# Teaching an Introductory Engineering Course that also Satisfies a Humanities General Education Requirement

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***Abstract* - The freshman engineering class at Southern Utah University, ENGR-1010: Engineering in the 21st Century, is an introduction to engineering methods and thought as well as an examination of the interaction of society and engineering. The engineering department uses the course to introduce engineering students to a variety of topics in engineering and to attract students considering engineering. To accomplish this, the course is required for engineering majors but also can be taken for humanities general education credit. While many of the non-engineering students are considering engineering as a major and therefore have a science and math background, many students majoring in non-science related areas also take the course. This broad range of student backgrounds poses unique challenges compared to other engineering courses. This paper describes the basic approach to teaching such a course, some of the advantages and disadvantages, examples of topics, an examination of the successes and failures. Given the fact that many students do not have the appropriate math and science background to complete an introduction-to-engineering course that introduces students to engineering problem solving, the course largely covers concepts and methods used in engineering. Additionally, the course overviews broad engineering technologies and examines them from two perspectives; the impact of the technology or discipline on society, and how society impacts how engineers design. The intent is to introduce engineering students to many of the concepts they will need to use during their studies and throughout their career early in the curriculum. The results from a student survey found that the non-engineering majors in the course find value in many of the topics more focused on engineering majors taking the course.**

*Index Terms* – Engineering, multi-disciplinary, introduction to engineering,

## INTRODUCTION

ENGR-1010: Engineering in the 21st Century at Southern Utah University is an introduction to engineering methods and thought, as well as an examination of the interaction between society and engineering. The engineering department uses the course to introduce engineering students to a variety of topics in engineering and to attract students considering engineering. To accomplish this, the course is required for engineering majors but also can be taken for humanities general education credit.

While many of the students are declared engineering majors or are majoring in science fields such as mathematics, chemistry and biology, a significant portion of the students that take the course are majoring in non-science areas. These range from accounting and finance on the more math-based end of the spectrum to philosophy and sociology and elementary education. Typically about $^1/_3$ to ½ of the class is made up of engineering students. Teaching engineering principles to this broad range of backgrounds and interests poses challenges that are typically not found in other engineering courses.

This paper will focus on two primary areas. First, an overview of the course will be provided. This includes a discussion of program philosophy behind the course and the learning objectives for the course material. Additionally, specific topics will be discussed in some detail to give the reader an idea of the approach used (as it relates to the broad range of majors). Secondly, data will be presented based on a survey of students on various aspects of the course. The questions ranged from basic interest in the course and the overall value of the course to the student, to the student perceptions of the usefulness of specific modules of the course. The data-set is limited (about 40 students) but general trends and insights will be presented. This information can benefit those developing curriculum to increase engineering students' awareness of society.

In order to provide the backdrop for ENGR 1010, some general information the engineering program and Southern Utah University (SUU) is provided. SUU has a total of about 8,000 students. Science majors make up about 25% of the student population. The engineering program is relatively small, with only about 1.5% of the students majoring in engineering. The engineering program offers a bachelor's degree in general engineering.

ENGR 1010 evolved out of a university requirement for the students to have some interdisciplinary exposure. Over time the requirement was dropped, however there was a desire to continue the cross-disciplinary nature of the course. This transition led to the course being offered to satisfy a general education humanities credit. Additionally, there is a growing trend that engineers need to have more exposure to humanities, resulting in improved critical thinking and an

increased awareness towards engineering solutions benefiting people [1].

To illustrate the overall objective of the course, the catalogue description states:

"Civilization in the 21st century has been enabled and shaped by science, engineering and technology. The foundations and social contributions of infrastructure, industry and manufacturing are investigated from the perspective of science, engineering and technology, and demonstrated through hands on applications. (Fall, Spring)" [2].

The course catalog description is vague (relative to typical engineering course descriptions). This leaves much of the actual course material open to the instructor. Thus, over the years the material and teaching philosophy and approach has varied widely. According to past students (prior to the author's arrival at the university), this course was at times essentially a 'weed-out' course by some instructors and taught with the rigor of most engineering courses. In more recent offerings however, a conscious decision was made to avoid "scaring-off" students that may not have a great interest in engineering. This was done for two reasons. First, this course is seen as a way to attract students that are interested in engineering but undecided. Additionally, for students not interested in engineering as a career, the hope is that the course gives students an appreciation for engineering and a better understanding of how engineering influences society (and vise-versa).

Recent offerings of ENGR 1010 have included topics such as: introduction to engineering disciplines, units and unit conversion, teamwork, the engineering design process, Microsoft Excel, measurement and data collection, historical perspective of structures, infrastructure, aviation, renewable energy and the electric grid. Additionally, labs or 'hands-on' projects are used to reinforce many of these topics and introduce students to various engineering tools. These include labs on measurement, a cardboard boat race, a paper airplane contest, data collection, and a solar home project. For these projects students design, fabricate the device, measure data and write a report.

One can imagine that these topics can be covered at a level that appeals to different types of students. However, the challenge is that the topics need to be presented at a level that appeals to the different types of students at the same time. These topics are covered with the dual intent of introducing the engineering students to engineering related material, but at the same time providing non-engineering students tools they can use in their own fields while learning about engineering.

As many engineering programs have found, students entering engineering programs are not necessarily prepared to succeed in engineering [3]. In addition to many students struggling with initial courses such as math, chemistry and physics, often students lack sufficient time-management, study and teamwork skills and do not have sufficient proficiency with engineering tools. To address some of these issues, the engineering faculty at SUU are adding a 1 credit course (ENGR 1000) to the curriculum that will teach study skills and time management and introductory use of engineering tools (such as Microsoft Excel, PowerPoint, units and significant figures, etc.). In initial discussions the proposal to adapt ENGR 1010 was considered since much of the material is taught in the ENGR 1010 course. However, the diverse backgrounds of students prevents teaching some of these topics at an engineering level. Since the ENGR 1010 course will still be to be available to non-engineering students, the decision was made to develop ENGR 1000 specifically for engineers.

Thus, the debate over the distribution of topics between the two similar courses began. Since engineering students would be required to take both courses, both courses could not simply cover all of the same material at different levels. To assist in the distribution of material between the courses, the ENGR 1010 students were given a short survey. The purpose of the survey was to help understand which topics were of most interest and value to the students as a function of their respective majors. The results of the survey are presented in this paper (the survey is available as an appendix).

## DISCUSSION OF RESULTS

A short survey was given in class on the last day of classes. Students were not required to submit a survey and the instructions explained that the survey was not tied to any coursework or grade and that the surveys would not be examined until after final grades were assigned. A total of 37 students took the survey out of 40 in attendance on the day the survey was given. Table I shows the distribution of majors. Engineering students make up less than half of the respondents (43%). This is similar but slightly higher than the percentage of engineering students typically in the class each semester (25% - 35%).

TABLE I
MAJORS OF STUDENTS THAT RESPONDED

| Major Category | # of Students | Specific majors |
|---|---|---|
| Engineering | 16 | |
| Science | 7 | Chemistry, Biology, Computer Science, Agriculture |
| Technology | 5 | Aviation Technology, CAD/CAM, Construction Management |
| Other | 9 | Education, Exercise Science, accounting, undecided |

Students were asked questions based on the entire course, specifically whether they felt the course was relevant to their major/career and whether they felt some of the material

would be useful in their chosen field. The average of the responses for different majors are shown in Figure 1. The students were asked to rate statements numerically, with a value of 2 being associated with "Strongly Agree," 0 being "No Opinion" and -2 indicated "Strongly Disagree." While there is not a significant sample size, the data tend to indicate that the non-engineering students do not feel the entire class supports their major as might be expected. However, these students do seem to indicate that portions of the course are useful. As one might expect, the engineering students found the course relevant to their major. It should be noted that the "Some material useful in major" column is not accurate for the engineering students. The survey question (question 3 on the survey in the appendix) was worded such that it focused on the non-engineering majors. Subsequently, most of the engineering students did not mark anything for that question on the survey (which gives a score of 0). The responses of the technology majors is also interesting. A similar trend is seen in the technology majors. From the responses, the course appears to be relevant for the students, but the material is not perceived as useful. This result does not seem to make sense and is perhaps clouded by the low number of students in this category (n=5). Additionally, students are often confused thinking that engineering and engineering technology are the same (particularly first-year students). Thus, they may have responded similarly to the engineering students in question 3.

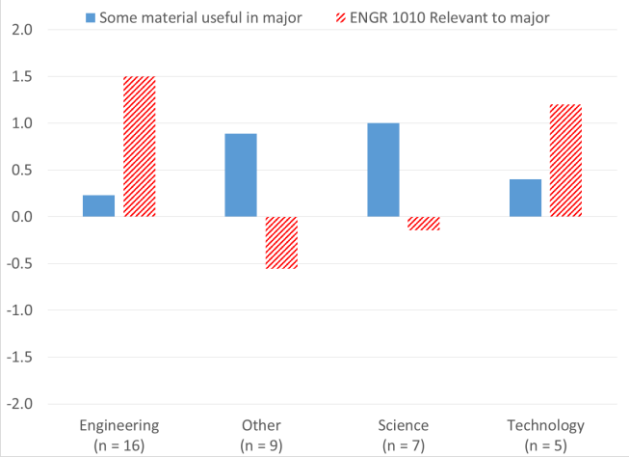


FIGURE 1
COMPARISON OF STUDENT PERCEPTION OF ENGR 1010 BASED ON MAJOR.

In an attempt to understand where non-engineering students had interests, the second portion of the survey asked the students to rate several topics covered in the course (listed in Table II). The selected topics were purposefully chosen such that there were some "Engineering-tools" topics (Units and Excel), some engineering-specific topics (Introduction to Engineering and Engineering Design Process), more general topics that might be applied in any field (Teamwork and Ethics), and finally topics related to societal/humanities aspects. The aviation and civilization topics were presented as historical perspectives, highlighting the interaction and influences of society and engineering during the evolution of the two technology areas.

TABLE II
COURSE TOPICS SURVEYED

| Topic |
|---|
| • Introduction to Engineering |
| • Units and Unit Conversions |
| • Engineering Design Process |
| • Teamwork |
| • Using Microsoft Excel |
| • Engineering and Society: Civilization |
| • Engineering and Society: Aviation |
| • Engineering Ethics |

One might expect the non-engineering majors to have more interest in topics that were more general and not as math intensive such as the topics related to the interaction between engineering and society. However, it appears the opposite may be true; the non-engineering students found the engineering-tools topics to be more valuable. The students were asked to select topics they felt were valuable, and to also indicate which topics they felt were not useful. The responses are represented numerically with a value of 1 being valuable, -1 being not useful, and a value of 0 for no indication of either from the student. The figures show the average of the responses for each category presented in the figure. Thus, positive values indicate that the majority of students found that particular topic useful. Conversely, negative values tend to indicate students did not see a particular topic a useful. Figure 2 shows the average scores for each topic. The data show that students in all different majors found the engineering and math related topics useful. Additionally, one can see from the figure, team, ethics and the societal topics were not found as valuable and had much greater variation amongst the majors. Each type of topic will be explored in more detail in the following discussion.

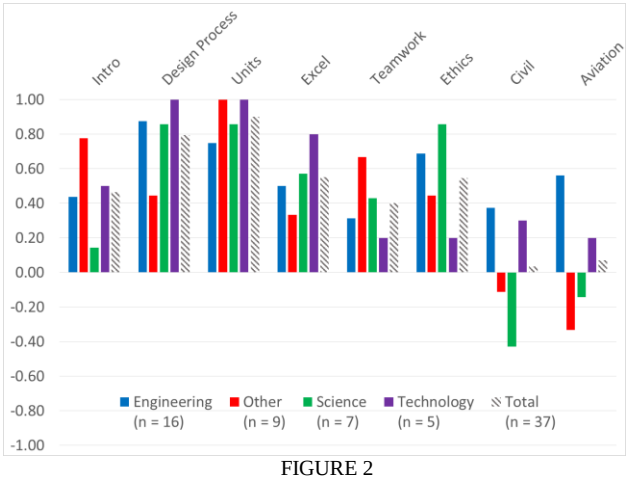


FIGURE 2
AVERAGE OF RESPONSES FOR VALUE FOR ALL TOPICS (VALUABLE = 1, NOT USEFUL = -1).

Figure 3 shows the survey results for the engineering tools topics. Across the board, students felt that learning about units and unit conversions and learning about how to generate, manipulate and plot data as valuable. This was somewhat of a surprise to the author, because comments made by students during class and office hours tended to indicate a fear of math and calculations in many of the non-science majors (such as "afraid of" or "not good at" math).

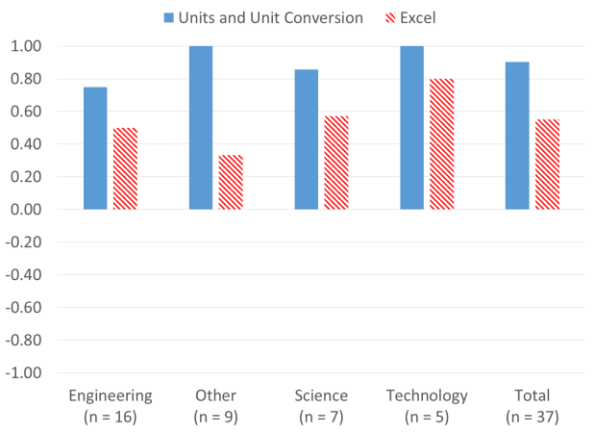


FIGURE 3
AVERAGE OF RESPONSES FOR VALUE OF "ENGINEERING TOOLS" COURSE TOPICS (VALUABLE = 1, NOT USEFUL = -1).

Almost as much of a surprise, the students responded that the engineering specific topics were very valuable (Figure 4). Perhaps most interesting of all, the non-science majors found the introduction to engineering topic even more valuable than the engineering students did (and the science majors). Some of this may be explained by the fact that several students provided additional comments that they would like to see more detail presented in this section. Thus, perhaps the engineering students found it less valuable because they did not have enough detail.

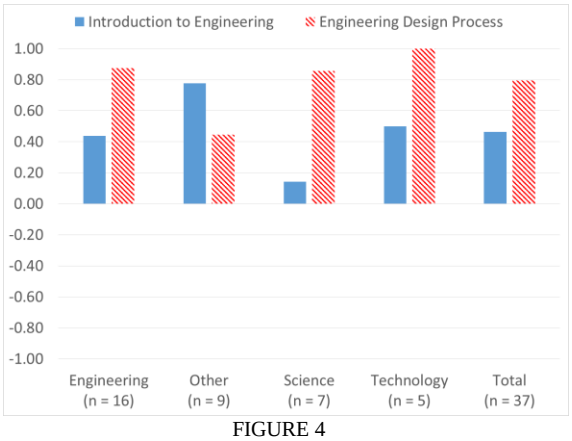


FIGURE 4
AVERAGE OF RESPONSES FOR ENGINEERING-SPECIFIC COURSE TOPICS (VALUABLE = 1, NOT USEFUL = -1).

Interestingly, topics that might be expected to apply across many disciplines were not as valued by the students. Figure 5 shows the survey averages students perceived value of the Teamwork and Ethics modules. While the results are positive (more students found the sections valuable than did not), the response was not as high as the topics previously discussed. Obviously, these two topics apply nearly across the board to different fields, so it is worth noting a couple of items. The reader should keep in mind that the different topics are taught using very different teaching methods. For example, unit-conversion is focused on mathematical techniques and individual problem solving, while teamwork and ethics involve group work, class discussions, and open-ended questions without a clear 'right' answer. The author will readily admit that he finds these topics more difficult to teach and assess accurately. Thus, the student responses may also reflect these differences in their responses. Additionally, since the majority of these students are freshman, they are typically focused on their grade. Therefore, an assignment without a clear answer causes concern. Also, they may not have a full understanding of the importance of these topics in their college success and future career at this point.

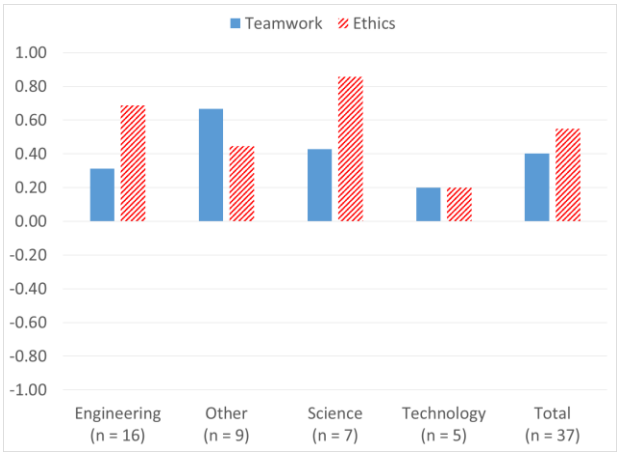


FIGURE 5
AVERAGE OF RESPONSES FOR TEAMWORK AND ETHICS COURSE TOPICS. (VALUABLE = 1, NOT USEFUL = -1).

Finally, Figure 6 shows the responses for the two topics most closely associated with humanities and social issues. As with the Teamwork and Ethics topics, these do not fit the typical 'problem solving' model familiar to most engineers. Thus, the same caveats mentioned for the Teamwork and Ethics topics apply here. In this case it is also worth mentioning that the instructor for this course has an aerospace engineering background. Thus, some of the difference between the two topics may be attributable to the enthusiasm and additional knowledge presented by the instructor rather than some real trend between civilization and aviation.

However, it is interesting to note that the class seems to split on these topics. The engineering and technology majors enjoyed or saw value in these topics, but non-engineering students did not. The most straightforward explanation seems to come from the additional comments made by students on the survey. One of the aspects many students

enjoyed about the class was that it made the connection between engineering and real-world applications. One could perhaps draw the conclusion that the engineers and technology students saw how their major applies and has value to society, while students not majoring in engineering do not connect to this topic.

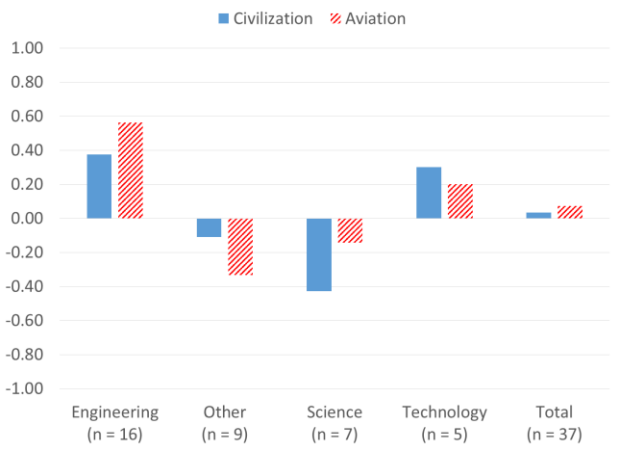


FIGURE 6
AVERAGE OF RESPONSES FOR SOCIETAL COURSE TOPICS. (VALUABLE = 1, NOT USEFUL = -1).

As was mentioned previously, one of the reasons for conducting the survey was to determine what material should be shifted from ENGR 1010 to the engineer specific course (ENGR 1000). The seemingly obvious answer is that the topics specific to engineers and their success are the appropriate topics. Thus, topics like an introduction to engineering that helps students understand what engineering is and the various disciplines within the field. Also one might think including modules on skills engineers might need such as understanding dimensions and units and giving the students some skills in manipulating and graphing data. Yet, many of these topics are valued by the non-engineering students taking ENGR 1010, so completely shifting them out of the class is most likely not the solution (assuming the intent is to keep ENGR 1010 a course available and interesting to all students). Another thought might be to keep ENGR 1010 material and focus on additional topics in the new course. Unfortunately, part of the reason the new course is being created is that several of the topics are not covered in adequate depth in ENGR 1010 for the very reason that it is designed to attract non-engineering students. Conversely, while engineers should be familiar with societal issues, the primary reason ENGR 1010 is accepted as a humanities course is that it examines societal issues from an engineering perspective.

## CONCLUSIONS AND RECOMMENDATIONS

While it is admitted that the data-set is not large, survey results from the introductory engineering course at Southern Utah University tend to indicate that non-engineering major students value several aspects of the course traditionally directed specifically towards the engineers in the class. In addition to collecting more data from future classes, the survey needs to be clarified in an attempt to get the students more clearly identify their perceived value of various topics. However, the data do indicate that non-engineering students find value in engineering-related topics. Thus, courses such as ENGR-1010 could be used to not only broaden the awareness of engineering students to society, but also to introduce other students to the value and benefits of engineering.

## ACKNOWLEDGMENT

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## REFERENCES

[1] ASCE Body of Knowledge Committee 2008, *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*, second eition, 2008, pp 117-118.

[2] Southern Utah University, "2016-2017 General Catalog," http://catalog.suu.edu/.

[3] Dey, Pradip Peter, et al., "Emerging Paradigms in Engineering and Science Education", *American Society for Engineering Education, Pacific Southwest Conference 2015 Conference Proceedings*, San Diego, CA. April 10-11 2015, pp 19-27.

## APPENDIX

*I. Course Survey*

Questions for Engineering the 21st Century, ENGR 1010

General Information:
Major:_____
Reason for taking ENGR-1010:
_____

Please use the following scale to rate the statements relative your about ENGR-1010 "Engineering in the 21st Century."

1 – Strongly Disagree
2 – Disagree
3 – No opinion
4 – Agree
5 – Strongly agree

1) _____ ENGR-1010 is relevant to my major and/or my envisioned career.

2) _____ My interest in majoring in engineering has increased because of this course.

3)_____ Even though I do not intend to major in engineering, I will apply some of the material learned in my chosen field.

Please put a check (√) next to the topics that are most useful and an 'X' by the topics that were least useful.

_____Introduction to Engineering
_____Unit conversions
_____Engineering Design process
_____Teamwork
_____Using Excel in engineering applications
_____Engineering and Society: Civilization
_____Engineering and Society: Aviation
_____Engineering Ethics

What did you enjoy most about the course?

What do you feel needs improvement?

Additional comments: