A Teaching Philosophy for Developing Engineering Intuition

Introductory Statement
I believe students should leave the classroom with a practical intuition of advanced concepts that will enable them to develop novel solutions to today’s largest engineering challenges. This last spring, I had the opportunity to teach Introductory Heat Transfer (UIUC’s ME 320) to a class of 40 juniors and seniors as a Graduate Teaching Fellow. With full responsibility for the course, I successfully implemented the following teaching philosophy and practices to build this intuition.

Teaching Philosophy in Practice
Intuition is the ability to understand something immediately, without the need for conscious reasoning and is the skill at the top level of the Hierarchy of Competence. This hierarchy follows the “Four Stages for Learning Any New Skill,”[1] where a student:

1) starts without knowing what they do not know,
2) then becomes aware of what they do not know,
3) begins deliberately utilizing the new skill, and finally
4) naturally applies the new skill.

My role as a teacher is to aid and motivate each student to reach this final stage of intuition.

To effect this growth, I have implemented three key practices that form a supporting foundation: in-class self-assessment, demonstrative analysis, and applied concepts. Identifying knowledge gaps is the first step, and in-class self-assessment allows these gaps to be known by the student and the instructor in a stress-free, collaborative environment. Using a real-time student response system (e.g. iClickers), I created an opportunity for students to learn what they should know, but do not, while allowing me to gauge the progress of each student and the class as a whole. From these identified knowledge gaps, I was able to present customized demonstrative analysis, in the form of example problems worked out in class to highlight key procedures, equations, and analyses. These steps alone would not be effective if students were not motivated to fill their own knowledge gaps and follow the demonstrative analysis through additional practice and study outside the classroom. Thus, the final key practice is to increase motivation through applied concepts. At the introduction of takeaway ideas presented throughout the semester, I tied what the students were learning to relevant and inspiring applications. For my Heat Transfer class, I presented examples of how core heat transfer concepts are used in modern innovative system designs to achieve higher performance and/or efficiency. I showed how the fundamentals they are learning apply to commercial products, my own research, and other cutting-edge research in related fields. Following these guiding practices, with an unwavering and contagious passion and excitement for the material, I enjoyed the opportunity to guide and witness the transition from ignorance to intuition in my students.

Teaching Effectiveness

The effectiveness of this approach resulted in my recognition on UIUC’s “List of Teachers Ranked as Excellent by Their Students.” Additionally, my teaching effectiveness was quantified through the final exam, where exam grades were statistically similar with the other two sections of this course, which were taught independently by experienced faculty members. With this initial success, I am eager to continue to improve while focusing on how I can better reach the less motivated students in the class.

Proposed Teaching

With my research interests and background covering several fields, I am prepared to effectively teach undergraduate and graduate courses on a variety of subjects including (but not limited to) the following courses equivalent to UIUC’s:

- ME 300 Thermodynamics
- ME 310 Fundamentals of Fluid Dynamics
- ME 320 Heat Transfer
- ME 340 Dynamics of Mechanical Systems
- ME 360 Signal Processing
- ME 460 Industrial Control Systems
- ME 540 Control System Theory & Design

I also propose to develop a course on Model Predictive Control (MPC), the mostly widely used advanced control strategy in industry. This class would focus on control-oriented system modeling, model-based control formulation, application-specific extensions from the basic formulation, and analysis of theoretical properties like stability and feasibility.

To provide the invaluable experience of implementing control on actual hardware, I plan to develop an educational experimental hardware platform for lab-based development and implementation of various MPC and classical control designs. This hardware platform will be conceptualized, designed, built, and tested through close collaboration with undergraduate and graduate student researchers. Despite the important role of control systems, the roles and capabilities of control are rarely well understood by engineers outside of the field. Demonstrating the value and abilities of this mathematically intensive field through hands-on and visual experimentation, especially at the undergraduate level, could significantly raise student interest and understanding in this area.

Mentoring

Throughout my undergraduate and graduate studies, I have benefited from a series of exceptional mentors. Following their example, I plan to establish a cohesive and diverse research group including both graduate and undergraduate students. From the mentorship of Dr. Andrew Alleyne and as a member of the Alleyne Research Group (ARG) at UIUC, I have first-hand experience working in a world-class research environment and will follow these best-practices when developing my own research group. Specifically, I recognize importance and tangible benefits of assembling a social and diverse group of students who are strongly connected by a shared eagerness and aptitude for learning.