WIP: Comparing Career Exploration to a Hands-on Experiential Learning Approach for a First-year Engineering Course

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Abstract

This Work in Progress looks at a redesign of the course, ENGINR 1000, Introduction to Engineering, a part of the First-Year Engineering Program (FYEP). In fall 2022, the University of Missouri adopted a two-semester sequence of courses including ENGINR 1000 and ENGINR 1050, Foundations of Engineering. Historically, the Introduction to Engineering course has taken on the appearance of a survey of engineering disciplines with awareness of Student Services resources.

As part of an effort to make the first semester experience a more hands-on approach to problem solving and introduction to the interdependent and collaborative nature of engineering disciplines, as well as decrease class size, a new syllabus has been created. We wanted to measure the effect on students' sense of belonging in our test group as one of the intents of a FYEP is to increase the student's feeling of belonging, not just within their own cohort of students, but also with faculty, the college, and the university. In previous work, we used a survey to understand the effects of a new first-semester of the FYEP on students' sense of belonging in a small pilot study that was conducted in fall of 2024. Students self-selected into a test section implementing the new syllabus (n = 19), while the remaining students (n = 594) completed the course under the original syllabus. All participants completed anonymous surveys at both the beginning and end of the semester. While many of the results indicate positive trends in both groups, the test section showed a generally higher rate of improvement. Some negative shifts were observed (feelings of alienation, or that courses in engineering were not of interest), and further investigation was warranted. The lack of a tested survey instrument and limited sample size of the initial test group is a noted limitation and may affect the generalizability of the findings.

In academic year 2025-2026, implementation was expanded to a larger cohort (181 students) to better assess its impact. In fall 2025, we used two new, validated surveys. These surveys allow us to look at self-determination within these students, specifically in the areas of autonomy, competence, and relatedness as well as the students' overall satisfaction with life at the university. Results show that the test group in the course with the new syllabus saw benefits compared to the control group as measured by the survey.

Keywords

First year engineering, hands on, problem solving, career exploration, faculty paper.

Introduction

First Year Engineering Programs (FYEPs) are common among engineering institutions. The goals for these programs are typically aimed at improving retention and success of students in engineering programs by improving sense of belonging, promoting career and major exploration, increasing awareness of resources, teaching foundational engineering and problem-solving skills, and building study skills.

The University of Missouri started a first-year engineering program in fall of 2022 and spring of 2023 that includes a two-course sequence with a peer mentoring program, lectures, and labs. The first (fall) course, ENGINR 1000 Introduction to Engineering is a one credit hour course with both a weekly lecture and lab. Both the lectures and labs focus on study skills, foundational engineering concepts, and engineering career exploration. The lectures are conducted in large groups with faculty leading a traditional presentation of material. The labs focus on hands on experiences in smaller groups organized by graduate teaching assistants (GTAs) and upper-level undergraduate students who serve as peer learning assistants (PLAs). ENGINR 1000 is required for most students in multiple engineering programs and has taken on the appearance of a survey of engineering disciplines with awareness of student resources. This arrangement is similar to courses at other universities [1].

While many other college and university-wide interventions and program innovations were made, enrollment and retention of first-year students increased after implementation of the first-year courses. Nationally, bachelor's in engineering first year retention for 2021, 2022 and 2023 cohorts were 85.4, 86.7 and 86.8% respectively [2] while retention for our engineering programs was higher and showing greater increases at 88.2, 92.8, and 93.8% (See trends in Fig. 1). However, a significant number of students commented that the career exploration part of the course was not of interest and that they were satisfied with their choice of major before taking the course. Data shows that few students changed majors because of the course. Of the 529 students that completed the 2024 survey, 151 indicated that they had or would be changing their majors. Of those, 44 were students who had changed from Undecided to a declared major (one half of our initial undecided group). The retention rate for engineering programs at the University is still good, but down to 90.4% for the fall, 2024 cohort.

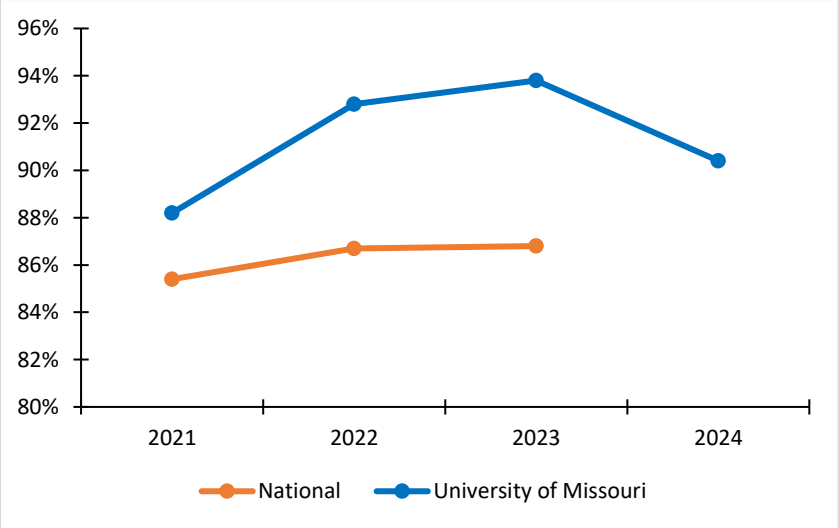

Figure 1. Retention for 4-year engineering programs at our program and nationally[2]

In fall of 2024, a small section of ENGINR 1000 was created to study the feasibility of redesigning the course with greater hands-on content and less career and major exploration. The redesigned syllabus included a team project-based interdisciplinary introduction to engineering degree programs as well as collaborative interdisciplinary work that included an introduction to

programming using Matlab® (Mathworks, Natick, MA USA) and a team project that involved mobile robots (using hardware similar to courses at other universities[3]) with programing and problem-solving skills. The students were given an open-ended prompt for their final project, "Consider the disciplines on your team, and program your robot to tackle a problem that your combined disciplines may encounter." A small test section (19 students) was compared to the larger section (594 students) using a survey. Similar to a University of Hartford study on sense of belonging [4], 22 questions were asked at the beginning of the semester and 23 questions at the end of the first semester. Results indicate positive trends in both groups, with the test section showing a generally higher rate of positive improvement. However, some negative shifts were observed (feelings of alienation, or that courses in engineering were not of interest), and further investigation was warranted. The lack of a tested survey instrument and limited sample size of the initial test group was a noted limitation and may affect the generalizability of the findings. [5].

In the test section class time and lab were combined into one longer session compared to the control where the lecture was separate from lab sections (see Table 1). In the control section, labs were focused on discipline specific content including simulations where each week was stand alone in that there was no relation between labs. The test section included lab time where students worked collaboratively on a project that spanned much of the semester. There were some common labs including ethics. There were also some common lecture material including student resources and student success.

Table 1. Comparison between the control and test sections of ENGINR 1000

Week	Control	Test
1	Introduction to Class and Peer Mentoring	Introduction to Class and Peer Mentoring
2	COE Student Orgs	MU Engineering & Academic Success
3	MU Engineering and Academic Success	Engineering Career Services & Student Orgs
4	Chemical Engineering (ChE) & Electrical Engineering	Interdisciplinary Company Visit 1/Intro to Matlab
5	Computer Science (CS) & Data Science & Information Technology	Plotting & Data Import
6	AI	Debugging and Writing Functions
7	Industrial & Systems Engineering (ISE)	Interdisciplinary Company Visit 2/ Flow Control Matlab
8	Advising & Study Abroad & Counseling Services	Logicals, Structures, Pseudocode (GRADS)
9	Civil and Environmental Engineering (CEE)	Interdisciplinary Company Visit 3/ Intro To Robots
10	Mechanical & Aerospace Engineering (MAE) & Biomedical & Biological (BBE)	Study Abroad & Counseling Services, Image Processing
11	AI Prompting and Effective Use	Class time to work on robotics project
12	Financial Literacy	Class time to work on robotics project
13	Ethics for Engineers FE Exam	Team Presentations!
14	Career Services	Ethics for Engineers FE Exam

In fall of 2025, a larger test section using the new syllabus was formed that was comparable in size (number of enrolled students) to the section using the original syllabus. A new set of survey questions was adopted to analyze autonomy, competence, relatedness, and overall satisfaction of first year students and the differences in the students in the two sections of ENGINR 1000.

We next present the methods used to form the course sections (test and control groups) as well as survey students and analyze data. Then, survey results are presented, followed by a discussion and conclusion.

Methods

Two sections of ENGINR 1000 were formed in fall of 2025, one with the original syllabus focusing on career exploration and the other with new syllabus focusing on experiential learning. Due to the nature of this study being "Quality Improvement" IRB provided documentation indicating "No Approval Necessary".

Student Population

Students had a choice of which section of ENGINR1000 to enroll; they were told that the newer test section was a more technical section but met for a "merged" time slot with lecture/lab components held back-to-back. Of the 181 students enrolled, 119 completed the end of semester survey. The remaining 422 students enrolled in the original version of the course, of which 227 completed the survey. The original version of the course will be described as the control group while the new version of the course will be described as the test group. The students in the ENGINR 1000 course are predominantly first-time college students with some transfer students and some students who are taking the course late or retaking.

Survey

Two sets of questions were used in the surveys: Basic Needs Satisfaction at College Scale (BNSC-Sl) [6] and an adapted version of the Satisfaction with Life Survey (SWLS) [7]. The details of these questions can be seen in the references and the appendix. Compared to our previous work, these surveys will better allow us to look at self-determination within the first-year engineering students, specifically in the areas of autonomy, competence, and relatedness, as well as overall satisfaction. The online surveys implemented anonymously using Qualtrics (Qualtrics, LLC Seattle, WA USA) were distributed to the students for one week with closing dates prior to the end of week two in August and before the beginning of finals week in December.

Analysis

In our analysis of all data (Basic Needs and Satisfaction with Life described below), the null hypothesis is that the mean score in the test group is less than or equal to the mean score in the control group.

Basic Needs Satisfaction at College Scale: Prior to analysis, we reverse-coded negatively worded questions and then checked for internal consistency (Cronbach's alpha) for each of the three main topic areas of the BNSC-Sl survey. We did find that our autonomy scores fell outside of the usability for internal accuracy. We then looked at the mean score for autonomy, relatedness, and competency as well as standard deviation, and skew. A two-sample t-test assuming unequal variances (Welch's t-test) was completed as well as calculation of Cohen's d.

Adapted Satisfaction with Life Survey: Survey questions were answered with values ranging 1-7. Individual student survey values were summed and allowed each response to be placed into

categories ranging from extremely dissatisfied (5-9) to extremely satisfied (31-35). The percentage of students falling into each of the categories was calculated. Like the previous survey, internal consistency was verified and then mean, standard deviation and skew values were identified to verify the validity of two-sample t-test assuming unequal variances (Welch's t-test).

Results

Three surveys were conducted with the number of respondents given in Fig. 2 varying slightly in the analysis depending on which set of questions because one survey response was not complete in some cases. The August survey, given at the beginning of the semester, included all students as one group, combining both the test and control groups with a total of 467 responses. Surveys at the end of the semester were analyzed according to their section (test section with 119 responses and control section with 227 responses).

When comparing the two groups at the end of the semester, the test group showed significantly higher values for both competence and relatedness ($t(245) = 1.974$, $p = 0.049$ and $t(283) = 2.82$, $p = 0.0051$) (See Table 2). The Cohen's d indicates that the effect size is small for competence (0.22) and more moderate for relatedness (0.30). Table 3 shows the combined data for beginning and end of the semester.

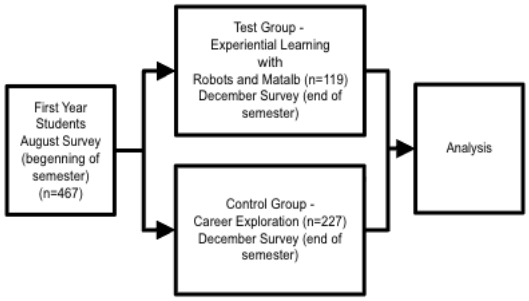

Figure 2. Flow of survey responses for all students (test and control groups)

Table 2. Comparison of the test to control group at end of the semester showing differences in mean values and analysis for each category (autonomy, relatedness, competency).

	Autonomy		Competence*		Relatedness*	
	Test	*Control*	*Test*	*Control*	*Test*	*Control*
Mean	3.908	3.821	3.618	3.482	3.846	3.637
Variance	0.402	0.449	0.367	0.386	0.367	0.539
n	119	226	119	226	119	226
df	252		245		283	
t	1.195		1.974		2.824	
p	0.233		0.049		0.005	

* Indicates categories with a significant difference between the two group ($p<0.05$)

Table 3. Comparison of beginning of the semester to end of the semester showing the mean values and differences for each category of questions (autonomy, relatedness, competency).

	Autonomy*		Competence*		Relatedness	
	August	*December*	*August*	*December*	*August*	*December*
Mean	4.033	3.851	3.637	3.526	3.703	3.705
Variance	0.279	0.433	0.272	0.380	0.351	0.485
n	463	345	462	344	461	344
df	643		665		668	
t	4.21		2.693		0.0482	
p	2.87×10^{-5}		0.007		0.962	

* Indicates categories with a significant difference between the August and December surveys ($p<0.05$)

When comparing the Satisfaction with Life Survey results, we saw distinct differences between the two groups. Table 4 shows the percentage of students in each category. Nearly 78% of respondents in the test group fell into categories of satisfaction while 61.7% of respondents in the control group did. Unsurprisingly, the Welch's t-test showed statistically significant differences between the two groups with $t(277) = 2.71$, $p = 0.007$. The Cohen's d indicates a small to moderate effect size (0.29). Statistics are also shown in Table 4. Combined beginning and end of semester data is given in Table 5.

Table 4. Comparison of the test to control group at the end of the semester showing the percentage of students in each category of satisfaction with life including the differences in mean values and analysis of mean scores.

	Test	Control
extremely dissatisfied	0.92%	4.08%
dissatisfied	2.75%	10.20%
slightly dissatisfied	14.68%	13.27%
neutral	3.67%	10.71%
slightly satisfied	28.44%	24.49%
satisfied	33.94%	23.98%
extremely satisfied	15.60%	13.27%

	Difference between mean values	
	Test	*Control*
Mean	25.241	23.317
Variance	32.689	*48.429*
n	116	218
df	277	
t	2.711	
p	0.007	

Table 5. Comparison of beginning and the end of the semester showing the percentage of students in each category of satisfaction with life including the differences in the mean values and analysis of mean scores.

	August	December
extremely dissatisfied	1.09%	2.95%
dissatisfied	1.74%	7.54%
slightly dissatisfied	8.71%	13.77%
neutral	3.27%	8.20%
slightly satisfied	27.67%	25.90%
satisfied	43.57%	27.54%
extremely satisfied	13.94%	14.10%

	Difference between mean values	
	August	*December*
Mean	25.826	24.012
Variance	29.207	43.802
n	459	305
df	629	
t	4.116	
p	4.37×10^{-5}	

Discussion

Competence and relatedness were both higher in the test group in the December survey data. We believe that group work and learning skills with Matlab and robotics as well as creating a solution/project result contributed to the feelings of competence and relatedness. The clearest improvement is in relatedness for the students in the test group who report feeling more connected (peers/instructors/community). That aligns with the high engagement nature of the experiential group work that likely motivated a strong sense of belonging.

In the December survey, we found that the test group had a significantly higher satisfaction score compared to the control group. The nature of the final project in the test section likely gave a sense of accomplishment, contributing to the satisfaction level. August survey data showed a very high level of satisfaction and autonomy and competence compared to December data in the combined group of students. This is likely due to lack of college experience (i.e. midterm exams, etc.) for entering students. The data indicate that feelings of autonomy and competence are higher at the beginning of the semester compared to the end.

Conclusions

The introduction of the ENGINR 1000 course section with the new syllabus emphasizing experiential learning and hands on teamwork did not cause any adverse difference in responses to the survey questions when comparing the test group to the control group. Higher survey scores were seen in students' feeling of accomplishment and relatedness for the test group compared to the control group suggesting that the new section had some benefit to students due to the experiential learning aspects of the course. The downward trend in autonomy, competence, and satisfaction with life from start to end of semester appears to be a natural response as initial optimism gives way to the realities of the course and a full course schedule that includes calculus, English, and chemistry for many students. The positive effects of the course redesign have an important impact due to the large numbers of students involved and because the gains may be concentrated in retention-relevant constructs like relatedness and belonging. Based on this data, we will continue to implement group projects across FYEP, including in ENGINR 1050. We will also further study the downward trend in some survey results at the end of the semester.

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Appendix – Survey Questions

Autonomy		
	5	I am free to express my ideas and opinions at school
	11	I feel like I can pretty much be myself at school.
	12	I understand the purpose of my classroom requirements.
	13	I am encouraged by my professors at the University of Missouri to participate in my classes.
Competence		
	2	I do not feel very competent with schoolwork
	3	People at the University of Missouri tell me I am good at what I do in school
	7	I have been able to learn interesting new skill in college.
	8	Most days I feel a sense of accomplishment from attending class and studying
	9	At school, I do not get much of a chance to show how capable I am.
Relatedness		
	1	I really like the people I got to school with
	4	I get along with people at the University of Missouri
	6	I consider the people I attend the University of Missouri with to be my friends.
	10	There are not many people at the University of Missouri that I am close to

Figure 3. Basic Needs Satisfaction at College Scale survey questions. [6]

Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding.

- 7 - Strongly agree
- 6 - Agree
- 5 - Slightly agree
- 4 - Neither agree nor disagree
- 3 - Slightly disagree
- 2 - Disagree
- 1 - Strongly disagree

____ In most ways my life at the University of Missouri is close to my ideal.
____ The conditions of my life at the University of Missouri are excellent.
____ I am satisfied with my life at the University of Missouri.
____ So far I have gotten the important things I want in life at the University of Missouri.
____ If I could live my life at the University of Missouri over, I would change almost nothing.

- 31 - 35 Extremely satisfied
- 26 - 30 Satisfied
- 21 - 25 Slightly satisfied
- 20 Neutral
- 15 - 19 Slightly dissatisfied
- 10 - 14 Dissatisfied
- 5 - 9 Extremely dissatisfied

Figure 4. Satisfaction with Life survey [7]