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-to-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