BEEC Share and Learn Report: March 2026

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**Topic:** Exploring Connections - Geometry Independence of Stress-Strain Curves: ASEE Education Showcase Deep Dive

**Resources:**

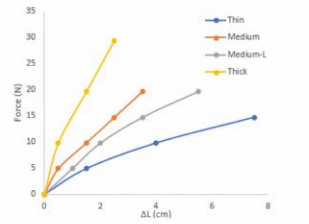
- Rubber Rods: https://www.mcmaster.com/
- NIH 3D: https://3d.nih.gov/
    - https://3d.nih.gov/discover?q=tensile+test&sort=relevance

**Discussion and Lecture Notes:**

Lecture Notes:

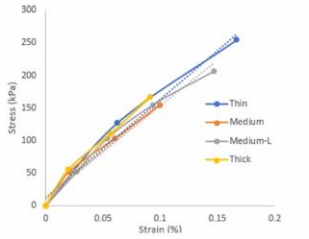
- Background: 2nd Year Biomechanics Course
    - Statics + Dynamics + Deformable Materials
    - Introduce Stress and Strain curves via textbook formulas and graphs showing if you normalize to area and length you can get information about the material and not material + geometry
    - Calculate stress and strain, on
- How would the stress-strain diagram change if the diameter is doubled but the material and testing conditions stay the same?
    - Only 25-30% of students got it correct
    - Many jumped into equation for stress that included area but did not realize that the diagram is normalized to geometry and if material doesn't change, Young's modulus doesn't change and therefore diagram wouldn't change
- Problem: How to help students internalize the concept of stress and strain and not just how to plug numbers into equations?
    - Connect between equation and concepts of real world behavior
    - Lab can work but would be offset from the course and had to be within the lecture course based set up
    - Attempted in class demo but did not have impact
- Created a Hands On In Class "Lab"
    - Bought rubber rods from McMaster Carr with different cross sectional areas and stiffness
    - Asked to figure out if rods are made of same material vs. different material
    - 1) Make a hypothesis based on pulling on them and needed forces
    - 2) Conduct tensile test to collect material deformation test and quantify deformation
- Lab Experience:
    - Teams of 3
    - Calipers and rulers to record dimensions
    - Metal holder and weights to hand weights, measure change in length, and repeat with different weights. Do with all 3 different rods
    - Problem set guided with data collection, processing, and analysis

- Problem set:
  - Instructions for data processing
    - Convert force instead of mass
  - Guided results and discussion
    - Initial hypothesis
    - Plot force vs deformation and stress vs strain
    - Fit stress-strain and report Young's Modulus




Thin Rod

| Weight | New Length |
|---|---|
| | |
| | |
| | |
| | |




- Which graph is more useful for extracting information about material properties? Normalize to geometry with stress and strain you can get only the material aspects
- Impact:
  - 75 minute class used for lab
  - Only 15-20 minutes of data collection, rest used time to finish problem set
  - Extra assignment – more grading for team, but more practice for students
  - Had substantial improvement on same exam question "How would the stress-strain diagram change if the diameter is doubled but the material and testing conditions stay the same?"

    - Students found it enjoyable and useful from survey
- Areas for Improvement:
    - Trouble with measurement imprecision – where to start and stop measuring for each rod or weight
    - So not all students got a convergence of all 4 curves across the different thicknesses and lengths
    - Variability – some said Young's modulus differed by 10% or so and would then say it is clearly different
        - Learning objectives to talk about natural variability in a material and when you can draw conclusions vs. not
    - Maybe incorporate statistics and learning of variability
- Future Changes
    - Include materials that differ in both geometry AND material properties?
        - Instead ask: Which of these rods is made of a different material?
    - Add markings to rod so they know where to start and stop measurements to improve precision

Discussion:

- Any overlap with body materials or tissues, e.g. bone or body tendons?
    - Can include in biomaterials course
    - Bio tissue has differing mechanical properties of tissues and biological variability
- Non-lab class activity needs low tech and low cost and minimal activity to do
    - Bone would be too stiff and require significant equipment and infrastructure
- Could we use a cheap load cell on Arduino?