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Evaluating Project Management Courses in Higher Education with Problem-Based Learning Game Theory

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Abstract

This study examines the effectiveness of problem-based learning with game theory versus thesis format in graduate project management degrees as the capstone course. The project management body of knowledge based on ISO was established as the rules of play with modifications to fit into the classroom context. We supplied a work breakdown structure (WBS) and project charter to reduce cognitive overload associated with the initiation phase instead of focusing on the planning phase, so strategic decision-making was needed other than producing a proposed project plan as the deliverable. We developed three scenarios to fill three sections: Buying a house, training staff, or selecting an enterprise system. We contrasted the satisfaction of the three sections and then measured how learning compares to our historical program benchmark. We used project sponsor meetings to approve stakeholder registers and work breakdown structure resource allocations with network analysis Gantt charts, with instant feedback through sponsor panel questions and answers followed by substantiated yes/no decisions. All graded items were presented by teams (groups) and scored in classroom meetings, making it competitive with realistic motivation and engagement. The professors were the project sponsors, so they used constructive feedback to improve student learning, motivation, and engagement. We avoided materialistic outcomes disassociated with project theory, and there were no individual points or badges.

Introduction

The rapidly changing technological innovations require innovative approaches in higher education to ensure that academic knowledge is suited for real-world applications and requirements. Capstone courses are seen as culmination of the academic journey of students presents an opportunity for this integration between academic knowledge and real-world applications (Devine, Bourgault, & Schwartz, 2020; Gilbert & Wingrove, 2019; Schwering, 2015). Traditionally, capstone courses were relying on a mix of case studies, textbook-based learning, and written tests (Chang, 2019; Safapour et al., 2019). While this is reliable approach, this approach was no longer relevant in preparing the students for the complex challenges they encounter in real-time professional settings.

There is a definite need for an alternative instructional model focusing on problem-based learning (PBL) integrating game theory elements in a project management capstone course (Desai, Tippins, & Arbaugh, 2014; Kapralos, Fisher, Clarkson, & van Oostveen, 2015). This approach is more relevant as it replicates real-world project management challenges by focusing on the planning phase and using strategic decision-making frameworks. This approach also creates a competitive collaborative work and learning environment for students like what they will experience while working in professional settings (Boom-Cárcamo, Buelvas-Gutiérrez, Acosta-Oñate, & Boom-Cárcamo, 2024; Daba, Rosmansyah, & Dabarsyah, 2019; Junior, Reis, Mariano, Barros, de Almeida Moysés, & da Silva, 2019).

PBL is an ideal choice for capstone courses because the focus shifts from passive knowledge consumption to active problem-solving as students take charge of their learning by working on real-life scenarios (Almulla, 2020; Chandra, Stewart, & Meyer, 2024; Lin & Tu, 2021). PBL can be enhanced by including game theory to introduce competition among student teams (Desai, Tippins, & Arbaugh, 2014). In this study, students were tasked with identifying stakeholders, allocating resources, and managing project timelines through a Work Breakdown Structure (WBS) by applying the principles of project management based on the ISO standards. The advantage of adding game theory to the PBL educational framework is that another layer of complexity is added to the educational framework providing students with critical constructive feedback on their decision-making processes through simulated sponsor settings (Farooq, Hamid, Alvi, & Omer, 2022; Tumpa, Ahmad, T., Naeni, & Kujala, 2024). In the current study, the professors could act as the sponsors and provide feedback in real-time simulating the challenges that professionals would face in real-time project management scenarios. This process not only encourages critical thinking but also enhances engagement and builds on students' theoretical understanding with practical application.

Traditional methods of teaching capstone courses often encounter several challenges, including varying student motivation and uneven levels of participation (Debs, Miller, Ashby & Exter, 2019; McCubbins, Paulsen, & Anderson, 2018). The introduction of game theory as a pedagogical tool addresses some of these common challenges (Turkay, Hoffman, Kinzer, Chantes & Vicari, 2014). The competitive aspect introduced by the introduction of game theory ensures that students can refine their strategic thinking and develop their communication and leadership skills (Grant & Baden-Fuller, 2018). The traditional approach to handling capstone courses does allow coverage of core concepts but lacks the dynamic feedback loops and interactive learning elements present in the PBL-game theory model (Paretti, Kotys-Schwartz, Ford, Howe & Ott, 2020). This study attempts to address this critical gap in the traditional capstone model where students can absorb the theoretical knowledge but usually lack the practical experience needed to apply the knowledge effectively in professional scenarios.

Literature Review

Capstone courses are the final academic challenge for undergraduates, integrating their accumulated knowledge and skills. As educational paradigms shift, innovative methods for delivering these pivotal courses emerge. This study examines a new teaching approach in a Bachelor of Science in Management capstone course, contrasting it with traditional instructional methods. The new approach involves industry collaboration, where students engage in 16-week real-world projects in core subjects such as marketing, management, finance, and others sourced from local businesses. The study's objective is to evaluate the effectiveness of this industry collaboration model compared to the traditional capstone course, which relies on textbook cases and business strategy presentations. Data collection methods include analyzing university grading records, course feedback surveys, and reviews from external platforms to ensure a comprehensive evaluation. The study examines student performance and engagement to determine whether this hands-on, practical approach enhances learning outcomes more effectively than traditional methods. The findings will contribute to the broader discourse on modernizing capstone courses to better prepare students for the dynamic demands of the professional world.

Project-based learning (PBL) represents a transformative approach to education, emphasizing student-centered learning through practical and immersive projects (Pan et al., 2019). This method is highly adaptable and can be implemented across various subjects and educational levels, from elementary to higher education and in disciplines as diverse as the sciences and the arts. PBL offers numerous benefits, including enhanced engagement and a deeper understanding of content (Hall & Miro, 2016). Participating in hands-on projects makes students more likely to retain knowledge and develop a profound comprehension of the material. Additionally, PBL fosters essential skills such as research, problem-solving, communication, and teamwork. The engaging nature of PBL projects often results in increased student interest and participation compared to traditional instructional methods. This approach also prepares students for real-world challenges by honing their critical thinking and problem-solving abilities. However, the time-intensive nature of PBL and the need for resources—such as materials and expert input—can present challenges in its implementation. Traditional assessment methods may not effectively capture the learning outcomes of PBL, necessitating innovative evaluation techniques. Educators can utilize various assessment tools, including rubrics, self-assessments, peer evaluations, and reflection journals, to measure student performance and engagement in PBL (Cifrian et al., 2020). Despite these challenges, PBL's benefits, such as the development of practical skills and increased student engagement, make it a valuable educational strategy. Its successful implementation requires careful planning, adequate resources, and tailored assessment strategies that align with its unique characteristics (Whitley et al., 2015).

The convergence of technology and experiential learning in education has given rise to innovative teaching methods, particularly simulation and gamification, which are especially beneficial in Bachelor of Science capstone courses. These methods offer significant advantages in reinforcing complex concepts, fostering critical thinking, and enhancing student engagement. Simulations involve creating detailed instructional scenarios where learners interact within a teacher-defined environment that closely mirrors real-world conditions (Tilak, Glassman, Kuznetcova, Peri, Wang, Wen, & Walling, 2020). This approach allows students to visualize and engage with abstract scientific concepts, making them more tangible and understandable. In the realm of simulations, students can experiment, make errors, and learn from them without facing real-world repercussions—an aspect that is incredibly valuable in fields such as engineering, medicine, and chemistry. Students develop vital analytical skills by participating in simulations as they interpret data, make predictions, and evaluate outcomes. This hands-on learning process reinforces theoretical knowledge and enhances practical problem-solving abilities. However, the development and implementation of simulations can be resource-intensive, require significant time and financial investment, and are sometimes prone to technical difficulties that hinder the learning experience. Despite these challenges, simulations remain a potent educational tool, providing an immersive learning experience that significantly improves student comprehension and engagement in complex subjects. This method exemplifies how the integration of technology and experiential learning can transform traditional educational practices, offering students a deeper, more interactive learning journey.

Gamification incorporates game-design elements into non-gaming contexts, such as education, to enhance learning experiences (Wiggins, 2016). By integrating features like point scoring, competition, and rules of play, gamification aims to boost student motivation and engagement. One key benefit of gamification is the provision of instant feedback, which helps students quickly identify their mistakes and learn how to correct them. This immediate response fosters a better understanding of the material and promotes continuous improvement. Additionally, gamification encourages the development of essential skills such as teamwork, strategy, and adaptability. Despite its advantages, gamification presents challenges. Students may become overly focused on the gaming elements, such as collecting points or badges, and lose sight of the primary learning objectives. Effective gamification strategies must balance educational content and game mechanics to address this, ensuring that the learning outcomes remain the central focus. In summary, while gamification can greatly enhance student engagement and skill development, its implementation must be carefully designed to maintain a balance between the educational goals and the game elements.

Simulation and gamification offer innovative methods to enhance the educational experience in Bachelor of Science capstone courses. These techniques provide interactive, engaging, and immersive learning experiences, enriching students' academic journey and equipping them with practical skills essential for their future careers. Simulations create realistic scenarios that mirror challenges students may encounter in their professional lives. This hands-on approach allows students to apply theoretical knowledge in practical settings, better preparing them for real-world problems.

Simulations can effectively bridge various scientific disciplines, fostering an interdisciplinary approach that is particularly valuable in capstone courses. Gamification, on the other hand, incorporates game elements like point scoring, competition, and rules into educational contexts. This method increases student motivation and engagement by making learning more enjoyable. The competitive and rewarding nature of gamification encourages active participation and can enhance skills such as teamwork, strategy, and adaptability. Both simulation and gamification promote collaboration among students, which is crucial for projects that require diverse skill sets and perspectives. Educators can provide a more comprehensive and dynamic learning environment by integrating these methods into capstone courses. This approach prepares students academically and equips them with the critical thinking and problem-solving abilities needed in their careers.

Methods

The researchers held a post-positivist ideology meaning the goal was to collect quantitative data and use statistical techniques to test hypotheses. The purpose of the study was to implement game theory into a new project management laboratory course and test student learning effectiveness against the previous historical program benchmarks. The RQ was focused on determining if three new course sections developed using game theory - which required students to create project plans in randomized teams and present them - to make them more interesting and competitive, would be liked better by students as compared to the original pedagogy format which used individual learning (not teams) assisted by textbooks and assessed through knowledge tests. There were two units of analysis, student learning and materials satisfaction. The units of analysis were comparative. The aim was to compare student learning and materials satisfaction levels from all three sections against historical program benchmarks of (learning mean = 4.3, SD = 0.5; materials mean = 3.7, SD = 0.6), hopefully to prove the new course design based on game theory was perceived by students as better. The course enrolments were well over 30 seats so we assumed parametric statistical techniques could be used. Since benchmarks were available, a mean without a standard deviation (SD), z tests could be used for that. The second unit of analysis was to contrast the new course sections with one another, again in terms of student learning and materials satisfaction. An ANOVA or ANCOVA test could be used for that, the latter because we had additional factors available from the course opinion surveys to use in the model.

Sampling, Instruments, and Materials

Three cohort sections, three courses, constituted the sample of convenience. These were bachelor of science programs in the supply chain discipline. The university was based in USA and regionally accredited. The students were in the last year of their four-year degree, and this was considered a capstone course. The same professor designed the course sections and taught each section with the same team of assistants. Most courses were 16 weeks but some courses in the program were 8 weeks. The targeted courses were the 16-week version. All courses were taught in hybrid format, with some live lectures and labs, followed by online delivered recorded lectures, materials, and so on. The student population was aged 23-27, balanced gender, roughly 55% were in state and the remaining 45% were out of state including international (non-citizens). We used the same course opinion survey (COS) which had been used previously. It was a simple instrument with proven validity. It was also designed to be simple, short, and easy for students to navigate so as to encourage them to complete it on time.

We collected anonymous data from the COS using a 1-5 scale (strongly disagree = 1, disagree = 2, unsure = 3, agree = 4, strongly agree = 5), with the following eight factors:

1. The professor was organized and presented subject matter clearly through lecture, discussion, and/or activities.
2. Through the syllabus, course objectives were clearly defined.
3. Through the syllabus, class assignments were clearly explained
4. I received timely feedback on tests and assignments that helped me understand what I had learned or what I still needed to learn.
5. The professor was accessible to answer questions and explain material outside of class (in person, by email, in iLearn, etc.)
6. The professor made effective use of required textbooks and other supplemental materials to facilitate learning.

7. The professor made effective use of iLearn and online resources to facilitate learning.
8. This course has helped strengthen my critical thinking skills, problem-solving skills, and research skills.

The internal student learning objectives of all three sections were identical, to understand how to complete a Gantt project plan with all ten-project management body of knowledge (PMBOK) areas included (scope, cost, time, quality, procurement items, human resources, risk identification/mitigation, communications, stakeholders, and integration of WBS activities into a network diagram). All materials were supplied, as a case study, so students needed only to develop the artefacts and then complete the Gantt chart and network diagrams to address all the required PMBOK areas. students were required to together as a team (randomly selected by instructor), appoint a PM, and properly plan out the work which they would not necessarily be familiar with. The course was designed to ensure the number of materials and difficulty was approximately equivalent across all sections. This is the reason for testing the students' satisfaction with the materials as the second unit of analysis.

The course was designed and delivered in hybrid mode. The professor gave introductory live lectures in person at one of the university's campuses, which was recorded and made available for all students to review. This introductory set of lectures introduced the nature of the course, the project, letting students know there were three sections, identical except for different projects (house buy plan, company training plan, or ERPS selection plan). The remaining lectures were all videotaped and made available online. The professor acted as the project sponsor and project authority. The professor held several Q&A sessions periodically, at different milestones, to answer student questions, and request draft presentations of certain deliverables to ensure progress was being made. For example, the professor checked to see each student team had a valid stakeholder register, a valid staffing pool database, and knew how to develop the Gant plan schedule and network diagram from the WBS tasks. Quality, not quantity, was emphasized. Some points were given to each team periodically over the duration of the course as they completed these milestones and deliverables. Each time the professor graded a deliverable, he listed the best to worst in terms of rank (but without noting the actual score), so as to make it competitive and encourage transparency.

Again, all three sections were identical in terms of expected outputs except the content would be customized for the specific section's case study (house, training, or ERPS). Teams were randomly selected to ensure roughly equal size, balanced gender, and mix of domestic versus international (out of state) students. This was also done to reduce the amount of assessment workload on the professor and his assistant. Generally, each team was 5-6 people to make 3-4 teams per section, which would result in 3-4 project plans to assess at the end of the course. This final deliverable was weighted more heavily, at approximately 40% of the total grade weight, since it involved a culmination of all PMBOK areas plus presentation skills. Students were required to deliver a short electronic PDF of the Gantt chart showing the details of resources and dependency links between tasks. Students also had to present this in a short four-minute video uploaded to the course site. All deliverables were visible to other teams in the same section, so students learned from one another. The 16-week course allowed sufficient time for the students to incrementally learn and add to their project plan. This duration also allowed sufficient time for the professor and assistants to grade the work quickly, usually with a 24-hour turnover.

Procedures and Measures

The first unit of analysis was student learning satisfaction in each section. Note we did not use grade, learning achievement, in this study. Our goal was only to compare satisfaction. Each course section used a different canned project. Section A was focused on developing a project plan to buy a house, section B a company training project, section C was an enterprise resource planning system (ERPS) selection. We also wanted to determine if students had higher learning satisfaction from one of the new sections as compared to the others (a contrast). Since the program was a Bachelor of Supply Chain Management, we expected students would prefer developing an ERPS plan (section C) over the other two. The three sections ran in parallel, so students had the option to select which section they wanted to take over the 16-week course and they were allowed to drop or change the section prior to the second week. Our hypothesis was the new courses would each result in higher learning satisfaction, as per below:

- H1a: Student learning satisfaction in course section A (buy house plan) > program benchmark (4.3);
- H1b: Student learning satisfaction in course section B (company training plan) > program benchmark (4.3);
- H1c: Student learning satisfaction in course section C (ERPS select plan) > program benchmark (4.3);
- H2: Student learning satisfaction section C (ERPS select plan) > sections A and B.

The second unit of analysis was student satisfaction with the materials between the three sections. The goal was to determine which project students liked best compared to one another. Each section used a different project, with the WBS and charter already developed to reduce cognitive overload. The students needed to work in randomized teams (not self-selected) in a competitive situation to develop and present a project plan in Gantt chart format at the end of the course. These three courses were identical to previous courses except that the three different projects were used, and the grade was qualitative rather a knowledge tested used previously in the program. So prior courses used knowledge tests, but these three new sections used a simulated project in the planning phase with a qualitative assessment in the form of a presentation. The purpose was to ensure the student satisfaction with the materials was greater than the program benchmark of 3.7, in each course section, otherwise we would have wasted our time creating a new course. Again, as with the actor learning satisfaction, we assumed students would prefer the ERPS project plan as materials and rate that higher than sections A and B. Therefore, the hypotheses were:

- H3a: Student materials satisfaction in section A (buy house plan) > program benchmark (3.7);
- H3b: Student materials satisfaction in section B (company training plan) > program benchmark (3.7);
- H3c: Student materials satisfaction in section C (ERPS select plan) > program benchmark (3.7);
- H4: Student materials satisfaction section C (ERPS select plan) > sections A and B.

Results

Preliminary Analysis

Table 1 lists the descriptive statistics. We calculated the bivariate correlations, but we did not display them because every combination of factor was significantly correlated with each other ($p < .001$). That result is typical of a COS which essentially measures the same overall factor student satisfaction. Since our RQ is a between-groups comparative strategy, we do not need to analyze the correlations (a within-group design). Although the means are high for all six factors in Table 1, it will be useful to explain certain estimates. We will not discuss the minimum or maximum values from Table 1 as they are included to reveal the range of the data. There were at least a few very low responses at 1 (strongly disagree), up to the highest scale value of 5 (strongly agree). We can also share that since these students are in their final year of the program and in a capstone course, they are seniors, familiar with this COS instrument, and have used it many times. We can also mention that these descriptive statistics cover all three sections, a new course designed with game theory. All estimates will be rounded up to one decimal point from Table 1, where precision was shown for completeness.

Table 1. Descriptive Statistics of Sample (N = 178, all Sections)

Variable	**Median**	**Mean**	**SD**	**Minimum**	**Maximum**
Lecturing	4.8	4.503	0.784	1	5
Objectives	4.6	4.459	0.649	2	5
Assignments	4.4	4.325	0.667	2	5
Feedback	4.9	4.503	0.819	1	5
Materials	4.2	4.069	0.921	1	5
Scaffolding	5	4.633	0.659	2	5
Learning	5	4.679	0.609	2	5
Section	A = 67, B = 47, C = 64				
Gender	Female (0) = 84 (47%), Male (1) = 94 (53%)				
Domestic	In state = 49%, out of state or international non-citizens = 51%				

Note: Standard deviation (SD), percentages shown for categorical variables, section is a control variable

The key factor from Table 1 is learning, which is commonly looked at first by professors to determine if students on average were satisfied with what they learned in the course. Learning had a mean of 4.7 (rounded) with an SD = 0.61 (rounded), and a median of 5. This is a good result because the values are close to the top of the 1-5 scale, and the median is larger than the mean, signaling that most of the data points were higher than 4.7 approximating 5 (while also considering the SD was slightly higher than half a scale point value). This is also the highest scoring factor from the COS responses.

Materials are the next factor of interest to the researchers in the current study. Materials refer to the content of the course; in this study, this would reflect the materials for the three projects: house buy plan, training plan or ERPS selection plan. Other than learning, materials would essentially be the only factor differing in substance as compared to the others beyond learning. The materials mean was 4.1 (SD = 0.7), and the median was 4.3, which is certainly not as good as what we observed from learning. When considering the SD, it could be interpreted that most of the data values were closer to 4.3, which approximates 86% if we were to calculate a score based on the

1-5 scale. We would have preferred to see a 90% or a 4.5 value here, but the important issue is whether this will meet our hypothesis tests, which are covered in the following subsection.

The other variables in Table 1 are not of specific interest in this study, but we can briefly explain them. Scaffolding (mean = 4.6, SD = 0,7, median = 5) refers to how the course was designed online since that is the interface students face to learn. This value is excellent. Assignments (mean = 4.3, SD = 0.7, median = 4.4) tend to follow scaffolding from our experience. That estimate indicates students were adequately satisfied with the assignments and how those, along with the materials, were organized in the learning management system (LMS). Lecturing (median = 4.8, mean = 4.5, SD = 0.9) captures how well the professor delivered the live and video-recorded materials and answered students' questions. This was a good value in meeting our informal 90% pass goal for professors. The objectives (median = 4.6, mean = 4.5, SD = 0.7) refer to how well the course learning objectives matched the program and assignments, which was a good result since it also meets our informal 90% score benchmark. Finally, feedback is an important variable to pay attention to because it refers to how satisfied students are with the instructor’s grading constructive feedback. Although it is beyond the scope of this study, feedback (median = 4.9, mean = 4.5, SD = 0.8) also met our internal benchmark of 90%.

Hypothesis Test Results

We first tested the benchmark hypotheses using one-sided z-tests against our historical program benchmarks. Student learning satisfaction was the most important summative factor as we discussed above it represents how satisfied the student was with their learning. Since we needed means for each section, we further analyzed the data underlying the estimates from Table 1 to calculate section level descriptive statistics to be used with z-tests.

To test hypothesis H1a – H1c for the student learning factor, three z-tests were used, with a population mean (M) of 4.3, and deviation of 0.5m and we reported all coefficients including standard error (SE). The result was H1b and H1c were accepted, but H1a was not supported. The learning satisfaction estimates were: section C (ERPS plan), $N = 64$, $M = 4.8797$, $SD = 0.2601$, $SE = 0.0625$, $Z = 9.28$, $p < .000$ (significantly higher); section B (training plan), $N = 47$, $M = 4.8851$, $SD = 0.3007$, $SE = 0.0729$, $Z = 8.02$, $p < .000$ (significantly higher); section A (buy house plan), $N = 67$, $M = 4.3433$, $SD = 0.8267$, $SE = 0.0611$, $Z = 0.71$, $p = .24$ (not significantly higher). Even though section A learning was not statistically higher than our program benchmark of 4.3, the section A learning mean was 4.3 (sample estimate).

Next, we tested hypotheses H3a-H3c for the materials satisfaction factor again using one sample z-tests. The result was all three hypotheses H3a-H3c were accepted. The material satisfaction estimates were: section A (house plan), N = 67, M = 3.8209, SD = 1.0139, SE = 0.0733, Z = 1.65, $p < .050$ (significantly higher); section B (training plan), N = 47, M = 4.9277, SD = 0.0826, SE = 0.0875, Z = 14.03, $p < .000$ (significantly higher); section C (ERPS plan), N = 64, M = 4.9063, SD = 0.0871, SE =0.0750, Z = 16.08, $P < .000$ (significantly higher). We can also observe each section mean estimate (3.8 - 4.9) was higher than the program benchmark (3.7). We next proceeded to test hypotheses H2 and H4 which were between group comparisons within our sample (not against the program benchmarks). Therefore, we used ANOVA to compare the means and variances of both factors, student learning and material satisfaction levels across all three sections, followed by rigorous Bonferoni post-hoc p-value estimates to identify significant differences, and finally we calculated effect sizes.

Regarding student learning satisfaction across the three sections, hypothesis H2 (Student learning satisfaction section C (ERPS select plan) > sections A and B) was partly accepted. The ANOVA estimates for student learning satisfaction comparisons were F [DF=2,175] = 19.821, $p < .001$, $ETA^2 = 0.185$ (significant). The Bonferoni test indicated learning satisfaction for section A (house plan) was significantly lower than section B (training plan), with a mean difference of -0.542, $SE = 0.105$, $t = -5.149$, $p < .001$; A (house plan) was also significantly lower than C (ERPS), with a mean difference of -0.536, $SE = 0.097$, $t = -5.549$, $p < .001$; but B (training plan) was not significantly different than C (ERPS) with a mean difference of 0.005, $SE = 0.106$, $t = .051$, p = ns. Therefore, we could interpret these results as student learning satisfaction was significantly higher both the ERPS (section C) and training plan (section B) as compared to the house plan project (section A).

We could speculate as we earlier posited that students in the supply chain management program would prefer the ERPS project to work on, and those students were attentive enough to examine the course syllabi before registering, to ensure they selected the correct section. We further speculate that the students taking section B (the training plan) may have perceived this as an easier project since they could leverage their existing experience in higher education courses to create a training plan. By comparison, we speculate that students selecting the house buy plan (section A), some were less attentive in evaluating the different syllabi, and just opted into the first course by default. Secondly, we think supply chain students at least most of the section a cohort would have preferred a more supply chain aligned project rather than a business project like buying a house. We can also share the anonymous student comments (not reported in current study) substantiated our suspicions.

Next, we examined the student satisfaction with course materials across the three sections, hypothesis H4 (Student materials satisfaction section C (ERPS select plan) > sections A and B). This hypothesis was partly accepted and mirrored the above results from the student learning satisfaction. The ANOVA estimates for student learning satisfaction comparisons were F [DF=2,175] = 20.687, $p < .001$, $ETA^2 = 0.191$ (significant). The Bonferoni test indicated learning satisfaction for section A (house plan) was significantly lower than section B (training plan), with a mean difference of -0.816, $SE = 0.159$, $t = -5.147$, $p < .001$; A (house plan) was also significantly lower than C (ERPS), with a mean difference of --0.838 , $SE = 0.146$, $t = -5.757$, $p < .001$; but B (training plan) was not significantly different than C (ERPS) with a mean difference of -0.023, SE =-0.027, $t = -0.027$, p = ns. Therefore, we again could interpret these results as student satisfaction with the course materials was significantly higher both the ERPS (section C) and training plan (section B) as compared to the house plan project (section A). We could speculate as above those students preferred the ERPS (section C) projects but only the diligent students researched the syllabi to correctly select that course, leaving the other students to take the remaining seats in the other two sections. To that end we think some students simply went with the flow and self-refreshed in section a (house plan) without fully analyzing their preferences for ERPS or the training project. We could also suggest some students preferred the training project as they were aiming for less supply chain centric employment, maybe as managers of a department instead of a project manager so a training project may have seemed like a better choice. Again, the anonymous student comments suggested this motive for some.

Discussion

The results were quote interesting and over all they supported the goal of the study. We wanted to test a new project management course developed using game theory. We further wanted to assess what types of materials, or rather, which projects, the students preferred, a house purchase plan, a corporate training plan, or an ERPS selection plan. We wanted to assess student learning satisfaction and the materials in the course, more so the different project content. We wanted to compare these new course sections against one another and also against our program historical benchmarks.

We were successful in answering the RQ. Hypotheses were at least partly accepted; some were fully supported. The first unit of analysis was student learning satisfaction across the three sections and compared to historical benchmarks. We found student learning satisfaction was higher in the training plan (section B) and ERPS plan (section C) as compared to our historical program benchmark. These two sections were also higher in student learning satisfaction as compared to the house buy project plan (section A). We rationalized this was sue to student diligence in self-selecting into the best aligned section during registration, and that supply chain management students would prefer ERPS and then training projects over house buy projects.

The second unit of analysis was student satisfaction with the materials between the three sections. The goal was to determine which project students liked best compared to one another. The results were almost identical to the above student learning scenario. Students rated their satisfaction with course materials higher than the historical benchmark for the ERPS (section C) and training projects (section B) but it was not significantly different for the house buy plan (section A). Nevertheless, we observed the mean estimates were identical between the historical benchmark and these sections - only the deviation differed. Again, students preferred the ERPS over the house buy project in terms of satisfaction and course materials, but the ERPS was equivalent to the training project plan for both factors.

We completed additional analysis of the student learning and material satisfaction results, using a scatter plot to identify how these factors interacted with one another in the context of all three sections (house buy plan, training plan and ERPS plan). Figure 1 depicts the values of the student responses from all three sections grouped by section. The slope pattern, from a low on the X and Y axis on the left to the higher of those axes on the right, confirm and substantiate all the previous findings/

We created a scatter plot to further illustrate the comparison of student learning satisfaction versus materials satisfaction grouped by section (A = house plan, B = training plan, C = ERPS plan). Figure 1 depicts this data. We can observe that most of the student response values are clustered in the upper right quadrant of the scatter plot in Figure 1, at the top of the 1-5 scale. There are a few responses a lower scale levels towards the far right and bottom of the scatter plot. This suggests most students were satisfied with both their learning and the materials in all of the three sections. Interestingly though, we can see a few more low responses for the house plan (green dots in Figure 1). We also observe that this was the largest section and the first to appear on the student registration. We posit that these circumstances led to three students (three low scoring green dots at bottom of Figure 1) who did not really evaluate the different section materials when they signed up, became less satisfied with the house plan project and would have preferred another one, perhaps the ERPS, but it was too late to drop or change their section registration when they figured that out. To substantiate that, we can see there were fewer differences between section B and C, lower variances and similar scores in both materials as well as student learning satisfaction. Overall, we can say that this study successfully answers the RQ.

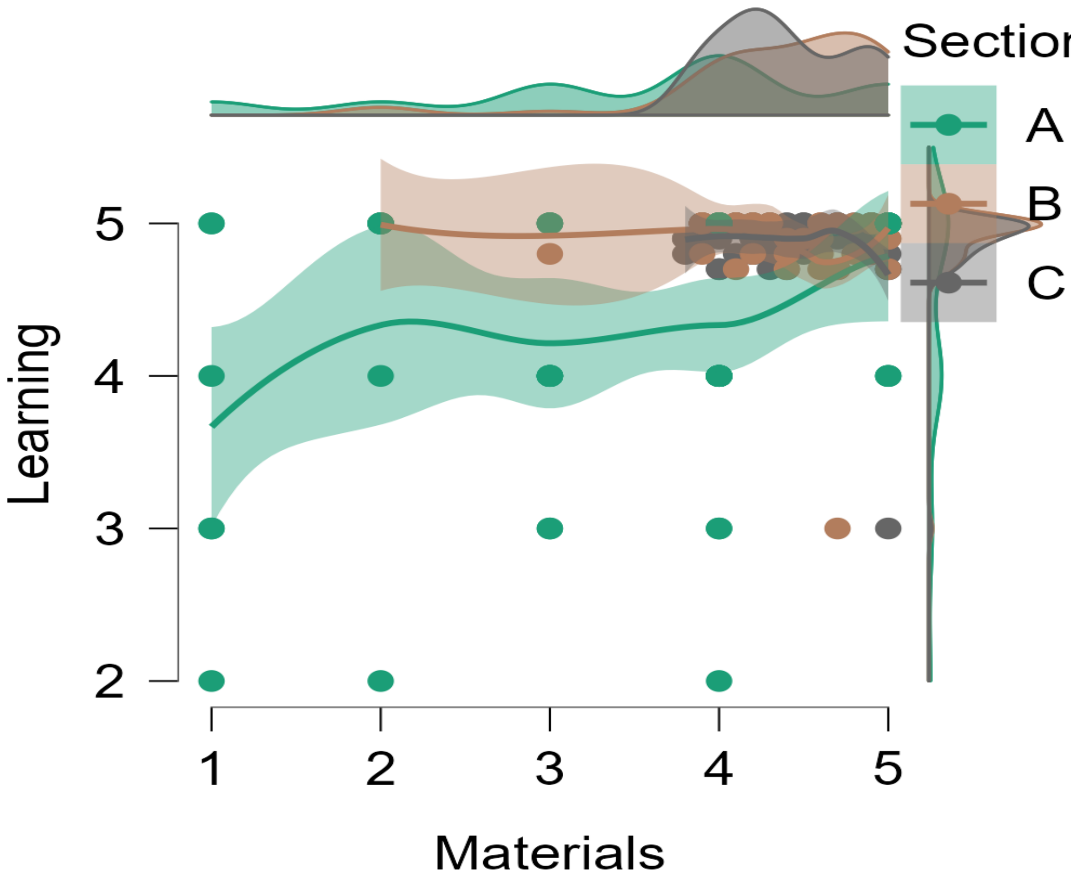

Figure 1. Comparison of Student Learning and Materials Satisfaction by A house, B training, C ERPS

Future Research Directions

While this study focused on integration of PBL and game theory in the project management program, there is a need for future studies to focus on other fields, such as engineering, healthcare, and humanities. This will provide valuable insights into how this framework can be applied across a wider range of disciplines allowing a broader understanding of potential benefits and limitations of this integrated framework. There is also a need for longitudinal studies to compare the career trajectories of the students who had completed the gamified PBL capstone courses as compared to students who took the capstone courses following the traditional format. This will allow a proper evaluation of long-term impact of the integrated framework on job placement, career advancement, and the practical application skills learned by the students. These longitudinal studies will allow researchers to assess whether the interactive nature of gamified PBL does translate into better job readiness and success.

There is also a need for qualitative studies to provide insights into student and faculty feedback for the gamified PBL approach in capstone courses. Future studies could include in-depth interviews and focus groups with students and faculty to provide rich qualitative data on their experiences with gamified PBL courses. These qualitative studies could offer valuable insights into understanding the challenges, benefits, and learning preferences from both the student and faculty perspectives allowing the refinement of the gamified PBL approach. There is also a need for comparative analysis of the gamified PBL approach with other innovative teaching methodologies, such as flipped classrooms, hybrid learning models, and the traditional lecture-based model. These comparisons will highlight the strengths and weaknesses of various approaches allowing educators to make informed decisions on which methods enhance student learning, engagement, and practical application in their fields.

There is also need for future studies to focus on exploring how advanced tools like virtual reality (VR), artificial intelligence (AI), and machine learning (ML) can be integrated into the gamified PBL model to take advantage of these technologies to provide immersive learning environment. These technologies will facilitate real-time feedback and personalized learning experience improving the scalability as well as improving student engagement and learning outcomes. However, the one of the issues or challenges with PBL-based gamified model is that it is resource-intensive in the context of both material and time investment. Hence, future research could explore testing streamlined version of this model or hybrid models where some aspects of the learning process are gamified while the others follow traditional methods. There is also scope for future research to examine how students from diverse academic backgrounds handle solving complex, real-world problems. Research in this domain could help understand the benefits of combining different skill sets in producing innovative and effective project outcomes. There is also a need to measure the practical benefits of these projects for organizations, communities, and industries to understand the actual value of the gamified PNL approach beyond the classroom.

Conclusion

Integrating industry crowdsourcing within an American Bachelor of Science degree program has demonstrated significant potential in bridging academic learning with real-world industry challenges. By creating an unincorporated business consulting organization, the capstone course enabled students to engage in various short-term projects sourced from five local chambers of commerce. These projects covered a broad spectrum of sectors, including Internet marketing design, eco-tourism planning, and biomedical device optimization, offering students comprehensive exposure to real-life business scenarios. This study aimed to provide evidence-based comparisons by evaluating the industry crowdsourced capstone course against the traditional capstone course within the same semester. As measured by grades, academic performance showed similar outcomes for both courses. Course opinion surveys indicated a strong preference for the industry-crowdsourced approach, highlighting increased student satisfaction and engagement. This preference was further supported by independent third-party course ratings, where the crowdsourced version consistently received more favorable feedback than the traditional case-based approach. The incorporation of industry crowdsourcing not only maintained academic rigor but also aligned with students' aspirations for practical, real-world relevance. The findings underscore the importance of evolving pedagogical strategies to close the gap between academia and industry, ensuring that curricula remain dynamic and relevant to contemporary business challenges. Adopting such industry-academia collaborations can be pivotal in preparing graduates who are ready to meet the demands of the professional world, fostering a learning environment that is both academically challenging and pragmatically enriching.

Recommendations

This study demonstrated that PBL when combined with competitive game theory elements can enhance student engagement and motivation. Hence, instructors could consider integrating PBL with game theory as part of curriculum for capstone courses across multiple disciplines. This will result in a shift of the instructional model from passive absorption of knowledge to active problem-solving, which the students will benefit from while dealing with real-world challenges. By adopting this framework, educational institutions can ensure that students are in a better position to apply theoretical knowledge in practical settings and develop critical thinking, teamwork, and decision-making skills. Also, considering the significant improvement in student satisfaction and learning outcomes, policymakers should prioritize funding and resources to support the development of PBL-based courses with gamification elements. These resources could include training for faculty members to effectively implement and manage the PBL-gamified courses. The investment made by educational institutions in these areas will enhance student learning and help bridge the gap between academic education and professional practice. In this study we applied PBL and game theory on capstone courses in project management programs, but these could be applied across other fields such as engineering, healthcare and humanities. The findings of this study indicate this integrated model provides benefits in encouraging engagement and practical skills which can be useful across different disciplines.

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