

Student Perceptions of Course Projects as a Learning Tool

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As project-based learning is becoming more prevalent due to learning effectiveness studies, student perception of the effectiveness of various types of active learning needs to be assessed. A pilot study was conducted on twenty-three students in a junior level Machine Design course. These students came from two sections of the course, each of which had a course project. One course project was a sponsored design and build project and the other project was a close-ended analysis project. Students were aware of the type of project in each section when choosing a section.

Students in the section with the sponsored design and build project were surveyed before and after the course. Students in the section with the closed-ended project were only surveyed after the course. Each student was asked to evaluate the effectiveness of four types of course projects—Closed-ended (Closed), Open-ended paper (Open Paper), Non-sponsored design and build (Non-sponsor D&B), and Sponsored design and build (Sponsored D&B). The survey was conducted on a Likert scale with 1 being, “Not at all effective” and 5 being, “Extremely effective”. The questions asked were,

1. How effective were the projects you completed at reinforcing course content?
2. How effective were the projects at enhancing your creativity?
3. How effective were the projects at enhancing your open-ended problem solution skills?
4. How effective were the projects you completed at teaching design methodology (design process, morphological matrices, decision matrices, etc.)?
5. How effective were the projects at enhancing your teamwork skills?
6. How would you rate the projects on time spent vs. learning?

Scores were evaluated as not effective ($\mu < 3.0$), marginally effective ($3 \leq \mu < 3.5$), somewhat effective ($3.5 \leq \mu < 4$), effective ($4 \leq \mu < 4.5$) or very effective ($\mu \geq 4.5$) where μ is the mean value of the responses. Students who chose the course without the sponsored project consistently rated all projects as less effective than those who chose to participate in the sponsored project. Students believed that effectiveness of projects increased with increasing category for all questions surveyed except reinforcing course material where Open-ended projects scored the highest.

Future work will be conducted to assess student perceptions five years after graduation and to examine a larger cohort of students.

Introduction

This study aims to understand how students perceive the effectiveness of various types of course projects on a) reinforcing course content, b) increasing creativity, and c) open ended problem d) design methodology, e) enhancing teamwork skills and f) time spent versus learning. Four types of projects were investigated. The types of projects were classified as follows: Close-ended (Closed), Open-ended paper (Open Paper), Non-sponsored design and build (Non-sponsor D&B), and Sponsored design and build (Sponsored D&B).

Close-ended projects are generally expanded homework projects with one correct answer. Open-ended paper projects require the students to design a solution to a given problem. There is no one correct answer and students do not build a prototype. Non-sponsored design and build projects are projects that require the students to design and build a solution to a given problem. However, the projects are not sponsored by an external company or organization. Non-sponsored design and build projects often take the form of all teams in a class solving the same problem. Sponsored design and build projects require the students to design and build a solution to a problem proposed by an external sponsor. Generally, the external sponsor supplies resources to allow the students to realize their designs. Sponsors typically include companies looking to solve the problem and organizations without access to engineers. Most faculty agree that the higher the project category number, the more time and effort is required to set up, manage, complete and wrap up a course project. The authors are interested in determining if students perceive a benefit greater than or equal to the increased effort required by the faculty and students.

Methodology

The Students

Twenty-two students taking a junior-level machine design course were surveyed. The 4 credit course met twice a week and is a requirement for Mechanical Engineering students and a technical elective for Product Design and Manufacturing students. In the summer of 2015 there were two sections of the course offered. The first section of the course (32 students) required an externally sponsored design and build project in the second section of the course (38 students) required a closed-ended analysis project. Students knew the type of projects in each course before registering for the courses. The section containing the externally sponsored design and build projects required students to use design methods, like morphological matrices and decision matrices, to complete the projects. Students in the section with the closed-ended analysis project were not required to use any design methods to solve the problem.

Students were surveyed before and after the class. In the first section of the survey, students were asked to select the reasons why they chose the specific section. Answer choices provided to the students were a) formal advising recommendation, b) class days best fit my schedule, c) wanted design and build project, d) wanted analysis project, e) unknown, f) preferred professor and g) section availability. No limit was placed on the number of reasons a student could choose. To understand the data better, students' responses were grouped into the following 4 categories. Students in the "Expressed desire for design/build project" cited answer c) wanted design and build project as one of their reasons for selecting a section. Students in the category "in design/build class W/O desire" registered for the class with the externally sponsored design and build project but did not cite the project type as a reason for choosing the class. Students in the "after design/build" were in the class with the externally sponsored design and build project and completed the survey at the end of semester. Finally, students in the "in analysis class" registered for the class with the closed ended design project. In the second section of the survey students were asked to identify the categories of course projects they had completed in the past. If they had participated in different types of course projects and their perceptions of those projects.

Table 1 shows the number of students completing the survey for each project type. Since some students did not complete all types of project, individual project category numbers may not match survey categories.

Table 1—Sample Sizes for Each Group and Category

Sample Size	Answered Survey	Closed	Open Paper	Non-sponsor D&B	Sponsor D&B
Expressed Desire for Design/Build Project	3	2	3	3	1
In Design/Build Class w/o Desire	13	10	13	12	1
After Design/Build (3 no desire, 1 w/desire)	4	4	4	4	4
In Analysis Class	2	2	2	2	0

The Protocol

Students in the section with the externally sponsored design and build project were surveyed at the beginning of the semester. Each student was asked to evaluate the effectiveness of the 4 categories of course projects if they had reported completing that category of project in the past. The 4 categories of projects include: Close ended, Open-ended paper, Non-sponsored design and build, and Sponsored design and build. The survey was conducted on a Likert scale with 1 being, “Not at all effective” and 5 being, “Extremely effective”. The questions asked were,

1. How effective were the projects you completed at reinforcing course content?
2. How effective were the projects at enhancing your creativity?
3. How effective were the projects at enhancing your open-ended problem solution skills?
4. How effective were the projects you completed at teaching design methodology (design process, morphological matrices, decision matrices, etc.)?
5. How effective were the projects at enhancing your teamwork skills?
6. How would you rate the projects on time spent versus learning?

Students in the class with externally sponsored projects worked in teams of 4 to 6 students to design and build solutions to problems posed by external sponsors. For example, a local school for children with special needs requested a chair that was capable of bouncing the student without human intervention. Another team of students worked on a device to provide mobility to a 5-year-old child with cerebral palsy. Students in the section with the closed ended project analyzed the effects of a rotating unbalance in a given motor and gear mechanism. Students in the section with externally sponsored design and build project and students with the closed ended project were surveyed at the end of the semester. This research was reviewed and approved by the University’s human subjects research review committee.

Data Analysis

To understand the interplay between the students and the project selections they made as well as their views of the effectiveness of different project types, the data was analyzed in two ways. First the data from before and after the Machine Design courses was analyzed. This was to determine the effect, if any, that the sponsored design and build project had on student perceptions of project effectiveness. The second was to compare the views of students who chose the design/build course because of the project with those who did not list that as a reason as well as the students in the analysis course.

Due to small sample sizes on the sponsored D&B projects in the after the machine design course (1 respondent who wanted the category 4 project and 1 who did not) conclusions with respect to that category are very hard to draw. Further study is needed to determine the actual effectiveness of those projects. However, understanding that this is a pilot study, preliminary conclusions will still be drawn with the available data. Sample sizes for other category projects were larger.

Results

Design and Build Class

In general, students in the design and build course showed increasing satisfaction with increasing project complexity. However, their response before and after the course are interesting.

As can be seen in Figure 1, before the course, students rated closed ended projects as ineffective in all but reinforcing course content and time spent versus learning (somewhat effective) and open-ended problem solving skills (marginally effective). After the course, category closed ended projects were rated lower than before the course on all but increasing teamwork skills.

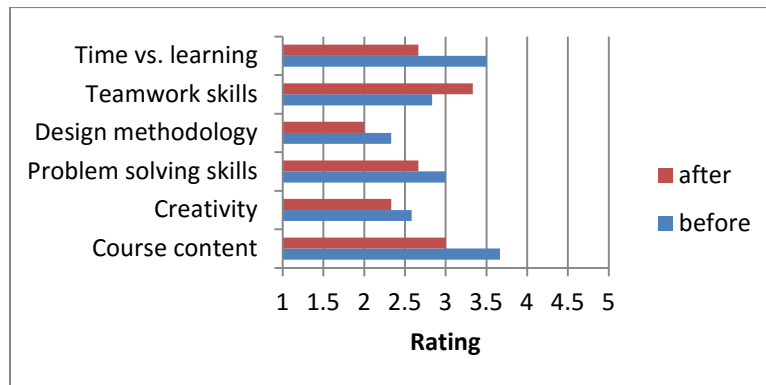


Figure 1—Closed-ended Projects Before and After Design and Build Class

Before the course, open-ended paper projects (Figure 2) were rated as marginally effective in reinforcing course content and time spent versus learning, somewhat effective in open-ended problem solving skills and teamwork skills, and effective in enhancing creativity and teaching

design methodology. After the course, the perceived effectiveness went down in all categories except teamwork skills and open ended-problem solving skills which stayed the same.

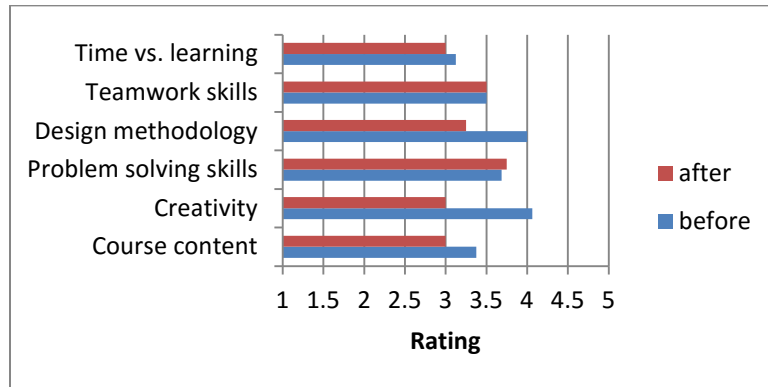


Figure 2—Open-ended Paper Projects Before and After Design and Build Class

Before the course, non-sponsored design and build projects (Figure 3) were rated as effective in all categories except teamwork skills where they were very effective and time spent versus learning where they were rated as somewhat effective. After the course, the ratings went down for all categories except enhancing creativity where they went up to very effective.

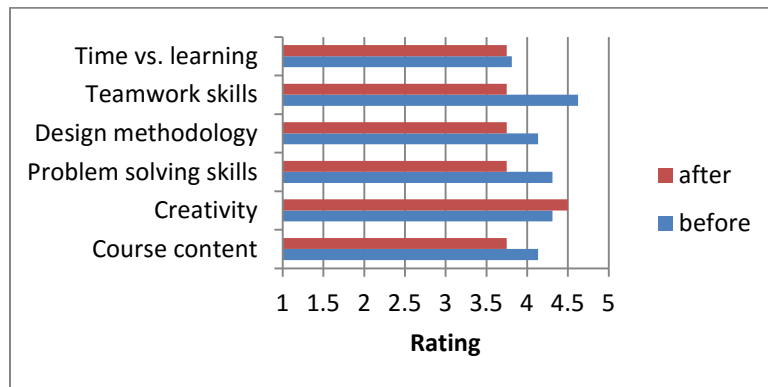


Figure 3—Non-Sponsored Design and Build Projects Before and After Design and Build Class

Before the course, sponsored design and build projects (Figure 4) were rated as very effective in all categories. After the course, the ratings remained the same for enhancing creativity, open-ended problem solving skills, and teaching design methodology. After the course, students rated sponsored design and build projects as effective in teamwork skills, somewhat effective in reinforcing course content and marginally effective in time spent versus learning all of which were lower than before the project.

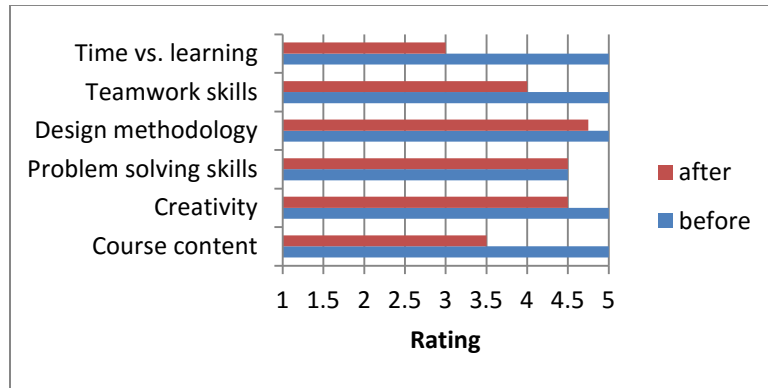


Figure 4—Sponsored Design and Build Projects Before and After Design and Build Class

Analysis Class

Figure 5 illustrates the results of the survey of students in the Analysis class. Students in the Analysis class rated closed-ended projects and open-ended paper projects as not effective at achieving all learning objectives. They also rated non-sponsored design and build projects as not effective in reinforcing course content. Overall, non-sponsored design and build projects were rated much better than closed-ended and open-ended paper projects by the Analysis class. Non-sponsored design and build projects were rated as effective in teaching teamwork skills, somewhat effective in teaching enhancing creativity, open-ended problem solving skills and time spent versus learning and marginally effective in teaching design methodology.

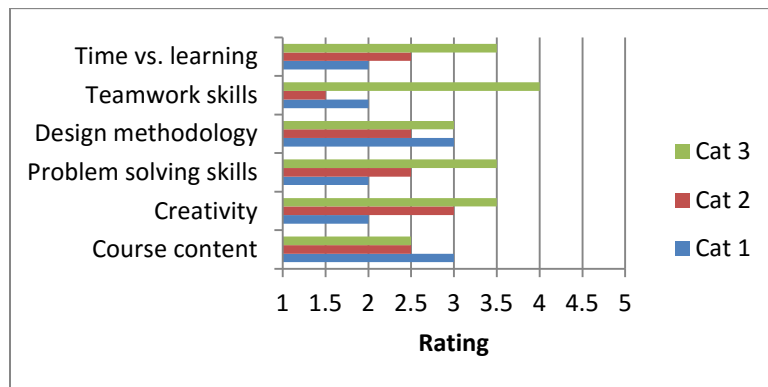


Figure 5—Survey Results from Analysis Class

Wanting Design and Build versus Not Interested in Design and Build

When answering the question, "How effective were the projects you completed at reinforcing course content?", results were very inconsistent (Figure 6). Students who wanted a design and build project ranked both open-ended projects and non-sponsored design and build projects as more effective. Open-ended paper projects were equally rated by both groups and sponsored design and build projects were rated better by those students who did not express an interest in a design and build project.

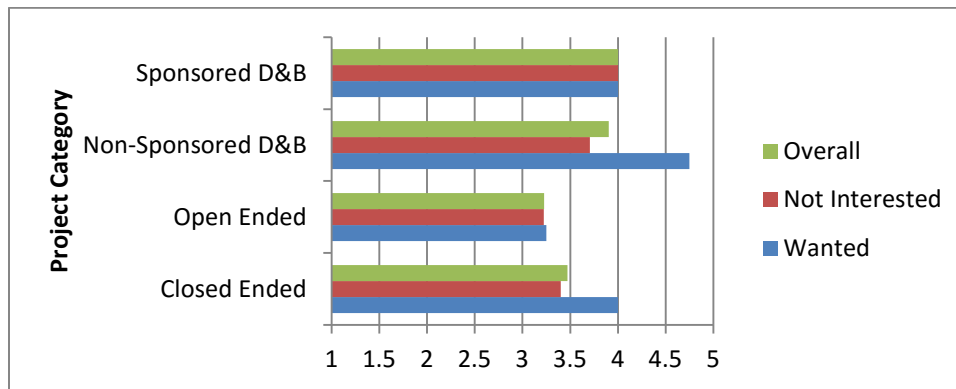


Figure 6—Survey Results from Question 1, Project Effectiveness at Reinforcing Course Content

When answering the question, “How effective were the projects at enhancing your creativity?”, Closed-ended projects, open-ended design and build projects and non-sponsored design and build projects were rated higher by the students who wanted to complete a design and build project (Figure 7). However, sponsored design and build projects were rated higher by those students who did not express an interest in completing a design and build project. Both groups rated higher category projects better with respect to enhancing creativity.

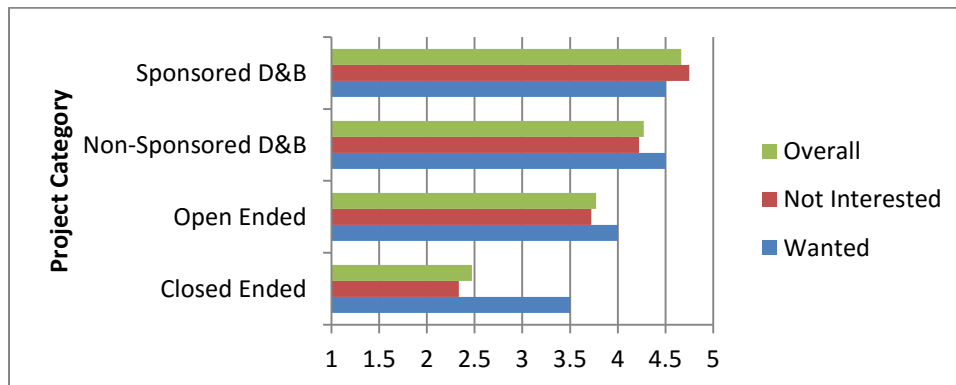


Figure 7—Survey Results from Question 2, Project Effectiveness at Enhancing Creativity

When answering the question, “How effective were the projects at enhancing your open-ended problem solution skills?”, students who wanted a design and build project consistently rated higher level projects higher (Figure 8). Both groups rated higher category projects better with respect to enhancing open-ended problem solving skills. The exception was students who did not express an interest in design and build projects rated sponsored design and build projects the same as non-sponsored design and build projects.

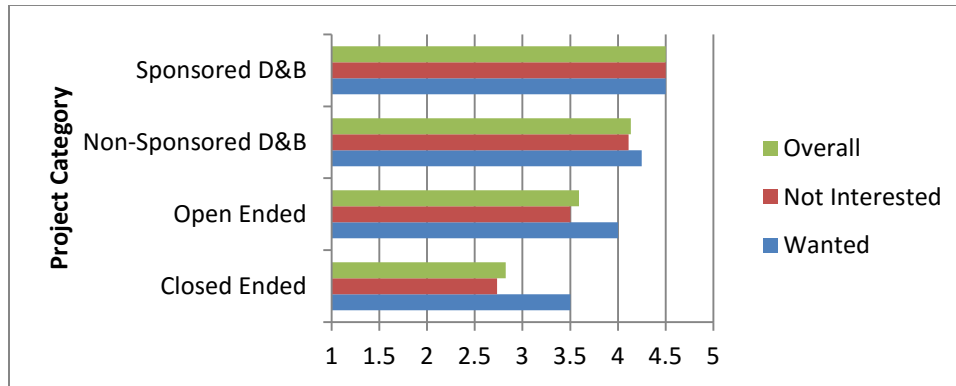


Figure 8—Survey Results from Question 3, Project Effectiveness at Increasing Open-ended Problem Solving Skills

When answering the question, “How effective were the projects you completed at teaching design methodology (design process, morphological matrices, decision matrices, etc.)?”, students who wanted a design and build project ranked both closed-ended projects and non-sponsored design and build projects as more effective. Open-ended paper projects were equally rated by both groups and sponsored design and build projects were rated better by those students who did not express an interest in a design and build project (Figure 9). Both groups rated higher category projects better with respect to teaching design methodology.

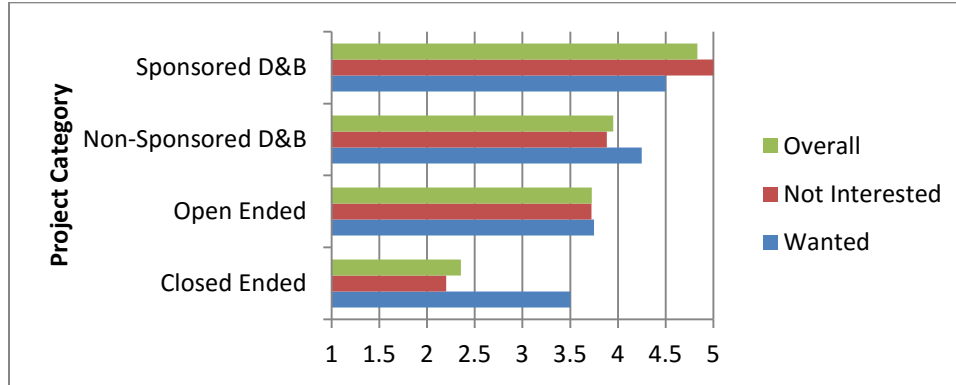


Figure 9—Survey Results from Question 4, Project Effectiveness at Teaching Design Methodology

When answering the question, “How effective were the projects at enhancing your teamwork skills?”, students who wanted a design and build project ranked both closed-ended and open-ended paper projects as more effective. Non-sponsored and sponsored design and build projects were equally rated by both groups (Figure 10). Both groups rated higher category projects better with respect to enhancing teamwork skills. However, the not interested category of students rated sponsored design and build projects as less effective in teaching teamwork skills than non-sponsored design and build projects.

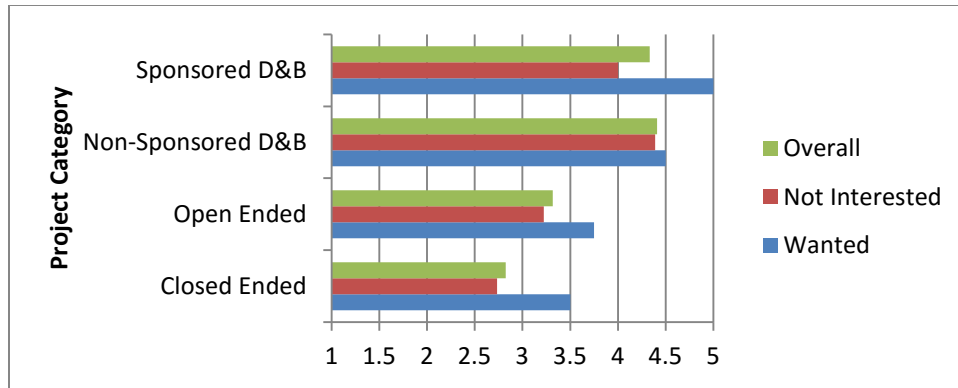


Figure 10—Survey Results from Question 5, Project Effectiveness at Increasing Teamwork Skills

When answering the questions, “How would you rate the projects on time spent versus learning?”, open-ended paper projects were the worst rated for both groups of students (Figure 11). For students who did want the design and build project, closed-ended projects and non-sponsored design and build projects were rated equally with sponsored design and build projects being the highest rated. For students who did not express an interest in a design and build project, with the exception of closed-ended projects, consistently rated higher-level projects higher. Students who wanted a design and build project rated closed-ended projects and non-sponsored design and build projects higher. These who did not express an interest in a design and build project rated open-ended paper projects and sponsored design and build projects higher.

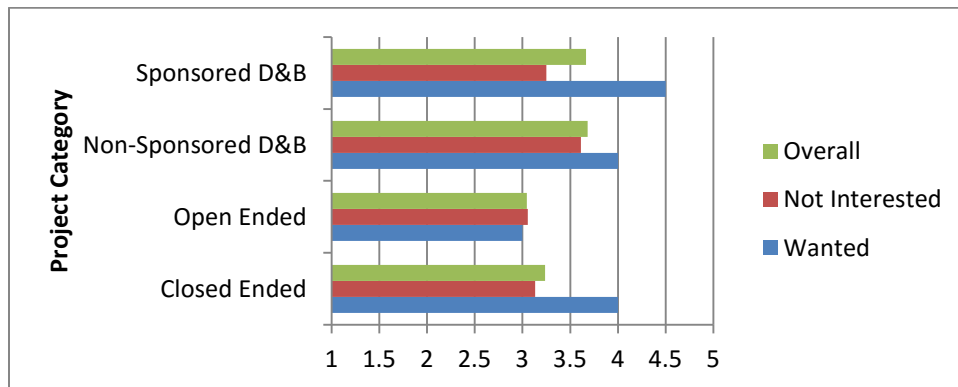


Figure 11—Survey Results from Question 6, Time Spent on Project vs. Learning

Course Selection

As a part of this research, the authors chose to try to understand student reasons for choosing one course over another. Students were allowed to select as many reasons as applied to their choice. Over 86% chose the section they were in because they preferred the professor making that the overwhelmingly most common reason. Only 22.7% stated they wanted the design and build

project and 4.5% wanted the analysis project. This left 72.8% who had ambiguous feelings about whether or not they completed the design and build project or the analysis project. Given this fact, it is difficult to discern a bias toward or away from projects from the data.

Table 2—Reasons for Choosing Section of Course

Reason For Choosing Section	Number of Respondents	% of Respondents
Preferred Professor	19	86.4
Class Days Best Fit Schedule	11	50.0
Section Availability	6	27.3
Wanted Design and Build Project	5	22.7
Formal Advising Recommendation	1	4.5
Wanted Analysis Project	1	4.5
Unknown	0	0

Discussion

Design Build Class

Overall, student perceptions of the effectiveness of all projects went down from the beginning of the project to the end. A variety of causes may be responsible for this decline. Students may have been fatigued from recently completing a major, extensive project (average student time spent around 80 hours during the semester) and therefore, less receptive to projects overall. Given time to recover from that fatigue, their responses may have been different. Another possible explanation is that, having completed the major design and build project, they perceived other projects as being less effective. This would be supported by Sponsored D&B projects being equally perceived or increasingly effective after the project. As there are only four data points for after projects and the two data points for Sponsored D&B projects before the course were both students who chose to take on another Sponsored D&B project, it is very difficult to form a valid conclusion about the reasons for this trend. It is also difficult to conclusively state that the trend is valid. As such, only hypothesis will be drawn to be verified through more extensive study.

Analysis Course

Overall, the views of students in the analysis course were less favorable on all levels of projects. This indicates there was a tendency of students who valued project experiences less to self-select into the course where a design and build project was not required.

Another interesting point is that students in this group found the Non-sponsored D&B projects to be at least marginally effective in all categories. This may suggest that students found design, build and test projects to be valuable in their learning.

Wanting Design and Build versus Not Interested in Design and Build

The first general trend is to note that, overwhelmingly, students perceived the more in depth projects as being more effective. The two exceptions to this are that in terms of increasing teamwork skills and time spent versus learning, Non-sponsored D&B and Sponsored D&B projects were even. As both faculty and student time and effort also increase with increasing complexity, it is difficult to draw a conclusion as to which type of project should be used in general. However, this does provide evidence that students understand that increased engagement yields increased learning.

Where there was a difference between students with a stated preference for the course with the design and build and those with no preference, those who chose the project consistently rated the effectiveness of projects higher than those without the preference.

Conclusions

The data indicate that further study is worthwhile and that the hypotheses that should be tested are:

- 1) Students find greater value in more difficult, more involved projects.
- 2) Student perceptions of the effectiveness of projects is influenced by completing higher level projects.
- 3) Students will self-select into courses with more extensive projects if they perceive projects to have more value.

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1. Chaparro-Peláez, Julián, et al. "Factors Affecting Perceived Learning of Engineering Students in Problem Based Learning Supported by Business Simulation." *Interactive Learning Environments* 21.3 (2013;2011): 244-19. Web.