CELT

CENTER FOR ENGINEERING LEARNING & TEACHING

UNIVERSITY *of* WASHINGTON
COLLEGE OF ENGINEERING

Overview: Integrating Research and Instructional Development

The Center for Engineering Learning & Teaching (CELT) at the University of Washington focuses on two synergistic activities: conducting research on engineering education and improving engineering teaching through instructional development. This dual-role structure is based on an awareness that a solid engineering education research base is needed to inform educators about how their students learn, and that this research should drive and support effective teaching. Similarly, a broad understanding of what takes place in engineering classrooms is important for pinpointing significant areas for research. Since 1998, CELT's model has proven successful in the UW College of Engineering and has had an impact on engineering education at national and international levels.

CELT's mission

- To conduct internationally recognized research in engineering learning
- To improve engineering teaching at the UW
- To be a model for effecting change in colleges of engineering

Conducting research in engineering student learning

CELT educational researchers work on funded research projects with colleagues from the University of Washington and across the nation to conduct research that advances engineering education. CELT's research agenda includes many aspects of scholarship in engineering education. Research is ongoing in the areas of design learning, understanding students' learning experiences and their preparation for professional practice, and integrating research findings with teaching innovations.

Improving engineering teaching at the University of Washington

CELT instructional consultants build on current research to offer a diverse set of program elements with the goal of improving engineering learning and teaching in the College of Engineering at the University of Washington. This includes working with individual instructors, conducting workshops and seminars, and actively participating in strategic-level initiatives.

CELT receives funding from the Boeing Company, the Leona M. and Harry B. Helmsley Charitable Trust, the National Science Foundation, and the University of Washington College of Engineering. Special thanks to Mark and Carolyn Guidry, and the Mitchell T. and Lella Blanche Bowie family.

Contact information

Dr. Cynthia J. Atman
Director
atman@uw.edu

Dr. Jim Borgford-Parnell
Associate Director
bparnell@uw.edu

Dr. Jennifer Turns
Affiliate Faculty
jturns@uw.edu

http://depts.washington.edu/celtweb/
celt@uw.edu

How does CELT integrate research and teaching improvement?

Instructional development efforts must be backed by good research, and research should be driven by what needs to be known about engineering education. One important objective in engineering education is to develop proficient engineering designers. CELT researchers are studying engineering design processes by asking questions concerning what students' engineering design processes look like, how the design processes of students at various levels compare, and how their design processes compare with those of experts. The results of this research are increasing the knowledge base for engineering faculty, and some of our findings are feeding back into improving teaching.

Conducting research in engineering student learning

Research questions: How do years of experience shape how expert engineers solve design problems? What have they learned to do that sets them apart from engineering students?

Method: 26 first-year engineering students, 24 senior engineering students, and 19 engineers with an average of 19 years of experience were given 3 hours to design a community playground (working individually in a lab setting) and asked to think aloud.

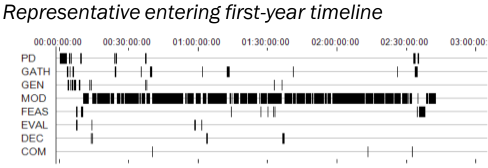
Analyses: Line-by-line coding of participants' think-aloud commentary by mode of design activity and type of information considered

Selected findings

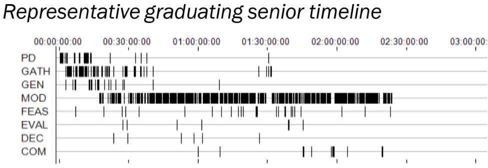
Compared to freshmen, *seniors*
- ...have higher quality designs
- ...scope the problem more effectively by
  - ...gathering more information
  - ...considering more categories of information
- ...make more transitions among design steps
- ...progress farther in the design process

Compared to students, *experts*...
- ...spend more time in all design stages
- ...exhibit a "cascade" pattern of transitions
- ...scope the problem more effectively by
  - ...gathering more information (explicitly)
  - ...covering more categories of information

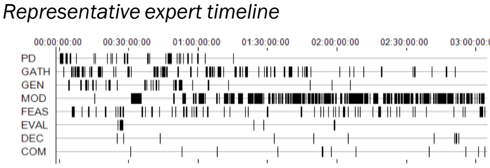
▼ *Representative entering first-year timeline*



▼ *Representative graduating senior timeline*



▼ *Representative expert timeline*



This research provides empirical insights and rich representations that can illustrate to students and faculty important aspects of the design process that may be difficult to describe in design texts. Examples include the importance of spending adequate time scoping the problem at the beginning of a design process and attending to each of the elements of project realization at the end of the process.

Journal of Engineering Education, 96(4), 2007; *Design Studies, 20*(2), 1999

Improving engineering teaching

In an ongoing project, the CELT team is collaborating with engineering instructors in project-based courses to improve their students' awareness of the components, complexities, and benefits of well-planned and executed engineering design processes. Drawing from our design research findings, we have developed interactive seminars, in which students analyze design process timelines and form insights for discussion. In these seminars, students compare findings from our design research to their own analyses and those of their peers.

Examples

We have conducted multiple instances of these seminars in classrooms for both our own lectures and as guest lectures:

- ► To 38 students in a senior capstone design course in materials science & engineering (Winter 2008)
- ► To 35 students in a junior-level structures course in aeronautics (Spring 2008)
- ► To 9 students in a senior capstone design course in mechanical engineering (Spring 2009)
- ► To 32 students in a senior capstone course in computer engineering & systems (Winter 2010/2011)
- ► To 22 students in a senior capstone course in human-centered design & engineering (Spring 2010)

We also conducted the seminar as part of a special workshop at the ASME Asia Pacific Congress in April 2009.

These examples illustrate how educational research that is current and discipline-focused can readily complement an instructional development process. Regardless of the audience, the response has been consistently enthusiastic. Attendees readily understand the timelines and make insights about the design process in agreement with our research findings. Students, in particular, discuss how the activity helps them reflect on their own development as engineers.

These interactive seminars benefit more than just students. By working collaboratively with engineering faculty in the planning and implementation of the seminars, we can concretely demonstrate important learning theories and pedagogical principles. This also benefits students in future courses. Additionally, by asking students and instructors to bench-test our findings, we get a better idea of their usefulness, their clarity, and what students view as important that we might study further.

International Journal of Engineering Education, 26(4), 2010

W
UNIVERSITY *of* WASHINGTON
COLLEGE OF ENGINEERING

CELT
CENTER FOR ENGINEERING LEARNING & TEACHING

20150605