A Novel Approach to Integrating Liberal Arts into Undergraduate Engineering

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Bridging Learning Gaps in Engineering

- Bridging engineering and the liberal arts
  - Collaborative UCLA and community college work supported by Teagle Foundation
- Bridging transitions
  - Combining diagnostic assessments with individual help, supported by ONR STEM and UCLA IIP grants

Motivation

- The future workforce will increasingly be engaged in personalized design
  - Must draw on full diversity of California
  - New design tools can enable broader participation if more students trained to varying degrees in liberal arts and engineering
- STEM pipeline is very leaky, especially for underserved populations
  - Barrier steps at multiple points; specific assistance required
  - Hands-on and socially relevant activities are proven motivators to continue

Collaboration Context: the ELC

- The California Engineering Liaison Council brings together all tiers of higher education in engineering in order to:
  - Articulate courses and programs across community college to 4-year school transition
  - Share best practices in instruction
  - Provide mutual support
- Collaborations built on links forged at the bi-annual meetings
  - Next one is Nov 10-11 at Asilomar—Join us! (caelc.org)

Part I: Engineering in Context

- Study of societal consequences of engineering in introductory courses, to set tone for four-year studies
  - Married to hands-on content for relevant courses in UCLA and community colleges
  - Students are involved in teaching students to enable individual attention
- Partners: UCLA, ELAC, El Camino, LATTC, Marin CC, MPC, SMC, Skyline

Materials Developed

- 2-unit course on engineering ethics, with modern examples of societal impact
  - Includes writing exercises such as short articles for general audience
  - Can be combined with 2-unit hands-on engineering course to produce General Education course for engineers/non-engineers
- Low-cost hands-on labs
  - Developed by Monterey Peninsula College
- Training materials for undergraduate mentors
  - Used to assist colleges, based on course developed at UCLA for training undergraduates to teach hands-on activities

Example: MPC

- Tom Rebold is only engineering faculty member; networking support vital
- Revamped intro to engineering course
  - Hired student tutors to enable multiple hands-on projects
  - Developed $70 kit subsequently used (with curriculum) at two other colleges
  - Employed engineering ethics materials developed at UCLA

Example: SMC

- Tram Dang was initially only faculty member
- Intro course initially modeled on UCLA course
  - Subsequently radically reduced cost of materials to better fit student demographics
  - Shared course with El Camino college
  - Developed and added EDI focused units to intro and graphics design courses
- Developed inclusive approach to syllabi
  - “do nots” replaced with welcoming language to seek assistance

Example: Marin College

- Erik Dunmire part time in engineering
- Re-introduced intro to engineering
  - Used training materials and curriculum developed at UCLA as well as from other partner colleges
  - Course includes high school students
  - Conversations with physics, environmental science, art to develop new projects
  - Added infectious disease modeling unit in intro to MATLAB programming class

Overall Progress

- All partner colleges have revised or established intro to engineering courses that include
  - Hands-on projects
  - Technology in society components in multiple courses
- Skyline college has found a way to make this a GE course; UCLA is on track for the same

Part II: Transitions

- Students need to deal with changed expectations at all major transitions
  - High school to college
  - Lower division to upper division
  - Undergraduate to graduate
- Broad variations in preparation at each of these levels (high schools, community colleges, universities, individual instructors within universities…)
- Diagnostics are needed throughout program to give students timely feedback on what is expected
  - Grant obtained from UCLA IIP for pilot study

Why Students Struggle

- Inadequate study skills
  - Not enough time scheduled, ineffective study techniques
- Lack of Prerequisite knowledge
  - Never taught, taught a long time ago, never properly learned (see above)
- New concept is difficult
  - May require tutoring, alternative treatment, extra problems
- Personal issues
  - Requires referral to appropriate campus services
- **None of these can be solved unless students talk to instructors and/or peers; trust-building is required for all students to feel comfortable doing so**

Example: UCLA Transfer Student Summer Bridge Program

- Begins with diagnostic test (uses Google sheets)
- Leads to three outcomes
  - Recommendation to take summer session course
  - Recommendation to take study bridge (using online textbook, tutor assisted)
  - Recommendation to enroll in traditional intensive 3-week bridge (preparation in programming)
- The last two provide technical knowledge and help build the cohort
  - Began with ONR STEM support, continues with donor/Dean funding

Transfer Student Bridge Outcomes

- Relatively few students engaged in first iteration of review bridge
  - Seemed to require more course-like structure to be familiar
- In traditional bridge, students valued training in peer-peer interactions well above technical preparation
  - Provided support network for upper division
  - Greatly increased likelihood of participating in design clubs (which have many downstream benefits)

Potential Next Step: Math Prep

- Math is the key topic for engineering success
  - Math apocalypse is possible: already CSU San Jose reports 18% not ready for *precalculus!*
- End of SAT presents additional challenges
  - A replacement diagnostic would also be gamed if it is used for admission
  - Instead need diagnostic that leads to bridge programs to help students get up to speed before classes begin; both technical assistance and study strategies

Engagement for Success in Engineering

- High school
  - Cram and dump studying
  - Rarely seek assistance
  - Low workload
- Engineering
  - Continuous/group study required for dense concept sequence
  - Individual help is often required
  - Workload is heavy

Basic Idea

- Prime student topics for interaction with instructors/peers in sequence of surveys
  - Technical concepts
  - Effective study methods
- Appeal to various motivations
  - Participation in feedback mechanisms will assist future classes
  - Helping fellow engineers will also help them
  - Participation grades awarded

Pilot Project (I)

- Intro document with concept map of course, best study practices, feedback requested
- Participation points for the following 3 elements:
- Diagnostic test
  - Prerequisite technical knowledge
  - Study approach, time available for study
- Concept mastery self-assessment
  - 5 times, to track progress (5-point scale)
- Final self-assessment
  - High level concepts; can compare to exam(s)

Pilot Project (II)

- Tests and homework mapped to course concepts
  - Enables comparison of self assessment to grades
  - Students receive prompts on topics for which they should study more—especially important early on
- Instructor sees which concepts students find difficult, can add discussion in progress
  - Both tests and self-assessments

Pilot Project (III)

- Two courses in Spring 2022
  - Introduction to Electrical and Computer Engineering (the great accomplishments of the profession, design of line-following robot); Freshmen/Sophomore
  - Digital Circuit Design (includes physical considerations, logic families, critical path analysis, culminating design); Junior/Senior

Preliminary Results

- Impact seems greater in lecture course
  - Increased feedback between students and instructor
  - Higher student satisfaction
  - Still need to do detailed analysis on individual topics

Key Issues

- Motivating students to take the actions that will lead to success
  - Time commitment, appropriate study strategies, seeking/giving help
  - Placing technical training in societal context
- Creating instructional system that
  - Builds the trust that effective help will be given when requested
  - Avoids additional instructional burden by focusing individual help on those who need it most, makes use of peer resources

Conclusion

- Engineering is a powerful societal force
  - Introductory GE course open to both engineers and non-engineers can broaden perspectives and augment the STEAM pipeline
- Encouragement of peer-to-peer and student/instructor interactions is key to providing personalized educational solutions
  - Rehearses the types of interactions that will assist in entire career