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Multivariate Analysis of Students Perception on Teaching with Client Based and Non-Client Based Team Projects

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Abstract—The classroom experience has evolved from traditional lecture, PowerPoint and whiteboards to a more active environment where students and instructors work together on hands-on activities to achieve the course objectives. Various names have been given to this pedagogy; experiential learning, project based learning (client based versus non-client based), active learning, and problem based learning are a handful of names used to describe this evolving pedagogy. The main challenge faced by educators in educating undergraduate students to be independent thinkers and problem solvers has been the driving force fueling the shift in pedagogy. This research looks into student's perception on project based learning with client based and non-client based projects in terms of: the project as a learning device, contribution to research knowledge, motivation to learn, contribution to skills and personal benefits, and their effects on student evaluation of teaching and motivation to learn. From the study, both project types motivate students, but, the non-client based had a higher statistically significant mean than the client based projects.

Keywords—active learning, project-based learning, team projects, experiential learning

1 Introduction

The needs of students and the ways through which they learn varies from student to student. While some students prefer the traditional all lecture classroom, others prefer a more intimate classroom that allows students inputs and hands-on activities. Having hands-on activity in classroom make it more active and engaging, shifting the focus away from the educator to the entire class. This pedagogy ensures that students have a practical feel of the course content. Hence, experiential learning, project-based learning, problem-based learning, or active learning has become a common practice in most colleges in recent years. Active learning is defined as a pedagogical activity “involving students in doing things and thinking about what they are doing” [1, 2]. For a classroom activity to be considered as active learning, students must “do more than listening” [3, 4]. This concept of active learning has been embraced by numerous educators in colleges around the globe [5-8]. Bonwell [1] itemizes classroom discussion, small group discussions, and think-pair-share as examples of active learning.

Project-based learning (PBL) keeps students active inside (and outside) of the classroom just like the active learning examples given in the previous paragraph [9]. It offers students the opportunity to understand class material through investigation, detailed discussion, and questioning traditional knowledge and assumptions [10-12]. In effect, PBL helps to prevent classroom boredom. Problem-based learning is similar to project based learning, however, while project based learning gives students a lot of control on the project worked on, problem based learning is usually geared towards attaining a solution to a specific structured or unstructured problem. Experiential learning, project based learning, and problem based learning are all forms of active learning as defined by Bonwell and Eison [1], and have a lot in common.

Research has shown that students learn better [13-19] and get higher scores in a project based learning classroom than the traditional classroom [20]. According to Krajcik and Blumenfeld [10], project based learning starts with a problem or a question. With this problem, the students will explore by applying a wide array of ideas to get a better understanding of the problem. The students then work with their team members (if it is team based), educator, and client (if client based) collaboratively to propose solution(s) to the problem. Usually, students are progressively introduced to new concepts and ideas along the course of the project which they are expected to apply to refine their solutions. At the end of the project, project deliverables are presented to stakeholders [10].

Even though PBL comes with a lot of advantages, it also has challenges [21]. Sometimes, students feel overwhelmed when the problem is not structured. This may demotivate some students, hence, they must be coached by the instructor [22]. PBL, therefore, brings multiple challenges to educators; educators must decide whether to use a client based or non-client based PBL. These are inherently different on several aspects. For non-client based PBL, the instructor may serve as an internal client to the students, or assign hypothetical projects to the students. However, with client based PBL, students work with external clients different from the instructor of the class, and the client can either be a for profit or not for profit business, either of which can be a large, medium or small business [23]. The project can go on for few weeks, or throughout the entire semester. PBL can also be team-based or individual, and with varying amount of contact between students and clients [24-26].

Choosing between client based and non-client based projects is always a challenge. Each of them has pros and cons, and the onus lies on the instructor. It is worth mentioning that PBL in general has barriers that the instructor must be willing to accept. Specifically, client based projects may limit instructor-student contact hours as the students have to also be in contact with client and the project site. Since students have different schedules, it is sometimes difficult to find a time that works for all team members on a client based project for site or client visit. Hence, class times are sometimes the ideal time for the students to meet with clients. In addition, there is the possibility that some students may not actively participate in team based PBL. Moreover, it is very challenging implementing PBL in large classes. There is also the concern that instructor may lose control of the class, and some students may not learn class content sufficiently. Even though these challenges are real, detailed planning may help to mitigate them.

It is therefore imperative that engineering educators carefully consider the choice between client and non-client based projects, and plan their classes to ensure that the challenges posed by PBL do not oblique the potential benefits. This research studies student perception of client based projects and non-client based projects and how that may influence: course evaluations, motivation to learn, personal benefit, the project as a learning device, and contribution to research knowledge. Both the client and non-client based PBL have been utilized in project management classes since August 2015 in an engineering technology 4-year undergraduate program. The next section gives details about the background of the students.

1.1. Background of the students

The project management classes used for this research is a required class for all undergraduate students in an Engineering Technology 4-year undergraduate program in the USA. This class serves as the prerequisite for senior design capstone class, and is taken at either the sophomore, junior or senior level. Almost all of the students are engineering technology majors, with few students from business school and engineering science programs. In each fall semester (August – December), two sections of the class are offered, while one section is offered in spring semester (January - May). The majority of the students were males, and there was approximately a 50:50 ratio of domestic to international students.

Client based projects were utilized during the fall semesters, and non-client based projects were used during the spring semesters. All of the client based projects came from nonprofit organizations, with only one project from a medical manufacturing for profit company. Majority of the projects were assigned from nonprofit firms because the project management class has been used to serve the local community by working on nonprofit projects. This is critical to the mission of the academic institution and the department. In all, there have been a total of 184 students, of which 162 completed the end of semester course evaluation (student evaluation of teaching) which indicates 88% response rate. The students also completed a voluntary survey about their perception of the project work at the end of the semester. The perception survey was analyzed to determine the perceived impact of the project types on student's motivation to learn, project as a learning device, contribution to research knowledge, and skills and personal benefits.

A similar study of students perception on client based project versus non-client based group projects was conducted by Amy and Elzbieta [23] with business students. This research was structured in a similar manner. However, it takes the question a step further by looking into the effects of these PBLs on the end of semester student evaluation of teaching (SET) survey. The next section itemizes the research questions and the methodology used in answering the questions.

2 Research Questions

- i. What project type provides a higher motivation for students to learn?
- ii. Do students perceive client based and non-client based projects as equally useful learning device?
- iii. From the student's perspective, what project type contributes most to research knowledge?
- iv. From the student's perspective, what project type contributes most to skills and personal benefit?
- v. Does project type impact student evaluation of teaching?

3 Methodology and Data Collection

In an attempt to answer the above questions, a project management class taught in the school of engineering at a private university in Midwest (USA) was used. This class, taught at the undergraduate level by the same instructor, serves as a prerequisite for the senior design capstone class. Hence, it is required by all undergraduate majors in the department offering the course. The department has 4 different majors; approximately, 47% of the students were mechanical engineering technology (MCT) majors, 25% were Industrial Engineering Technology (IET) majors, 16% were Electronic and Computer Engineering Technology (ECT) majors, and 6% were Global Manufacturing Engineering Technology (GMT) majors. In addition, approximately 7% were students whose major were not engineering technology (either Operations & Supply Chain, Mechanical Engineering, or undeclared). In terms of their level of education, 39.13% were juniors, 44.57% were seniors, and 16.3% were sophomores.

The students who took the class during the fall semesters were given client based projects while those who took it in spring had non-client based projects. Some of the client based projects involved designing a product to meet specific needs of the client, or researching and proposing possible ways that a particular problem can be solved. For example, in one of the projects, one team designed an aquaponics system, while another team from the same class designed a hydroponics system. As part of the projects, they had to estimate the budget, risk involved, and limitations of their designs. The team that designed the aquaponics system had to also determine the fish breeds that could survive in the geographic region. Likewise, the hydroponics team also had to determine the breeds of plants that can be grown successfully using this system. As a trait of aquaponics and hydroponics systems, the waste produced by the living organisms in each subsystem serves as nutrients for the other subsystem under a controlled PH level. These teams worked for the same client, thus, there was a lot of coordination. Since each project served as a component of the client's single demonstrational farming system, the student teams had to work collaboratively, ensuring that the two designs were complementary and compatible; thus, applying the systems methodology approach to problem solving. After projects are introduced each semester, the students plan the project from the beginning to the end and schedule client

meetings. At the end of the semester, the clients usually attend the students' presentations to offer them feedback on their project.

In the spring semester, students worked on hypothetical projects with the instructor as the client. These projects are considered non-client based projects. In one such project, students had to research on the best use of a 37-acre parcel of land recently purchased by the university. As part of the project, they were required to design the facility recommended for the land, evaluate the pros and cons, identify risks, and estimate the budget for the project. All of the students in both project types submit project reports which followed the same format, and completed a 20-minute team presentation.

Similar to Amy and Elzbieta's [23] approach, a survey was conducted using a 5-point Likert scale (5 = strongly agree, and 1 = strongly disagree). The information gathered from the survey were based on a modified perceived skills theory designed by Goodell and Kraft [27], and they fell under the following broad areas: Skills and Personal Benefits; Contribution to Research Knowledge; Project as Learning Device; and Motivation to Learn. In addition, the students were given an open ended question seeking comments on anything that they would like to say. The questions are provided in the appendix.

4 Results and Discussion

Using the modified skills measure tool developed by Goodell and Kraft, [27], the perception of students on client based and non-client based projects were evaluated. Students Motivation to Learn, Skills and Personal Benefits, Project as Learning Device, and Contribution of Project to Research Knowledge were the four dimensions on which the evaluations were done. The questions in Goodell and Kraft's model were expanded to include 3 other questions (in the appendix) which reflects the nature that the classes were taught. The survey data was statistically analyzed using 2 (project types) x 2 (domestic vs. international students) x 3 (sophomore, junior, senior) MANOVA tests. Post hoc test (Bonferroni) was conducted to identify the variables that differ, and the results are summarized in table 1. The average (table 2) ratings for the project types are also provided for further interpretations. Additionally, the scale reliabilities (α) have been provided in the appendix for cross referencing.

From the results in table 1, there was a significant main effect on the project type as a motivation to learn (Wilk's Lambda = 0.32; $F = 85.45$; $p = 0.000$). It appears that the type of project had a statistically significant mean (3.78 for the client based and 3.82 for the non-client based) in terms of the motivation to learn. A significant main effect was also observed for academic level (Wilk's Lambda = 0.86; $F = 3.13$; $p = 0.002$) and motivation to learn. Generally, client based and non-client based were highly rated in terms of the motivation to learn. However, the non-client based was surprisingly rated higher than the client based project. This is consistent with the findings of Amy and Elzbieta [23]. In addition, there was no statistically significant difference in the projects in terms of the project as a learning device (4.45 for client based and 4.47 for non-client based projects), contribution to research knowledge

(4.32 for client based and 4.35 for non-client based projects), and skills and personal benefits (4.39 for client based and 4.38 for non-client based projects). It is worth mentioning that the statistical significance observed for *motivation to learn* and *academic level* do not necessarily imply practical difference.

Table 1. Multivariate and Between Subject Results

Independent Variable	Pillai's Trace	Wilk's Lambda	Hotelling's Trace	Roy's Largest Root	F-Value	Motivation to Learn	Project as Learning Device	Contribution to Research Knowledge	Skills and Personal Benefits
Type of Project	0.685	0.315	2.177	2.177	85.452**	341.674**	0.795	1.161	0.662
Academic Level	0.146	0.858	0.162	0.132	3.127**	10.284**	1.863	0.859	1.569
Nationality	0.006	0.994	0.006	0.006	0.247	0.018	0.977	0.571	0.144
Type of Project x Nationality	0.001	0.999	0.001	0.001	0.039	0.051	0.074	0.029	0.003
Type of Project x Academic Level	0.083	0.918	0.089	0.076	1.726	5.64*	0.73	0.306	0.69
Nationality x Academic Level	0.011	0.989	0.011	0.007	0.224	0.38	0.07	0.016	0.229
Type of Project x Nationality x Academic Level	0.01	0.990	0.010	0.010	0.403	0.097	0.381	0.001	0.737

Note: **p<0.01. *p<0.05

Table 2. Standard Deviations and Averages for Project Types

Perception Scale	Client Based		Non-Client Based	
	Mean	SD	Mean	SD
Motivation to learn	3.78	1.24	3.82	1.28
Project as Learning Device	4.45	0.78	4.47	0.65
Contribution to Research Knowledge	4.32	0.85	4.35	0.83
Skills and Personal Benefits	4.39	0.81	4.38	0.72

Domestic and international students rated the projects equally, as there was no statistically significant interactions between them in terms of motivation to learn, project as learning device, contribution to research knowledge, and skills and personal benefits. Also, there was no interaction effect between the type of project and nationality, nationality and academic level, and type of project and academic level. Similarly, there was no statistically significant interaction effect between the 3 dependent variables (type of project x nationality x academic level). However, the Bonferroni test

indicates that there was a significant difference ($p = 0.037$) between seniors (mean of 3.92) and sophomores (4.25) in terms of the project as a motivation to learn. Juniors had a mean of 4.05 which is statistically insignificant at $\alpha = 0.05$. For further interpretation of the parameters in table 1, the reader is referred to [28].

5 Conclusion

The results support existing literature on students perception about Project based learning (PBL). Generally, the results indicate that team PBL, whether client based or non-client based is highly regarded (above 3.7) by students as a great pedagogical tool. The students perceive that they are motivated to learn by either client based or non-client based projects. However, non-client based projects were preferred to client based projects. This may be attributed to the fact that client based projects require a lot of time and occasional revolving client demands which could lead to scope creep when students are unable to control the changes. Also, some client-based projects are unstructured and could equally result in scope creep if there are no strong project management skills.

The students also perceive PBL as a valuable learning device. They highly rated (above 4.4) the projects as contributing to their learning. On average, the non-client based projects were rated slightly higher than the client based projects. The same trend was observed for the contribution of the projects to their research knowledge. This was rated above 4.3 for both types of projects. In terms of skills and personal benefits, the two project types were highly (above 4.3) perceived. Whether international student or domestic student was not significant in the way that the projects were perceived as an educational tool. However, there was an interaction effect between the academic levels of the students and the project types. A Bonferroni post hoc test indicated that there was a significant difference between sophomores and seniors in terms of how they perceive the projects as motivation to learn. On average, the sophomores gave a higher rating (4.3) compared to the seniors (3.9) on the projects as a motivation to learn. Per the educational culture of the institution, students are exposed to PBL usually by their sophomore years and thereafter. So, it is possible that the seniors at that time, have already been exposed to myriads of PBLs and are less motivated by them than they were in their sophomore years. On the other hand, juniors rated the PBLs higher (4.1) than seniors even though it was not statistically significantly different from the sophomore's and junior's.

During the semester, some teams complained about the fact that clients were not responding to emails and phone calls timely. Others also had questions about some of the clients' expectations since the scope of the project was dynamic in some part. They talked about the fact that some clients do not really know what they want, even though that was part of the experience that the students were expected to get out of the client based projects. In addition, they complained about the amount of time involved in meeting the class requirements. Three exams, 4 quizzes, and 2 home works were given in addition to the project work, and the few students who answered the

open ended question did complain about these. The majority of the students did not respond to the open ended question.

The workload and uncertainties from the client increased frustrations and may have contributed to reasons why they rated the motivation to learn lower than the other three parameters. However, there was a sense of accomplishment when they were able to deliver project deliverables to the client. Therefore, it can be deduced that both projects help students to understand and apply the knowledge acquired from the class. However, the non-client based projects make students more comfortable since they are usually structured, and directly work with the instructor who will be easier to access than a third party client.

For faculties involved in courses that require PBL, this research suggests that both client based and non-client based projects are effective. However, time is needed to coordinate the projects between the students and the client. As explained by Amy and Elzbieta, [23], faculties must ensure that the project is appropriate for the class, ask for written statement of works, visit the project site, establish milestones, schedule student-client meetings, and ensure that timely feedback is provided to both the students and the clients. These will be challenging when class sizes are large, hence, further studies are needed to determine the optimum class size, team size, and the number of projects per instructor for client based projects.

In terms of the class performance and learning outcomes, there wasn't a clear distinction between the two project types. The exam scores were relatively comparable. It, therefore, was not surprising that the student evaluation of teaching (SET) surveys appeared to be on a par. As seen in the appendix, all of the 11 questions were highly rated by the students. The only notable difference was question 7: this course stimulated my interest in the subject. The students who had non-client based projects rated the class notably higher than the client based projects. This is noteworthy since the question has direct relationship with student motivation to learn for which a statistically significant difference was observed in the MANOVA statistical analysis. Finally, the research did not measure student's motivation in taking the class at the beginning of the semester. However, having that information will give more insight into their progress throughout the semester.

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8 Appendix

Students Evaluation of Teaching (SET) Report

Question	Average Score	
	Semesters with Client Based Projects	Semesters without Client Based Projects
The instructor seemed organized	4.76	4.80
I knew what I was expected to accomplish in this course	4.52	4.70
The instructor presented the subject matter clearly	4.62	4.80
The instructor created an environment that supported my learning	4.82	4.80
The instructor demonstrated a genuine interest in my success	4.80	4.80
The feedback I received from the instructor improved my learning	4.72	4.80
This course stimulated my interest in the subject	4.48	4.75
This course increased my understanding of the subject	4.66	4.80
I learned a great deal from this course	4.64	4.60
I would recommend this course to other students	4.66	4.70
I would recommend this instructor to other students	4.90	4.75

Survey questions

Motivation to Learn

- I prefer an all lecture course to the project.
- I preferred the project to analyzing case studies.
- The project increased my interest in the course.
- The case studies increased my interest in the course.
- The project made discussions in class more enjoyable.
- The case studies made discussions in class more enjoyable.
- The project was time consuming, but worth the time spent on it.
- I prefer to have the instructor as the client instead of an outside (real) customer.
- The client is committed to utilizing a portion, or all of my project report information.

Project as Learning Device

- The project made the subject matter realistic.
- I integrated the material in the course into the project.
- The project illustrated concepts in the course.
- The project will help me remember the material better.

Contribution to Research Knowledge

- The project illustrated practical problems with doing research.
- The project helped me understand client/customer needs.
- The project will help me to evaluate product/feasibility research done by outside professional engineers.

Skills and Personal Benefits

- The project helped me develop my teamwork skills.
- The project helped my report preparation skills.
- The project helped me develop my interpersonal skills.

Scale Reliabilities (α)

Motivation to Learn ($\alpha = 0.747$)
Project as Learning Device ($\alpha = 0.797$)
Contribution to Research Knowledge ($\alpha = 0.718$)
Skills and Personal Benefits ($\alpha = 0.795$)