Session XXXX

Design Challenges as a Spine to Engineering Courses

Abhaya Datye,* Marina Miletic,* Jamie Gomez,* Eva Chi,* Sang M. Han,* Catherine Hubka,* Yan Chen,* Vanessa Svihla,* ** Sung Kang, Heather Canavan***
*Department of Chemical and Biological Engineering
**Organization, Information, and Learning Sciences
University of New Mexico

Abstract

The undergraduate Chemical Engineering program at the University of New Mexico has threaded design challenges throughout the chemical engineering core curriculum to relate real-world Community-, Industry-, Research-, and Entrepreneurship-based projects to fundamental course work. Faculty, graduate students, and dozens of chemical engineering students have developed, implemented, and refined these design challenges which stretch through the core curriculum from the first year to some graduate-level electives courses. Our goal with implementing these varied design challenges is to allow a diverse set of students the opportunity to see the numerous applications of chemical engineering to local and globally-relevant problems [1], and to help them develop the engineering skills and confidence which will empower them to solve these problems [2-7]. This paper presents the structure, sequence, and requirements of these team-based design projects as they form a spine across required chemical engineering courses. Participants are undergraduate students studying chemical engineering in the Southwest United States.

Variety and Sequence of Design Challenges

Design Challenges in the first year course (CBE 101: Introduction to Chemical Engineering and Biological Engineering) have involved a blend of student presentations (pitches), research, writing, and lab work framed within three projects of varying scope and application:

1. Students complete an entrepreneurship- and research-based project where they pitch potential applications of OPE (Oligo phenylene ethynylenes) polymers, solids with remarkable antimicrobial resistance. This prototypical entrepreneurial challenge exposes students to current research conducted by Dr. Dave Whitten.
2. Students complete a community water contamination remediation project where they investigate the hazards of acid drainage from abandoned mines, which are abundant in New Mexico. Students perform lab work and develop a treatment, prevention, and emergency response for rural communities, along with a community engagement strategy.
3. Students complete a "Why Chem E?" challenge which introduces them to the scope of the chemical engineering profession. Students work in teams to research and interview an alumnus, graduate student, or industry professional to learn more about their career. They produce promotional brochures that the UNM CBE Department can use to recruit new students to chemical engineering.

Design challenges in second year courses (CBE 251: Chemical Process Calculations and CBE 302: Chemical Engineering Thermodynamics) build on the teamwork and technical skills students established in the first year and introduce greater theory, optimization, research, and decision making.

1. In CBE 251, students work in teams to complete a community-, industry-, and research-based algal biofuel design challenge. Students develop a conceptual fuel source design for a community and explore generating fuel from algae through three production phases: growth, harvesting and extraction. All three phases involve extensive parlay-based decision making and prompt students to link knowledge gained from the design challenge to the disciplinary course content by way of deliverables, which are submitted with each of six homework assignments.
2. In CBE 302, students work in teams through a 7 week-long entrepreneurial- and community-based design challenge which tasks students with developing a solution to a global problem using thermodynamic principles. Students are charged with describing a common global problem and proposing a feasible solution or product that involves thermodynamic cycles, phase separation, work, or efficiency. Students submit a bibliography, technical report, final presentation, and group evaluation.

Design challenges in third year courses (CBE 311: Introduction to Transport Phenomena and CBE 321: Mass Transfer involve incorporation of more chemical engineering theory and conceptual understanding to applications for the end goal of developing new products and solutions to real-world problems. The technical and teamwork skills developed from these challenges prepare students for capstone design in the senior year.

1. In CBE 311, students work in teams to complete a community-based design challenge where they are tasked with characterizing and mitigating the jet fuel spill first detected in 1999 on the Kirtland Air Force Base in Albuquerque, NM. As part of a final presentation, students are expected to assess possible engineering approaches to contain and remediate the leak of ethylene dibromide, improve designs to prevent future breaches, and provide economically and environmentally sound long-term methods to assess the level of spread as well as monitor and treat the contaminated underground water.
2. In CBE 321 students work in teams on an entrepreneurship-based project which involves developing a separations-based consumer product, such as non-alcoholic beer. Students' deliverables for the project include writing memos, performing Aspen simulations, writing a short technical report, and creating a video design pitch for an alcohol removal-based product.

Design challenges in 500-level graduate-level and elective CBE courses have built on students' prior design and teaming experience to challenge them with solving a global health problem through the development of an engineered product or idea. Students also explore adaptive design for developing products for people with disabilities. Students use Maker's Spaces for prototyping, 3D printing, welding, woodworking, and laser etching.

Summary and Conclusions

UNM's CBE chemical engineering program has incorporated a wide variety of design challenges into core and elective courses, allowing students to explore research-, entrepreneurship-, industry-, and community-based projects and their intersection with chemical engineering principals. Students most of all develop a sense of the breadth of chemical engineering applications and the numerous possibilities for chemical engineering careers.

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ABHAYA DATYE
Dr. Abhaya Datye has been on the faculty at the University of New Mexico after receiving his PhD in Chemical Engineering at the University of Michigan in 1984. He is presently Chair of the department and Distinguished Regents Professor of Chemical & Biological Engineering. From 1994-2014 he served as Director of the Center for Microengineered Materials, a strategic research center at UNM that reports to the Vice President for Research. He is also the founding director of the graduate interdisciplinary program in Nanoscience and Microsystems, the first program at UNM to span three schools and colleges and the Anderson Business School. He served as director of this program from 2007 – 2014. His research interests are in heterogeneous catalysis, materials characterization and nanomaterials synthesis. His research group has pioneered the development of electron microscopy tools for the study of catalysts.

MARINA MILETIC
Dr. Marina Miletic served as a Lecturer in the Department of Chemical & Biomolecular Engineering at the University of Illinois at Urbana-Champaign for eight years. She taught Senior Design and Unit Operations among other courses and helped establish one of the nation’s first week-long Chemical Engineering summer camps for girls. Her research has focused on promoting concept-based learning in the classroom, developing Chemical Engineering video lectures, studying the efficacy of remote web-controlled Unit Operations experiments, and incorporating Design throughout the Chemical Engineering curriculum. She currently works as a freelance Engineering Education Consultant and Chemical Engineer. She is the Project Manager for NSF grant #1623105, IUSE/PFE:RED: FACETS: Formation of Accomplished Chemical Engineers for Transforming Society, for which she

is advising and coordinating assessment.

JAMIE GOMEZ
Dr. Jamie Gomez is a Senior Lecturer III in the department of Chemical & Biological Engineering (CBE) at the University of New Mexico. She is a co- principal investigator for the following National Science Foundation (NSF) funded projects: Professional Formation of Engineers: Research Initiation in Engineering Formation (PFE: RIEF) - Using Digital Badging and Design Challenge Modules to Develop Professional Identity; Professional Formation of Engineers: REvolutionizing engineering and computer science Departments (IUSE PFE\RED) - Formation of Accomplished Chemical Engineers for Transforming Society. She is a member of the CBE department's ABET and Undergraduate Curriculum Committee, as well as faculty advisor for several student societies. She is the instructor of several courses in the CBE curriculum including the Material and Energy Balances, junior laboratories and Capstone Design courses. She is associated with several professional organizations including the American Institute of Chemical Engineers (AIChE) and American Society of Chemical Engineering Education (ASEE) where she adopts and contributes to innovative pedagogical methods aimed at improving student learning and retention.

EVA CHI
Dr. Eva Chi is an Associate Professor in the Department of Chemical and Biological Engineering Department at the University of New Mexico. The research in her lab is focused on understanding the dynamics and structures of macromolecular assemblies including proteins, polymers, and lipid membranes. Undergraduates, graduate students, and postdoctoral scholars are trained in a multidisciplinary environment, utilizing modern methodologies to address important problems at the interface between chemistry, physics, engineering, and biology preparing the trainees for careers in academe, national laboratories, and industry. In addition to research, she devotes significant time developing and implementing effective pedagogical approaches in her teaching of undergraduate courses to train engineers who are critical thinkers, problem solvers, and able to understand the societal contexts in which they are working to addressing the grand challenges of the 21st century.

SANG M. HAN
Dr. Han is a Regents Professor in the Departments of Chemical & Biological Engineering and Electrical & Computer Engineering at the University of New Mexico. He earned his Ph.D. in chemical engineering from the University of California at Santa Barbara and his B.S. in chemical engineering with honors from the University of California at Berkeley. Dr. Han has over 25 years of experience in electronic and photonic materials engineering and fabrication. His current research topics include (1) writable/rewritable quantum structures by stress patterning; (2) low-cost, crack-tolerant, advanced metallization for solar cell durability; (3) thin film processing and nanoscale surface corrugation for enhanced light trapping for photovoltaic devices; and (4) microsphere-based manufacturable coatings for radiative cooling. He has close to 70 publications in peer-reviewed journals and over 200 invited/contributed papers at academic institutions, national laboratories, and conferences. He received a UNM Junior Faculty Research Excellence Award in 2005 and an NSF Career Award in 2001. He is a recipient of STC.UNM Innovation Award consecutively from 2009 to 2018, and he was elected as the 2018 STC.UNM Innovation Fellow. Dr. Han holds 17 UNM-affiliated U.S. patents and 6 pending U.S. and PCT patent applications. He currently serves as the Chief Technical Officer of Osazda Energy LLC, a startup company based on his intellectual

property generated at UNM. Prior to his entrepreneurial venture, Dr. Han served as the main campus faculty member of the STC.UNM Board of Directors from 2015 to 2016.

CATHERINE HUBKA
Catherine (Cat) Hubka, MFA, holds dual appointments at the University of New Mexico in the Departments of Chemical and Biological Engineering (CBE) and Department of English. For CBE, she is embedded in the 300 and 400 labs where she supports curriculum redesign focused on incorporating content-based writing approaches. In the Department of English, Cat teaches in the Core Writing Program where her pedagogy incorporates creative writing approaches to professional and technical writing and collaborative writing projects in online platforms.

YAN CHEN
Dr. Yan Chen is a Postdoctoral Fellow in the Departments of Chemical & Biological Engineering at the University of New Mexico. Her research interests focus on computer supported collaborative learning, learning sciences, online learning and teaching, and educational equity for multicultural/multiethnic education.

VANESSA SVIHLA
Dr. Vanessa Svihla is a learning scientist and associate professor at the University of New Mexico in the Organization, Information & Learning Sciences program and in the Chemical & Biological Engineering Department. She served as Co-PI on an NSF RET Grant and a USDA NIFA grant, and is currently co-PI on three NSF-funded projects in engineering and computer science education, including a Revolutionizing Engineering Departments project. She was selected as a National Academy of Education / Spencer Postdoctoral Fellow and a 2018 NSF CAREER awardee in engineering education research. Dr. Svihla studies learning in authentic, real world conditions; this includes a two-strand research program focused on (1) authentic assessment, often aided by interactive technology, and (2) design learning, in which she studies engineers designing devices, scientists designing investigations, teachers designing learning experiences and students designing to learn.

SUNG “PIL” KANG
Dr. Sung “Pil” Kang is an assistant professor at the University of New Mexico. His academic interests include change management, change model validation, and mindset evolution. He may be reached at pilkang@unm.edu

HEATHER CANAVAN
Dr. Heather Canavan is a Professor in the Department of Chemical & Biological Engineering at the University of New Mexico. She earned her Doctorate and MPhil from The George Washington University in Physical Chemistry, with a minor in Forensic Chemistry. She earned her Bachelors from the University of California at Santa Barbara in Biology. She has worked at Los Alamos National Laboratory and the Naval Research Laboratory, and did her postdoctoral fellowship at the University of Washington in Seattle. Her research focuses on cell/surface interactions, bioactive polymers and biocompatibility, and the design of adaptive tools and devices for enhanced mobility. She is also extremely active in engineering and scientific education. Her funding is primarily from the National Science Foundation and the National Institutes of Health.