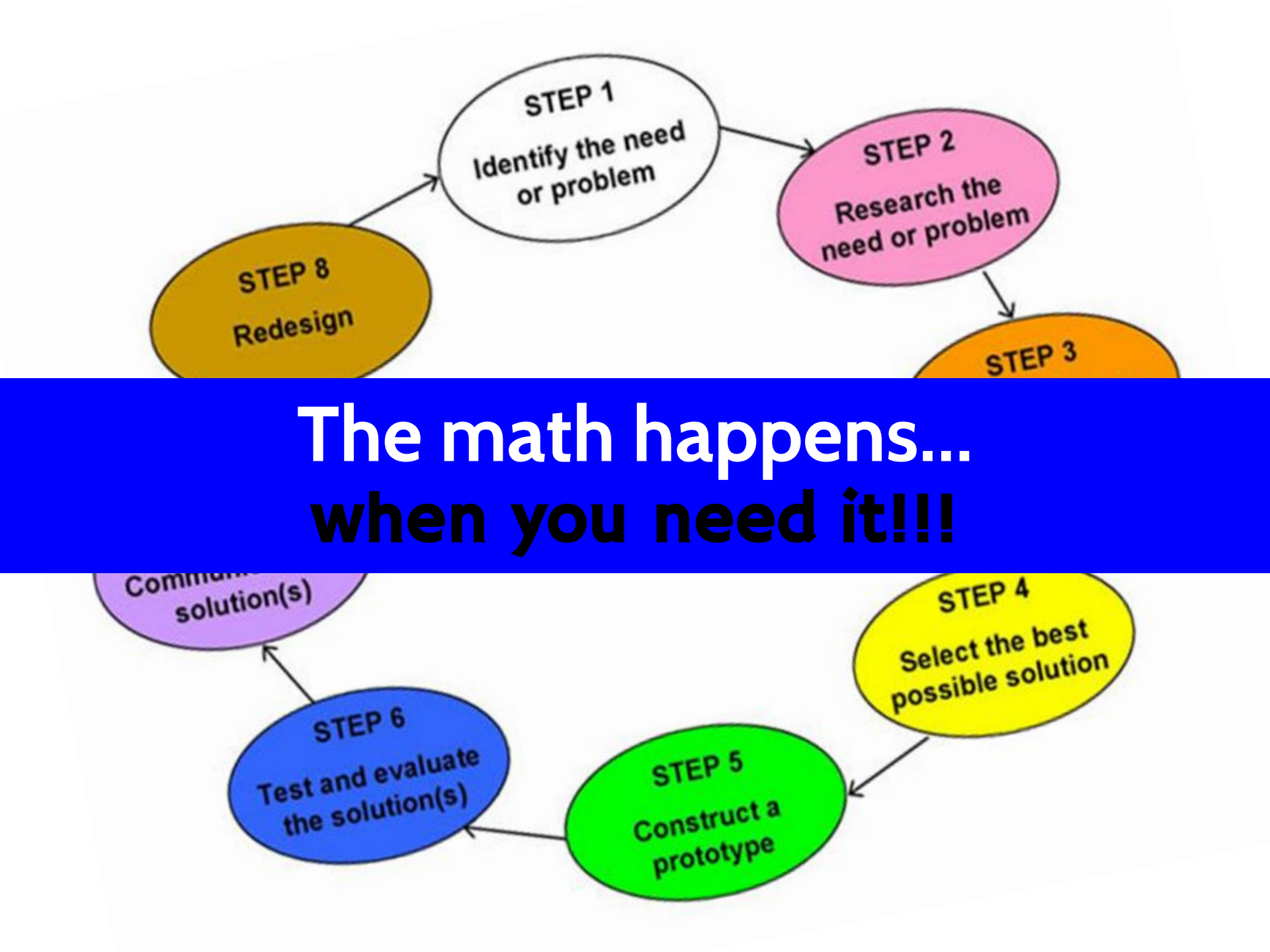
Catapult Launchers - Steps 7 & 8

Communicate Solution:
Share your results with the whole group!

Redesign:
How could you improve your solution?

Other Tasks

- Barbie Zipline (Pythagorean Theorem)
- Amusement Park Rides (Circular Motion)
- Hotel Snap (Surface Area, Profit)
- Tinfoil Geometry (Surface Area)
- Make Your Own Visual Patterns (Functions)
- Bouncing Ball Investigation (Exponential)
- Mini Golf Hole Design (Angles, Reflection)
- Buried Treasure Maps (Triangle Congruence)
- Food Container Design (Geometry)



The math happens...
when you need it!!!

References

Emerging Engineers Design a Paper Table. (2013). *Mathematics Teaching in the Middle School*,*18*(6), 362-369.

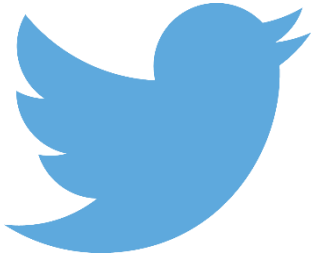
Fosmire, M., and Radcliffe, D. F. (2014). *Integrating information into the engineering design process*. Purdue University Press.

National Council of Teachers of Mathematics (NCTM). 2000. Principles and Standards for School Mathematics. Reston, VA: NCTM.

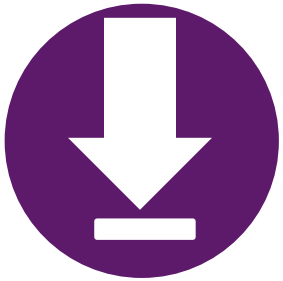
The Engineering Process in Construction and Design. (2013). *Mathematics Teaching in the Middle School*,*18*(6), 332-338.

Sweeney, Sean. (2009, Sept 1). M&M Catapult project pt. 2- The project [web blog post]. Retrieved from http://sweeneymath.blogspot.com/2009/09/m-catapult-project-pt-2-project.html

Rate this presentation on the conference app! Search "NCTM 2016" in your app store or follow the link at nctm.org/confapp to download



Join in the conversation! #NCTMannual



Download available presentation handouts from the online planner at nctm.org/planner