2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34868

Work-in-Progress: The Design of Up-to-Date Industry Problems for a Sophomore Chemical Engineering Course: Challenges and Gains of Industry Mentors

Dr. Betul Bilgin, The University of Illinois at Chicago

Betul Bilgin is Clinical Assistant Professor of Chemical Engineering (CHE) at the University of Illinois at Chicago (UIC) and has been teaching the Senior Design I and II courses for 6 years and Introduction to Thermodynamics for two years. Since her appointment in 2014 she has been exploring active learning, peer instruction, team-based, hands-on, application-based techniques in her classes to fully engage her students. She was selected as a UIC Teaching Scholar for Spring 2017, named as an American Institute of Chemical Engineers (AIChE) ”35 under 35” winner in the education category for 2017 and named as American Society for Engineering Education (ASEE) ”20 under 40” awardee for 2018.

Prof. James W. Pellegrino, The University of Illinois at Chicago

James W. Pellegrino is Liberal Arts and Sciences Distinguished Professor and Founding Co-director of the Learning Sciences Research Institute at the University of Illinois at Chicago. His research and development interests focus on children’s and adult’s thinking and learning and the implications of cognitive research and theory for assessment and instructional practice. He has published over 300 books, chapters and articles in the areas of cognition, instruction and assessment. He has served on several National Academy of Sciences study committees, including chair of the Committee for the Evaluation of the National and State Assessments of Educational Progress, co-chair of the Committee on the Foundations of Assessment, chair of the Committee on Defining Deeper Learning and 21st Century Skills, and co-chair of the Committee on Developing Assessments of Science Proficiency in K-12. For several years he served as a Senior Editor for the Journal of Engineering Education. He is a past member of the Board on Testing and Assessment of the U.S. National Research Council, and a lifetime member of the National Academy of Education and the American Academy of Arts and Sciences.

Dr. Vikas Berry, The University of Illinois at Chicago

Work-in-Progress: The design of up-to-date industry problems for a sophomore chemical engineering course: Challenges and Gains of industry mentors

Abstract

The chemical engineering field has expanded over the past few decades and now encompasses diverse fields such as pharmaceuticals, renewable energy, nanoparticles, food products, and safety. However, the chemical engineering curriculum has not evolved accordingly. Thus, the gap between the industry's needs and the competencies developed in chemical engineering (CHE) programs has grown. To adequately address this problem, the authors' goal is to synergize industry-student-academic integration by enculturating classrooms with connections to industrial realities. Implementation of this model is particularly important in the early years of the curriculum. As the first step, the authors are working on designing and incorporating up-to-date industry problems as assignments in a course on "*Materials and Energy Balance*". The authors have been working with industry mentors from various areas of the chemical engineering field to design up-to-date application-based problems/projects for the selected CHE class. Two industrial mentors with different areas of expertise were selected. For example, one industrial mentor from the process safety area was chosen to integrate safety concerns into the course. This synergistic model's sustainability is dependent on understanding the gains and challenges of integrating industry mentors into the academic environment. As part of the data collection, industry mentors are interviewed about the course integration activities, including faculty and student mentorship, to determine the integration efforts' perceived costs and benefits. Data will also be obtained from students about impact on academic and professional attitudes and competencies. This paper provides the details of a poster describing the integration efforts and the data sources of the project that will be presented in the Poster Session at the 2021 ASEE Annual Conference & Exposition. The findings of this study will reveal effective principles of industrial engagement for the evolving field of chemical engineering. The knowledge gained will provide insights regarding important aspects of industry-faculty engagement and the impact on students and help uncover best practices. The results can help other institutions build and maintain industry-faculty relationships that assist in engineers' professional formation.

Introduction to the Synergistic Approach

It is necessary to synergize industry, faculty, and students to integrate fundamentals, applications knowledge, and interpersonal and intrapersonal skills. Traditionally these three constituencies are disconnected. In a deductive approach (see Figure 1), faculty deliver fundamentals to students, and students are expected to learn applications and develop interpersonal and intrapersonal skills in the industry. In the integrated approach (Fig. 1), pair-by-pair interactions are introduced: faculty are expected to learn about applications from interactions with industry, students are expected to learn fundamentals from interactions with faculty, and students acquire interpersonal and intrapersonal skills through interactions with industry. These pair-by-pair interactions have proven to be partially effective ways of knowledge transfer and skill development, but they lack coherent and synthetic integration.

To enrich the integrated approach, we engaged one more step, bringing industry professionals into classrooms. With this "*Synergistic approach,*" all three constituencies, students, industry professionals, and faculty will work synergistically to improve fundamentals, develop interpersonal and intrapersonal skills, and integrate applications simultaneously (Fig. 1). This NSF PFE: RIEF funded project focuses on implementing the "*Synergistic Approach*" in a sophomore-level chemical engineering course, *CHE 210 Mass and Energy Balance*. The project team is collaborating with professional engineers (industrial mentors) from different industry areas to integrate up-to-date practices into the target course. Every industry mentor will be in the class when related concepts are taught. During the regular instructors' lecture, the mentor will observe and complement that material with a twenty-minute presentation that relates the focal concept to an industry problem and application. In parallel, the project team and industry mentors will work on up-to-date application-based problems/projects to be implemented in the course instructor's homework and assignment(s). The project team will also work with safety professionals to blend essential topics like process safety, risk management, and environmental impact into the targeted course.

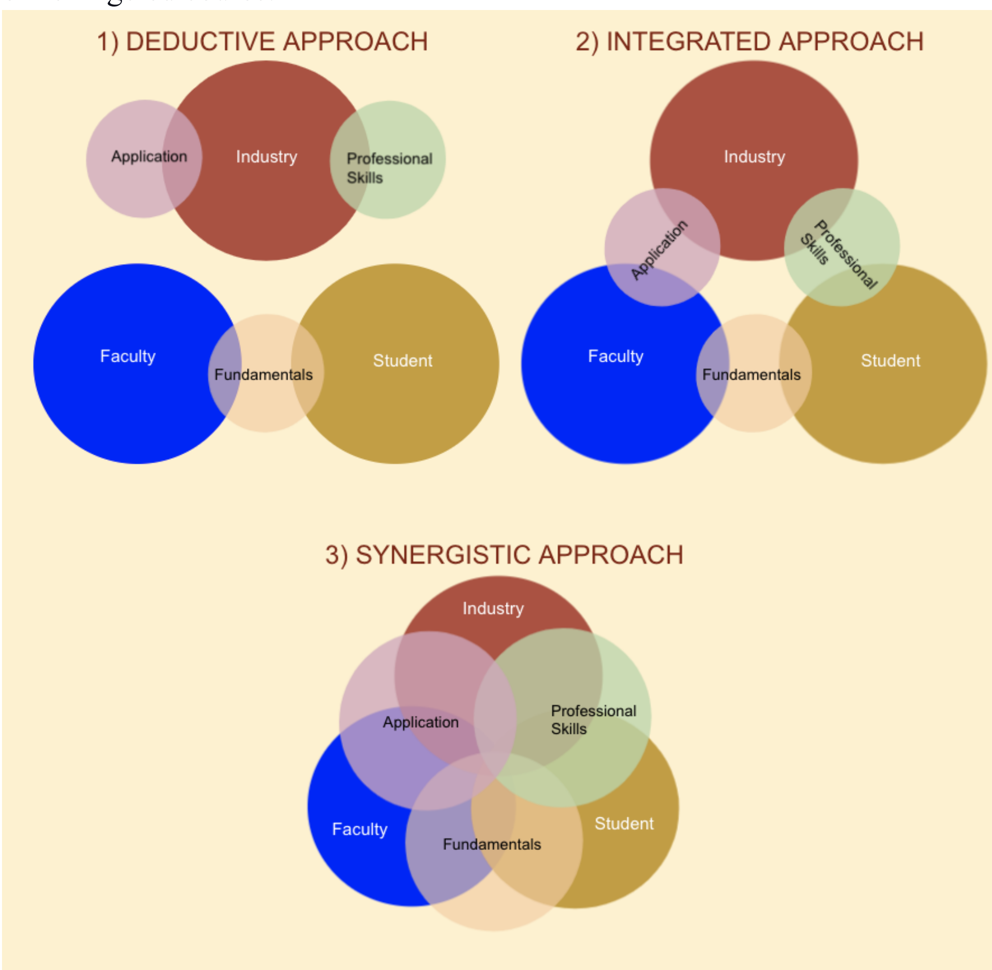

Figure 1. Schematic of constituent relations of different approaches. Interpersonal and intrapersonal skills are labeled as professional skills.

We hypothesize that the "*Synergistic Approach*" will engage students in a new and compelling manner, introducing them to up-to-date industry problems accompanied by industry professionals' presence in the classroom. This unique approach will integrate technical fundamentals, industry applications and foster the development of interpersonal and intrapersonal skills resulting in significant improvements in students' professional development and engineering identity formation. It draws upon research showing that culture and social contexts shape identities and that the process of engineering identity development is affected by the culture of a program [1, 2]. Research also shows that having ongoing interactions with professional engineers fosters identity formation and results in longer persistence in the field [3-5]. Research also shows that cultivating culture is especially important for women [6-8]. We thus aim to create such a culturally supportive environment for the CHE 210 class and measure the impacts of industry-student-faculty connections on development of students' engineering identity.

Design of Industry-Relevant Up-to Date Problems

To be able to distinguish the impacts of changes in the course curriculum from the impacts of interaction with industry mentors, multiple implementation conditions will be evaluated. In Spring 2021, only up-to-date problems/projects designed by industry mentors are introduced to the course. However, students did not interact with industry mentors; mentors did not give guest lectures and were not present during end-semester presentations. This baseline condition serves to measure the impact of changes in the curriculum on attitudes and identity development. The project team plans to implement all the synergistic approach components during the Fall 2021 and Spring 2022 semesters. With the full implementations, the research team will be able to analyze each element's impact, redesign and enact again.

During the Fall 2020 semester, the project team reached out to industry mentors, and many industry mentors graciously agreed to volunteer for the project. Even though other mentors were willing to volunteer for the project, the project team chose two industry mentors to work on industry-relevant problem designs due to time constraints. Industry mentors, course instructor and the project team met and brainstormed the design criteria for the problems. It was decided that each problem will have multiple stages with increasing difficulty. The first stage is the basic economic calculation, second is reactor mass balance, third is separation mass balance, fourth is recycling loop, and fifth is energy integration. One problem was chosen from the carbon recycling process and one from renewable fuel production. Both topics were highly interesting for the students. Mentors received the course instructor's approval after they designed their problems. The course instructor made sure that problems' difficulty level is appropriate for students, challenging and understandable. Upon approval, industry mentors recorded a video introducing the problem and its relevance to their job. Videos start with introducing the mentor and their company, continued by introducing the process, introducing the problem, and its relevancy to their work. Problems were introduced to students as HW assignments: first, they needed to watch the video and understand the process. Then each stage of the problem was distributed to HW sets. Both the video and written form of the problems were delivered to students. Overall time commitment from mentors was around 10 hours (3 hours of problem design, 2 hours of meeting with the project team, 3 hours of recording, and 2 hours of interviews), and tasks were as below:

- Meet with the course instructor to exchange information on the course and industry projects. As an output, mentors and course instructors design a project that aligns the course learning outcomes with the mentor's industrial expertise and field of work. This project will be assigned to students as an HW problem, and students will be working on it individually. The project needs to align with the course outline, student's knowledge levels, and difficulty.

- Meet with the project team to finalize the details of the project and record the video. The video will have 4-5 parts; each part will build on the previous part and successively add more aspects to the project such as safety, economics, energy, etc.
- Video parts will be 10 min max, the first part being the longest.
- In the last video, the mentor will explain how this project is done in the industry, how they approach it, solve mass-energy balances, and address safety and economics concerns.
- Mentor will be interviewed to gain insights on the implementation.

Feedback from the Industry Mentors

After problem design, the project team interviewed the industry mentors about their experiences. Both mentors stated that they were motivated to participate in the project and satisfied with the output. They are looking forward to seeing the impacts on students. The main motivation for both mentors was that they did not know what chemical engineering is when they started undergraduate studies, and they wanted to help students to gain a better insight into areas of chemical engineering and the contributions of chemical engineers. One mentor who is female and young stated that she would like to show students that the chemical engineering field is changing and welcoming individuals from more diverse backgrounds.
Moreover, both mentors wanted to change students' perspectives on the importance and relevance of the contents of the university courses. The main challenge for them was the time window. Since the project team contacted them late in the Fall semester and wanted to introduce the problems early in the Spring semester, they had only three weeks to design and record the videos.

COVID-19 Modifications of the Project

Traditionally, CHE 210 course has been taught in-person each Fall and Spring semesters at the University of Illinois at Chicago (UIC). Due to the COVID-19 pandemic, the course has to be moved online. The course instructor decided to deliver the course asynchronously. Every week, he records his videos, posts online, and assigns HW/Quiz/Exam via Learning Management System, Blackboard. With this set-up, he has minimal contact with students, only if they attend to his office hours. Industry-relevant problems are introduced to the course in this online set-up.

Future Plans

The project team has successfully implemented two industry problems into the course. During Summer 2021, the project team plans to collaborate with five more industry mentors and create a library of problems. The team plans to incorporate problems from various chemical engineering fields such as cosmetics, food, safety, beverage, and energy. Also, mentors representing different gender, ethnicity, and backgrounds will be selected to diversify the role models for students.

These problems will be introduced to the course during the Fall and Spring semesters of the 2021-2022 academic year.

Generation of Knowledge

This project is focused on developing key aspects of student competence in the workplace and academia. With the implementation, the project team seeks to identify both the challenges and effectiveness of implementing the synergistic approach. Overall, the project team is planning to measure engineering identity and self-efficacy development. To date, only the gains and challenges of industry mentor involvement have been identified but future work will include more outcomes related to mentors, the course instructor, and the students.

Acknowledgment

Support for this work was provided by the National Science Foundation Scholarships in PFE: RIEF program under Award No. 2024960. Any opinions, findings, and conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

1. Henderson, C., & Dancy, M. H. (2011) Increasing the Impact and Diffusion of STEM Education Innovations. *Increasing the impact and diffusion of STEM education innovations, Washington, DC: National Academy of Engineering. [Online]*
2. Besterfield-Sacre, M., Cox, M. F., Borrego, M., Beddoes, K., & Zhu, J. (2014) Changing Engineering Education: Views of U.S. Faculty, Chairs, and Deans. *Journal of Engineering Education, 103(2),* 193–219.
3. Ponton, M. K., Edmister, J. H., Ukeiley, L. S., & Seiner, J. M. (2001) Understanding the role of self-efficacy in engineering education. *Journal of Engineering Education 90(2),* 247-251.
4. Downey, G. L., & Lucena, J.C. (2004) Knowledge and professional identity in engineering: code-switching and the metrics of progress. *History and technology 20(4),* 393-420.
5. Howard, P. (2009) Articulating the learning: Professional practice made explicit. *International Journal of Work-Integrated Learning 10(3),*177.
6. Dehing, F., Jochems W., & Baartman, L. (2013) Development of an engineering identity in the engineering curriculum in Dutch higher education: an exploratory study from the teaching staff perspective. *European Journal of Engineering Education 38(1),* 1-10.
7. Tonso, K. L. (1999) Engineering Gender− Gendering Engineering: a cultural model for belonging. *Journal of Women and Minorities in Science and Engineering 5(4)*.
8. Shane, J., Puerto, C. L., Strong, K., Mauro, K., & Wiley-Jones, R. (2012) Retaining women students in a construction engineering undergraduate program by balancing integration and identity in student communities. *International Journal of Construction Education and Research 8(3)*,171-185.