BEEC Share and Learn Report: December 2025

Presenters: Jennifer Hatch, Department of Biomedical Engineering, Purdue University

Topic: Understanding Tensegrity: ASEE Education Showcase Deep Dive

Resources:

- YouTube link of Tensegrity using Home Science:
  - https://www.youtube.com/watch?v=ROnxjj5jPDs
  - https://www.youtube.com/shorts/6DGbx0Vxi6c
- Power Tool Institute: https://www.powertoolinstitute.com/
- Don Ingber Cellular Tensegrity Paper:
  - https://hmieducation.com/pub/publications/hmi_4fd619e42eb9e.pdf
  - https://pubmed.ncbi.nlm.nih.gov/12615960/

Discussion and Lecture Notes:

Lecture Notes:

- Build and analyze static mechanical principles of 3D tensegrity structures
- One lab period 2.5 hours
- Use saws, drills, etc. to build
- Project outcomes:
  - Understanding gap of what actually happens in static equilibrium
  - How to expand to 3 dimensions and think about things that are static and synamic as it adapts to a dynamic equilibrium in structures
  - Students become confident in use of new tools
  - Physical understanding of how dynamic equilibrium in body adapts
- Steps to Success:
  - Use of tools and safety
  - Woodshop practice
  - Cut, assemble, and balance piece
  - Mechanical analysis by calculating volume, density, center of masses, and what are forces acting on strings holding it together
- Tensegrity:
  - Property of skeleton structures that employ continuous tension members and discontinuous compression members in such a way that each member operates with maximum efficiency and economy
  - Models how our body are composed with bones (mineral moderators), bones that hold up body, and act in compressive and tensile elements
  - Inside cell – it is a model of tensegrity with actin-cytosin skeleton and equilibrium structures inside cells
- Youtube link: Adaptation of structure from home science: https://www.youtube.com/watch?v=ROnxjj5jPDs , https://www.youtube.com/shorts/6DGbx0Vxi6c
- Tools: use wood to get a hand on subtractive manufacturing – this is why we don't 3D print it! Used safety training by Power Tool Institute
- Taught to 200 sophomores across Purdue campus and done 6 semester offerings so far
  - Adapted to connect with dowel jigs, drill presses, and actively applying weights to top
  - Added applying to ANSYS to see what happens when you change things and learn how to simulate it
  - Debrief use to be done by biomechanics structures in lecture while the lab is currently being taught,

Open Q&A:

- Why use strings over an elastic cord to model the tension?
    - Need to consider scale. We tried fishing line, but hard to bond with anything so wouldn't adhere. Elastic didn't work because wood is very light so the tension from elastic overwhelmed it to make it unbalanced (tried rubber band and clothing elastic)
        - Twine and string works best
- Which materials and discussion? Beyond depth of exercise scope but would be ideal
    - The more you can play with them and build them the better
    - Don Ingber at Yale – how cells locomote and saw similar process associated with tensegrity (see above resources for paper)
- How to connect tensegrity in body through some simulations since using Ansys?
    - When doing calculations, we are starting to use FEA using Ansys since they approach it, maybe a good idea to incorporate a skeletal modeling element
- How does it fit with curriculum?
    - All sophomores take it and then they take an 8-9 module lab. Starts with exploration of forces – push up vs push up on incline, then move to tension and compression –
    - Paper on ASEE coming out on lab module on compression – using beam bending and pair with a mouse dissection – 3 point bending on mouse bones and 3 point bending on a design project
- How to make an improved structural skeletal tensegrity that looks more like the body?
    - Tried doing a truss system with rubber bands but was more difficult
    - Suggested creating a skeletal model of shoulder and made a trainer to teach ER physicians how to pop a shoulder back in place
        - Took an existing model of shoulder and modified it to provide better model of tension to train them on how to pop shoulder back in
    - Can try some feet, hips and hands and unstring them to get better models
- Do we look at self identification of "I am engineer" vs. "I am a maker" vs "I am an innovator"? I.e. self-efficacy
    - Mechanical and electrical engineering may be looking at this
    - Thea Pepperl – looks at student sense of belonging – nothing beyond self-responded studies
    - If we give project early in semester it helps advocate for themselves later when getting into group projects
- Are they in teams?
    - In small classes and piloted, everyone made their own
    - Now due to large sizes, students do in groups
- Do you see differences in group work advocacy vs. doing on your own to build that self-efficacy (e.g. women being pushed into writing or project management over use of tools)
    - Maybe notice not just a formal assessment and do it anecdotally
    - Everyone in lab is required to do 1-2 hand cuts on saw
    - There is a gender bias to who uses the tools, but students who came from farm families are happy to jump on dissection and wood working
        - Students who did robotics aren't as excited to jump on the woodworking
- What experiences correlate to potential directions in certain roles on projects?
    - In start, had 80% of students who never used a power tool before college
    - Had to talk a lot about measuring and how to be "1 inch on center" and how to use a ruler
    - How to use a measuring tape and ruler – lots of students who never used one
- How many students who have never touched a tool – may be an interesting study
    - Some work prior to last year was looking towards gender biases and tool use – no longer allowed to be studied
    - What if we include sewing as a power tool to change student perspectives?

    - Help frame students mindsets toward tool use to think about prior experiences, especially hobbies, to make cross-competency connections
- What are your directions now given restrictions from government etc?
    - Starting engineering education PhD program in spring to see how we can adapt systems to give them enough elasticity to give them change as you need them
    - Doing a neural network project/module, survey to see how students use AI and how to incorporate into the curriculum
    - How to incorporate standards in the curriculum
- Important to understand how to use tools and limitations of tools – easy in physical power tools, harder with AI
- Do students struggle with reading manuals and SOPs?
    - You use the power institute videos and manuals, TAs walk through manuals, and then have a follow up quiz
    - We have been taught to read using context – for non-native speakers this may be more difficult. It doesn't help you when you have a lot of jargon in scientific journals and manuals and students will skip over that.
    - Can use specific quiz questions to make sure that they re-read it.