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Factors Affecting the Success Rate of First Year Chemical Engineering Students

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Abstract

Recently, a high rate of withdrawal and failure (DFW) was noted for the freshman level Introduction to Chemical Engineering Laboratory course based on the Fall 2020 semester. Although listed as a hybrid course, all lectures were delivered through Zoom video conferencing with activities such as exams having an option of in-person or virtual delivery. Prior to the Fall 2020 semester, course curriculum changes were made to provide more active and experiential learning opportunities in the course. However, the switch to online learning limited the impact of the experiences during virtual learning. A review of submissions revealed a high number of students who did not attempt assignments. This paper analyzes student performance on similar assignments during the fall semesters of 2019 – 2021, discusses the potential causes of the high DFW rate including the switch to online learning, and proposes potential changes for future sections of the introductory course.

Introduction

The literature[1] states that, as an instructor, one of the most important times to interact with incoming freshman students is during the first weeks of course attendance. During this time, instructors introduce the concepts and careers available in chemical engineering and encourage students to progress through graduation. During an analysis of Fall 2020 engineering courses, a section of the chemical engineering introductory course was flagged as having a high withdrawal and failure rate (DFW) or a high number of students receiving grades of D, F, or W which corresponds to withdrawal. After receiving this information, several questions were posed in an attempt to address the high rate. The first question is whether the course instructor requires extra training or preparation to teach the course. Secondly, is the DFW rate primarily caused by the switch to online learning and are similar rates seen before remote learning? The final question is whether the chemical engineering department should reformat the delivery of the introductory course.

Initial Course Assessment

According to the online course catalog, the one-credit hour, introductory course is intended to introduce the field of engineering, industries, careers, and the chemical engineering curriculum. The course was designed to teach basic engineering terms, basic concepts, simple calculations to improve problem solving skills, ethics, and computer applications. Multiple sections of the course were offered in the fall semester while a single section is offered in the spring semester. Institutional data was used to create Table 1 depicting the cumulative enrollment numbers and DFW percentages from Fall 2016 until Fall 2021. A significant increase in the DFW percentage was recorded from

Fall 2018 to Fall 2019. The course was moved online during Spring 2020 which had the highest DFW and lowest overall enrollment. The DFW percentage remained above 20% during the online Fall 2020 semester and the hybrid Spring 2021. Courses returned to campus for Fall 2021 which say on overall drop in percentage that was similar to that of Spring 2019 before the pandemic. According to the data, the switch to online learning was a significant factor for the increase in DFW rate.

Table 1: DFW Data for Introductory Chemical Engineering Course from 2016 - 2021. Fall semesters are cumulative data of multiple sections.

Semester	Enrollment	DWF%
Fall 2016	37	5%
Spring 2017	12	8%
Fall 2017	51	0%
Fall 2018	51	4%
Spring 2019	12	8%
Fall 2019	34	15%
Spring 2020	6	33%
Fall 2020	34	21%
Spring 2021	9	22%
Fall 2021	29	10%

The impact of remote learning is not relegated to this intuition. Several studies[2,3] have reported on the sudden shift to online learning in 2020. According to literature[2,4], the effect of COVID and online learning greatly impacted the effectiveness of student comprehension throughout the country. Students were constantly presented with distractions to learning and were unable to focus solely on coursework. As a result, students did not submit assignments or stopped attending class. One study[2] suggested that a major contributor to student failure was the availability and functionality of computers and computer software in an online format. Table 2 shows the difference between the percentages of students who attempted assignments from Fall 2019 – Fall 2021. In Fall 2019, an average of 8.75 students attempted all homework, quiz, and exams which correlated to 75%. This percentage increased to 85% in Fall 2021 when students returned to campus. It was observed that students who failed to continue attending the course represented majority of the missing assignments; however, students who attended the course regularly would also fail to submit assignments. To better understand the student mindset, a survey was issued to the Fall 2021 students enrolled in the freshman introductory course.

Table 2: Assessment of Single Section of Introductory Course Fall 2019 - Fall 2021

Semester	Enrollment	Average Number Attempting Assignments	Average Percent of Student Attempting Assignments	Passing Percentage for those attempting assignment
Fall 2019	11	8.75	75%	77%
Fall 2020	14	11.3	81%	86%
Fall 2021	10	8.5	85%	92%

Fall 2021 Questionnaire Results

A Qualtrics survey was offered to 3 sections of the introductory course at the end of the Fall 2021 semester. Students were notified that the survey was optional and responses anonymous. A total of 25 responses were gathered from the survey. Of the respondents, 44% identified as first-year freshmen, 16% as continuing students, and 40% as transfer students (Figure 1). This information means that over 55% of students enrolled in the freshman course were not classified as freshman with a significant portion being transfer students.

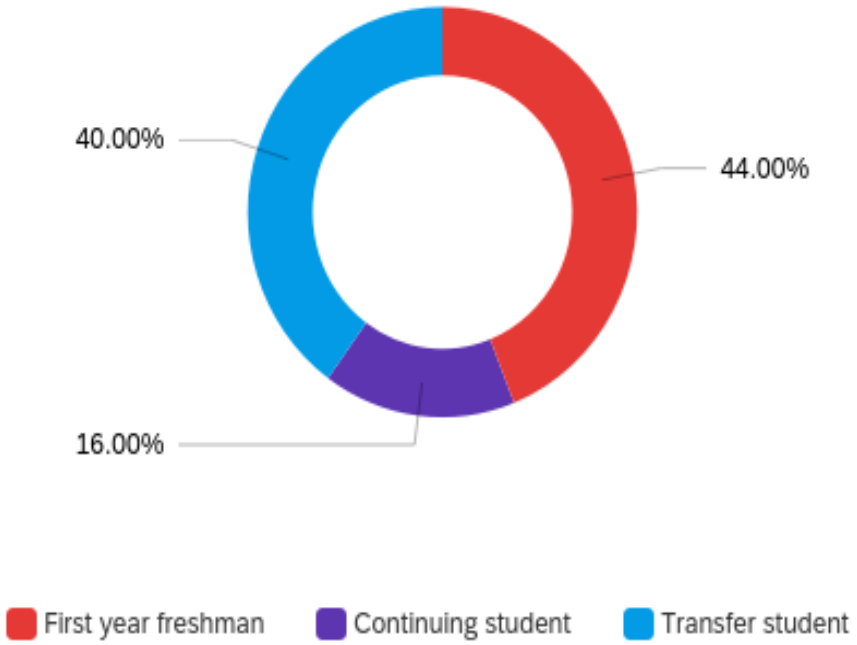

Figure 1. Classification of Students in Freshman Course

The next set of questions focused on student ability to submit assignments. Students were initially asked if the student had trouble keeping up with submitting assignments. The results are presented in Figure 2. About 60% of students disagreed/strongly disagreed with the statement which means that about 40% of may have experience some difficulty during the semester. When asked if the student submitted assignments on time (Figure 3), over 30% of students admitted to either not submitting or submitting late (not typically allowed by the instructor).

During the Fall 2019 semester, the department decided to include more hands-on experiences for students to encourage class participation. For example, one experiment tested the student comprehension of the relationship between mass, volume, and density. Students were given unknown samples and asked to determine the compound based on measurements of 4 pieces of the material. The experiments were moved online for 2020 with the in-person experiments returning in 2021. Figures 4-5 show student perception of the hands-on experiments. Over 90% of the students enjoyed using the measure tools with the same percentage believing that more hands-on experiments would be beneficial for the course.

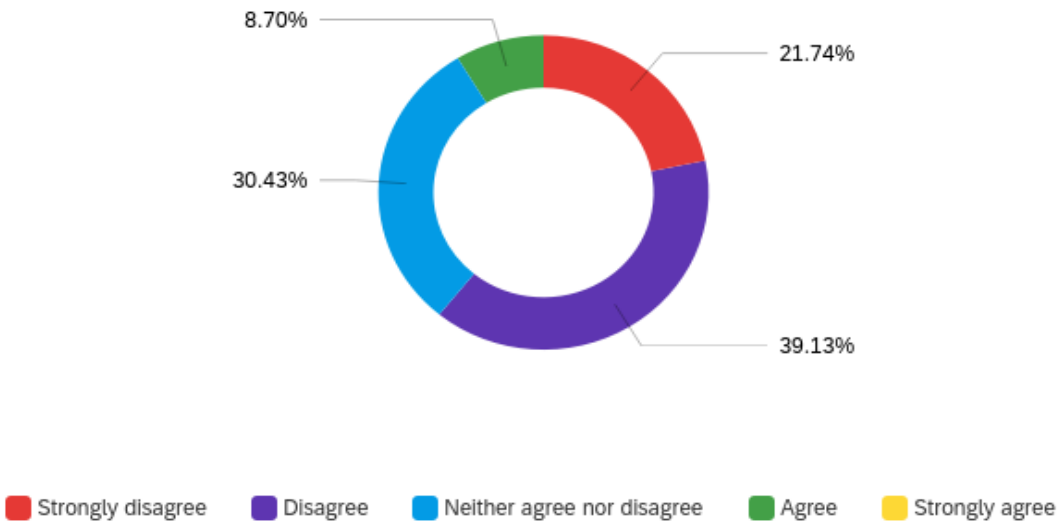

Figure 2. Student Response to “I had trouble keeping up with submitting my assignments”

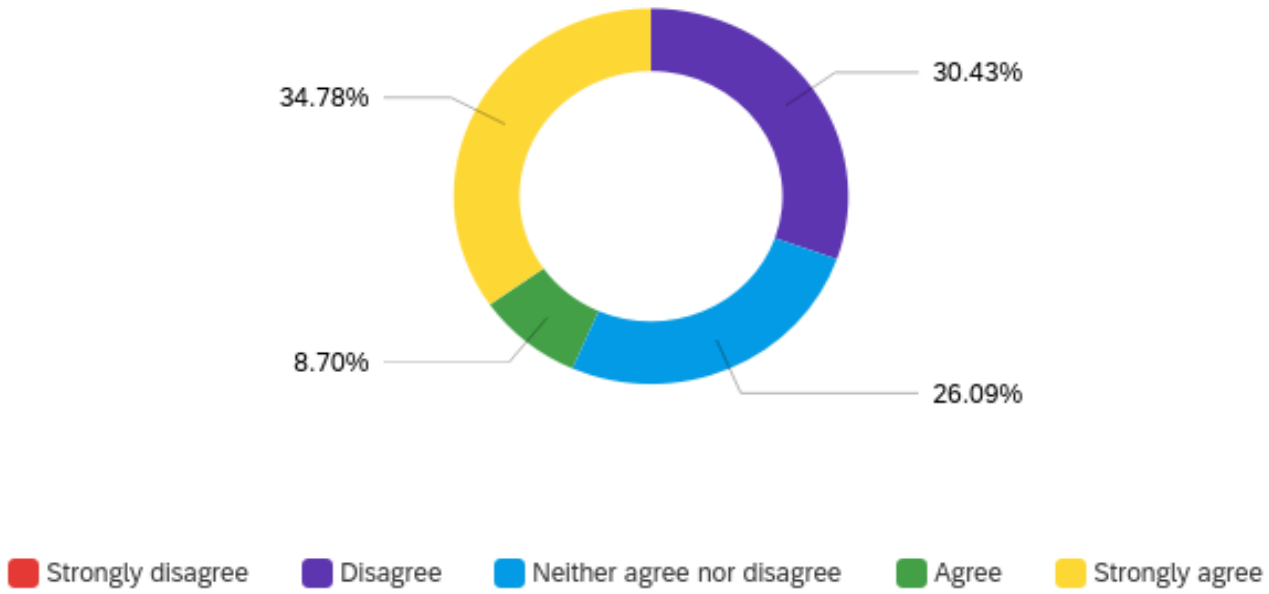

Figure 3. Student Response to "I submitted all of my assignments on-time"

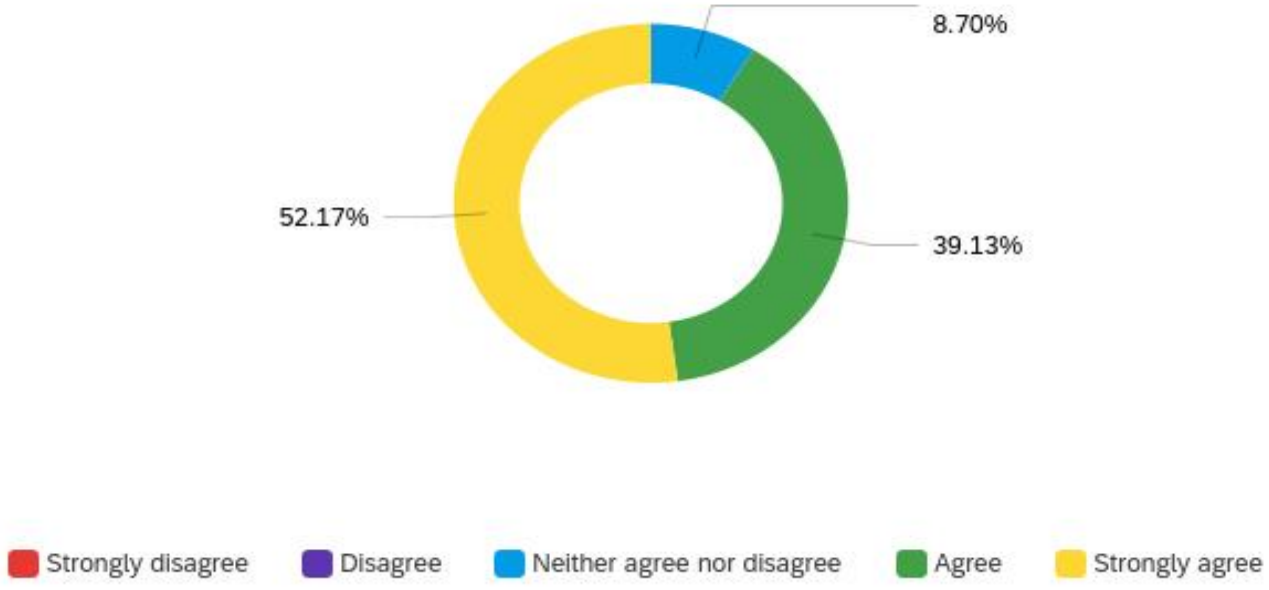

Figure 4. Student Response to "I enjoyed the hands-on experiments"

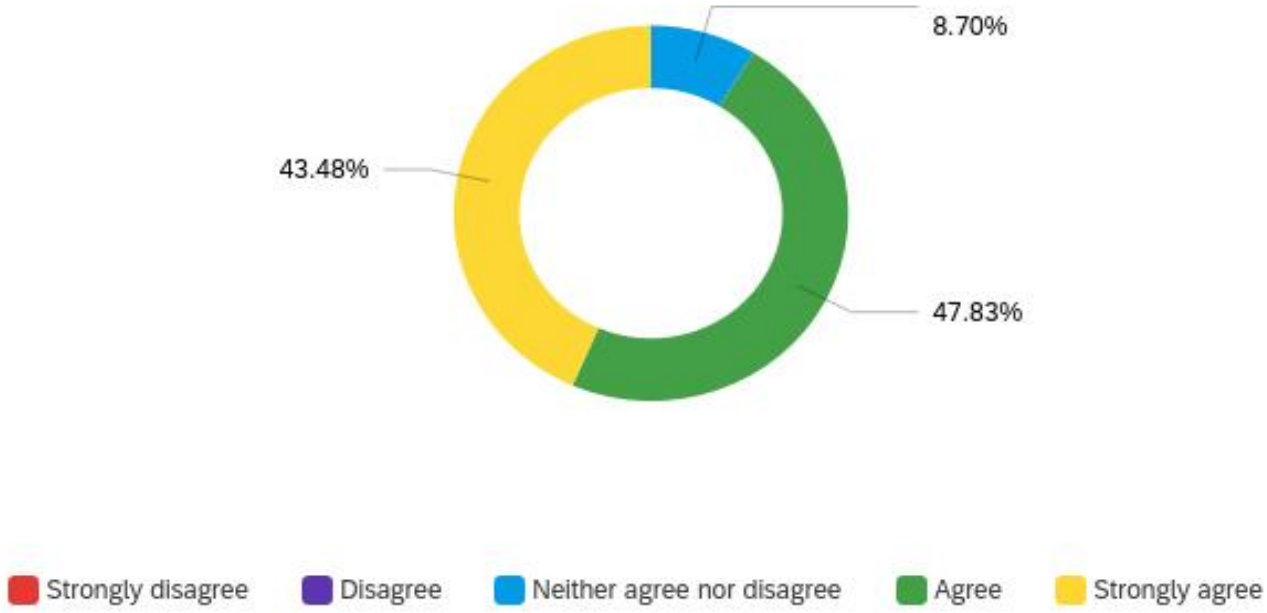

Figure 5. Student Response to "I believe the course should contain more hands-on experiments"

To determine parts of the course that were "liked" or "disliked" by the students, the students were given the ability to type individual responses. Word clouds, such as the ones presented in Figures 6 and 7, are a popular visualization technique of survey responses. According to the literature [5,6], a word cloud is a set of words in which the size of the font reflects the frequency of the appearance of a word in the response. A high frequency word will appear in a larger or bolder font than less frequent terms. In essence, the large font size represents the importance of the term. For this study, only the top 12 key words are shown in each cloud. Common words such as *the*, *our*, and *for* were removed from the word list.

Overall, students provided positive feedback about the course topics such as learning about careers in chemical engineering and different sources of energy. The students also reacted positively to the hands-on lab experiments as it *made class not boring*. Additional, but less significant, comments were made about the instructor and future careers. In contrast, the negative feedback was significantly focused on the length of the class, which is 3 hours on a single day. The students also felt that more time was needed to understand certain concepts before assignments were given (pace, assignments, work). One student commented that, at times, they felt *an information overload* during the semester which resulted in missing key concepts. The students mentioned that the once a week course maintained a fast pace of topics and did not provide opportunities to review concepts or information learned in previous weeks. In this area, the instructor must improve with highlighting the synergy of the topics. For example, the instructor can demonstrate how properly recording and reporting data during lab activities is related to certain chemical engineering careers or how misleading data (plagiarism) is related to ethical engineering.

As confirmed in the literature[7], motivation will factor into a student's level of course engagement. Sadikin et al.[8] report that a lack of motivation will eventually lead to dropouts of engineering students during the first year of study. Therefore, it is essential to provide engaging learning opportunities, such as simple laboratory experiments, to boost student motivation. Students are often engaged when given the opportunity to participate in hands-on or experiential learning activities. Kolb[9] reports that the personal and environmental experiences of experiential learning lead to an increase in knowledge about the topic. Others[10] have noted the impact of this form of learning in regards to passive, lecture style teaching. A study by Specht and Sanlin[11] discussed how experiential learning classrooms resulted in higher student retention of important course concepts than traditional classrooms. Another study by Cajiao and Burke[12] stated that the activities resulted in better communication between students, better communication between the student and the instructor, and an improvement in student self-efficacy in terms of class performance and skills.

Figure 6. Word Cloud for "What I like most about this course"

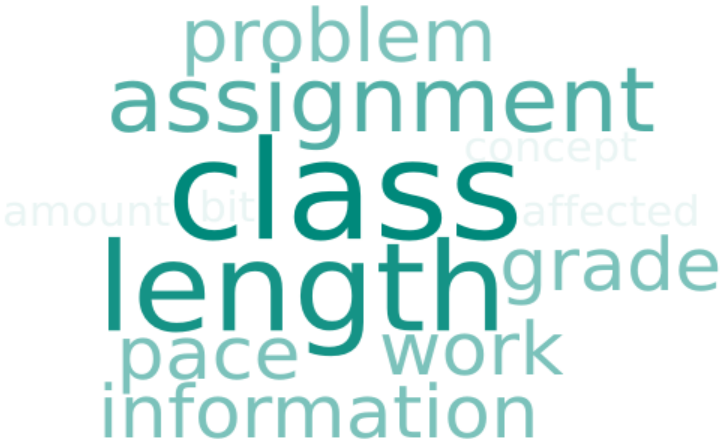

Figure 7. Word Cloud for "What I dislike most about the course"

Summary and Conclusions

The success of freshman students in the introductory year is a focal point of all institutions of higher education. A review of freshman success in the chemical engineering introductory class was directly related to the students not submitting assignments or leaving the university. The pandemic, as expected, had also an effect of student performance as well as student motivation. For Fall 2021, the feedback gathered from students revealed that the students felt overwhelmed with the return to face-to-face courses and workloads. The surplus of information and coursework proved to lower the engagement of students which was directly related to student motivation. Students heavily preferred and favored the two hands-on learning assignments. It is concluded that instructors should move forward with the reimagining of the chemical engineering introductory course by including more experiential learning opportunities that reinforce key learning concepts and moving away from the classic passive learning structure. In the future, the course instructors should seek more opportunities to engage with students in the introductory course. This action should lead to achieving DFW rates seen before Fall 2019.

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