Research-integrated Teaching of Graduate Statistical Mechanics Using Strategies of Education Research

Big Picture
Nationally Recognized Challenges
- Time-to-PhD is increasing steadily
- 50% attrition from PhD program
- Dissatisfaction: job prospect and mentor relationship
- Curriculum disconnected with real life examples
- No integrated curriculum reform in decades

Proposed Solution
Research-integrated reform of PHGN 530 STATISTICAL MECHANICS by engineering learning opportunities in statistical mechanics that build around the students’ questions and areas of research

WHAT WE ARE CHANGING
Statistical mechanics is the most important, yet least understood and often neglected course. The texts and teaching approaches to the course are outdated. I intend to modernize the course, both in content and teaching approach.

Following a backwards design of Engineering Learning, we have worked to clarify the outcomes for the course and have begun to re-envision how to best support graduate students in achieving these outcomes. Students come to this course with very diverse background and levels of understandings and skills. The learning opportunities that we are designing will build on where students enter the course and engage them in genuine research related to the chosen research area or question. Embedded alongside the research experiences will be structured learning opportunities to deepen their understandings and skills related to statistical mechanics.

Approaches to be Integrated into the course
For improved learning experience, we will use
1. Established norms of interactions: expected attendance, silent phones, and no jokes and loose talk.
2. Internet as a classroom: Flipped video, lecture notes, and research papers
3. Research-integrated teaching: Students ask the question and solve by managing resources at their disposal
4. Professional learning community (PLC): Group formation using CATME and self-reported skills
5. In class lectures and activities: Discussion of difficult concepts and students’ muddiest points

Learning Outcomes:
Students will be able to...
- theoretically derive and calculate the measured thermodynamic quantities in the materials appropriate for students’ individual research areas.
- explain (orally and in written form) thermodynamic measurements and theoretical explanations related to their research areas.
- peer review and provide constructive feedback on written and oral explanation of projects of other students in the class including those analyzing materials in other fields.
- select and apply appropriate concepts of thermodynamics and statistical mechanics (see modules below) to their individual research questions.
- formulate a summative project that is related to their actual or intended graduate research that includes a literature review to compare and contrast their results with the work of other researchers.

INTENDED OUTCOMES
- Higher levels of engagement by all students [measured by observations, participation logs, and surveys]
- Deeper understanding of statistical mechanics and application to students relevant field and research areas [measured by comparison of tests/quizzes, papers and projects, final projects, and student survey data]
- Greater integration and coherence amongst our physics graduate courses [measured by comparing syllabi, course artifacts, student and faculty survey]

Coherence across courses
Statistical mechanics and solid state physics are being transformed coherently to:
- Reduce redundancy
- Use uniform language
- Facilitate team teaching by two instructors
- Provide alternatives to students after differentiation of interests and abilities across courses

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June 2016 Cohort

Maintaining the Rigor
Past Student Projects:
- Textures deposition on quartz
- Experimental

Beyond the Comfort Zone:
Fall 2015 challenge project: Modeling the effect of 25° low rotation on melt fracture in a silicon sponge

Wider Dissemination
The course materials listed below will be available for other institutions as a design example through the Trefny Center:
1. Learning outcomes, assessments, and schedule
2. Syllabus, videos, lecture notes, and experimental data
3. Student feedback: descriptive and quantitative

The department head will inform AAPT/APS committee about our graduate reform as suggested by the national joint task force.