Innovating Engineering Thermodynamics Instruction at CSM:
Making the Abstract Concrete via Interacting Learning Opportunities

**CONTEXT**

Thermodynamics: incredibly rich topic, which can transform student thinking on processes/phenomena across their lives.

However, it is also incredibly abstract:
- Fundamentals come from interactions within and between molecules
- Applications can be incredibly large and complex (e.g. power plants, internal combustion engines, etc.)
- Class work: between these extremes.

Recently: thermo is more accessible!
- Students less intimidated.
- Greater percentage gain basic fluency.
- Greater interest/enjoyment.

However, we fear that we’ve watered down thermo’s richness. Top achievers fully challenged, given opportunities for deeper thinking and engagement?

Some concepts still elude most students.

Links to non-engineering thermo applications are non-existent.

**WHAT WE ARE CHANGING**

 Attempt to short-circuit false dichotomy of “quantity v. quality:” innovate content delivery and in-class activities.
- Traditional delivery dominated by lecture: High-volume, low-yield!
- Research is clear: constructive and interactive learning activities lead to greater, deeper learning.
- There are numerous ways to transmit basic knowledge; what is the best way to use our time in-class together?
- Move most content delivery outside of class (“flipped” video lectures).
- In-class lectures on “sticking points”
- In-class activities for deep learning:
  - Range of cognitive levels
  - Varying formats: small group, whole-class, individual work.
- Activities centered on “Big questions,” in addition to solving standard problem types.

**INTENDED OUTCOMES**

Students go beyond solving “standard” thermo problems, apply principles and problem solving strategies to a wide range of novel problems.
- Easily assessed by student performance on unsteady problems: common “sticking point” for students.
- Course teaches not a “list of steps” to analyze a set handful of problems; rather an approach to ID and analyze energy flows into and out of systems, and how system properties change as a result of these interactions.
- Varied instructional format and activities will help reach students with different levels of understanding and different learning style preferences.

The focus on “Big questions” will help students connect content to real-world design considerations and to the molecular interactions which underpin the thermodynamic concepts.

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Prior to graduate school, I taught elementary school (1st and 2nd grade).

I’ve long been fascinated by how students learn, how to help construct meaning based on prior conceptions.

However, my efforts to help students construct knowledge at the university level have been largely out-of-class (office hours), and largely ad-hoc (relying on student initiative, typically).

The Trefny Innovative Instruction Center Workshop has given me a new outlook on how to design innovative instruction so that these rich learning opportunities occur regularly and strategically in class.

The workshop has provided a logical and evidence-based framework for this design, and connected me to a whole community of similarly interested professionals at CSM. It has completely changed how I will design and teach my courses.