On the ”Introduction to Engineering” Course

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Abstract

"Introduction to Engineering" is a core course offered to freshmen students of all engineering disciplines. Students of non-engineering majors often select the course to learn more about the engineering profession and to find out how well it may fit their personal interests. The course content varies among higher education institutions, but they all place a significant emphasis on the delivery methods and the course outcomes. An online research of the latest posted offerings and catalogs shows the topics covered by the course and the credit hours dedicated to it. Student surveys conducted at two different institutions show why students select to become engineers and their preference for the different course components.

Introduction

"Introduction to Engineering" is a core course given to freshmen students of all engineering disciplines. The course aims to familiarize students with the engineering profession, the different engineering disciplines, the design process for exploratory projects, the work in interdisciplinary teams, the ethics and professional behavior, the lifelong learning, the written and oral presentation of technical concepts, and problem solving. As curriculum often changes, an online research was conducted on the most current catalogs (2018-2019) of 182 higher education institutions offering degrees in engineering. The purpose was to determine how many of these institutions teach the course, for how many credit hours, and which specific topics are covered. Courses that are introductions to a specific discipline, e.g., civil, mechanical, biomedical engineering, etc. are of no interest in this study. Neither are freshman seminars that aim solely to familiarize students with college life, the institution's facilities and resources such as libraries, etc. Based on surveys conducted at two universities, the preferences of the students about the course are revealed as well as their motivation for studying engineering.

Online Research Data

The course "Introduction to Engineering" aims to provide an orientation to the engineering profession and its different disciplines and to shed light to the skills that engineers possess. Students are instructed how to address societal problems by providing innovative solutions and designs. The most recent posted online catalogs of 182 higher education institutions were examined. The selection of the institutions was arbitrary and covered all states. Figure 1 shows the number of institutions considered in each state. From these universities, 19 (11%) do not teach any introductory course in engineering and 55 (30%) have a separate introductory course for each engineering discipline. The remaining 108 (59%) universities are of interest in this study. Eighty-four percent (84%) of the 108 universities have as a terminal degree the doctorate and the remaining 16% a bachelor's or master's in engineering.

Figure 2 shows the different course names used by the 108 institutions. The most common name is "Introduction to Engineering" followed by "Introduction to Engineering Design" and "Foundations of Engineering." Figure 3 shows the credit hours dedicated to the course. Most

institutions assign the course one or three credit hours. Credit hours noted as "1+1," "2+2," etc. refer to sequence courses, offered in the Fall and Spring semesters and have one or two credit hours per consecutive semester. Sixteen of the 108 institutions (15%) require mathematics (eight require precalculus and eight calculus) as a prerequisite or corequisite course, while 85% do not.

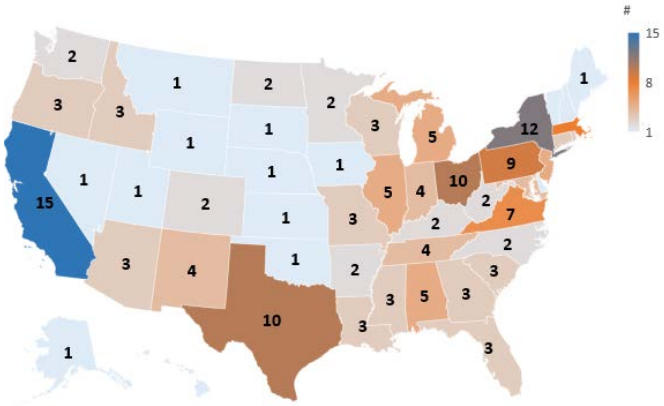

Figure 1: Location of the 182 higher education institutions

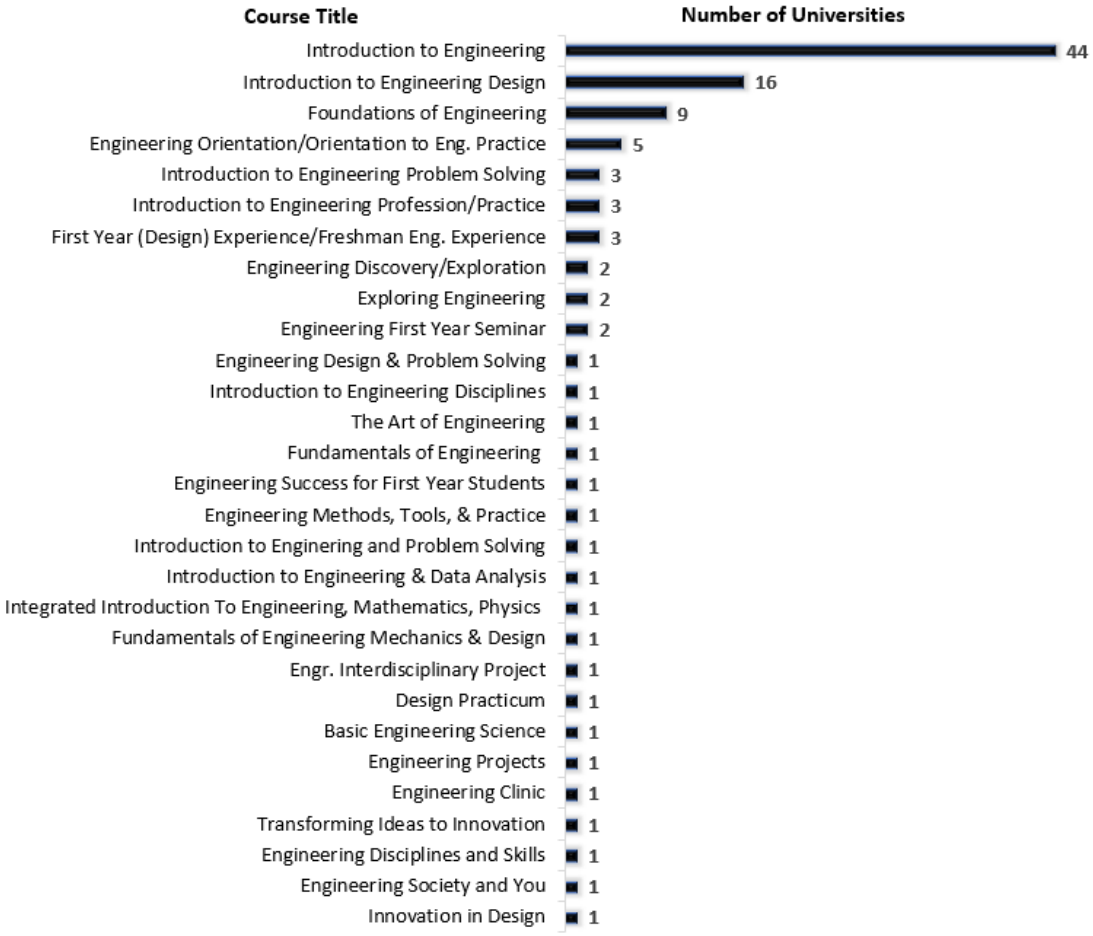

Figure 2: Names attributed to the "Introduction to Engineering" course

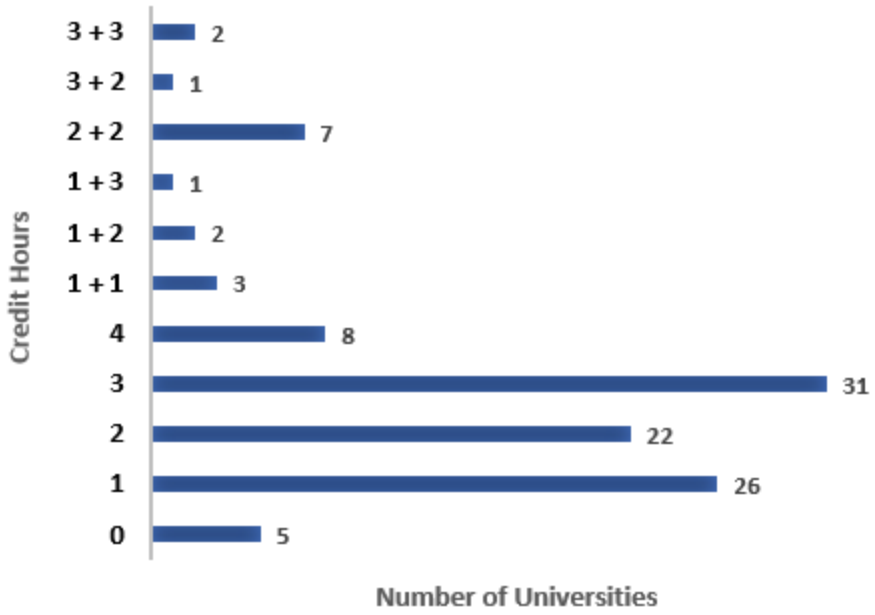

Figure 3: Credit hours

Table 1 lists major topics covered by the course. The topics were retrieved from the course descriptions and online catalogs for the 108 higher education institutions under consideration. The course topics were assigned to the most relevant student outcome (SO), 1 through 7, of the latest ABET Criterion 3 [1]. Not all topics are covered by each institution, but student outcomes 2, 4, and 7 seem to be addressed more than others. Table 2 provides the description of the student outcomes.

Table 1: Topics for the course and respective ABET student outcome.

Course Topic	ABET Criterion 3 Student Outcomes
Innovative solutions to problems in the real world	**1, 2, 7**
Graphical presentation, technical writing, oral presentation	**3**
Engineering interdisciplinary teams	**5**
Application of computer software to solving engineering problems	**1, 7**
Engineering design process	**1, 2, 7**
Cost estimation	**2**
Hands-on learning and experiments	**6**
Professional organizations	**4**
Integration of society and technology	**2, 4**
Overview of engineering disciplines	**4**
Field trips providing exposure to the impact of technology on society	**2, 4**
Ethical and professional behavior	**4**
History of technology	**7**

Course Topic	ABET Criterion 3 Student Outcomes
Engineering project planning and management	**7**
Computer aided design (CAD)	**7**
Prototyping methods	**7**
Relationship of engineering to social, global and contemporary issues	**2, 4**
Alternative solutions and optimization	**1, 2**
Provide peer reviews	**5**

Table 2: Criterion 3 student outcomes (SOs)

SO	Description
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3	An ability to communicate effectively with a range of audiences.
4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Student Surveys

Students from the four groups shown in Table 3 completed anonymous surveys. Groups A and C study engineering and groups B and D study engineering technology. Groups A and C are from the same institution and B and D from a different one. All students have completed an "Introduction to Engineering" course. Group D are transfer students from a two-year college, where they have already been introduced to engineering. All student groups are interdisciplinary and mutually exclusive.

Table 3: Surveyed student groups

Group	Program	Class Standing	Population, *N*
A	Engineering	Freshmen	22
B	Engineering Technology	Freshmen	18
C	Engineering	Sophomore	24
D	Engineering Technology	Transfer	35

Students were asked why they study engineering, what their study habits are, and what they think about the "Introduction to Engineering" course.

a. Why Students Study Engineering

Engineering is a very promising and desirable profession for college students. Per the Bureau of Labor and Statistics employment of architects and engineers is projected to grow 7%, the same as the average for all occupations [2]. The growth is expected mainly in areas of rebuilding infrastructure, renewable energy, oil and gas extraction, and robotics. Additionally, the annual wage for architects and engineers is approximately double the annual wage for all occupations in the economy [2]. Beggs, et. al., [3] showed that students select to study engineering in descending order for: good match with their interests, job characteristics, course attributes, social benefits, and financial success.

Based on the survey results illustrated in Figure 4, freshman students interested in engineering technology (Group B) follow the profession mostly for providing service to the society, while the engineering students (Group A) share equally their interest among helping the society, financial success, and intellectual satisfaction. Figure 5 illustrates that transfer (Group D) and sophomore students (Group C) are driven more by intellectual satisfaction and helping the society rather than financial success. More specifically, through engineering, the transfer engineering technology students (Group D) wish foremost to help the society, while the engineering students (Group C) to gain intellectual satisfaction. It seems that as students advance in their studies, they get challenged, appreciate the curriculum and their mission to solve problems for the society. "Not sure" in Figures 4 and 5 represents students doubtful about continuing their studies in engineering.

The Student Outcomes 2 and 4, which are incorporated in the course by several course topics (Table 1), could be strengthening the reasons, why students wish to pursue engineering.

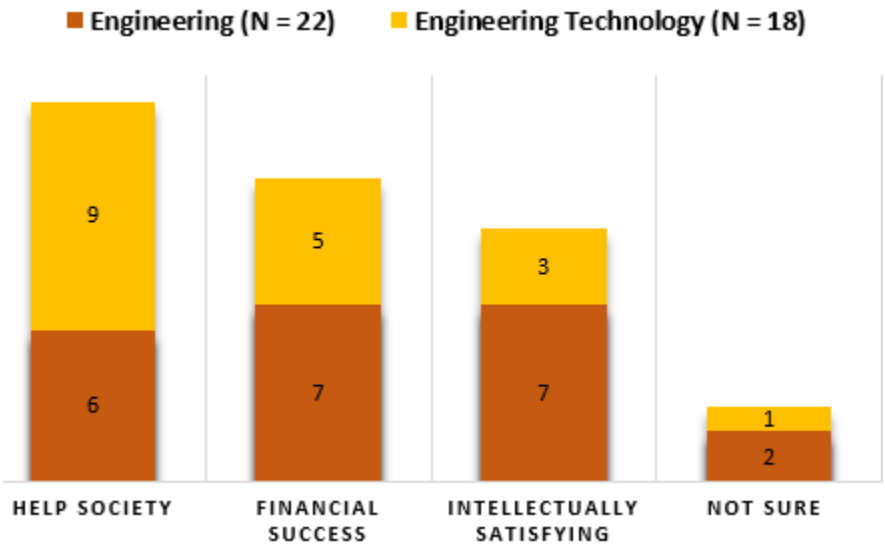

Figure 4: Freshmen' reasons for studying engineering

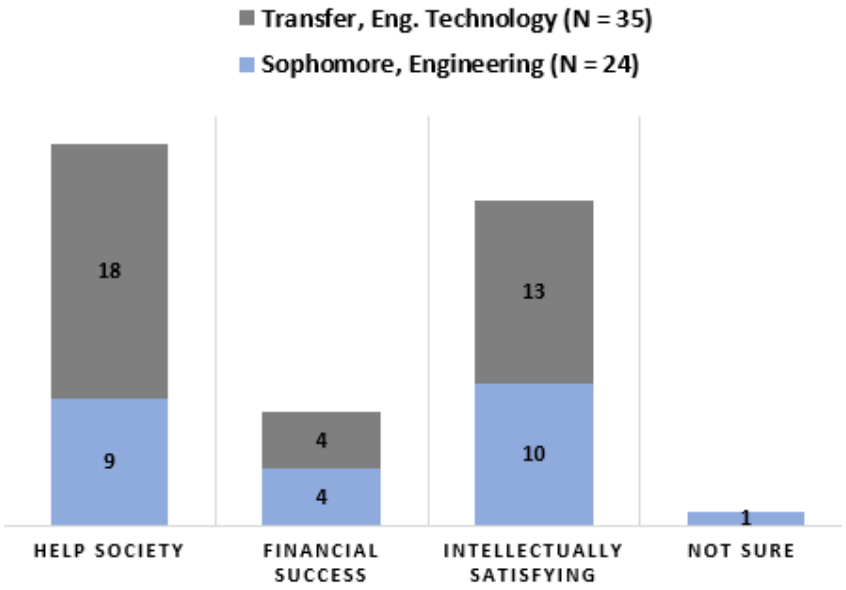

Figure 5: Sophomore and transfer students' reasons for studying engineering

b. Student Perspective

Survey results show the students' perspective on the "Introduction to Engineering" course and their study habits. The engineering students in Groups A and C took a three-credit hour course and worked in teams to design and build structures following specifications, prepare reports with design justifications, and make oral presentations. The course incorporated more hands-on activities and lectures focused on these activities. Survey results from Groups A and C are presented in Figures 6 through 10. Although the Likert scale was used, results are presented as percentages, having the categories "strongly agree" and "agree" merged, as well as the categories "strongly disagree" and "disagree." The population size, *N*, changes from question to question, because in some cases students have not answered the specific question.

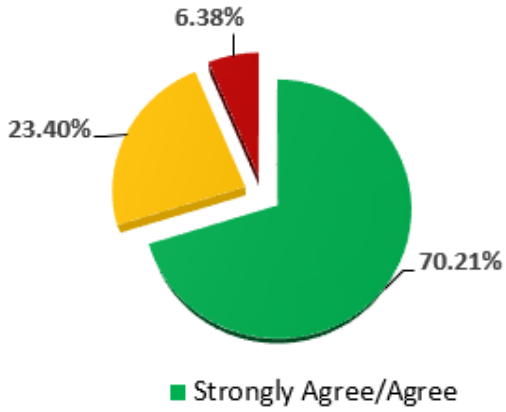

Figure 6: How do you feel about having a senior student as a mentor? (*N* = 46)

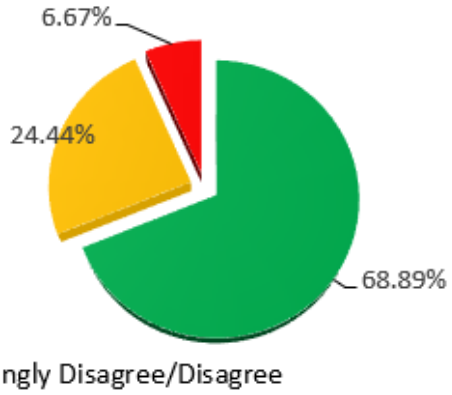

Figure 7: Have more hands-on activities than lectures (*N* = 45)

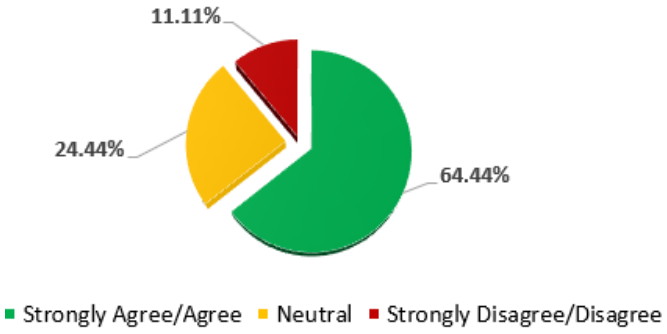

Figure 8: Enjoy working in a team? (*N* = 45)

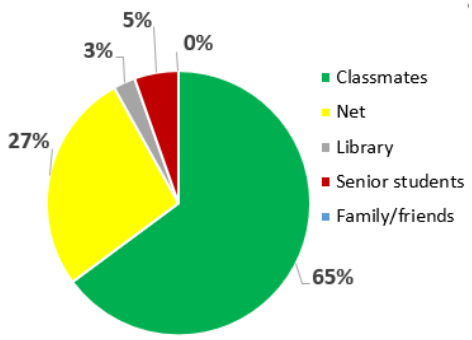

Figure 9: Getting help from? (*N* = 37)

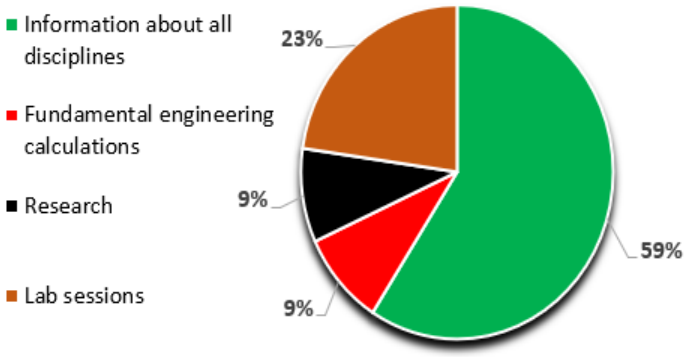

Figure 10: What should the "Introduction to Engineering" course include? (*N* = 46)

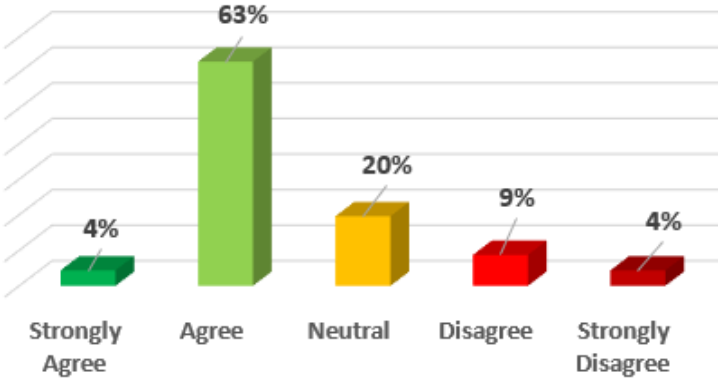

Figure 11: The design-build projects helped understand the engineering design process? (*N* = 46)

Data in Figures 6 through 9 show that 70% of the students would have appreciated the mentoring by a senior student and strongly prefer having hands-on activities rather than lectures. Sixty-four

percent (64%) enjoyed the team work. When students were asked how they get their questions answered, while working on the design projects (consulting with the instructor excluded), 65% answered consulting with their peers, 27% using the net, and the remaining 8% using the library resources. As far as it concerns the content of the course, when asked to choose a single improvement, 59% of the students would prefer to get more information about all available engineering disciplines and 23% to have lab sessions incorporated in the course. Research and fundamental engineering calculations appeal less to the students (Fig. 10). Figure 11 shows that the hands-on projects clearly helped 67% of the students to better understand the engineering design process.

The freshmen in the engineering technology program, Group B, completed a three-credit hour course. They attended lectures in engineering topics, identified and researched a societal problem, found engineering solutions for it, made presentations, and wrote technical reports. However, they had no hands-on activities. Instead, they were required to meet with senior students, work together on senior design projects in the lab and practice the engineering design process. At the beginning of the class, the senior students made presentations and the freshmen had the opportunity to select a project and join a senior design team. Figures 12 through 14 present the student answers to anonymous surveys using the Likert scale. The aim was to reveal the effect that the lab sessions with senior students had on the freshmen learning.

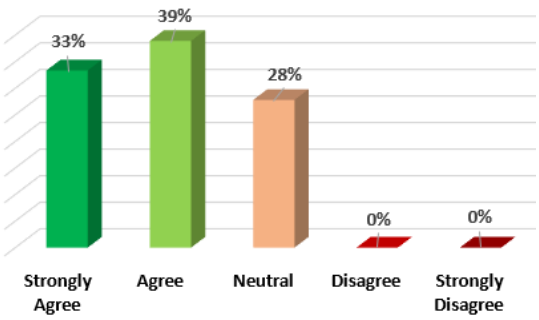

Figure 12: Have the lab sessions increased your interest in engineering? (*N* = 18)

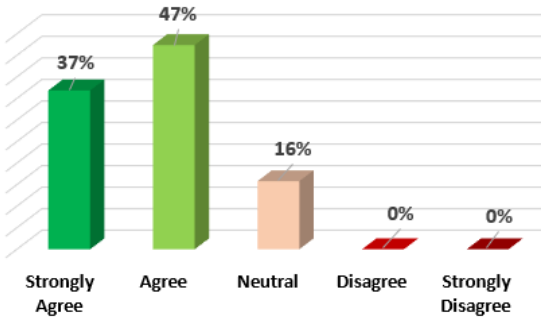

Figure 13: Did the lab sessions help better understand the design process? (*N* = 18)

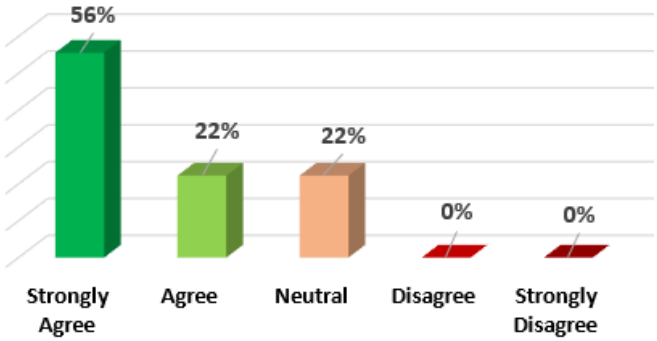

Figure 14: Was it beneficial to include lab sessions in the course? (*N* = 18)

Seventy-eight percent (78%) of the freshman group of engineering technology students agreed or strongly agreed that they benefit from the lab sessions and working with seniors. Eighty-four percent (84%) reported that they understood better the design process through the lab sessions.

Student Retention

According to a multi-institutional study, the "Introduction to Engineering" course can be beneficial to undecided students in making an informed decision [4] and help retain students in engineering [4], [5]. In the current study conducted at two institutions offering engineering and engineering technology programs, only 9% and 6% of the students, respectively, are reluctant to continue their studies in engineering after completion of the course (Fig. 4). From the engineering students (Groups A and C) approximately 45% are undecided about which major to follow. This percentage is high and in accordance to these students' desire to add to the course more information about the different disciplines (Fig. 9). Seventy-two percent (72%) of Group B engineering technology students agreed that the lab sessions increased their interest in engineering. Similar results were reported in [6].

Conclusions

From the 182 universities examined nationwide, 59% offer a core interdisciplinary introductory course in engineering. The most common name used for the course is "Introduction to Engineering" and more often it is assigned with three or one credit hours. The course topics considered at different institutions well align with several of the latest student outcomes of ABET criterion 3. Through surveys conducted among engineering students at two universities, after completion of the "Introduction to Engineering" course, it is revealed that 72% agree that the course increased their interest in engineering and less than 9% are thinking about changing major. The primary reason, why students study engineering, is the desire to help the society followed by the intellectual satisfaction. Engineering and engineering technology students see great benefit in working with senior students in labs or having a senior student as a mentor. During their first year of studies students seek primarily the help of their peers to answer their questions and they wish to learn more about the different engineering disciplines.

References

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