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Applying Different Modalities to Redesign a First-Year Industrial Engineering Technology Course: Giving Students Flexibility.

Dr. Troy Tonner, Purdue University Fort Wayne

> Troy C. Tonner, PhD, Purdue University Fort Wayne

Dr. Rebecca R Essig, Purdue University Fort Wayne

> Rebecca Essig is an Associate Professor of First-Year Engineering and a First Year Engineering Program Coordinator at Purdue University Fort Wayne. She received her BS, MS, and PhD from the Purdue University Lyles School of Civil Engineering in 2010, 2013, and 2016

Michelle Rene Parker
Xiaokai Jia, Purdue University Fort Wayne

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Abstract

First-year engineering and technology students face various challenges during their transition to college. This study aimed to address these challenges through two course structure modifications in a first-year industrial engineering technology (IET) program at a metropolitan campus. The first modification was a "choose your modality" offering modal flexibility, and the second modification was developing an 8-week recovery option for students who struggled at the beginning of the semester. The grade distributions were analyzed, and a voluntary survey was given before final grades were posted to draw insights from both experiences. The survey results showed that students in year 1 of the study evaluated themselves significantly higher (p-value = 0.03, $\alpha = 0.05$) on their competency of the learning objectives compared to the students in year 2. However, neither cohort of students performed significantly better (p-value = 0.23, $\alpha = 0.05$) in the class compared to before modifications were implemented. No significant student performance difference was found between the two modalities indicating that both are equally effective course structures. However, the condensed 8-week course seemed to pose unique challenges for some students. The suggested course structures give students flexibility and the ability to remain on track with their academic program regardless of difficulties faced at the beginning of the semester.

Introduction

Student success during the transition to college is impacted by many factors, particularly for those working while attending or returning after a break from schooling. Due to their unique circumstances, these students may need more time and flexibility than traditional students. Traditional students are those considered to be 18-21 years old and have taken a linear path from high school to college [1] while nontraditional students have been classified as students that are 22+ years old [1], 24+ [2], or 25+ years old [3]. Typically, nontraditional students have more commitments, such as working part-time or full-time, being caregivers, or having more financial responsibilities. Another definition for nontraditional students includes adult learners, young mothers, low-income students, and working professionals [4]. These definitions leave out other groups, such as first-generation college students and traditional students working part-time to help with education costs. Each group has been found to have their own learning typologies [1] and inherent levels of motivation [5]. The diversity in the student populations requires a need for flexible teaching methods to help adjust to individual student needs [6].

Existing literature explores how different modalities (asynchronous, synchronous, face-to-face (F2F), and hybrid/blended) can be used to improve various measures of student success [1], [2], [3]. Additionally, different modifications applied to these modalities were studied [7] especially during and following the COVID-19 pandemic when technology accessibility was increased in classrooms, and more instructors incorporated different teaching styles and modalities [8]. Building from the existing research, two course structure modifications were developed and explored to give students more flexibility and address student retention concerns. The goal was to give students more options and a second chance to stay on track while not sacrificing course learning objectives (CLO). Two course structure ideas are presented to give students more flexibility and address student retention concerns. The goal was to give students more options and a second chance to stay on track while not sacrificing course learning objectives (CLO).

Background

This study was conducted in an engineering technology (ET) program at a metropolitan campus with a large representation of nontraditional students, commuters, and first-generation students. The university has seen an increase in traditional students in recent years, but over half of the students still fall within the non-traditional student classification. In addition to the majority being non-traditional students, most engineering technology students work at least part-time while going to school full-time, which significantly complicates their educational journey.

Over half of the ET majors at this university take an introductory industrial engineering technology course during their first year, which will be called IET 100 for the purposes of this paper. All ET programs are ABET accredited, and CLO are mapped to ABET student outcomes. The CLO were evaluated by self-reported student evaluations and through mapped graded assessments. During the study period, there were typically three to five IET 100 sections in the fall, two in the spring, and one in the summer each year. In the fall, most sections were F2F, with one asynchronous online section. In the spring, one section was F2F, and the other was online. This study focuses on the modifications of the spring sections since they were taught by the same

instructor both years. All data collected and presented was approved through the university's IRB exemption protocol.

Methods

In year 1 of the study, an online course section and F2F course section were cross-listed together. Students were given the option to attend the class asynchronously, synchronously, or F2F. At any point during the semester, they could switch their modality. For example, if they typically attended F2F but were sick one day, they could attend remotely or watch the lecture later.

In year 2, the course sections were taught separately. Students were allowed to take the 16-week F2F section or an 8-week asynchronous redesigned version of the course. The students technically could choose to complete the 16-week asynchronously as lectures were posted online after the lecture, but the option was not explicitly stated. The goal for this modification was to create a failsafe, or second-chance, course for students, so the 8-week course was placed in the second half of the semester. If students had a poor start or were behind in the 16-week course, they could start over in the 8-week section and stay on track in their academic careers.

The course was redesigned from year 1 to year 2. Both semesters, the students had access to an open-source textbook, recorded lectures, and recorded tutorials from book examples. The same homework questions were given from the book, and exams were written in the same structure as the homework. A semester-long report addressing social issues related to U.S. industry was given in place of a cumulative final both years.

In year 2, the tutorial recordings were improved, and prerecorded lectures were created using a professional recording booth. The CLO were updated, and the course was realigned. Because of the modifications to the CLO, only the CLO that were the same for both study years are presented. Additionally, during year 2 the semester-long report was broken into milestones to guide students more and give them more feedback throughout the project. The same assessments were used in both semesters. Rubrics were adjusted from year 1 to year 2 by changing the problem points from 20 points to 10 points each. Similar rubric criteria were used both years. Each problem was worth 3% of the final grade in year 1 and 2% of the final grade due to the increased problems, additional milestones, and increased focus on Microsoft Excel skills.

Student evaluations of CLO, final letter grades earned in the class, exam scores, and final project report grades were used to assess the impact of these modifications. Additionally, an end-of-semester survey was given to students during the last week of classes, and the questions are located in Table 1. The CLO have been shortened for presentation purposes. The surveys were conducted using Qualtrics, and all data analyses were done using Microsoft Excel. A two-sample t-test assuming unequal variances was performed to compare year 1 and year 2 as a whole, while ANOVA: Single Factor tests were used to test if the means were the same from year 1, year 2 16-week F2F, and year 2 8-week F2F. Graphs were created to visually present multiple datasets while the tests were performed on aggregated data. For example, every CLO response was combined into one dataset for year 1.

Table 1: End of the semester survey. Year one was only the CLO questions.

Survey Question	Question Type	Scale
What is your Major?	Multiple Choice	Various Majors Listed
How many semesters have you completed?	Multiple Choice	0,1,2,3,4,5,6,7,8+
Do you commute to campus?	Multiple Choice	No, <15 minutes,>15 minutes
Are you a first-generation college student?	Multiple Choice	Yes/No
How are you paying for college?	Select all	Various Options Listed
How many credits are you taking?	Multiple Choice	3-11, 12-18, 18+
On average, how many hours a week do you spend working at a job?	Multiple Choice	0,1-5,6-20,21-30,31-40,40+
What motivated you to choose the 16-week or the 8-week section?	Open Answer	N/A
CLO_1: Can demonstrate knowledge of concepts or perspectives within a given social issue.	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_2: Can identify the strengths and weaknesses of explanations on social issues.	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_3: Productivity calculations	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_4: Operations process chart	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_5: Number of machines calculations	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_6: Methods analysis (flow process chart)	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_7: Standard time calculation	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_8: From-to chart and activity relationship chart	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_9: Activity-based costing	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_10: Breakeven analysis	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_11: ABC technique	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_12: MRP	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_13: Master production schedule	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_14: Drawing of a network	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_15: Critical path method	Multiple Choice	0(F),1(D),2(C),3(B),4(A)
CLO_16: Pareto chart and cause-and-effect diagrams	Multiple Choice	0(F),1(D),2(C),3(B),4(A)

Students who never submitted work and never attended a class were omitted from the data collection. Students on track for a D or F at midterms were encouraged to enroll in the 8-week online course in year 2. Additionally, students who were performing poorly in other courses could have joined the 8-week online course in year 2 in order to still meet requirements for athletics or financial aid or avoid academic probation.

Results and Discussion

Demographics from Year 2

Approximately 50% of students completed the demographics survey that was distributed during the second year. 53% of the responses were from the online section, which had more students since it was not restricted by room size. 82% of the responses were full-time students, 12% of the students were completely personally financially responsible for college, 63% had some form of financial help, 18% had no financial responsibility, and 6% preferred not to answer. 39% were first-generation students, 6% did not know if they were or not. 70% were commuting to campus, and over half of those were commuting more than 15 minutes away. 41% were in their first year, and 8% had been in college for over four years. Only 24% of the respondents were not working, compared to 53% of the students who worked at least 21 hours per week. Major distribution is shown in Figure 1. IET 100 is a service course for the engineering technology department and a university general education course.
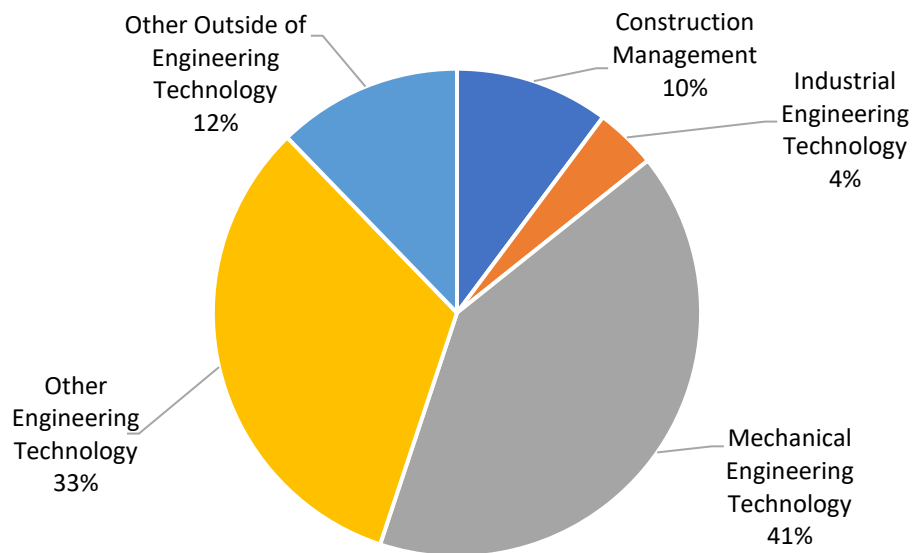

Figure 1: The majors of students taking the course are split by percentage. Total responses were 49.

Grade Distributions

Final grades, total exam scores, and final report grades were compared between year 1 and year 2 by using a t-test. Results are given in Table 2. Year and modality were compared using the ANOVA test. Results are given in Table 3-5.

Table 2: Comparison of grade distributions from year one to year two.

	N	Mean	Final Grade Standard Deviation	Final Grade P-Value	Total Exam Score Mean	Total Exam Score Standard Deviation	Total Exam Score P-Value	Final Report Mean	Final Report Standard Deviation	Final Report P-Value
Year 1	58	83%	12.20%	0.225	85	11.7%	0.002	78%	19.5%	0.496
Year 2	61	80%	18.30%		76	19.4%		78%	25.0%	

Table 3: ANOVA output of final grade distribution within each modality

Groups	Count	Sum	Average	Variance		
Year 1 F2F	27	2287	84.70	125.58		
Year 1 Online	31	2504	80.79	165.83		
Year 2 F2F	26	2160	83.09	366.40		
Year 2 Online	35	2748	78.50	312.95		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	671.781	3	223.927	0.918	0.434	2.683
Within Groups	28040.500	115	243.830			
Total	28712.281	118				

Table 4: ANOVA output of exam grade distributions within each modality

Groups	Count	Sum	Average	Variance		
Year 1 F2F	27	2381	88.20	65.07		
Year 1 Online	31	2520	81.29	182.57		
Year 2 F2F	26	2092	80.48	271.06		
Year 2 Online	35	2542	72.63	438.77		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3771.649	3	1257.216	5.009	0.003	2.683
Within Groups	28863.478	115	250.987			
Total	32635.127	118				

Table 5: ANOVA output of final report grade distribution within each modality

Groups	Count	Sum	Average	Variance		
Year 1 F2F	27	2058	76.22	533.10		
Year 1 Online	31	2452	79.10	258.89		
Year 2 F2F	26	2054	79.00	883.04		
Year 2 Online	35	2692	76.91	451.90		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	184.200	3	61.400	0.120	0.948	2.683
Within Groups	59068.119	115	513.636			
Total	59252.319	118				

Comparing the two years in Table 2, the final grade and final report were not significantly different. However, year 2 had lower test scores despite the new course materials. This suggests that year 2 did better on the homework, or the additional report milestones in year 2 inflated their

final grades, which offset their lower test scores. It is worth noting that the online section in year 2 had a student grader to help grade the homework, which could be another reason for the perceived increase in year 2 homework scores. Additionally, the grade distributions had larger deviations in year 2. This is possibly caused by the sections being taught as two separate courses.

Analyzing Tables 3-5, it is important to note that year 1 was cross-listed, and only 10-13 students (depending on the day) would attend F2F. The year 2 F2F data is more representative of a traditional F2F section as about 25 of the 30 attended in-class. The course F2F sections were maxed out at 30, but the data does not include students who never submitted work nor attended class. It is also important to remember that the online section in year 2 was designed to be a failsafe course in which seven students from the F2F were recommended to drop and start over in the 8-week section. Two students followed the recommendation, with one of them passing. Two of the remaining five stayed enrolled in the F2F section and passed. One other student joined from a different class (that they were not doing well in) and passed.

Further analyzing Tables 3-5, similar observations are made that the additional milestones on the report likely inflated grades or homework scores influenced by different graders offset the lower exam scores. The lower exam scores also could have been caused by the increased content, new rubrics, and a condensed course section. The effect of the improved course materials is unknown and was not enough to offset the increased perceived course difficulty, which is being represented by exam scores.

Student Perceptions

Students in year 2 were asked why they registered for their particular course section on the end of the semester survey. The responses for the 8-week online section ranged from preferring online, saving on the commute, work, schedule reasons, or it was shorter to not realizing they registered for an online 8-week course. Similarly, students in the 16-week F2F course chose it to have a set schedule, did not want to have a condensed 8-week course, and preferred to be F2F. The responses are not surprising but illustrate the diversity of student needs and preferences.

Students self-evaluated their mastery of each CLO on a scale from 0 (F) to 4 (A). Comparing from year to year with a t-test of all evaluated scores showed that students in year one significantly evaluated themselves higher (p-value = 0.026, $\alpha = 0.05$). The means were also significantly different (p-value = 3.29E-14, $\alpha = 0.05$) from the ANOVA test that compared year 1, year 2 F2F, and year 2 online. The average ratings of self-evaluations were 3.3 (year 1), 3.5 (year 2 F2F), and 3.0 (year 2 online), showing that the 8-week online students evaluated themselves the lowest, which is in agreement with the exam grade distributions. This is expected to be more related to the course being condensed than from being online. F2F vs. online cannot be done as the year one survey did not ask what section students were in, and the majority chose online. Comparing year 1 and year 2, the F2F difference could be caused by several factors beyond online vs. F2F, including the course redesign, which gave the course more structure, improved rubrics, and more explicit mapping of assessments to CLO.

Each averaged CLO self-assessment was analyzed and plotted in Figure 2 with one standard deviation error bars to compare how the three different modality options evaluated themselves.
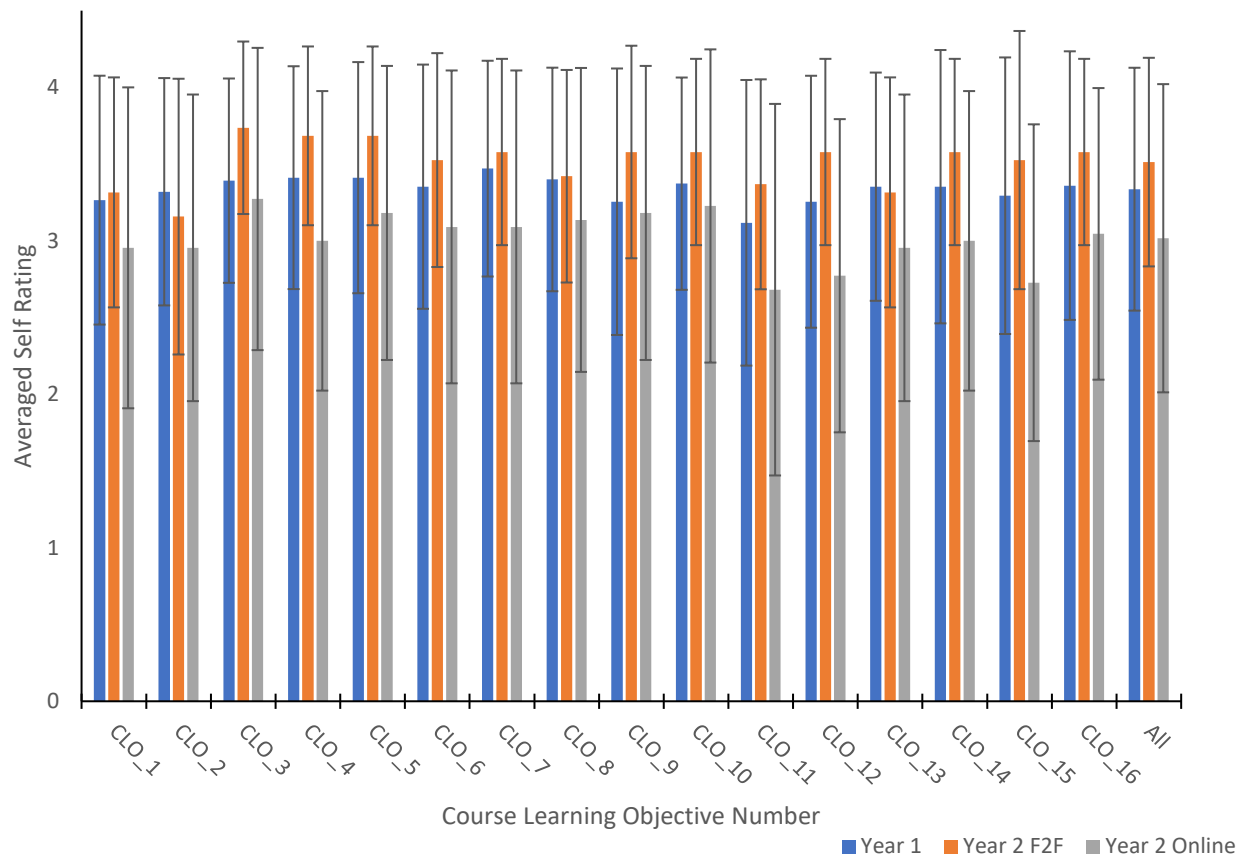
Figure 2: Each CLO averaged within each year and modality rated by students on a scale from 0 (F) to 4 (A). Overall average for all CLO is also plotted as "ALL".

The 8-week online section consistently evaluated themselves lower on CLO while year 2 F2F and year 1 were closer to each other, with year two F2F being evaluated the highest with the exception of CLO_2 and CLO_13. CLO_13 was a more complex concept in the course, but it is not surprising that CLO_1 and CLO_2, which map to the final report, were the most similar between each modality. This aligns with the final report grade distribution analysis. However, it was expected for the year 2 sections to outperform year 1 given the increased milestones with feedback before the final report. Year 1 did have more content related to social issues, while year 2 had a stronger focus on how to complete the assessment.

Conclusion and Limitations

Two course modification ideas for increasing retention and giving students flexibility were developed and explored: a 16-week "choose your modality" course and an 8-week online failsafe course. Students in each section could watch lectures and tutorials or follow the textbook. In the first year of design, students could pick which modality to learn from at any given time. In the second year, the course was restructured and redesigned. The redesign improved the course alignment of CLO and assessment. It is perceived that the improvements deflated the exam grades while the homework scores or additional milestones inflated the final grades, especially given a second person helped grade homework in year 2.

The study suggests that students feel they do better when given the flexibility to choose. However, this cannot be definitively proven as the study years also had differences in grading, and 8-week vs. 16-week, which likely played a larger role in the results. Students preferred to be asynchronous online. This was not

surprising given the large number of students that are commuting to campus and working 21+ hours per week.

The idea of an 8-week failsafe course should be explored more as it did help two students who possibly would have failed another course and would have had progress to graduation delayed as a result. However, the condensed course had lower evaluations and performances, likely due to the increased pace. Finding a way to restructure the failsafe course should be explored so more students have the option to choose their modality, as the 16-week F2F has limited enrollment due to classroom space availability.

The data is limited to suggestions and comparisons as the course had multiple changing parts from each year. Additionally, there was not a 16-week online only section to compare to in year 2. Finally, the year 2 demographic data was used to approximate the overall study demographics since demographic data was not collected in year 1. Age was not a demographic question asked, so analysis comparing traditional vs. nontraditional students related to returning adult learners cannot be done despite the university having a significant nontraditional student population.

The two presented ideas demonstrate ways to give students more flexibility and second chances when immaturity or, simply put, life happens. To maximize effectiveness and benefit to students, the failsafe course needs to be evaluated and structured more. Finally, a more rigorous study needs to be done with consistent course materials to draw conclusions on the effect of the different modalities for diverse student demographics.

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