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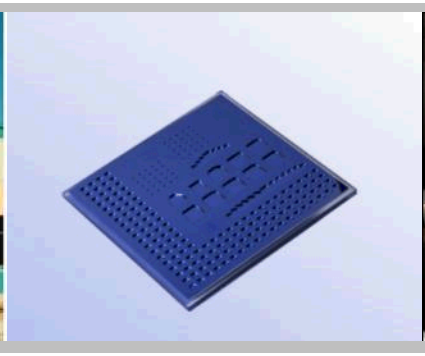

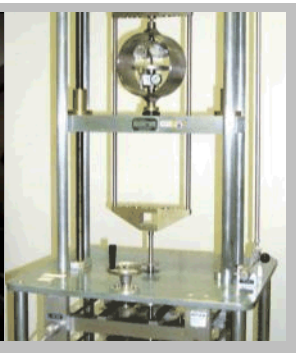

Engineering for Teachers: A Case Study of Professional Development for K-12 STEM Teachers

NCSLI Workshop & Symposium; August 15, 2017

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Desired outcomes

- The attendee will be familiarized with next generation science standards (NGSS)
- The attendee will learn about professional teacher perspectives and needs
- The attendee will be provided with resources that can be used in outreach events.

Outline of presentation

- Quick intro to NGSS, “what’s new” in NGSS
- Needs for professional development for teachers
- New Mexico Public Education Department’s STEM Symposium as a professional development resource
- The “Breaking Chocolate” activity
  - Design of the activity
  - Key points to make the activity valuable (and likely to be used) for teachers
  - Teacher feedback
- Scaling to other states in the US
- Resources

Science teaching standards

- Purpose of education is to disseminate knowledge and skills
- Educational standards generally describe the knowledge that is to be disseminated. They do ***not*** describe a curriculum (sequence of instruction, etc.)
- In K-12 (primary and secondary education) in the US, educational standards are controlled at the state level; curriculum is at the local level
- The US National Research Council published a framework for Next Generation Science Standards in 2012 (NGSS)

What's different about NGSS

- NGSS describes performance expectations (outcomes)
- NGSS includes engineering as a practice
- NGSS integrates core disciplinary ideas with science and engineering practices and with cross-cutting concepts
  - Core disciplinary ideas: The fundamental disciplines, such as physical sciences, life sciences
  - Science and engineering practices: How scientists and engineers work and solve problems
  - Cross-cutting concepts: Common interdisciplinary themes, such as cause-and-effect, patterns, scale-and-proportion
- NGSS is closely coupled with Common Core State Standards

Why teacher professional development?

- Leverage point for STEM (Science, Technology, Engineering, Mathematics): Greater potential impact if you provide teachers the resources
- Professional development in schools of education (teacher education program)
- Professional development for pre-service teachers
- We focus on professional development for career teachers, especially for elementary and middle school levels

New Mexico K-12 education

- Public Education Department (PED) sponsors various professional development programs, some from commercial providers, and a STEM conference in June every year
- Many professional engineering societies with Albuquerque sections, interested in K-12 outreach

Components of successful PD?

- Clear ties to standards
- Content is correct, current, and appropriate to grades
- Low barriers to adoption (time, other resources such as equipment, recurring supplies cost)
- Should be engaging to students (for example, inquiry-based)
- Collaborate with teachers to develop successful PD program!
- Team was formed by reaching out to local engineering societies and to the NM Science Teachers' Association e-mail list server

Which experiment?

- Many educational resources available!
  - NCSLI Metrology Ambassador resources
  - www.tryengineering.org
  - ACerS “Chocolate Strength—How Strong is your Chocolate”?

- Select a project that is relatively simple, but can involve various elements of science and engineering

Breaking Chocolate

Written and Distributed by the President's Council of Student Advisors

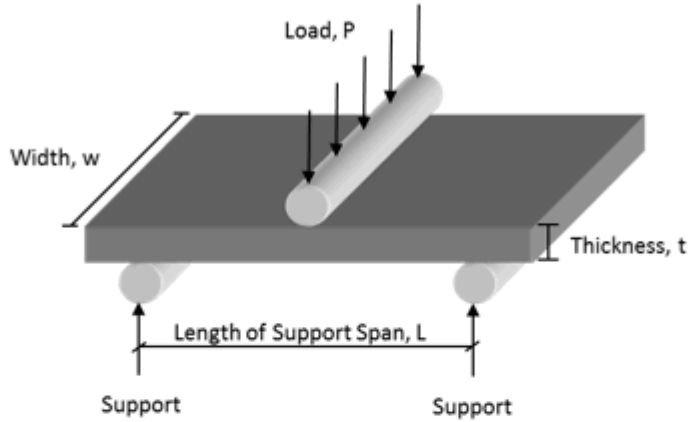


Figure 1. Test set-up for a 3-point bending test

For this test set-up, chocolate bars are placed on two supports (making 2 points of contact), and a force is applied to the center of the bar (making the 3rd point of contact in the 3-point bending test). The flexural strength of the bar is essentially the highest stress that the material experiences during its moment of rupture (failure) and can be calculated from the following equation:

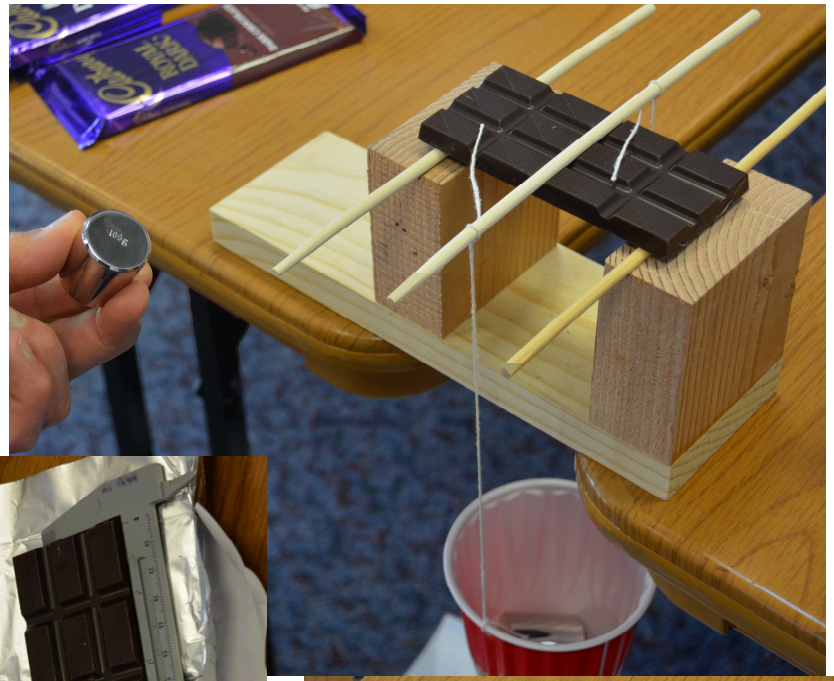
$$\sigma = \frac{1.5PL}{wt^2}$$

where σ is the flexural strength (MPa), P is the applied force (N), L is the span length (mm), w is the width of the bar (mm), and t is the thickness of the bar (mm).

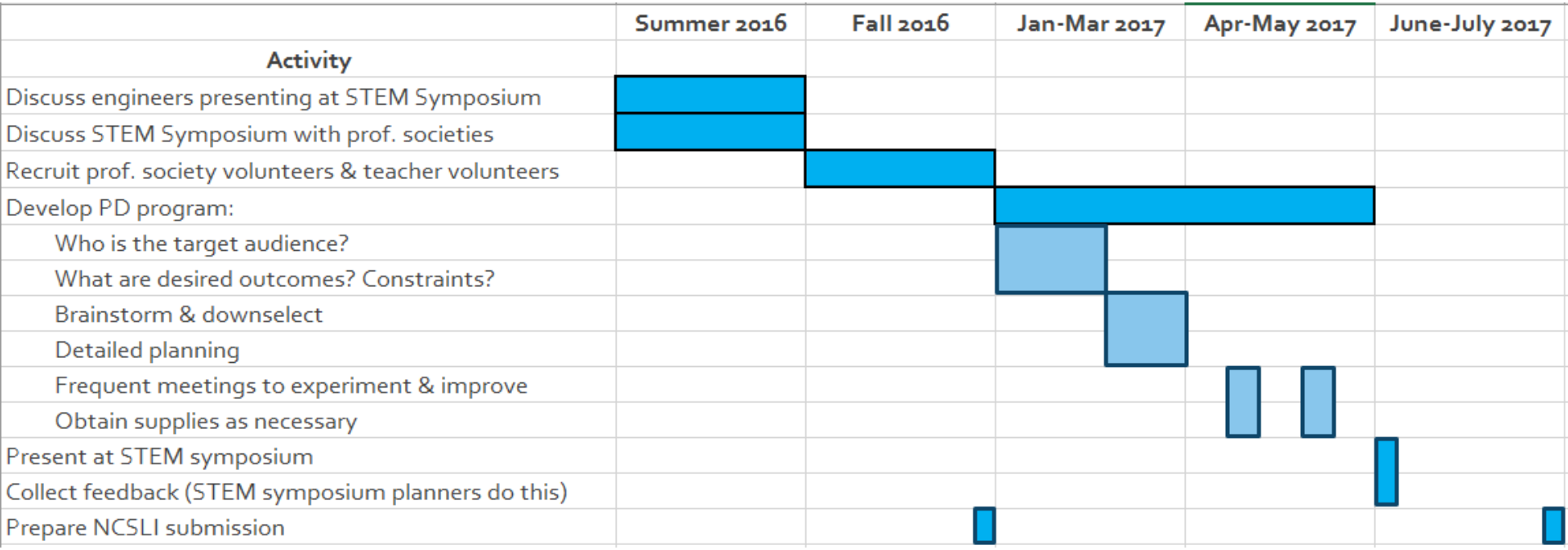
- Too complex for K-8?
- How do you bring in engineering concepts?
- What about metrology?

Modifying the experiment

- Design apparatus to measure flexural strength; design 5-second rule apparatus (Engineering design)
- Test measurement instruments (metrology)
- Reporting the results (ties to math, language arts; also ties to modeling—is dark chocolate stronger than rice crispies chocolate?)



Project plan



- Although this was a lengthy project, total effort was not large
- Most challenging aspects:
  - Scheduling time
  - Learning the needs for teacher PD and communicating how the program would help

Presenting the PD program

- 45 minute session (we've been asked to submit again for next year, and we will be given a longer time slot)
  - Designing flexural strength apparatus, with some provided supplies
  - Calibrating a luggage scale (for force measurement)
  - Calibrating rulers (for length measurements)
  - Performing experiments
- Prepared for 50 participants. We had > 60
- Inquiry-based, active participation (workshop, not lecture)
  - Teachers were given a few minutes of exposition, experimental kits, and were asked to then brainstorm ideas, perform experiments, etc
- Handouts & relevant materials are posted at: sites.ieee.org/albuquerque and also at the New Mexico Public Education Dept. website

Objectives

- Intro to Engineering processes
  - Breaking chocolate as a vehicle
- Measurements of physical properties (quantities)
  - Different physical quantities, such as length and force
- Uncertainty in measurements
- Calibration of a measurement instrument (applying the methods of the engineering design process)

Electronic resources will be hosted at: sites.ieee.org/albuquerque

Intro to Engineering

- Engineers solve real world problems using a structured process:
  - Identify and understand needs or requirements
  - Generate potential solutions
  - Evaluate and analyze
  - Produce and document the solution

Use math & science in these steps

- Handout engineering decision matrix (example slide next)

Electronic resources will be hosted at: sites.ieee.org/albuquerque

Materials used

Coin Specifications

The following table gives specifications for The United States Mint legal tender coins presently in production for United States Mint Annual Sets.

Denomination	Cent	Nickel	Dime	Quarter Dollar	Half Dollar	Presidential $1	Native American $1 Coin
Composition	Copper Plated Zinc 2.5% Cu Balance Zn	Cupro-Nickel 25% Ni Balance Cu	Cupro-Nickel 8.33% Ni Balance Cu	Cupro-Nickel 8.33% Ni Balance Cu	Cupro-Nickel 8.33% Ni Balance Cu	Manganese-Brass 88.5% Cu 6% Zn 3.5% Mn 2% Ni	Manganese-Brass 88.5% Cu 6% Zn 3.5% Mn 2% Ni
Weight	2.500 g	5.000 g	2.268 g	5.670 g	11.340 g	8.1 g	8.1 g
Diameter	0.750 in. 19.05 mm	0.835 in. 21.21 mm	0.705 in. 17.91 mm	0.955 in. 24.26 mm	1.205 in. 30.61 mm	1.043 in. 26.49 mm	1.043 in. 26.49 mm
Thickness	1.52 mm	1.95 mm	1.35 mm	1.75 mm	2.15 mm	2.00mm	2.00 mm
Edge	Plain	Plain	Reeded	Reeded	Reeded	Edge-Lettering	Edge-Lettering
No. of Reeds	N/A	N/A	118	119	150	N/A	N/A

Content last updated on September 20, 2016

Electronic resources will be hosted at: sites.ieee.org/albuquerque

Some photos from the session

Electronic resources will be hosted at: sites.ieee.org/albuquerque

Connection to standards

- Explicit connection of metrology to education standards helps teachers (double click in doc & scroll to page 2)

Metrology

Educator's guide (student guide at sites.ieee.org/albuquerque)

Overview

Metrology is the science of measurement. Measurement standards are found in the earliest written documents from Sumeria. Metrology is a foundation for science, for engineering, and for commerce.

Key Concepts

- What makes a good measurement?
  - Measurement is a comparison
  - Understanding that there is uncertainty in measurement
  - Understanding the sources of uncertainty
- What is calibration?
  - Understanding the comparison to a better standard, and ultimately back to the SI system

Learning Objectives

- Measurements of physical properties (quantities)
  - Different physical quantities, such as length and force

Some participant feedback

NM STEM Symposium
Presenter Evaluation

Session Name: Breaking chocolate

Presenter Name: H. Tran

What did you enjoy most about this session?

The ideas! Great interesting ideas for incorporating engineering.

What is your biggest take away from this session (what are you going to take back to your classroom)?

Everyday materials can be used to create complex opportunities to explore engineering

What feedback do you have for the presenter?

I wish the session was longer and we could have explored ~~ideas for~~ how everyone approached ~~creating~~ then creating their set up and their results.

How would this be scaled?

- Almost every state in the US has a chapter of the National Science Teacher's Association (NSTA): www.nsta.org. These chapters have newsletters and meetings. They are happy to work with STEM professionals
  - We encourage metrology ambassadors to reach out to local NSTA groups and present a workshop at the NSTA meeting, or other teacher professional development meetings
- We intend to submit to one of the NSTA journals

More Resources

- All handouts for this particular session at sites.ieee.org/albuquerque
- For more info about NGSS: https://www.nextgenscience.org/framework-k-12-science-education
- For quicker guides to NGSS: http://www.nmsta.org/stem-symposium-2017/
- National Science Teachers Association: http://www.nsta.org
- Engineering resources for K-12, including lessons & lesson plans: http://www.tryengineering.org

What would we do to improve?

- Ask for a longer time slot (we are likely to get that)
- Now that we have the initial plan, practice timing. It takes longer when you have teachers doing an activity than you think it does! (for a 45 minute session, just the calibration of the rulers and breaking the chocolate would have been sufficient)
- Seek donations from the professional societies (in Fall 2017 for a Summer 2018 presentation), so we can have more giveaways (we gave away 10 electronic luggage scales, 10 digital dial calipers, and lots of chocolate)

Acknowledgments

- Kevin Strong, Melissa Teague, Chris DiAntonio, Meaghan Carpenter, Trish Briscoe, Mike Jackovich, Jason Neely, Gilberto Zamora, John Saldana, Lee Smith, Selena Connealy, Zane Kominek, John Emerson, Malva Knoll, … Apologies if a name was omitted or misspelled
- The Albuquerque IEEE section and Sigma Xi, the UNM IEEE student section, Sandia Nat'l Labs, the Albuquerque inter-technical-society council, including SAMPE, ACerS, and ASME, and NCSLI