An Examination of the Factors that Influence Students' Capstone Project Choices*

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During the project selection phase in a capstone course, it is often the case that some projects are more popular than others. To understand the factors students consider when selecting a capstone project, Mechanical, Biomedical, and Electrical engineering students were surveyed. An initial survey in 2015 of 83 participants rated how important each of 14 pre-determined factors were in their recent individual project selection process. The data was analyzed to determine the relative importance of the factors. A second survey was conducted in 2016 with 69 participants using a slightly modified set of 18 pre-determined factors. The results of these two surveys were consistent and showed that a majority of students are taking into account a diverse range of factors when they select their capstone projects. The top rated factors in both surveys relate to three main areas: (1) to gain experience in a particular field or technology, (2) the desire to work with industry partners and (3) the quality and completeness of the information about the particular project available at bidding time. These results are used to identify some specific actions that can be taken to significantly increase the chance that students have a positive educational experience in capstone courses.

Keywords: engineering capstone design; project selection; survey; student opinion

1. Introduction

The formation of project teams and the matching of teams and projects are challenging issues in capstone design courses [1, 2]. A related question that has received much less attention is what drives student interest in particular projects. In other words, if students are given the option to rank project preferences as a part of the team and project matching process, why do they prefer certain projects? In fact, only one study could be found that addressed this question [3].

Interest in students' perception of projects was motivated by the project assignment process used in the capstone engineering courses at the University of Texas at Dallas (UTD). Project assignment is done using a bid process that involves students ranking their project preferences from a list of available projects. In reviewing the project bids, it is usually the case that some projects are very popular while others are not. This observation prompted the more general question of why students prefer some projects over others.

Anecdotal evidence suggested that students were considering factors such as exposure to a preferred employer, familiarity with the project topic, and whether the project appeared to be "easy" or "hard". In a couple of instances, students asked not to be matched with projects that involved controversial topics such as animal experimentation or military weapons systems. Beyond this, one can wonder how much peer pressure, the ability to immediately envision a solution, or perhaps some personal life experience influences project choice.

To help answer the question about why students prefer certain projects, a study was conducted to discover what factors students consider when selecting a capstone project. Two separate cohorts of capstone students were surveyed to gather responses to a set of pre-determined project selection factors. The results of these two surveys conducted in Fall 2015 (Year 1) and Fall 2016 (Year 2) are analyzed and presented here. It is expected that a better understanding of the factors that influence project choice will help to improve the educational experience in capstone courses by enabling instructors to offer appealing projects that excite and engage students.

2. Background and methodology

At UTD, two-semester engineering capstone projects are completed by students in the Mechanical (MECH), Biomedical (BMEN), and Electrical engineering (EE) departments. Both the mechanical and biomedical engineering departments are relatively new additions to the UTD engineering school with the capstone course being first offered in these departments in Fall 2012 and Fall 2014, respectively. Although the electrical engineering department is older, their capstone course switched to the current format in 2013.

At the beginning of the semester, the set of available projects is presented during one of the

first class meetings to the students in each departmental capstone course. The respective instructors, or, in some cases, a sponsor representative, explain the background, objectives and deliverables of each project using slides that are prepared by each sponsor based on a provided template. The capstone instructors review the projects in advance and determine the disciplines required (BMEN, MECH, EE) for each project. These requirements are communicated to the students at the time projects are presented. Time is allowed for students to ask questions after each project is described. The slides and any other sponsor provided materials are also made available to the students afterward. As much as possible, all projects are presented equally (i.e., without expressing any opinion on expected difficulty level, workload expectations, etc.). Students are also not specifically coached to look for factors that might lead to a more successful project (e.g., well-defined requirements).

Following the project presentations, students are given a few days to consider their choices and submit their bids. No specific instructions or advice are provided to the class about what factors they should consider when selecting projects. Each student completes a bid form that captures information on skills, interests, electives completed, hands-on experience, etc. The form also includes a table in which students rank their project preferences. On the bid form, students can express a preference for working with particular classmates, but it is made clear that it may not be possible to honor all such requests. Team formation and project matching are done by individual instructors using information from the bid form and student résumés. Every effort is made to place each student on one of their top project choices or with their preferred team members, which we believe helps their motivation level.

To gain some insight into the project selection process, data was gathered using a voluntary on-line survey that was distributed to Mechanical, Biomedical, and Electrical engineering students in the Fall 2015 and Fall 2016 semesters (UTD IRB Approval No. MR 15-226). The survey was sent shortly after project assignments were completed so that the project selection experience would be fresh on the minds of students. Students were excluded from participating in the survey if they were on teams that proposed their own project topic. Therefore, all of the students receiving the survey had the option to pick from among the available set of industry- and faculty-sponsored projects. This distinction was made because it did not make sense for students who worked on their own project to participate in the survey since they did not actually select a project.

The survey asked respondents to identify their engineering major, gender, and to rate the importance of each of a set of pre-determined project selection factors. The factors on the survey were generated based on the authors' experience and perception of what considerations they believed might be important to students in the project selection process. In response to the question: "How important were each of the following factors in your project selection decision?", respondents were asked to evaluate the importance of each factor on their personal project selection process using a 5-point rating scale (*Very Important, Important, Moderately Important, Of Little Importance, or Unimportant*). The factors were presented to all participants in the same order and the order had no particular significance. The 14 factors included in the Year 1 survey are as follows:

1. Perceived level of project difficulty.
2. Desire to work on an industry-sponsored project.
3. Desire to work on a faculty-sponsored project.
4. Quality of information available before selection.
5. Previous knowledge, experience, or familiarity with project technical area.
6. Being able to envision one or more possible solutions to solve problem.
7. Desire to gain exposure to a company for employment or internship opportunities.
8. Reputation of company sponsoring project.
9. Desire to gain experience in a particular field or with a specific technology.
10. Project had well-defined requirements and goals.
11. Potential impact of project or value to sponsor.
12. Positive or negative social or ethical considerations.
13. Desire to work on a project with friends.
14. Project involved a topic that was personally relevant or important.

For the Year 2 survey, some revisions were made to the set of project selection factors based on feedback received from the presentation of the preliminary results at the 2016 Capstone Design Conference [4]. It was believed that more detailed information could be obtained by splitting the factors related to project difficulty (Factor 1) and social and ethical considerations (Factor 12) so that respondents could express a definite opinion. Therefore, these two factors were removed from the survey and each was replaced with a pair of more specific factors. In addition, two completely new factors were added. To summarize, the changes made in the Year 2 survey were the removal of Factors 1 and 12 above, and the addition of the following factors:

15. Wanted a project that would be a challenge.

16. Wanted a project that would be easy
17. Positive social or ethical considerations.
18. Negative social or ethical considerations.
19. Opportunity to innovate and develop something that is potentially patentable.
20. Desire to work on a multidisciplinary project with teammates from outside my discipline.

In the Year 1 survey, valid responses were obtained from a total of 83 students. In the sample, there were 63 males and 20 females. The departmental distribution was as follows: Mechanical = 27, Biomedical = 26, and Electrical = 30. In the Year 2 survey, valid responses were obtained from a total of 69 students. In the sample, there were 51 males and 18 females. The departmental distribution was as follows: Mechanical = 30, Biomedical = 24, and Electrical = 15.

3. Results and discussion

To create a convenient metric for use in judging the relative importance of the project selection factors, the percentage of *Important* and *Very Important* responses were summed for each of the project selection factors. The rationale for this approach is that the top two ratings express a definite preference for a given factor while the other ratings show a neutral or negative response for the factor. Unless otherwise specified in the following, the "rating" of a factor refers to the combined percentage of respondents rating that factor as either *Important* or *Very Important*.

3.1 Overall ratings

The overall results obtained from the Year 1 and 2 surveys are presented in Figs. 1 and 2, respectively. The factors in each figure are organized and ranked by rating (i.e., the combined percentage of respondents rating a given factor as *Important* or *Very Important*). It can be seen that in Year 1 more than half of the students surveyed rated 11 of the 14 factors above 50%, meaning that these factors were seen as being either *Important* or *Very Important* in their project selection process. In Year 2, 13 of the 18 factors were rated above 50%. The fact that most of the factors in the survey are rated above 50% by a majority of students shows that students are taking into account a diverse range of factors when they select their capstone projects.

In the Year 1 survey, working with friends, ethical considerations, and wanting to work on a faculty-sponsored project were rated under 50% meaning that these factors were seen as being either *Important* or *Very Important* by less than half of the students. The same factors again appeared under the 50% rating threshold in the Year 2 survey. In addition, the newly-added factors related to multidisciplinary projects and projects that were perceived to be easy were also not considered *Important* or *Very Important* by a majority of students.

As many factors were rated above 50%, the data was further analyzed to determine which factors students considered *Very Important* in selecting projects. This breakdown is also shown in Figs. 1 and 2, and Table 1 displays the factors that received 30% or higher ratings in at least one of the two
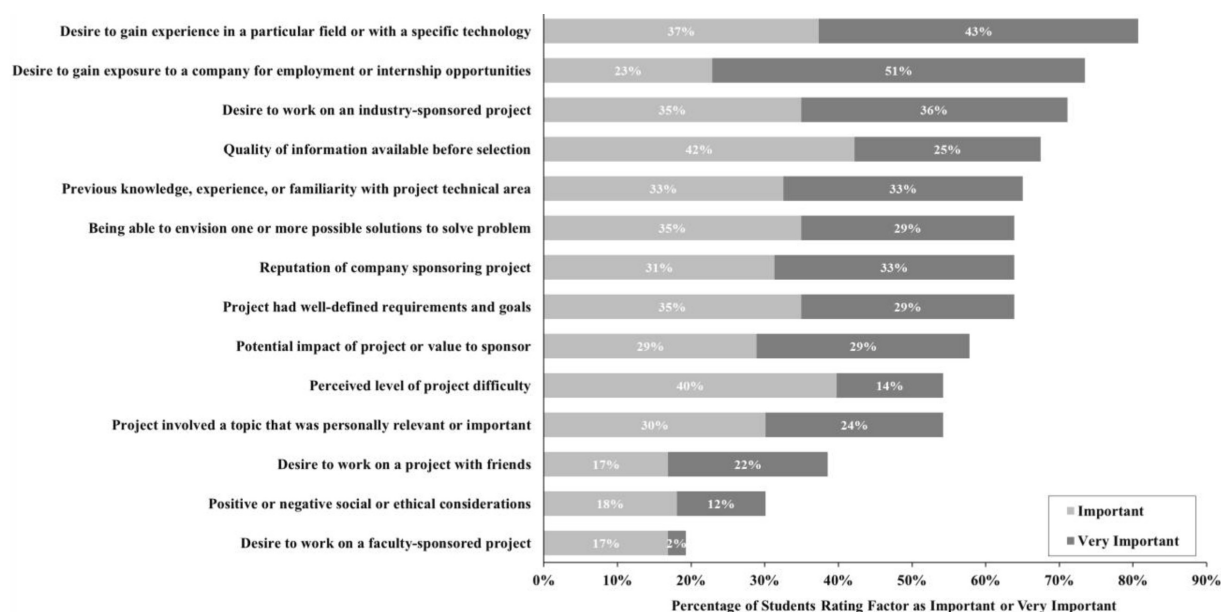

Fig. 1. Percentages of the 83 respondents from the Year 1 survey rating each project selection factor as either *Important* or *Very Important*.
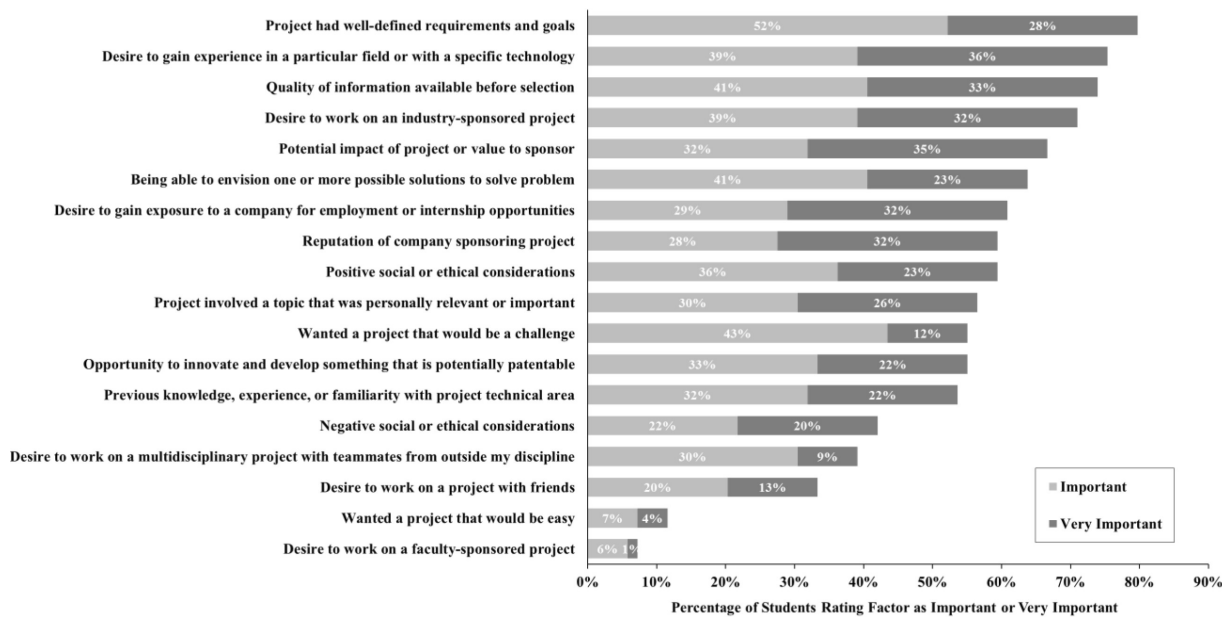
Fig. 2. Percentages of the 69 respondents from the Year 2 survey rating each project selection factor as either *Important* or *Very Important*.

Table 1. Factors rated as *Very Important* by more than 30% of respondents in at least one of the two cohorts

Factor	Percentage Rating Factor as Very Important	
	Year 1	Year 2
Desire to gain exposure to a company for employment or internship opportunities	51%	32%
Desire to gain experience in a particular field or with a specific technology	43%	36%
Desire to work on an industry-sponsored project	36%	32%
Reputation of company sponsoring project	33%	32%
Previous knowledge, experience, or familiarity with project technical area	33%	22%
Potential impact of project or value to sponsor	29%	35%
Quality of information available before selection	25%	33%

cohorts. The Year 1 survey revealed that only one factor ("Desire to gain exposure to a company for employment or internship opportunities") had more than 50% of students rating it as *Very Important*. One additional factor ("Desire to gain experience in a particular field or with a specific technology") exceeded 40% in the *Very Important* category, while three others ("Desire to work on an industry-sponsored project"; "Previous knowledge, experience, or familiarity with project technical area"; and "Reputation of company sponsoring project") were above 30%, giving a total of five factors rated above 30%. In the Year 2 survey, the highest ranked single factor had 36% of respondents rating it as *Very Important*. However, the Year 2 survey had six factors with more than 30% of students rating them as *Very Important*. Four of the five factors in Year 1 survey exceeding 30% were also above 30% in the Year 2 survey. The single exception was for the factor "Previous knowledge, experience, or familiarity with project technical area", which was rated *Very Important* by 22% of the respondents in Year 2. The two factors that exceeded 30% in Year 2 only were "Quality of information available before selection" which was 25% in Year 1 and "Potential impact of project or value to sponsor" which was 29% in Year 1.

3.2 Comparison of student cohorts

Since the survey was given to two student cohorts, it is possible to examine how the rating of the factors changed from year to year. These results are summarized in Table 2. The first column in the table lists the survey questions that were common to both years. The second and third columns report the combined percentage of *Important* and *Very Important* responses received in each year. The last column shows the absolute (not relative) change from Year 1 to Year 2 (i.e., Year 2 result–Year 1 result).

It is difficult to pinpoint specific reasons for these changes and it is possible that they are the result of natural variations between student cohorts. However, two-thirds of the year-to-year rating changes are less than ±10% and only one factor changed by more than 15%, demonstrating that overall there is good consistency in the ratings for the two independent cohorts. This consistency provides some addi-

Table 2. Comparison of responses for factors that were included in both the Year 1 and Year 2 surveys

Factor	Percentage Rating Factor as *Important* or *Very Important*		Change from Year 1 to Year 2
	Year 1	Year 2	
Desire to gain exposure to a company for employment or internship opportunities	74%	61%	–13%
Desire to work on a faculty-sponsored project	19%	7%	–12%
Previous knowledge, experience, or familiarity with project technical area	66%	54%	–12%
Desire to gain experience in a particular field or with a specific technology	80%	75%	–5%
Desire to work on a project with friends	39%	33%	–6%
Reputation of company sponsoring project	64%	60%	–4%
Desire to work on an industry-sponsored project	71%	71%	0%
Being able to envision one or more possible solutions to solve problem	64%	64%	0%
Project involved a topic that was personally relevant or important	54%	56%	+2%
Quality of information available before selection	67%	74%	+7%
Potential impact of project or value to sponsor	58%	67%	+9%
Project had well-defined requirements and goals	64%	80%	+16%

tional confidence in the results obtained. Some reasons for the differences between the results for the two student cohorts are discussed in the following section.

3.3 Discussion of factors

The survey results from both years showed that one of the most important considerations for students in selecting a capstone project is obtaining experience. More specifically, students view the project as an opportunity to get experience in a particular field or technical area. This could mean for example that a student prefers an oil and gas industry project because that is the field they intend to enter upon graduation. It could also mean that they selected a project based on a specific personal interest such as robotics or prosthetics. In either case, it appears that students are selecting projects that align with their personal interests and goals. Students seem to recognize the importance of experience and they view their capstone project as one way of building and customizing their experience.

The most recent decennial capstone design survey [5] found that industry/government followed by faculty were the two largest sources of capstone projects. The present results show that students place a high value on working on an industry-sponsored capstone project. There was a consistently high interest in industry-sponsored projects (71% in both years) while a preference for faculty-sponsored projects was the lowest ranked factor in both surveys (19% and 7%). In addition, the decreased interest in faculty-sponsored projects from Year 1 to Year 2 likely reflects the increasing emphasis that is being placed on industry-sponsored projects as the capstone program at UTD matures. Although the survey did not probe the reasons for such preferences, consideration of the other top-ranked factors makes it reasonable to assume that students are being career-minded in making project selections. They want projects that

give them experience with real-world engineering projects in their field of interest and exposure to potential employers. Employer reputation, which ranked near the middle of the factors, may also reflect this same reasoning. Similar benefits of industry-sponsored projects have been noted in other studies [6, 7].

In the Year 1 survey, the second highest overall ranked factor (and the highest factor ranked *Very Important*) was "Desire to gain exposure to a company for employment or internship opportunities". Although the rating of this factor decreased somewhat from Year 1 to Year 2, the Year 2 results still showed that 61% of students felt like it was either *Important* or *Very Important* to them in selecting a project. This suggests that career opportunities are a major driver in student project selection decisions. The results show that one reason students select projects sponsored by companies is that they hope to gain either an internship or full-time employment with the sponsoring company. In the authors' experience, student recruitment is one of the most frequently mentioned reasons companies give for wanting to sponsor a capstone project. In terms of recruitment, capstone projects are valuable to both students and sponsoring companies.

The results suggest that students give significant weight to their "comfort-level" with a project in the selection process. In other words, students are looking for projects that match their experience and that involve problems they think they know how to solve. The factor "Being able to envision one or more possible solutions to solve problem" was rated as being either *Important* or *Very Important* to 64% of students in both cohorts. A related factor "Previous knowledge, experience, or familiarity with project technical area" received ratings of 66% and 54% respectively for the two cohorts. The 12% decrease in the rating of this factor may be partly due to an increased emphasis on telling students prior to project selection that all projects

will require some self-directed learning of specialized skills and that they should not let the limitations of their current skill set discourage them from selecting projects that match their interests.

Among the factors that were added or refined for the Year 2 survey, it was disappointing to see that initially most students do not see the value in working on a multidisciplinary project. This has been an area of emphasis in the UTD capstone program, and at the end of the project students that were on multidisciplinary teams usually agree that the experience was positive, valuable and better emulates real-world design experience. On the other hand, it was encouraging to see that very few students (11%) are just looking for an easy project. In fact, the opposite appears to be true with 55% of those surveyed saying that a challenging project was either *Important* or *Very Important* to them. In addition to a challenge, students want a capstone design project that affords them an opportunity to innovate and make a difference for the sponsor. Ratings for both of these factors ("Opportunity to innovate and develop something that is potentially patentable" and "Potential impact of project or value to sponsor") showed that more than half of the students surveyed felt they were either *Important* or *Very Important* in their project selection decision. In short, these results suggest that most students want to demonstrate their engineering skills by working on a challenging capstone project that allows them to do novel work that matters to a client. These findings are consistent with the authors' experience in which they see students being more motivated on projects in which the students are doing original work that has the potential to make a significant impact for a sponsor.

Previous comments from students led to the inclusion of factors related to a project topic being something that was personally important or that a student liked or disliked from the standpoint of personal ethics or social considerations. For example, one student mentioned wanting to work on a particular project because a family member with a medical condition could be helped by the device that was to be designed. On the contrary, students have occasionally objected to working on projects sponsored by defense contractors. Selecting a project involving some personal relevance was an *Important* or *Very Important* factor to slightly more than half of the students surveyed in both cohorts. In the Year 1 survey, the "Positive or negative social or ethical considerations" factor received a 30% rating. Apparently, the wording of this factor was somewhat ambiguous in the survey because splitting it in the Year 2 survey yielded much different results, with 59% rating "Positive social or ethical considerations" as *Important* or *Very Important* while only

42% rated "Negative social or ethical considerations" as *Important* or *Very Important*. This confirms the anecdotal evidence about students taking their personal experiences and feelings into account in their project selection decision.

It is also encouraging to see that the ratings of factors that can directly influence the success of a project such as the quality of the information available before selection and whether the project had well-defined requirements and goals increased from Year 1 to Year 2. One of the biggest surprises in the Year 1 survey was that students did not rate well-defined requirements and goals higher. Perhaps a lack of experience led students to be less concerned about project requirements and goals. Then, in the Year 2 survey, the "Project had well-defined requirements and goals" factor jumped to an 80% rating and was the highest ranked factor in the survey. Despite students not being specifically told in class prior to project selection to look for these attributes, students seem to have a better awareness of their importance. One possible explanation is that the overall quality of the information presented to the students in Year 2 was higher, which led to an overall perception of better defined projects and drove the increase that was observed.

One of the lower ranked factors involved working with friends. As mentioned above, the project bid process allows students to suggest others that they would like to have on their team. If students do this, they are instructed to make sure that all the proposed team members are included on each student's bid and that all have selected the same project. The "working with friends" factor was included to see if students were changing their project preferences in order to be placed on a team with their friends. The consistently low ranking for this factor suggests that students are either not changing their project preferences to work with friends or perhaps groups that want to work together already have similar project preferences.

3.4 Gender and departmental affiliation

Figures 3 and 4 show the results broken down by gender and Figs. 5 and 6 show the results separated by departmental affiliation. There are, as would be expected, numerical and ranking differences in the importance metric (percentage of *Important* and *Very Important* responses) between males and females and between Mechanical, Biomedical, and Electrical engineering majors for each of the project selection factors. However, further analysis using the chi-square test showed that the differences for only two factors were statistically significant. A few other cases were marginal, but only the results for two factors strictly met the criteria for statistical significance ($p < 0.05$). Both of the following statis-
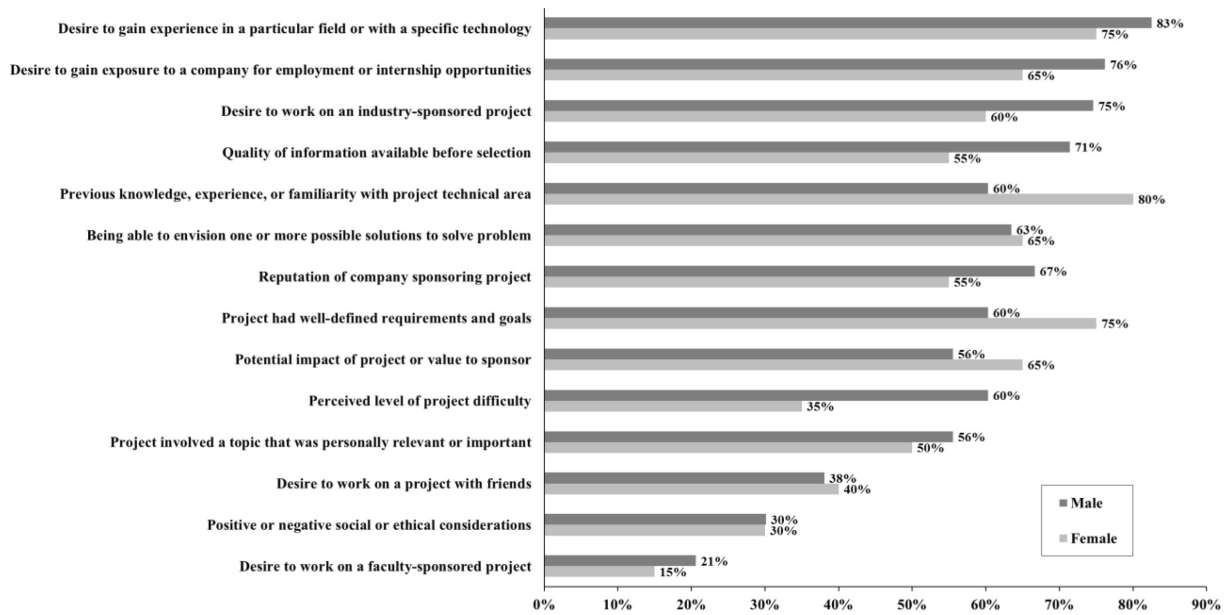
Fig. 3. Percentages of the total male and female respondents from the Year 1 survey rating each project selection factor as either *Important* or *Very Important*. Results shown as the combined percentage of *Important* and *Very Important* ratings.
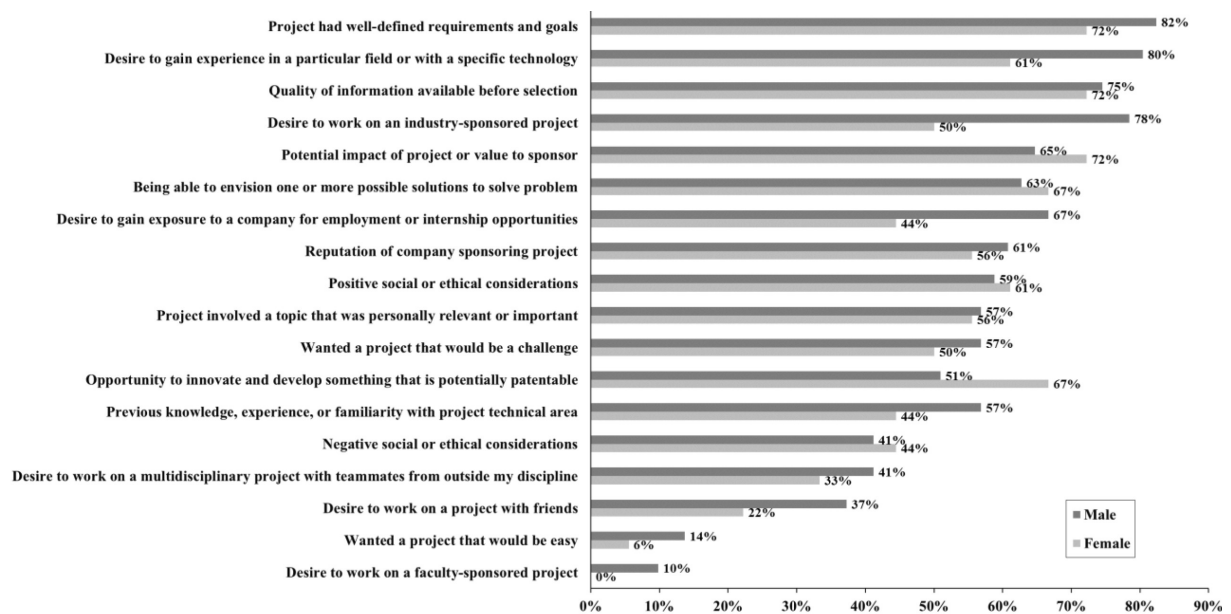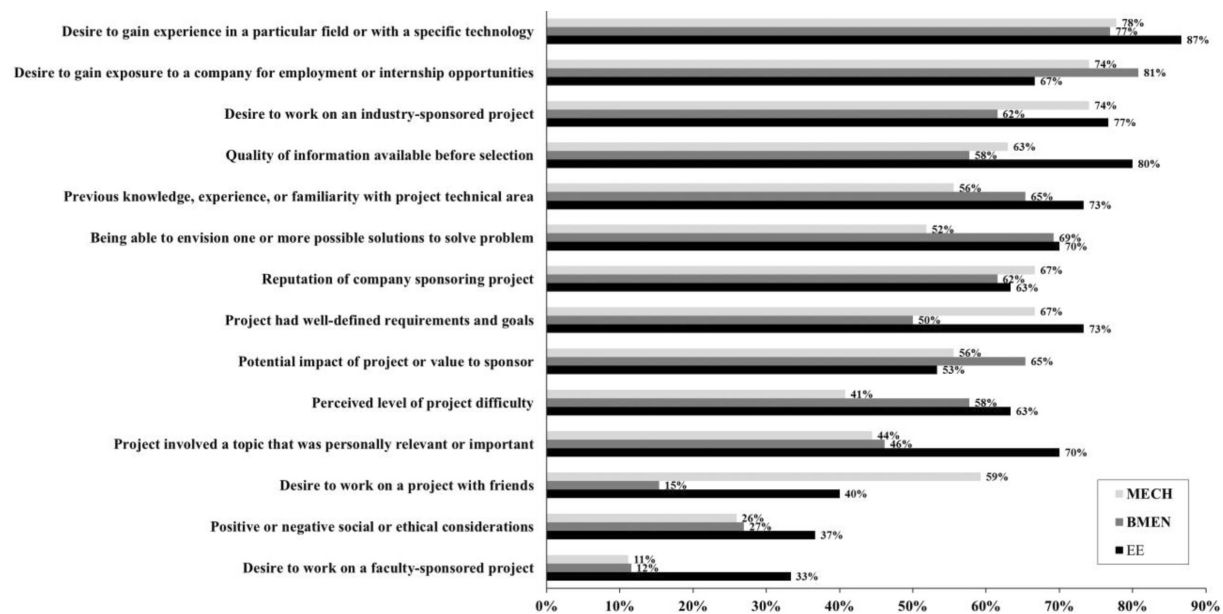

Fig. 4. Percentages of the total male and female respondents from the Year 2 survey rating each project selection factor as either *Important* or *Very Important*. Results shown as the combined percentage of *Important* and *Very Important* ratings.

tically significant results relate to differences seen among departmental affiliation: "Desire to work on a project with friends" in the Year 1 survey (p = 0.01) and "Being able to envision one or more possible solutions to solve problem" in the Year 2 survey (p = 0.04). No specific reasons could be identified for why there should be a departmental difference for these two factors. It should also be noted that due to the sample size, some of the requirements for the expected frequencies in the chi-square test were not met by the data that was

analyzed. In summary, it appears that the factors that influence the selection of students' capstone projects do not strongly depend on gender or departmental affiliation.

4. Implications for capstone courses

In light of what has been learned about the factors that motivate students when they select a project, what can be done to provide students with the best possible experience in a capstone course? Based on

Fig. 5. Percentages of the total respondents in each discipline from the Year 1 survey rating each project selection factor as either *Important* or *Very Important*. Results shown as the combined percentage of *Important* and *Very Important* ratings.
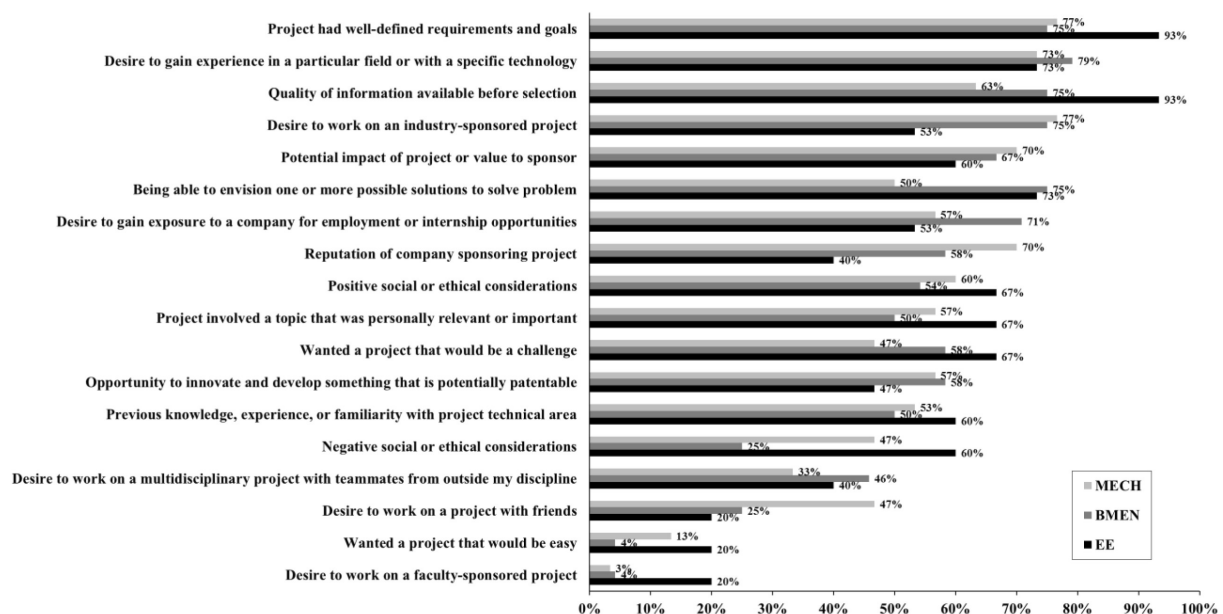
Fig. 6. Percentages of the total respondents in each discipline from the Year 2 survey rating each project selection factor as either *Important* or *Very Important*. Results shown as the combined percentage of *Important* and *Very Important* ratings.

the results found in this study, some recommendations are as follows:

- There is a strong preference for industry-sponsored projects. Students want both the experience and exposure offered by working with a corporate sponsor.
- Students view the capstone project as an opportunity to gain valuable experience. Ideally, a diverse range of projects should be available to the class to allow students to work on a project or in a technical area that is of interest to them.

- The quality of the information available at initial project presentation is important. Descriptions, slides and other materials should be carefully prepared so that students have a clear understanding of what a project involves.
- Project requirements and goals should be well-defined. It will be difficult for students (especially inexperienced students) to be successful if the sponsor cannot clearly articulate the project specifications and desired outcomes. Those responsible for soliciting and scoping projects

should work closely with sponsors to ensure that requirements and objectives are clear.

- Students tend to look for projects that match their previous knowledge and experience or projects where they can immediately see a solution. It would be good to remind students during the project section phase that they need not constrain their choices by these factors and that they will have time later to learn needed skills and develop a solution.
- Students do not seem to fully recognize the value of working on a multidisciplinary team when selecting projects. Perhaps being on such a team seems like more work to students and they do not appreciate what an important skill this is in industry. It would be beneficial to emphasize to students the importance of multidisciplinary skills. At the same time, educators should work across engineering departments to facilitate such projects.

Overall, we see a strong alignment between the type of projects that meet faculty requirements and the projects that students value when making their selections. Our program here at UTD is heavily focused on providing industry-sponsored projects, which we feel provides the best overall learning experience for our capstone students. As seen from the data, these are the projects that students overwhelmingly prefer.

5. Conclusions

A study was performed to understand the factors students consider when selecting a capstone project. Two cohorts of Mechanical, Biomedical, and Electrical engineering students were surveyed in Fall 2015 and Fall 2016 to determine the importance of a set of pre-determined project selection factors. Most of the factors in the survey were rated as *Important* or *Very Important* by a majority of students showing that students are taking into account a diverse range of factors when they select their capstone projects.

The top ranked factors suggest that students strongly prefer industry-sponsored projects to ones offered by faculty and they view the project as an opportunity to obtain engineering experience

in a particular field. Students are also using the project to gain exposure to a company for employment opportunities. Factors that ranked lower included working with friends on a project and seeking a project just because it appeared "easy". Other than two factors, no statistically significant differences were found with regard to gender or departmental affiliation. Taken together, these results point to some specific actions that can be taken to significantly increase the chance that students have a positive experience in capstone courses.

Further research is needed to confirm the trends and conclusions presented here. We plan to move forward with the Year 2 list of survey factors for future capstone cohorts to obtain longitudinal data. To determine if these results generalize to other capstone student populations, we have invited capstone instructors from other universities to participate, to broaden the data set beyond UTD.

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