



Work in Progress: Transitioning to Two Semesters: The Development of a Full-Year Cornerstone

Ms. Uma Lakshman, NYU's Tandon School of Engineering

Uma Lakshman is a rising fourth-year undergraduate student at NYU Tandon studying Civil Engineering with a minor in Urban Informatics. She is the Head Teaching Assistant of the Introduction to Engineering and Design Course at NYU Tandon, and manages the 115 Teaching Assistants of the course. She has previously worked at AECOM as a Civil Engineering and Highway Design Intern. She has worked on projects such as the Nassau Expressway Reconstruction and the FDR Median Barrier Change. She currently is the Vice President of her school's chapter of the American Society of Civil Engineers and oversees the Concrete Canoe and Steel Bridge competition teams. She will be the president of the chapter next year.

Dr. Jack Bringardner, NYU's Tandon School of Engineering

Jack Bringardner is the Assistant Dean for Academic and Curricular Affairs at NYU Tandon School of Engineering. He is also an Assistant Professor in the General Engineering Department and Civil Engineering Department where he teaches the First-Year Engineering Program course Introduction to Engineering and Design. He is the Director of Vertically Integrated Projects at NYU. His Vertically Integrated Projects course is on Smart Cities Technology with a focus on transportation. His primary focus is developing curriculum, mentoring students, and engineering education research, particularly for project-based curriculum, first-year engineering, and transportation. He is active in the American Society for Engineering Education and is the Webmaster for the ASEE First-Year Programs Division and the First-Year Engineering Experience Conference. He is affiliated with the Transportation Engineering program in the NYU Civil and Urban Engineering Department. He is the advisor for NYU student chapter of the Institute for Transportation Engineers.

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Abstract

This Work in Progress paper describes the plans for the development from New York University's one-semester introductory engineering course, referred to as EG 1003, to a full-year cornerstone. Several universities have implemented a two-semester cornerstone model. This study builds on past research in making this transition, and surveys students to determine their goals for their first-year. If the university decides to develop a year-long version of EG 1003, it will be oriented around the first-year students' goals. This study addresses the components students enjoy in the one-semester cornerstone, what gaps they would like to fill in a second semester, and their expectations for the first year engineering experience. An existing introduction to major course would electively be replaced by a pilot section of students in the project-based second semester course. The curriculum in the second semester should contain the content from the existing introduction to major courses, help students transition between the first year and the rest of their coursework, and provide additional support for major selection. The survey results indicate that 25 percent of students would electively enroll in a second semester of the introduction to engineering course. Students indicated that they would like the second semester to explore more project opportunities.

Introduction

The motivation of this study is to determine whether students at New York University would electively enroll in a second semester of EG 1003. Incoming students are being increasingly exposed to engineering concepts in high school, resulting in a desire for engineering challenges in a project-based format. Integrating project-based curriculum early in engineering education will introduce the engineering design process to socially relevant engineering challenges. The goal of the course is to be a comprehensive cornerstone course for students, which provides the foundation for first-year students to be prepared for the engineering coursework and future projects like their senior design capstone course. The cornerstone is one of the few project-based courses in the first-year engineering experience, which usually is composed of the fundamentals (mathematics, physics, computer science).

Many universities, including Northeastern University, Purdue University, Penn State University, and The Ohio State University, have implemented a year-long cornerstone [1-6]. Before changing the first-year curriculum, the investigators for this study want to determine the students' interests for this model. The learning objective of the proposed year-long cornerstone is to have students develop interdisciplinary problem solutions through the ideation and prototyping of design projects. The proposed second semester would be based around a second multidisciplinary semester long design project, with lectures and recitation focused on project development and project management skills.

From a grant provided in 1993 by the National Science Foundation, New York University's EG 1003 was created with learning objectives on project management, teamwork, technical communication, engineering experiments, and design. 300 students per semester, or 82 percent of first-year students in the college of engineering enroll in EG 1003. The curriculum of EG 1003 is broken up into four components. The laboratory exercises occur in a three-hour period where students learn key concepts of engineering through hands-on prototyping and

developments. Recitations are weekly sessions where students give professional presentations on the technical skills practiced in the laboratory exercise. Lectures are given by industry professionals discussing the cutting-edge topics in their respective fields. The semester-long design projects provide students with the option of a robotics project, a building design project, a biomedical device project, and an open-ended project of their choosing.

Literature Review

Several universities have implemented the full-year cornerstone model successfully and have observed its impacts on first-year students. Seminal research has shown that successful cornerstone classes focus their first semester on instilling the fundamentals of engineering [1-4]. This includes the engineering design process, design software and programming, project management, and teamwork. As students progress with the rest of the curriculum, they will implement the techniques into long term open-ended team projects.

Northeastern University's cornerstone consists of two semesters, where the first semester focuses on engineering principles and the second semester focuses on the application of those principles through design projects [1,2]. Notre Dame's college of engineering employs a two semester long cornerstone that encourages students to design and prototype a drone-like device in the first semester. In the second semester, students learn the skills of 3D modeling and Computer Aided Design (CAD) to improve on the work done in the semester prior [5].

In California Polytechnic State University, students work on a two-semester embedded systems project that helps the elderly. The second semester of the cornerstone focused on skills of computer science, while the first semester focused more on the hardware. It was reported that the two semester cornerstone class helped students choose or solidify their major and increased retention rates, as well as attracting and supporting underrepresented populations [6].

At the United States Military Academy at West Point, system engineering students participate in the two-semester cornerstone model, where they work on multidisciplinary engineering projects that are focused on the design process. The first semester teaches fundamentals of engineering and the second semester encourages students to employ the skills learned as they work on a project for the United States Department of Defense. Graduates of the program reported that they can effectively solve problems using concepts of engineering using the engineering design process [7].

With an additional semester, universities are given the opportunity to expand their curriculum beyond technical skills. Clarkson University's two semester introduction to engineering course emphasizes the importance of engineering for a societal cause. By the end of the course, students of all majors (engineering and non-engineering) were able to determine the scientific principles behind the various disciplines of engineering. With the two semester model, students had sufficient time to learn and utilize business and risk-management skills during design projects [9].

The success of these two-semester cornerstone courses has provided an incentive for this study to determine student interest in a similar first-year model. Although student interest is not the only factor in determining the design of the engineering curriculum, the courses they take should align with their intrinsic motivation. The primary goal of this study is to determine if students would enroll in a two-semester introduction to engineering course. If students would elect to take a second semester, then the survey also assesses what they would want to learn in that semester.

Methods

The survey was given in the eighth out of the eleventh week of the course. At this time, students were two thirds through their semester long design project. In the last week of the class, students are expected to complete their project and to present a business-like pitch about their project, which contributes to 30 percent of their final grade. When the survey was conducted students were stressed about the workload of the course, but were also registering for the classes for the next semester.

EG 1003 has 300 students enrolled per semester. The students enrolled in the class are mostly first-year students. The teaching assistants of the introduction to engineering course were also surveyed. EG 1003 has undergraduate teaching assistants that span most majors at New York University's Tandon School of Engineering, including majors that are not required to take EG 1003. Students that did not consent to their data being collected and students under the age of 18 were not considered for this survey. Out of the 415 students and TAs polled, 260 responses were recorded and considered for analysis. The survey has been approved under IRB protocol IRB-FY2020-3863.

The survey was developed using questions derived from survey questions in formative literature on the cornerstone model [10]. Students were asked both qualitative and quantitative questions. Students were asked questions about their demographics, desire to continue components of the course, opinions on the first-year engineering experience at New York University and their general interest in taking a second semester of project-based introduction to engineering. The motive of the survey was to gauge any interest for a full-year cornerstone of EG 1003 and to determine why or why not students would be interested.

Data Analysis

Students and TAs were asked for their general demographics, such as major, gender, and internship experience. Figure 1 presents the participating students broken down by major. In this semester of the course, chemical and biomolecular engineering, computer science, and mechanical engineering majors were predominant. The distribution seen in Table 1 accurately represents the distribution of majors at the college of engineering. The majors with small or no enrollment are not required to take EG 1003.

Table 1: Breakdown of students participating in survey by major declared

	%	Count
Applied Physics	0.9%	2
Chemical and Biomolecular Engineering	19.4%	42
Civil Engineering	5.1%	11
Computer Engineering	8.8%	19
Computer Science	22.7%	49
Electrical Engineering	3.2%	7
Electrical and Computer Engineering	5.1%	11
Mechanical Engineering	19.4%	42
Sustainable Urban Environments	2.3%	5
Undeclared	12.0%	26
Other	0.9%	2
Total	100%	216

Table 2 presents the distribution of students by year that participated in the survey. The response rate for TAs was low compared to students, as students were provided in-class time to complete the survey. It should be noted that over half of the TAs are second year students.

Table 2: Breakdown of students participating in survey by year

	%	Count
First-Year	79.7%	173
Second-Year	10.1%	22
Third-Year	6.0%	13
Fourth-Year	3.7%	8
Fifth-Year	0.5%	1
Total	100%	217

Students were asked a series of five-point Likert-scale questions on their experience taking the class. Time spent in recitations, lectures, laboratory exercises, and in-class time working on their semester long design project were evaluated.

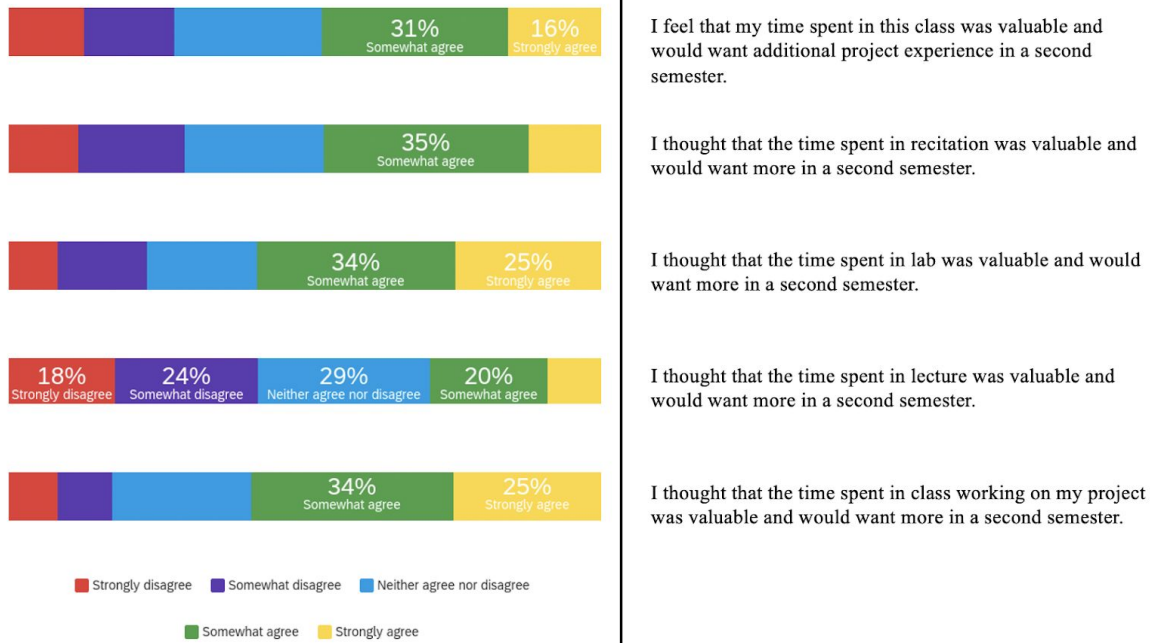


Figure 1: Student responses when asked about their time spent in the introduction to engineering course and its various components.

In Figure 1, 47 percent of students find this course to be valuable to their degree and would want more experience working on hands-on projects. Students also value the class time they had to work on their semester-long design project, 59 percent of participating students agreed that they would want more in-class sessions to work on their projects. The time spent in recitation and lab were also seen as beneficial to the students, as about 40 percent of students found it to be valuable. The majority of students felt ambivalent or disagreed to having more lectures. Students were asked about the first-year engineering experience at New York University. The motivation of these questions was to determine if students were interested in a common first-year for students of all majors.

Table 3: Student responses when asked what class they would not like to take in their first year at New York University's Tandon School of Engineering

	%	Count
Introduction to Engineering and Design	13.38%	53
Introduction to Major	3.03%	12
Engineering and Technology Forum	21.72%	86
Intro to Programming (Python or Matlab)	7.07%	28
Calculus 1	2.53%	10
Calculus 2	2.78%	11
Physics 1 (Mechanics)	4.04%	16
Chemistry	5.56%	22
Biology	3.28%	13
Expository Writing 1	23.74%	94
Expository Writing 2	12.88%	51
Total	100%	396

Table 3 shows that students would rather not take New York University’s one credit engineering and technology forum course, as well as expository writing. The engineering and technology forum consists of weekly lectures, small homework assignments, and a semester-long design course. Students often feel as this is too much work for little reward for a one credit class. From the data obtained, students found that their core classes (calculus, physics, chemistry) were valuable to their first-year engineering experience. Students were asked about the courses that they would want to include in their first-year engineering experience.

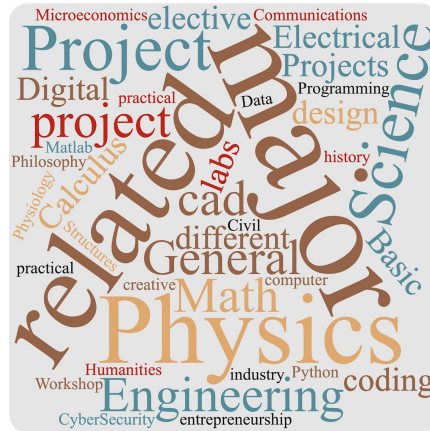


Figure 2: Student responses when asked what classes they would like to take in their first year New York University’s Tandon School of Engineering

From Figure 2, students want more major related courses in their first year and more hands on project-based courses. Students also state the need for the foundational classes, such as computer science. A well-rounded first-year curriculum is suggested, with terms such as “entrepreneurship” and “philosophy.” Students were asked about a common first year for every student at New York University’s Tandon School of Engineering. Students would declare their major after their first year. Figure 3 displays the breakdown of students that would be in favor of declaring their major at the end of their first year.

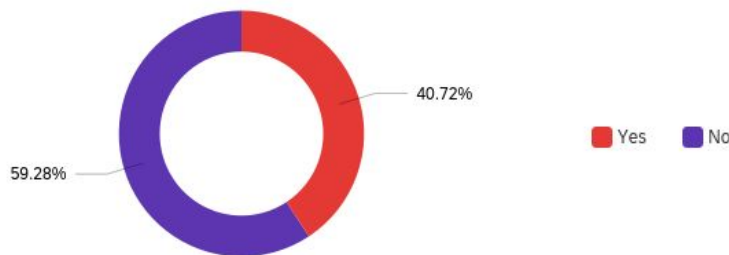


Figure 3: Student responses when asked if they would prefer majors at New York University’s Tandon School of Engineering be declared after their first year

The majority of students would not want to declare their major after a common first year curriculum. However, one student wrote “It would help give people a chance to fully explore their options as to what they could end up enjoying and help them see what they like and don't

like. This could especially help people who have multiple interests in different fields.” Another student mentioned, “College is expensive, having the first year undecided would mean a full year of taking classes that might not even matter to my degree.” At New York University, some students begin taking major specific classes in their first semester, while others may be taking their major specific classes after their first year.

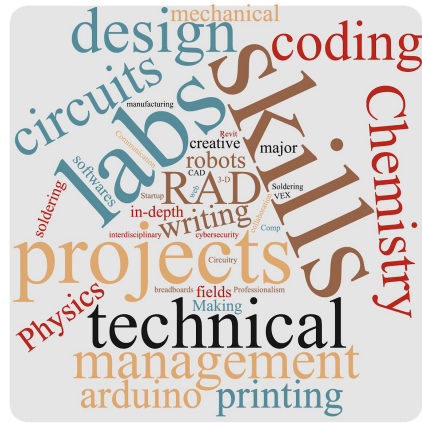


Figure 4: Student responses when asked what skills they would like to further refine in a potential second semester of the course

The survey asked students about what skills they would want to further develop in a second semester of EG 1003. Students cited that they would want to further their technical skills through the usage of coding and circuits. Students were then asked if they would electively enroll in a second semester of EG 1003 if given the opportunity.

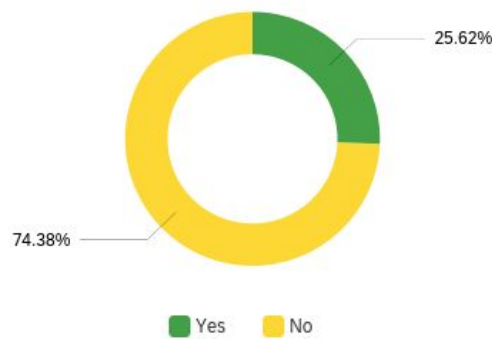


Figure 5: Student responses when asked if they would electively participate in a second semester of EG 1003

Approximately 25 percent of students reported that they would be interested in enrolling in a second semester of EG 1003. When asked why, students mentioned that “Because [EG 1003] offers a rigorous curriculum that allows me to work on multidisciplinary projects. It would help me gain more industry based experience.” The other students that reported that they would not enroll in the course cited the work-load. A student wrote, “It is interesting to learn and do labs about them but long the amount of work in presenting and writing reports is not necessary and adds stress to a student in pursuit of a specific area of engineering.”

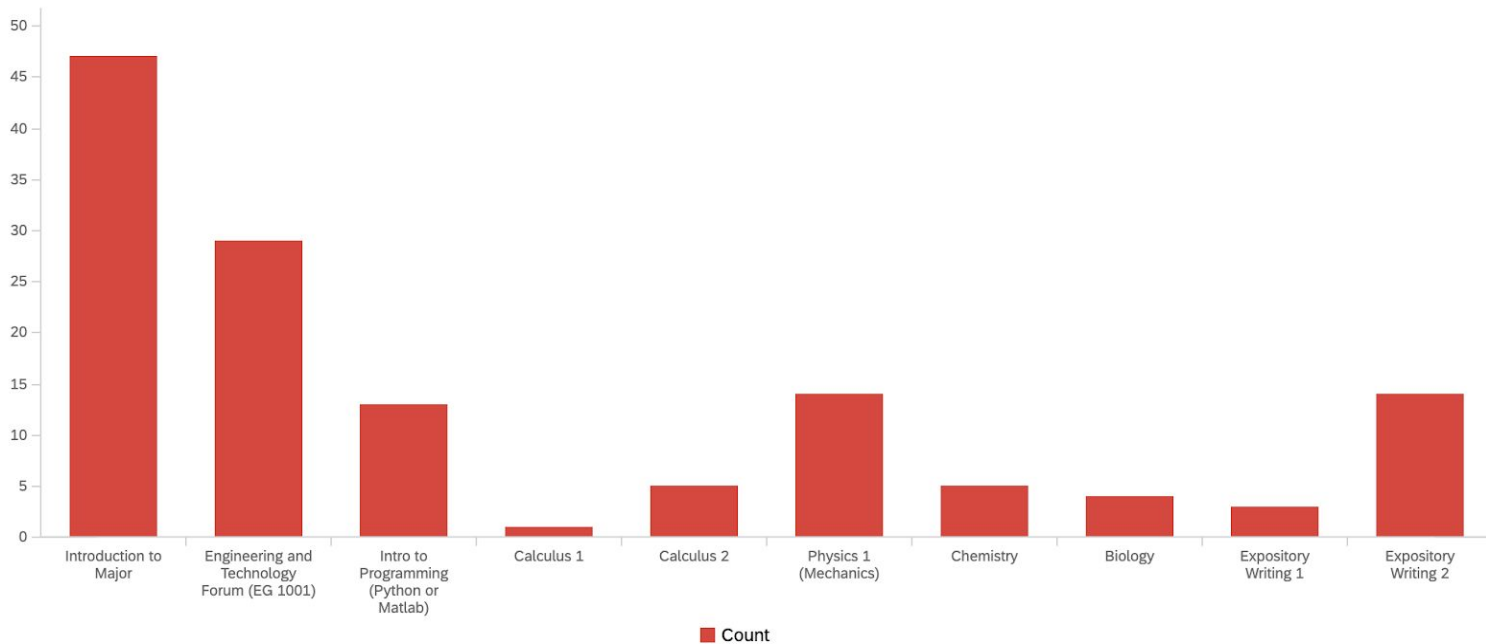


Figure 6: Student responses when asked what course they would replace in their first-year curriculum in order to enroll in a second semester of the introduction to engineering.

Students that stated that they would enroll in the second semester extension of the course were asked what course in their first-year engineering experience they would replace so that they could take the second semester extension. According to Figure 6, this subset of students that would enroll in the second semester would be most willing to replace their introduction to major courses and their engineering and technology forum with a second semester of EG 1003. These students would rather keep their core classes in their first-year engineering experience.

Conclusions and Recommendations

The feedback obtained from first-year students and TAs in the survey provides insight on New York University’s implementation of a comprehensive two semester cornerstone. Overall, 47 percent of students found that if the course content were to be extended into a second semester that it would be valuable to their degree and professional careers. Students reported that the in-class time to work on their projects was beneficial, and expressed an interest in additional time in a second semester of the course. Discipline based courses and project-based curriculum are of interest to students. 25 percent of students polled would be interested in electively enrolling in a second semester of EG 1003. Anecdotally, students feel that a second semester of EG 1003 would be beneficial if there was an emphasis on technical skills and well-rounded curriculum. Students are wary of enrolling in the second semester extension due to the work-load of the first semester.

This evidence indicates that a pilot section of a second semester of EG 1003 could be tested with a quarter of first-year students. Further research questions regarding the curriculum and logistics of the potential second semester cornerstone follow (1) Through what methods can entrepreneurship be incorporated in a cornerstone course to give students the toolkit to take their project beyond the course? (2) What should be the breakdown of classroom time when working on an open-ended project for a second semester cornerstone? With the additional research questions on the implementation of the second semester cornerstone, more insight could be provided to determine if a second semester of the cornerstone course should be integrated into the curriculum.

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APPENDIX of Student Survey Questions

This survey aims to determine the interest of students at New York University's Tandon School of Engineering in taking a second semester of introduction to engineering and design . This second semester would be an additional 3 credits, focused on a second open-ended project. Students who have already completed a RAD project could continue working on the RAD project in the second semester.

1. Consent question
2. How many years have you been at New York University's Tandon School of Engineering?
 - a. First-Year
 - b. Second-Year
 - c. Third-Year
 - d. Fourth-Year
 - e. Fifth-Year
3. What is your major?
 - a. Applied Physics
 - b. Biomolecular Sciences
 - c. Business and Technology Management
 - d. Chemical and Biomolecular Engineering
 - e. Civil Engineering
 - f. Computer Engineering
 - g. Computer Science
 - h. Electrical Engineering
 - i. Electrical and Computer Engineering
 - j. Integrated Digital Media
 - k. Mathematics
 - l. Physics and Mathematics
 - m. Mechanical Engineering
 - n. Science and Technology Studies
 - o. Sustainable Urban Environments
 - p. Undeclared
4. How many semesters (fall/spring/summer) of internship/co-op experience do you currently have?
 - a. No Internships/co-ops
 - b. 1 Internship/co-op
 - c. 2 Internships/co-ops
 - d. 3 Internships/co-ops
 - e. 4 Internships/co-ops
 - f. 5 + Internships/co-ops
5. What gender do you identify with?
 - a. Female
 - b. Male
 - c. Other
 - d. Prefer not to say

6. Respond to the question: I feel that my time spent in introduction to engineering and design was valuable and would want additional project experience in a second semester of introduction to engineering and design.
 - a. Strongly Disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly Agree
7. Respond to the question: I thought that the time spent in recitation was valuable and would want more in a second semester of introduction of engineering and design.
 - a. Strongly Disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly Agree
8. Respond to the question: I thought that the time spent in lab was valuable and would want more in a second semester of introduction to engineering and design.
 - a. Strongly Disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly Agree
9. Respond to the question: I thought that the time spent in lecture was valuable and would want more in a second semester of introduction to engineering and design.
 - a. Strongly Disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly Agree
10. Respond to the question: I thought that the time spent in class working on my project was valuable and would want more in a second semester of introduction to engineering and design.
 - a. Strongly Disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly Agree
11. Which classes did you wish you did not have to take in the first year?
 - a. Introduction to Engineering and Design
 - b. Intro to Major
 - c. Engineering and Technology Forum
 - d. Intro to Programming (Python or Matlab)

- e. Calculus 1
 - f. Calculus 2
 - g. Physics 1 (Mechanics)
 - h. Chemistry
 - i. Biology
 - j. Expository Writing 1
 - k. Expository Writing 2
12. Which types of classes do you wish you could have taken in your first year?
13. Would you prefer if majors were to be declared after your first year at Tandon? Everyone would enter the school as an undeclared student and would be taking the same classes.
- a. Yes
 - b. No
 - i. Why?
14. What skills would you like to refine through a potential second semester of introduction to engineering and design? In other words, if there was a second semester of introduction to engineering and design. what projects, topics, skills, and disciplines would you like to learn more about.
15. If a second semester of introduction to engineering and design was offered, would you electively take the course?
- a. Yes
 - b. No
 - i. Why?
 - ii. What course would you replace it with?