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Developing Professional Identity: Integrating Academic and Workplace Competencies within Engineering Programs

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Abstract

Chemical engineering education needs a new rational approach commensurate with the evolution and expansion it has undergone via the inclusion of key elements from several fields: pharmaceuticals, renewable energy, biotechnology, and food and consumer products, among others. With the expansion of industry and growing needs for communication and leadership skills in the 21st century, practicing engineers are expected to be technically knowledgeable and professionally skillful. However, the typical chemical engineering undergraduate core curriculum has not adapted to prepare students for the multiple needs encompassed by the chemical industry. Lack of industry-relevant examples/topics and applications in the course contents results in less motivated and/or engaged students. Students therefore often struggle to identify with the profession and are not ready for the workforce when they graduate. This NSF PFE: RIEF project examines a unique experience where a student-faculty-industry integrated community is created to help bridge the gap between industry needs and the competencies developed within chemical engineering programs.

The project's main goal is to better understand how implementing up-to-date industry problems into one of the sophomore chemical engineering courses impacts students' engineering identity formation and self-efficacy development. To analyze the impacts of the intervention, this project employs design-based research (DBR) approach to guide the development, implementation, and evaluation of materials and methods reflecting the proposed synergistic model for a course and program design. Implementing up-to-date industry-relevant problems into the course will foster student-industry-faculty engagement (PI, engineering Co-PI, and course instructor), develop student knowledge, skills, and abilities needed in the chemical engineering world today and in the future, and support professional identity formation. Moreover, industry-student engagement through the methods proposed

will develop students' societal and environmental awareness. This paper provides findings from Spring 2021 that will be presented in the National Science Foundation (NSF) Grantees Poster Session during the 2022 ASEE Annual Conference & Exposition.

Major Activities

To understand the impacts of the intervention on self-efficacy and engineering identity, up-to-date industry-relevant problems were designed, introduced to the targeted course, instruments for self-efficacy and engineering identity were developed and employed. Two problems were designed by industry mentors during the Fall 2020 semester, which was continued as introducing those problems into the targeted course in the Spring 2021 semester, chosen as a baseline condition. Two survey instruments to measure self-efficacy and engineering identity were chosen based on the literature [1,2]. Both surveys were implemented at the beginning and end of the Spring 2021 semesters. On the other hand, six randomly selected students, stratified by gender, were interviewed at the beginning and end of the Spring 2021 semester to determine reactions to the instructional design and instructional events and materials. This content analysis helped the project team identify challenges, difficulties, and gains of adopting this approach to the engineering program and provide an appraisal of student outcomes, including cognitive and affective responses.

Up-to-Date Industry Problems Design

During the Fall 2020 semester, the PI and project team worked with two mentors on problem design. The challenges and gains of mentors by participating in the study was published in 2021 ASEE Conference [3]. Both mentors stated that they were motivated to participate in the project and satisfied with the output. 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. 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.

During Summer 2021, the project team worked with two other mentors to design two more problems for the course. Those problems were from the plastic recycling process and pharmaceutical applications, which are exciting topics for students.

Introduction of Up-to-Date Industry Problems into Targeted Course and COVID-19 Modifications

To be able to distinguish the impacts of changes in the course curriculum from the impacts of interaction with industry mentors, multiple implementation conditions were planned to be evaluated. In Spring 2021, only up-to-date problems/projects designed by industry mentors were 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. Traditionally, CHE 210 course has been taught in-person each Fall and Spring semester at the University of Illinois at Chicago (UIC). Due to the COVID-19 pandemic, the course has to be moved online in the Spring 2021 semester. The course instructor decided to deliver the course asynchronously. With this set-up, he had minimal contact with students, only if they attended his office hours. Industry-relevant problems are introduced to the course in this online set-up with minimal interaction between the course instructor and students.

Instrument Development and Employment

Two survey instruments to measure self-efficacy and engineering identity were chosen based on the literature. Both surveys were implemented at the beginning and end of the Spring 2021 semesters. We had a low response rate to survey questions (18 at the beginning of semester, and only 5 at the end of semester), possibly because of minimal in-person contact with students due to the asynchronous delivery of the course.

The graduate research assistant interviewed six randomly selected students, stratified by gender, at the beginning and end of the Spring 2021 semester to determine reactions to the instructional design and instructional events and materials. During Summer 2021, the graduate assistant transcribed interviews via software tools. PI, social science co-PI, and the graduate student coded and analyzed the interviews using analysis software MAXQDA. Based on this baseline condition (Spring 2021), the interview process was piloted, coding was refined, and responses were analyzed.

Ongoing and Future Work

Continue up-to-date industry problem design work

To date, the project team has collaborated with four mentors and created four different up-to-date industry-relevant problems from various areas of chemical engineering. During Fall 2021, the project team plans to collaborate with two more industry mentors and develop a library of problems. The team plans to diversify the problems by incorporating various chemical engineering fields as well as mentors representing different gender, ethnicity, and backgrounds.

Introducing problems to class and student-mentor interactions

The project team successfully completed the baseline condition in the Spring 2021 semester, even with the modifications having to be made due to the COVID-19 pandemic. The Fall 2021 semester was planned to be the first full implementation where in addition to introducing industry problems as HW questions, mentors visited classrooms and presented their work and had one-on-one interaction with students and students presenting to mentors at the end of the semester. The implementation was modified based on Fall 2021 feedback and started to be enacted in Spring 2022.

Data collection

Students were surveyed at the beginning and end of the semesters in Fall 2021 and Spring 2022 semesters. To increase the survey response rate, the course instructor offered extra credit to

students who filled out the surveys as an incentive. Furthermore, interviews were conducted with industry mentors, course instructor, course teaching assistant, and ten randomly selected students, stratified by gender at the beginning and end of the semester. Those interviews will be transcribed, coded, and analyzed.

Generation of Knowledge

The findings of this project were presented at the American Society for Engineering Educators (ASEE) conference in July 2021. Challenges and gains of industry mentors to design up-to-date industry-relevant problems for the implementation were shared as a poster presentation [3]. Futhermore, findings were presented at the 2021 AIChE Annual Conference titled.

Conclusion

One of the main focus of this project is to develop PI's skills on engineering education research. With working Prof. Pellegrino, she has been gaining knowledge and expertise on quantitative and qualitative social science research methods. Findings from baseline condition in Spring 2021 helped the project team to further improve the design for Fall 2021 and Spring 2022 semesters with full implementations.

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