

Work in Progress: Definitions of Success and Sense of Preparedness among Engineering and Mathematical Sciences Students in a College-wide First-Year Seminar Course

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Introduction

First year experience courses for undergraduate students have long been associated with improved retention and graduation rates in STEM fields ^{[1],[2],[3]}. Although examples of FYS exist in specific engineering disciplines and combinations of engineering disciplines ^{[4],[5],[6]}, there are relatively few examples of first year, project-based courses that integrate engineering, mathematics, statistics, computer science, and physics majors ^[7]. The one-credit FYS described in this study was developed in Fall 2020 as a required, common learning experience for first-time-first year (FTFY) students majoring in engineering (Civil, Environmental, Biomedical, Electrical, Mechanical, Engineering, and Engineering Management), Computer Science, Data Science, Statistics, Mathematics, and Physics. This FYS utilizes several strategies known to promote retention in the first year of college:

- Providing students information on various community and extracurricular opportunities;
- Pairing students with an undergraduate peer mentor;
- Students practice key skills common across STEM disciplines and engage in common learning outcomes
- A major campus-based project provides a central focus for students to engage with the course learning outcomes and work directly with community partners on a meaningful real-world problem
- Opportunity for students to work in interdisciplinary teams of peers and engage in other community-building activities

This work-in-progress paper describes the design of a first-year seminar (FYS) course and its impacts on student self-assessments and measures of retention among first year undergraduate students in engineering and mathematical sciences programs. Student self-reflections and self-assessment of learning were used to gain insight to students' personal definitions of success, sense of preparedness, and sense of belonging, as well as the influence of the course activities on key learning outcomes and student decision making after the first semester of college. The goal of this work is to evaluate the impact of a college-wide FYS course on student self-assessment, student flow, and one-year retention rates for the first three years that the course has been offered (Fall 2020, Fall 2021, Fall 2022). One-year retention rates are not yet available for the most current term in the study (Fall 2022). Additionally, analysis of student qualitative survey data is in progress and therefore not included in this report.

Project Approach

Course Design

The FYS was developed following the Backward Design Model of Wiggins and McTighe ^[8]. The learning goals and assessments identified for the course were selected based on their shared relevance to the student majors represented in the course (engineering, mathematics, statistics, data science, computer science, physics; Table 1). The (1) Design Thinking, (2) Teamwork, (3) Communication, (4) Ethics in the Field, (5) Research Skills, and (6) Student Success goals were assessed through a series of assignments developed to scaffold student teams as they worked toward completion of a final campus-based project.

The campus projects are based on current problems facing the campus community and associated with specific departments or organizations on campus, introduced to students as ‘Project Partners’ (e.g., Custodial Services, Transportation and Parking Services). Students are introduced to the Project Partners and project challenges in the second week of classes and provided a one-page description of each challenge on which to base their decision. Students choose one of 3-5 project options and are placed into teams of three to four students based shared project interests, major, and desired project role (Team Coordinator, Communication Lead, Document Controller, Technical Lead). This enables students to exercise choice of project and requires them to go out into the campus community and interact with people and programs that they might not otherwise gain exposure to in the first year.

Project challenges are categorized by theme: Resources, Sustainability, Energy, Health, as inspired by the National Academies of Engineering Grand Challenges themes ^[9]. Examples of past challenges include the “Student Center Water Efficiency Challenge”, in which students were asked to design a greywater collection system for the student center roof to replace potable water in toilets, and “Staying Connected and Active During a Pandemic”, in which students were asked to design new features for a campus wellness app that encourages healthy habits and connection for students during the COVID-19 pandemic. Supporting information such as relevant data from Project Partners and related studies or examples are also provided for each project as a starting point for student research.

Table 1. First Year Seminar learning goals and assessment methods.

#	Learning Goals	Assessment Method
1	(Design Thinking) Apply the core elements of the design thinking process and propose a solution to a campus-based problem	Design Thinking Assignment MicroDesign Project Campus-Based Project Assignments Final Poster Presentation
2	(Teamwork) Practice the key components of effective and inclusive team work including self-awareness, reflection, communication, and goal setting	Teamwork Activity MicroDesign Project Team Contract Assignment Project Planning Assignment Peer-Team Evaluation Assignment Final Poster Presentation
3	(Communication) Effectively communicate the technical	Project Research & Bibliography Assignment Project Problem Statement Assignment

	aspects of your project to an audience of instructors, mentors, peers, and project partners	Project Planning Assignment Poster Presentation File Poster Presentation Practice Final Poster Presentation
4	(Ethics) Reflect on ethical and/ or societal issues as related to your semester project or field of study	Poster Presentation File (Potential Impacts Sect.) Inclusion and Bias in STEM reflection activity
5	(Research) Gather and evaluate relevant and reliable information and data from a variety of sources	Project Research & Bibliography Assignment Project Problem Statement Assignment Final Poster Presentation
6	(Student Success) Demonstrate key skills necessary for success in college and beyond	Academic Planner Assignment Student Self-Reflection Activity* Study Habits: Metacognition Assignment Library Resources and Tutorial Assignment Draft Schedule for Spring Registration End-of-Semester Critical Reflection*

*Student responses to self-reflection assignments used to evaluate familiarity with key skills, sense of success, belonging, and preparedness at the end of the first semester.

Student Outcomes

The influence of the FYS on student outcomes was evaluated through a series of student self-reflection activities, self-assessment of learning, and analysis of institutional student flow and retention data for cohorts in three consecutive years of study (fall 20-22; totaling 292-358 students). Student Success assessments (Table 1, Goal #6) including the ‘Student Self-Reflection Activity’ and the ‘End-of-Semester Critical Reflection’ provide information on personal definitions of success, personal goals, sense of preparedness, identification of personal assets and limitations, and the influence of the course on academic decision-making (Table 2). In the inaugural year of the course (Fall 2020), only the end-of-semester reflection was deployed, in contrast to Fall 2021 and 2022 in which a beginning-of-semester reflection was added to identify changes in attitudes over the first semester of college. Therefore, comparative analyses of student self-reflection in the first semester of college is limited to Fall 2021 and Fall 2022 cohorts.

Table 2. First Year Student Self-Reflection questions deployed at beginning of the semester

Question Topic	Quantitative Questions (Likert 1-5)
	<i>How prepared¹ do you feel to...</i>
Sense of Preparedness	begin your journey at the university?
	<i>How familiar² are you with...</i>
Academic	the different academic programs in the college?
Extracurricular	the extracurricular opportunities at the university and college?

Prof. Development	the professional development opportunities at the university and college?
Academic Integrity	the academic integrity policies at the university?
Design Thinking	the Design Thinking process?
Teamwork	best practices for effective teamwork?
Communication	technical communication in your field of study?
Ethics	ethical issues in your field of study?

Question topic	Qualitative Questions
Success	What does a successful first semester of college look like to you?
Personal goals	Share one to two goals that you would like to accomplish this semester
Assets	What personal strengths or assets do you think will help you to accomplish these goals?
Limitations	Can you think of anything that would limit your chances of accomplishing these goals?
Support needs	What would help to improve your chances of success this semester?

¹ Likert Preparedness: 1 – Very unprepared, 2 – Somewhat unprepared, 3 – neither unprepared nor prepared, 4 – Somewhat prepared, 5 – Very prepared. ² Likert Familiarity: 1 – Very unfamiliar, 2 – Somewhat unfamiliar, 3 – neither unfamiliar nor familiar, 4 – Somewhat familiar, 5 – Very familiar.

Additionally, the End-of-Semester reflection asks students to comment on whether it was a successful first semester, whether they feel prepared to continue their journey in the college, and whether they feel included and welcomed (Table 3). Questions on familiarity with university support and policies, and with course goals repeat questions from the week 1 survey (Table 2). Comparisons of familiarity questions across surveys provides an indication of relative gains in understanding of these areas and comprises the *Student Self-Assessment of Learning* in this study. Additionally, qualitative questions in the end-of-semester reflection ask students to provide further detail on what contributed to or detracted from their success, what they learned, and how the course influenced their academic decision-making.

Table 3. First Year Student Self-Reflection questions deployed at the end of the semester.

Question Topic	Quantitative Questions (Likert 1-5)
<i>Please indicate how much you agree¹ with the following statement:</i>	
Sense of Success	“I feel like this was a successful semester and I accomplished my goals”
Sense of Preparedness	“I feel prepared to continue my journey at the university after completing this course”
Sense of Belonging	“I feel included and welcomed in the college this semester”
<i>After completing this course, how familiar² are you with...</i>	
Academic	the different academic programs in the college?
Extracurricular	the extracurricular opportunities at the university and college?
Prof. Development	the professional development opportunities at the university and college?
Academic Integrity	the academic integrity policies at the university?
Design Thinking	the Design Thinking process?
Teamwork	best practices for effective teamwork?
Communication	technical communication in your field of study?

Ethics ethical issues in your field of study?

Question Topic	Qualitative Questions
Success	What contributed to your success or could have helped you to be more successful this semester?
Learning	What do you think is the most important thing you learned in this course?
Decision making	How did this course influence your plans for college?

¹ Likert Agreement: 1 – Strongly disagree, 2 – Disagree, 3 – neither disagree nor agree, 4 – Agree, 5 – Strongly agree. ² Likert Familiarity: 1 – Very unfamiliar, 2 – Somewhat unfamiliar, 3 – neither unfamiliar nor familiar, 4 – Somewhat familiar, 5 – Very familiar.

Student Self-Reflection Surveys

Student self-reflection surveys were built in MS Forms (Microsoft Office 365, 2020) and deployed on the following dates: Beginning-of-Semester: September 6, 2021, September 5, 2022; End-of-Semester: December 13, 2021, December 12, 2022. Surveys were fully anonymous with no personally identifying data recorded. Paired-samples t-tests were used to compare means between Likert responses to familiarity-type questions in the beginning and end-of-semester question sets *within a given year*. Percentage change in Likert scores was calculated for questions with significantly different means ($p < 0.05$). Means of all other Likert questions (Sense of Preparedness, Sense of Belonging, Sense of Success) were compared *across years* by paired-samples t-tests ($p < 0.05$)^[10]. Common themes identified in the qualitative responses were summarized and quantified where possible by ranking the most common responses and calculating percent abundance.

Student Flow and Retention Data

Student flow was evaluated for first year student cohorts during the study period (AY20-21, AY21-22, AY22-23) as well as the year preceding implementation of the course (AY19-20) for comparison to pre-study outcomes. Count and percentage of students in original program after one year, in original college after one year, in different college after one year, and leaving institution after one year are considered. One-year retention data is evaluated for Fall 2020 and Fall 2021 cohorts but not the Fall 2022 cohort as it is not yet available. Data was sourced through the university's quasi-public repository as managed by the university's Office of Institutional Research and Assessment^[11].

Results and Discussion

Quantitative Survey Results

Overall, Likert type responses indicate a positive effect of the course on students' familiarity with key skills and resources deemed necessary for success during the course design. Survey response rates ranged from 59% to 88% in Fall 2021 and from 69% to 78% in Fall 2022 (Table 4). Average Likert responses in pre- and post-semester self-reflection surveys for Fall 2021 and 2022 indicate a significant ($p < 0.05$), positive impact of the course on student sense of preparedness (+10-15%) and familiarity with academic programs (+32-40%), extracurricular

opportunities (+32-57%), and career readiness strategies (+62%) at the end of the first semester. Student familiarity increased over the course of the FYS semester with respect to an understanding of the design thinking process (+69%), effective teamwork strategies (+18-23%), technical communication in the discipline (+27-36%), and academic integrity policies (+5-6%). Students' overall sense of success averaged 3.9 out of 5 in both Fall 2021 and Fall 2022. Overall sense of belonging ranged from 2.93 to 3.53 out of 5, and overall mentorship experience from 3.89 to 4.02 out of 5 (Table 4).

Table 4. Average Likert Scores from student self-reflection surveys administered at the beginning and end of the First Year Seminar course and %Change in scores over fall 2021 and 2022 semesters.

Question Topic	Fall 2021			Fall 2022		
	Beginning	End	% Change*	Beginning	End	%Change*
Familiarity with Academic Programs	2.80 ± 0.84	3.70 ± 0.95	32%	2.80 ± 0.79	3.93 ± 0.87	40%
Familiarity with Extracurricular Opps	2.29 ± 0.86	3.60 ± 1.04	57%	2.93 ± 1.02	3.86 ± 0.94	32%
Familiarity with Career Readiness Strategies	2.08 ± 0.88	3.37 ± 1.09	62%	2.17 ± 0.90	3.52 ± 1.01	62%
Familiarity with Design Thinking	2.54 ± 1.19	4.29 ± 0.92	69%	2.57 ± 1.19	4.33 ± 0.88	69%
Familiarity with Teamwork Practices	3.49 ± 0.93	4.14 ± 0.99	18%	3.51 ± 0.95	4.30 ± 0.79	23%
Familiarity with Communication in the Discipline	2.85 ± 1.02	3.62 ± 1.08	27%	2.81 ± 1.03	3.82 ± 1.01	36%
Familiarity with Ethics in the Discipline	3.04 ± 1.07	3.28 ± 1.22	8%	2.96 ± 1.08	3.43 ± 1.24	16%
Familiarity with Academic Integrity Policies	4.29 ± 0.85	4.56 ± 0.68	6%	4.11 ± 0.90	4.33 ± 0.83	5%
Sense of Preparedness	3.69 ± 0.72	4.23 ± 0.91	15%	3.57 ± 0.75	3.93 ± 0.94	10%
Overall sense of success, first semester		3.90 ± 0.85			3.90 ± 0.85	
Overall sense of belonging, first semester		2.93 ± 1.49			3.53 ± 1.07	
Overall mentorship experience, first semester		4.02 ± 1.05			3.89 ± 1.20	
Response Count	307	205		270	238	
Response Rate	88%	59%		78%	69%	

* Average responses at the beginning and end of the first semester were significantly different for all comparisons (p<0.05). Positive values indicate an increases familiarity with key topics and sense of preparedness from the beginning to end of the first semester.

On average, the impact of the FYS on familiarity scores and sense of preparedness in Fall 2021 and 2022 was positive, with greater gains associated with knowledge of academic programs, extracurricular and professional development opportunities and design thinking (Figure 1). Students appear to have entered the program with relatively greater familiarity with academic integrity policies (4.29, 4.11), teamwork practices (3.49, 3.51), and sense of preparedness (3.69, 3.57) at the beginning of the semester and therefore gains in these areas were correspondingly modest (Table 4, Figure 1). Analysis of the qualitative survey results for both years is still in progress and is expected to provide insights to the specific factors influencing these trends in student sense of preparedness, success, and academic decision making in the first semester.

Student Flow and Retention

The number of students remaining at the institution and in their original college after the first year of study has increased since the course was implemented in fall 2020 (Table 5). The one-year retention rate has increased from 84.8% in Fall 2019 to 89.7% and 89.6% in Fall 2020 and Fall 2021, respectively. Students remaining at the institution in a given cohort increased by 5% (15-18 students) from fall 2019 (prior to course implementation) to fall 2020 and 2021. Student flow between majors indicates that the number of students remaining in their original college increased from 22% (78 students) for the fall 2019 cohort to 27% (94 students) for the fall 2021

cohort. The percentage of students remaining in their original program ranged from 52% to 62% over the study period. Analysis of one-year outcomes for the fall 2022 cohort and 3rd and 4th year retention rates for all cohorts is still in progress.

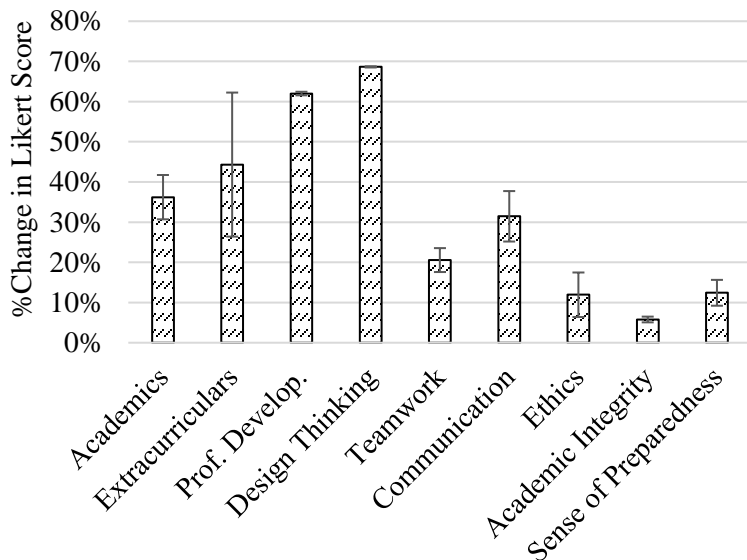


Figure 1. Average percentage change in student familiarity scores over two consecutive years (Fall 2021, 2022) including familiarity with academic programs, extracurricular, professional development opportunities, course learning goals (Design Thinking, Teamwork, Communication, Ethics in the Profession), academic integrity policies, and students’ overall sense of preparedness. Positive %Change indicates an increase in Likert scores for related questions from the beginning to end of the first semester.

Table 5. Retention rates and 1 year composite student flow for pre-study term (Fall 2019) and terms associated with implementation of a college-wide First Year Seminar course.

Cohort Term	# in					
	Original Cohort	Retention 1 yr	% Original Prog. 1 yr	% Same College 1 yr	% Diff. College 1 yr	% Left Institution
Fall 2019*	348	84.8	53.4	22.4	8.9	15.2
Fall 2020	292	89.7	62.0	19.2	8.6	10.3
Fall 2021	347	89.6	51.9	27.1	10.7	10.4
Fall 2022	346	-	-	-	-	-

*Pre-study term; Percentages indicate students remaining in original program, in the same college, in a different college, or having left the institution entirely after the first year of study. Dashes indicate data that is not yet available.

Conclusions and Future Work

Overall, the college-wide FYS course described in this study resulted in positive learning, sense of success, and sense of preparedness among the FTFY students that completed the course in Fall 2021 and 2022 based on student self-reflection surveys. The data identifies opportunities to improve the course and support FTFY students, including a greater focus on sense of preparedness and sense of success. Further analysis of qualitative survey data will be helpful in identifying specific barriers to success and ways in which students feel more or less prepared for college at the end of their first semester. One-year retention rates increased in the years following the implementation of the course and preliminary analysis (sans Fall 2022 cohort data) indicates greater movement of students within programs in the college and within the university, but fewer

leaving the institution entirely. Future work will focus on two-year retention and 4- and 6-year graduation rates for these cohorts.

Acknowledgement

Special thanks to the faculty that laid the groundwork for this course: John Lens, Nicole Caisse, Karen Benway, Eva Marie Cosoroaba, Zachary Ballard, and many others; To Dean Linda Schadler for supporting the development and continuous improvement of the first year experience in our college; To the faculty that have co-taught and helped to improve the course for the past three years: Jeffrey Buzas, Doug Dickey, Jeff Frolik, Joseph Kudrle, Linda Schadler; To our Project Partners that have provided real-world projects for our students to work on; To the undergraduate peer mentors that provide invaluable support to our first-year students each year and the Office of Equity, Belonging, and Student Engagement, which supports and trains them, and to the many other faculty and staff that have visited and made the course possible.

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