Board 144: Work-in-Progress: A Course Collaboration Between Chemical Engineering and Mechanical Engineering

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A course collaboration between chemical engineering and mechanical engineering

Abstract
The First Year Engineering (FYE) program at the University of Kentucky aims to foster collaboration among students in engineering and computer sciences. As interdisciplinary interactions are limited as students move to upper-class courses, the project aims to develop and sustain collaboration between mechanical and chemical engineering lecturers for junior level courses. The enhanced presence of multidisciplinary collaboration could overcome the knowledge fragmentation of a specialized engineering curriculum and be a better representation of the workplace.

Introduction

Engineering programs are structured based on employability, the fourth industrial revolution, and sustainability. Students need to understand and solve complex problems based on context and their ability to connect multiple disciplines [1]. Many US institutions have adopted the First Year Engineering (FYE) program model in which students majoring in engineering and computer sciences take the same classes together for a year. The FYE program facilitates the transitions between majors for undecided students and aims to promote collaboration among peers in their introductory courses. These interdisciplinary interactions are unfortunately often limited as students move to upper-class courses [2, 3]. In the Paducah Campus of the University of Kentucky, we identified an additional opportunity for a collaborative course in Fluid Mechanics. The fluid mechanics course is taken by both chemical engineers (ChE) and mechanical engineers (ME). In the past years, combining cohorts of students in a single class was not seen positively by the students as the emphasis on the course material can be different from one major to another despite the same learning outcomes. Therefore, ChE's take a Fluid Mechanics course separately from the ME's with an increased focus on compressible flows. The aim of this study is to investigate how the integration of a collaboration on certain dates and specific assignments could enhance the perception of multidisciplinary collaboration in upper-level chemical and mechanical engineering undergraduates.

Background

Interdisciplinarity, multidisciplinarity and transdisciplinarity have been used broadly without recognizing their main distinctions. Multidisciplinarity involves the collaboration of multiple experts from at least two disciplines to achieve a common goal, with limited interaction. Interdisciplinarity involves researchers from different academic disciplines (more than 2) working together to produce combined reports, documents, and recommendations. Transdisciplinarity is a group of investigators formed by individuals from different disciplines working together to create a shared conceptual model that integrates and transcends each disciplinary perspective [4]. The lowest level of collaboration can be defined by intradisciplinarity in which collaboration is confined to the same discipline. On the other hand, the transidsciplinary approach is the highest level of integration between individuals.

Engineering specialization has led to knowledge fragmentation, affecting students' mastery of physics, mathematics, and engineering topics. An inter/multidisciplinary approach can counterbalance specialization by broadening horizons and increasing global awareness. A two-year project implemented inter- and multidisciplinary engineering case studies to enhance fundamental concepts while fostering an environment for creativity and teamwork. The project was successful which shows that multidisciplinary teams can develop and create new content which is otherwise limited by fragmentation [5].

Entrepreneurial Mindset framework

Technical proficiency, opportunity recognition, and value addition are crucial elements of the entrepreneurial mindset (EM). "Entrepreneur" refers to both starting a new business and assisting an established business in growing. According to the modified Kern Entrepreneurial Engineering Network (KEEN) framework, EM in engineering is based on curiosity, connections, communication, and collaboration. The EM framework adapted from [6, 7] shows the potential outcomes of this study as shown in Table 1.

Table 1 – EM framework outcomes for this study

Curiosity	Communication
Connections	Collaboration

Concept maps are a useful tool for evaluating someone's comprehension of a certain subject. Through nodes and links, the concept map's graphical representation conveys the participant's in-depth understanding from a wider angle and serves as a tool to assess EM [8]. Concept maps can be scored based in qualitative and quantitative ways. The qualitative approach considers the holistic, proposition rating and coding concepts. The quantitative approach considers the counting components and similarity. The intersectionality of both considers categorical and rubric [9, 10]. A study using concept maps in a Statics class developed a module which covered both technical and entrepreneurial mindset topics. The activities used formative assessment tools. Results showed that concept maps were beneficial to students early in their engineering coursework to reflect on both technical knowledge and entrepreneurial mindset [11].

The main issue with a multidisciplinary approach is how to assess it. It could be by the number collaborations or even publications. However, in a classroom setting, these outcomes are not organically seen nor do students have the time required to develop them. This is why concept maps which focus on connections and value creation are such important tools to assess student collaboration and interactions. Since concept maps are tools used in the EM framework and as such based-on connections and collaboration, it made sense to combine all three elements in this study: multidisciplinarity, EM, and concept maps.

Methodology

The project consists of a pre- and post-activity and an intervention in the form of 1) a one-time lecture on a topic of interest to either the ME or CME professor to the opposite major group; 2) collaboration in projects and assignments in fluid mechanics as shown in Figure 1. Concept maps are used as an assessment tool to determine the level of connections among topics and the collaboration with the other engineering department. The one-time lecture for Fall 2024 will be in ANSYS. Collaborative assignments will contain the same topic covered in the lecture. At the end of the semester, students are also asked to reflect on the collaboration with the other engineering department.

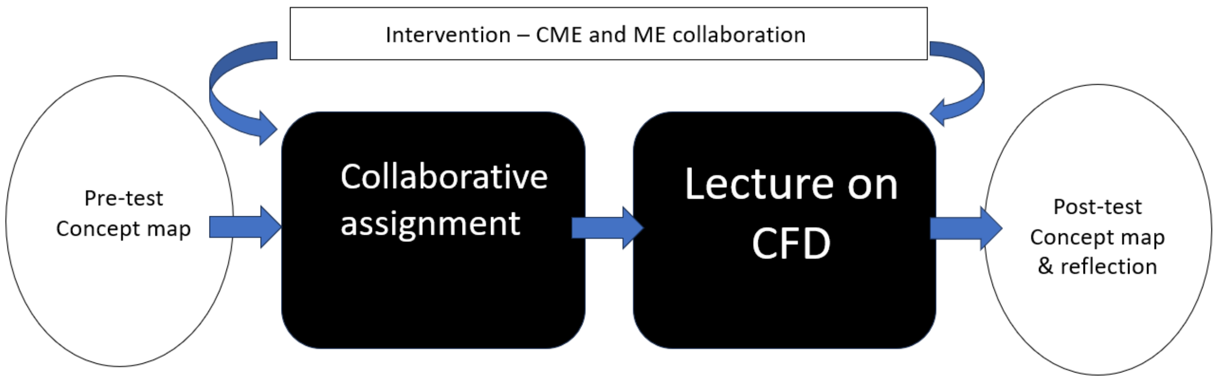

Figure 1. Study design

Within the first month, students will complete an individual assignment in which they will learn how to design a concept map based on the content covered in their Fluids class. Once students familiarize themselves with the use of the energy equation to predict pressure drop across pipes, students will have the first collaborative class in which they will collect and analyze data from a head loss experiment. Groups will be formed of both ChE and ME individuals. At another class meeting, students will conduct an experiment with Venturi meter. They will collect and analyze data. There are no changes in group dynamics for the second activity.

A guest speaker from the ME department will provide a lecture in CFD and show students how to develop their fluid flow model using ANSYS workbench. Students will learn how to plot pressure, velocity contours, velocity vectors and statics pressure along centerline for one of the activities they conducted as an experiment. Students will have a group project in which they will use ANSYS to design the flow model using data from the other experiment that was conducted in the class.

During the last month of the semester, students will be asked to create a concept map from all the content learned throughout the semester which will be complemented by a reflective statement on their collaborative work.

Results and Discussions

We expect a positive outcome from this study and that students feel motivated to collaborate with their peers. Due to the nature of the institution, students from both degrees would have either had classes or an interaction prior to enrolling on campus. In addition, they would have been able to work with peers they had already met during their FYE classes. We are particularly interested in knowing whether students perceive distinctions on the Fluid Mechanics course based on the instructor, the curriculum and other nuances that might appear on their reflections. The introduction to advanced computational tools, for ChE students, comes in the latter half of their junior year. Hence, a lecture on CFD might be a challenge to them. Variable names might also present a challenge to students as they may vary from one major to another. For instance, pressure as a lower p as opposed to upper case P.

Concept maps are used as assessment tools to the EM framework at two different stages of Fall 2024. The traditional quantitative method will be used in the analysis. This method considers three variables: the number of concepts, the level of hierarchy, the level of connectedness between concepts. We expect that the number of concepts be lower on their first concept map. We also expect a higher level of connectedness on their second concept map in addition to an increase in the number of concepts. Concept maps would also be great tools to determine the content absorbed by the students throughout the semester. We expect that concept maps aid students in preparing for their examinations.

Reflection is an important component of the post-test of this study because it complements the ability to make connections from the collaborative environment. We expect students to mention these connections and have them outlined in the concept maps. If not, we expect them to be present in the reflection. No mention of these outcomes in either one of the activities would most likely reflect a negative result to this study. We expect to repeat this study in Fall 2025 to confirm these results.

Conclusion

Fewer credits and more specialization within the engineering curriculum has led to knowledge fragmentation. One way of counterbalancing this model is by broadening horizons and promoting a multidisciplinary approach with a chemical and a mechanical engineering collaboration. This preliminary study shows great potential in applying entrepreneurial mindset as a framework to enhance multidisciplinary collaboration to both students and faculty. Our campus has hired new faculty members and the collaboration between Paducah campus and Lexington could support the increase of specialized lectures other than CFD for both majors.

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