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Comparing Project-Based Learning (PBL) Approaches in BIM Education: Student-Identified vs. Industry-Provided Projects

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Before starting his academic career, he gained experience in the design and construction of plumbing, sewage, and fire protection systems for buildings, managed two major environmental planning projects, and co-founded a company that integrated multiple building-design disciplines to streamline the design process for its clients.

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The classroom is Prof. Gutierrez's special place and helping students identify their purpose is what he loves the most about his job. He is a father, a husband, and the founder of the UVA Construction student team!

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Abstract

Project-based learning (PBL) is a widely adopted pedagogical approach in construction management and architecture education, offering students hands-on opportunities to bridge theory and practice. This study explores the effectiveness of two distinct PBL approaches—Student-Identified and Industry-Provided—within an introductory Building Information Modeling (BIM) course. The Student-Identified approach allows students to select projects within instructor-defined boundaries, fostering autonomy and ownership. In contrast, the Industry-Provided approach involves working on real-world projects provided by industry partners, emphasizing practical challenges and real-world relevance. The study compares these approaches across two course sections at Florida Gulf Coast University, analyzing their impact on student engagement, satisfaction, and learning outcomes. Data were collected through pre-course and post-course surveys, measuring students' familiarity with and proficiency in BIM concepts, their engagement and enjoyment, and their perceptions of the learning methods. Final exam and overall course grades were also analyzed to assess performance differences between the two sections. Results indicate that both approaches effectively improved students' familiarity with BIM concepts and software. The Student-Identified approach fostered greater engagement and ownership, while the Industry-Provided approach enhanced students' understanding of real-world applications. However, no significant differences were observed in overall academic performance between the sections. The findings suggest that a hybrid model, combining autonomy with real-world relevance, could maximize the benefits of PBL in BIM education. This study contributes to the development of effective pedagogical strategies for BIM education and underscores the need for further research into hybrid models and long-term impacts on career readiness.

1 Introduction

1.1 Background

Project-based learning (PBL) is widely recognized as an effective pedagogical approach for fostering critical thinking, collaboration, and practical application of knowledge in real-world contexts. This approach is particularly relevant in construction management and architecture education, where bridging theoretical concepts with practical skills is essential for preparing students to meet industry demands. Building Information Modeling (BIM), a digital methodology that integrates construction-related objects and processes, has become a cornerstone of modern construction education. By enabling streamlined workflows and enhanced decision-making, BIM is transforming the architecture, engineering, and construction (AEC) industries.

To ensure that students gain the necessary skills and competencies to thrive in this digital environment, educational programs must adopt effective teaching strategies. Among these, Project-Based Learning (PBL) has shown significant promise in helping students engage with complex BIM tools and concepts. However, while PBL is a common practice in BIM education, its implementation varies widely, and the relative effectiveness of different approaches remains underexplored.

1.2 Problem Statement

The effectiveness of project-based learning in BIM education often depends on how it is implemented. Two prevalent approaches include the Student-Identified project approach, where students select projects within boundaries set by the instructor, and the Industry-Provided approach, where students work on real-world projects provided by industry partners. The Student-Identified approach fosters autonomy and ownership, potentially increasing engagement and motivation. In contrast, the Industry-Provided approach exposes students to practical challenges, offering insights into real-world applications. Despite their merits, the effectiveness of these approaches in achieving learning outcomes, fostering engagement, and preparing students for professional practice is not well understood. This gap in understanding necessitates a closer examination of how these approaches influence student experiences and outcomes in BIM education.

1.3 Research Objectives

This study aims to compare the Student-Identified and Industry-Provided PBL approaches in an introductory BIM course. Specifically, it seeks to:

1. Evaluate the impact of these approaches on students' engagement, enjoyment, and satisfaction.
2. Assess students' learning outcomes, including familiarity with and proficiency in BIM concepts.
3. Examine students' preferences for learning approaches and their perceived preparedness for applying BIM knowledge in professional settings.

By addressing these objectives, this study contributes to the development of best practices for project-based learning in BIM education. The findings aim to inform educators on how to optimize teaching strategies to better prepare students for the evolving demands of the AEC industries.

2 Literature Review

2.1 Building Information Modeling (BIM) in Education

BIM teaching is still in the process of being fully integrated into university curricula. Müller et al. (2016) propose a two-stage approach to facilitate this process. The first stage focuses on hiring professionals proficient in BIM to lead its implementation, encouraging undergraduate BIM-related research projects, and introducing dedicated courses. The second stage emphasizes training faculty members across disciplines and advancing BIM research at the postgraduate level to create a robust academic foundation for its integration.

Abbas et al. (2016) highlight the need for academic institutions to modernize their curricula by incorporating emerging technologies like BIM. They emphasize that the flexibility of BIM education, delivered through technological tools, allows for in-person and online learning options, making it adaptable to various educational settings. Succar et al. (2013) further delineate BIM competencies into eight domains, including managerial, functional, technical, and operational skills, emphasizing the broad range of skills required to effectively implement BIM in professional settings.

Peterson et al. (2011) advocate for using BIM as a pedagogical tool for project management education. By simulating real-world scenarios, BIM-supported teaching fosters deeper engagement and understanding compared to traditional methods. However, challenges such as interoperability and the need for continual technological updates pose limitations to its integration (Jin et al., 2018).

2.2 Project-Based Learning (PBL) in BIM Education

PBL is a student-centered instructional method that emphasizes autonomy, collaboration, and problem-solving within real-world contexts. Kokotsaki et al. (2016) identify key factors for successful PBL implementation, such as effective teacher guidance, the integration of digital tools, and well-structured assessments. PBL has been successfully applied across various educational levels, including higher education, to enhance student engagement and learning outcomes.

Stewart (2007) examined the relationship between Student-Identified learning readiness and PBL outcomes, finding that students with strong self-management skills were more likely to succeed. Larmer and Mergendoller (2010) distinguish meaningful PBL from superficial projects, emphasizing the need for a well-designed structure incorporating elements like a driving question, 21st-century skills, and public presentation of results.

In BIM education, PBL has been shown to support interdisciplinary collaboration and enhance student engagement. Wu and Hyatt (2016) demonstrated the effectiveness of experiential, project-based approaches for teaching BIM in sustainable design contexts. Similarly, Zhang et al. (2019) highlighted the use of real-world projects to enhance BIM project execution planning. However, challenges such as reduced instructor-student interaction in online PBL environments may require additional monitoring efforts (Tai et al., 2019).

2.3 Research Gap

Despite the demonstrated potential of BIM-integrated PBL approaches, several gaps remain. The alignment of PBL with student learning objectives, tailored to their knowledge and skill levels, requires further investigation (Zhang et al., 2019). Additionally, while PBL has been effective in teaching BIM tools, its long-term impact on professional readiness remains underexplored. Research into hybrid models that combine the strengths of Student-Identified and Industry-Provided PBL approaches could provide deeper insights into optimizing BIM education.

BIM teaching, when paired with PBL, offers a powerful platform for equipping AEC students with the interdisciplinary and technological skills needed for their careers. However, addressing challenges like technological interoperability and maintaining a balance between autonomy and structured guidance is crucial for its successful implementation.

2.4 Research Hypotheses

To address the identified gaps, the following hypotheses have been formulated to guide the study's development:

- **Hypothesis 1:** Students who participate in an Industry-Provided PBL approach will demonstrate significantly higher academic performance than students who participate in a Student-Identified PBL approach.
- **Hypothesis 2:** Students' familiarity with and interest in BIM and related software will increase over the duration of the course, regardless of whether they participate in a Student-Identified or Industry-Provided PBL approach.
- **Hypothesis 3:** Students will report similarly high levels of satisfaction with PBL, regardless of whether the approach is Student-Identified or Industry-Provided.

3 Research Methodology

3.1 Study Design

This study was conducted in two sections of an introductory Building Information Modeling (BIM) course at Florida Gulf Coast University, which is an American Council for Construction Education (ACCE)-accredited Construction Management program. Both sections followed a standardized curriculum, which included identical lectures, in-class labs, homework assignments, and a final exam. The primary variable was implementing the semester-long group project, which was conducted using the two distinct PBL approaches: the Student-Identified and the Industry-Provided PBL methods. See Figure 1.

The **Student-Identified approach** allowed students to select projects within boundaries set by the instructor, including minimum building size, single or multiple building levels, site minimum size, minimum building and site details, and project file management and documentation. This approach emphasized autonomy and ownership, enabling students to align their projects with personal interests while meeting course objectives. The **Industry-Provided approach** required students to work on real-world projects sourced from industry partners. These projects offered practical challenges and exposed students to professional contexts, aiming to enhance their understanding of real-world applications. Figure 1 summarizes the research methodology of this study.

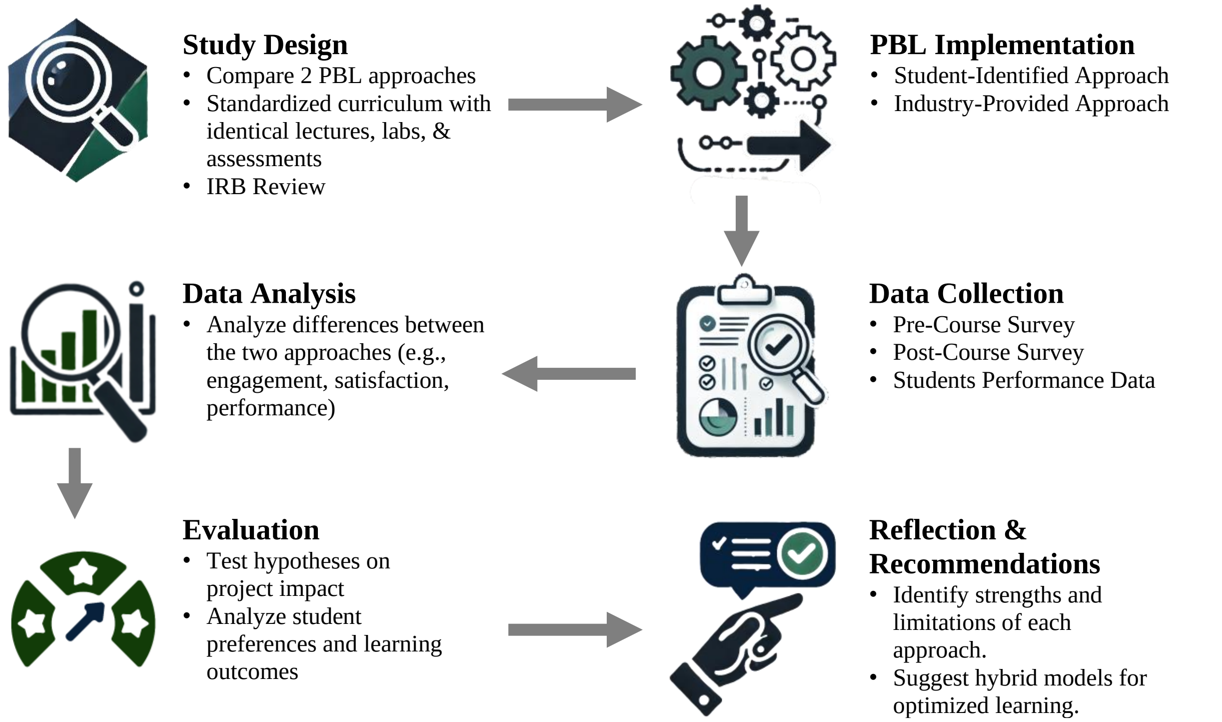

Figure 1. Research Methodology

3.2 Data Collection

The study employed three primary sources of data: student feedback collected through surveys before and after the course, and student performance data based on final exam and overall course grades. Each data source is described in detail below.

3.2.1 Baseline Survey: Student Feedback Before the Course

An online survey was conducted at the beginning of the course to establish baseline data on students' perceptions, familiarity, and interest in BIM-related tools and concepts. The survey had three primary objectives: to assess students' perceptions of teaching methods, to measure their familiarity and interest in BIM software, and to identify their understanding of specific BIM concepts.

The survey included questions on the perceived effectiveness of teaching methods used in the course, such as lectures, in-class labs, quizzes, exams, and group or individual projects. A 6-point Likert scale was employed to reduce neutral responses and capture students' preferences and biases toward different learning approaches.

Students were also asked about their familiarity and interest in various software tools relevant to BIM and construction management, including AutoCAD, SketchUp, Assemble, MicroStation, and Revit. These responses provided baseline data for assessing changes in familiarity and interest, with a particular focus on Revit, at the course's conclusion.

To further explore their initial understanding of BIM concepts, students rated their familiarity with ten key aspects of BIM, such as modeling objects, using Revit families, creating schedules and quantity takeoffs, navigating the project browser, linking CAD and RVT files, creating topography, and editing objects and families. This feedback, collected on a 6-point Likert scale, served as a benchmark for post-course evaluations.

3.2.2 Post-Course Survey: Student Feedback After Course Completion

At the conclusion of the course, a follow-up survey was administered to measure changes in students' perceptions, familiarity, and confidence and to evaluate their engagement and satisfaction with the course and the semester project. The survey included questions from the baseline survey to allow direct comparison, alongside additional questions designed to assess students' reflections on the course.

Familiarity and interest in Revit were specifically addressed in this survey to ensure focus and comparability with baseline data. Students also rated their perceived proficiency in the same ten BIM aspects covered in the baseline survey. These ratings provided insight into how their understanding and skills evolved over the semester.

The survey further included reflective questions on the effectiveness of teaching methods. Students evaluated the degree to which lectures, labs, quizzes, and projects supported their learning using a 5-point Likert scale. They also assessed how the semester project contributed to the development of skills deemed essential in architectural and construction education.

In addition to assessing learning outcomes, the survey captured students' levels of engagement, enjoyment, and satisfaction with the course. Students rated their engagement with the project and the overall class, their enjoyment during the project, and their confidence in their ability to create future BIM projects. A 7-point Likert scale was used for these questions to provide more granular insights. Finally, students were asked to rank their preferences for project selection methods, providing valuable data on their perceptions of the Student-Identified and Industry-Provided PBL approaches.

3.2.3 Students' Performance Data

Student performance was evaluated using final exam grades and overall course grades. The curriculum and grading structure were consistent across both sections, including graded in-class labs, homework assignments, and the final exam. The semester project, while differing in implementation between sections, was designed to produce comparable outcomes.

The semester project required students to develop a detailed model of a building or structure and its surrounding site. Deadlines and rubrics were standardized, and students were offered opportunities to earn bonus points. The final exam included up to 20% bonus points for advanced tasks, self-troubleshooting, and survey completion, which allowed some students to achieve grades exceeding 100%.

3.3 Data Analysis Methods

Data analysis focused on quantitative methods to evaluate the research questions. Descriptive statistics were used to summarize and compare data from baseline and post-course surveys, as well as performance metrics across the two sections. Independent t-tests were performed to identify significant differences between the two sections, while paired t-tests were used to analyze changes in individual student responses from the beginning to the end of the course.

3.4 Institutional Review Board (IRB) Review

The study design and its components were submitted to the Institutional Review Board (IRB) at Florida Gulf Coast University and approved under protocol ID 2025-28. Ethical considerations were made regarding the collection of personal information; therefore, the surveys were anonymous, and no demographic data were collected from participants. The IRB also raised concerns about the potential for student coercion. To address this, the surveys were both anonymous and voluntary, which helped minimize the risk of coercion. Because the data collection was anonymous, students could decline participation without their identity being known to the research team or instructors. Despite the voluntary nature of the survey, the response rate was high, with no less than 86.21 percent participation in the pre-survey for the Student-Identified section and higher on all other surveys.

4 Results

This section presents the findings from the statistical analysis of the data collected, highlighting significant insights related to the study's objectives. Results are organized into three primary areas: student performance, student feedback before and after the course, and a comparison of Student-Identified and Industry-Provided project-based learning approaches.

A total of 29 students were enrolled in the section utilizing the Student-Identified Project-Based Learning (PBL) approach, while 27 students were enrolled in the section employing the Industry-Provided PBL approach, resulting in an overall study population of 56 students.

Where statistically significant differences were identified, these were highlighted in the results and visualized using appropriate charts or graphs. These analyses provided insights into the relative effectiveness of the Student-Identified and Industry-Provided project-based learning approaches. Results are presented in the following section.

4.1 Students Performance

A review of the final grades, Figure 2 and overall course grades, Figure 3 across both sections was conducted to identify any differences in performance. The data revealed that the grades were comparable and quite similar. A t-test confirmed this similarity, showing no significant difference between the two sections.

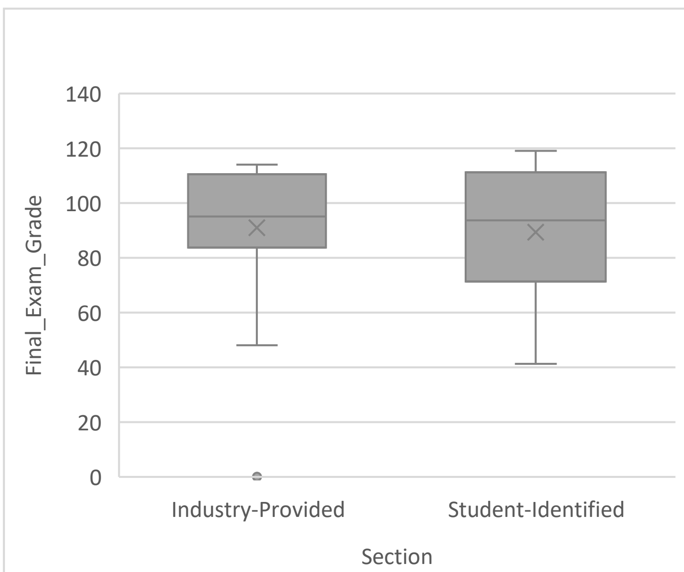

Figure 2. Students' Final Exam Grade for the two sections. No significance was found

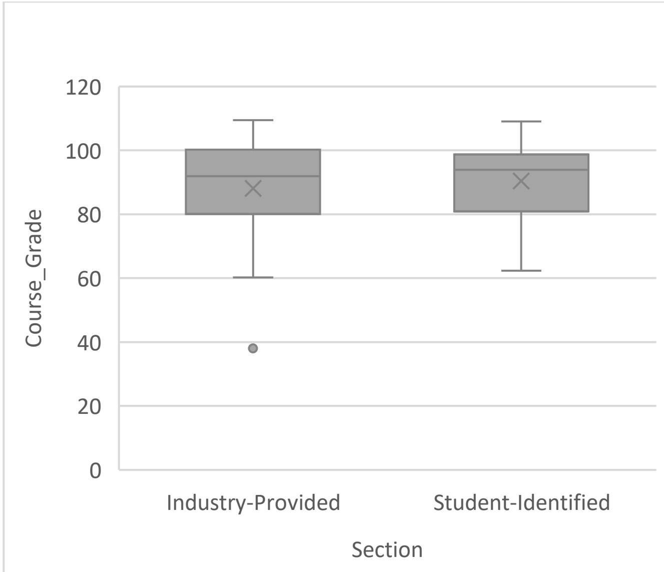

Figure 3. Students' Overall Grades for the two sections. No significance was found.

4.2 Student Feedback: Pre-course vs. Post-Course Survey

4.2.1 Familiarity and Interest in Revit and BIM Aspects

Analysis of the pre-course and post-course survey responses showed a slight increase in familiarity with Revit across both sections. However, paired t-tests did not identify statistically significant differences in familiarity for either section, as detailed in Table 1, and Table 2.

Notably, the level of interest in Revit decreased for both sections after the course. This change was statistically significant only in the Industry-Provided section, with a paired t-test result of t(47) = 3.498, and p = 0.00103, as shown in Table 1, and Table 2.

Table 1. Students' familiarity and interest Pre and Post-course for the Industry-Provided section

	Industry-Provided							
	Pre			Post			Comparisson	
Variable	**n**	**Mean**	**Var**	**n**	**Mean**	**Var**	**% change**	**significance, p<0.05**
Students FAMILIARITY with Revit	25	3.360	1.740	24	3.417	1.210	6%	n.s.
Students INTEREST in Revit	25	4.280	1.127	24	3.273	1.446	-101%	**t(47) = 3.498, p = 0.00103 (2-tails)

****indicates significance at p>0.05. n.s. indicated no significance at p<0.05*

Table 2. Students' familiarity and interest Pre and Post-course for the Student-Identified section

	Student-Identified							
	Pre			Post			Comparisson	
Variable	**n**	**Mean**	**Var**	**n**	**Mean**	**Var**	**% change**	**significance, p<0.05**
Students FAMILIARITY with Revit	25	3.320	1.060	26	3.420	0.494	10%	n.s.
Students INTEREST in Revit	25	4.160	2.056	26	3.384	1.846	-78%	n.s.

****indicates significance at p<0.05. n.s. indicated no significance at p>0.05*

4.2.2 Familiarity and Level of Proficiency pre-course and post-course

More specifically, students in both sections were asked about their familiarity with various BIM aspects in the pre-course survey and, later, about their perceived level of proficiency with the same BIM aspects in the post-course survey. A t-test was conducted for each section to compare pre-course and post-course responses, aiming to identify perceived learning gains in the BIM aspects covered in the class.

As anticipated, students reported increased levels of proficiency across all BIM aspects. The t-test results confirmed that these differences were statistically significant for every BIM aspect. Detailed results are presented in Table 3 and Table 4.

4.2.3 Engagement, Enjoyment, Satisfaction, and Confidence

Students were asked in the post-survey to evaluate their engagement, enjoyment, satisfaction, and confidence in applying what they had learned. See Figure 4. Overall, students in both sections responded positively to these aspects. A t-test was conducted to identify any significant differences between the sections, and only engagement with the project showed a statistically significant difference: t(47) = -2.182, p = 0.034. This indicates that students in the Student-Identified section were more engaged with the project compared to those in the Industry-Provided section. (See Engagement project in Figure 4). This finding aligns with the perceived effectiveness of learning methods discussed in the previous section.

Table 3. Statistical Analysis for Students' Feedback pre-course and post-course for the section conducting Industry-Provided Project

	Student-Identified							
	Pre			Post			Comparisson	
Variable	**n**	**Mean**	**Var**	**n**	**Mean**	**Var**	**% change**	**significance, p<0.05**
Modeling objects (e.g., walls, windows)	25	2.760	1.940	26	4.192	1.361	143%	**t(49) = -3.986, p = 0.0002 (2-tails)
Using Revit Families (e.g., changing object type, or editing its properties)	25	2.720	1.460	26	4.230	1.384	151%	**t(49) = -4.523, p = 0.0000 (2-tails)
Schedules and Quantity Take Offs	25	3.000	1.750	26	3.190	1.360	19%	n.s.
The Project Browser	25	2.440	1.590	26	3.615	1.686	118%	**t(49) = -3.27, p = 0.0019 (2-tails)
Dynamo	25	1.440	0.756	26	3.000	1.600	156%	**t(49) = -5.111, p = 0.0000 (2-tails)
Linking Multiple CAD and RVT files	25	1.960	1.623	26	3.920	1.430	196%	**t(49) =-5.672, p = 0.0000 (2-tails)
Using Different Views (e.g., Elevations, Floor Plans)	25	3.000	2.416	26	4.300	1.741	130%	**t(49) = -3.243, p = 0.0021 (2-tails)
Creating Topography	25	1.840	0.890	26	3.692	1.421	185%	**t(49) = -6.136, p = 0.0000 (2-tails)
Editing Objects (e.g., editing wall profiles, or changing its constraints)	25	2.520	1.926	26	4.153	1.255	163%	**t(49) = -4.634, p = 0.0000 (2-tails)
Editing Families (e.g., using family editor)	25	2.440	2.090	26	4.076	1.193	164%	**t(49) = -4.573, p = 0.0000 (2-tails)
Using Volumetric Objects (e.g. Masses, Generic Models)	25	1.680	0.893	26	3.961	1.158	228%	**t(49) = -8.031, p = 0.0000 (2-tails)

***indicates significance at p<0.05. n.s. indicated no significance at p<0.05*

Table 4. Statistical Analysis for Students' feedback pre-course and post-course for the section conducting Student-Identified Project

	Industry-Provided							
	Pre			Post			Comparisson	
Variable	**n**	**Mean**	**Var**	**n**	**Mean**	**Var**	**% change**	**significance, p<0.05**
Modeling objects (e.g., walls, windows)	25	3.080	1.743	24	3.958	0.824	88%	**t(47) = -2.702, p = 0.0095 (2-tails)
Using Revit Families (e.g., changing object type, or editing its properties)	25	2.880	2.027	24	4.087	0.810	121%	**t(47) = -2.738, p = 0.0086 (2-tails)
Schedules and Quantity Take Offs	25	3.120	2.027	24	3.609	1.067	49%	**t(47) = -2.738, p = 0.0086 (2-tails)
The Project Browser	25	2.560	2.090	24	3.700	1.519	114%	**t(47) = -2.985, p = 0.0044 (2-tails)
Dynamo	25	1.760	1.523	24	2.791	2.693	103%	**t(47) = -3.439, p = 0.0162 (2-tails)
Linking Multiple CAD and RVT files	25	1.920	1.410	24	3.333	2.753	141%	**t(47) = -2.493, p = 0.0006 (2-tails)
Using Different Views (e.g., Elevations, Floor Plans)	25	2.800	1.917	24	3.875	1.679	108%	**t(47) = -2.803, p = 0.0036 (2-tails)
Creating Topography	25	2.200	1.750	24	3.870	1.300	167%	**t(47) = -3.925, p = 0.0001 (2-tails)
Editing Objects (e.g., editing wall profiles, or changing its constraints)	25	2.480	1.593	24	3.916	1.818	144%	**t(47) = -3.851, p = 0.0001 (2-tails)
Editing Families (e.g., using family editor)	25	2.000	1.667	24	3.708	1.693	171%	**t(47) = -4.612, p = 0.0000 (2-tails)
Using Volumetric Objects (e.g. Masses, Generic Models)	25	2.040	1.873	24	3.541	1.824	150%	**t(47) = -3.864, p = 0.0003 (2-tails)

***indicates significance at p<0.05. n.s. indicated no significance at p<0.05*

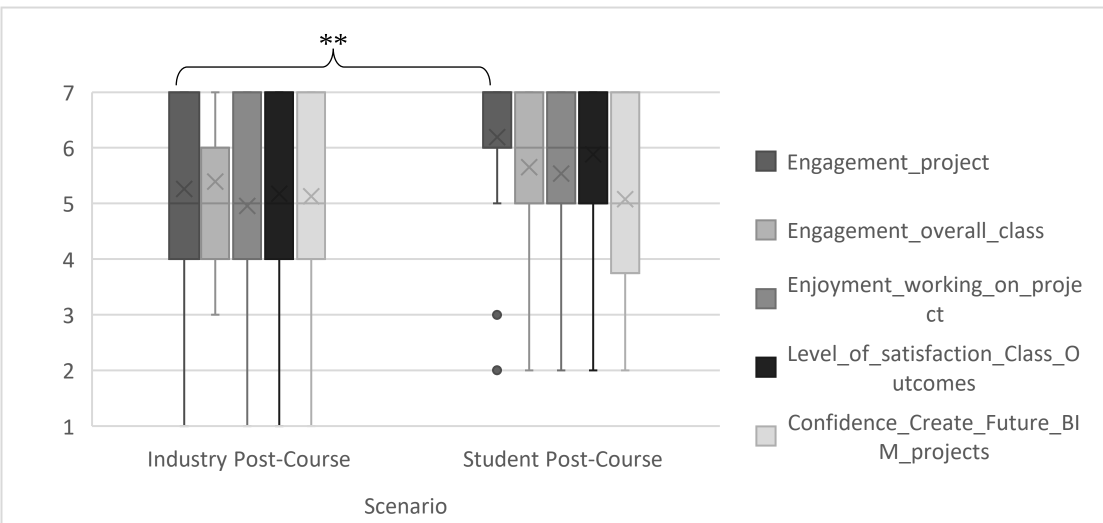

*Figure 4. Students' perceived engagement with the project, engagement overall with the class, enjoyment, and satisfaction across both sections after the course completion. **indicates significance at p<0.05. All others, no significance was found*

4.3 Comparison of Student-Identified and Industry-Provided project-based learning approaches

4.3.1 Reflections on Learning Outcomes

Students evaluated the effectiveness of various teaching methods in supporting their learning. The methods included lectures, student-led in-class labs, instructor-guided in-class labs, quizzes, exams, group projects, and individual projects.

Figure 5 presents the students' reported level of effectiveness on different learning styles, for the Industry-Provided section. Overall, students in this section ranked most of the learning methods moderately, between 3 and 5 points on the Likert scale. However, quizzes and exam were ranked lower, between 2 and 4.

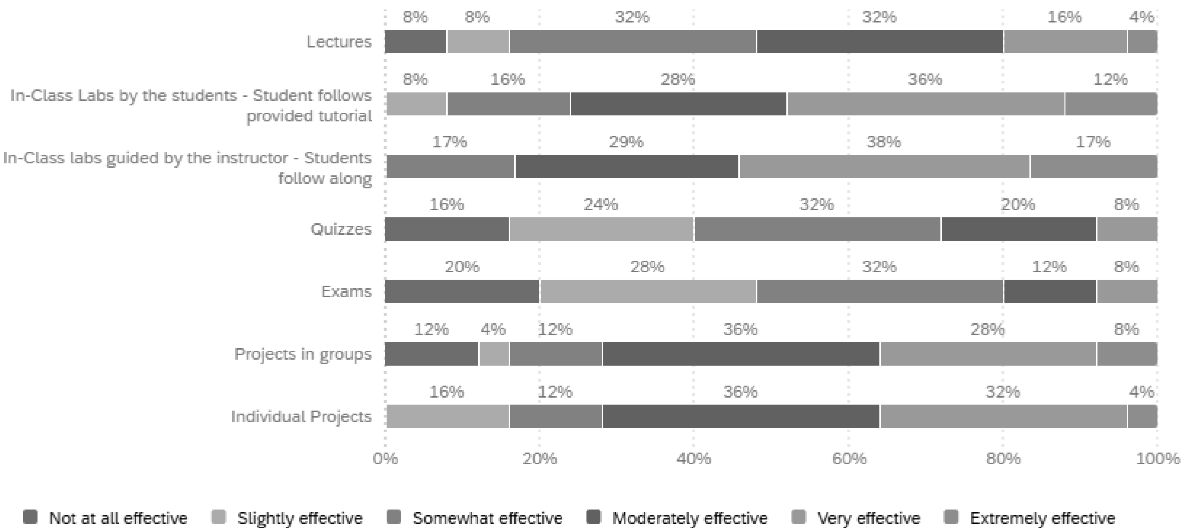

Figure 5. Students' perceived Levels of Effectiveness of different Learning Styles for the Industry-Provided section

Figure 6 shows the reported effectiveness of various teaching methods for the Student-Identified section. Students rated class labs by students, class labs guided by the instructor, and both group and individual projects as the most effective, with scores ranging between 4 and 5 on the Likert scale. Other methods, including lectures, quizzes, and exams, were rated lower, with scores between 2 and 4 on the scale.

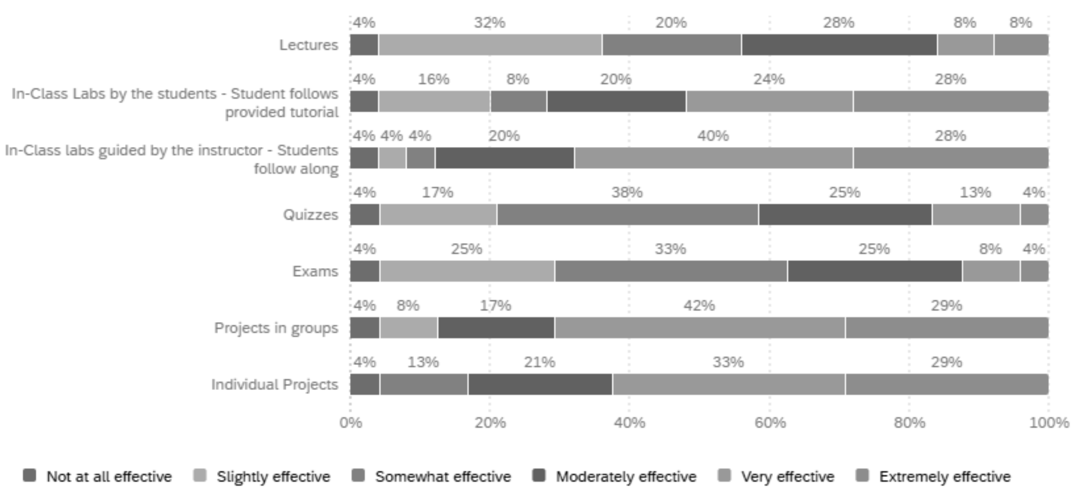

Figure 6. Students' perceived Levels of Effectiveness of different Learning Styles for the Student-Identified section

Given the observed differences in the perceived effectiveness of learning methods, an independent t-test was conducted to compare students’ perceptions across the two sections. The analysis revealed significant differences in perceptions for group projects, $t(47) = -2.076$, $p = 0.043$, and individual projects, $t(47) =$

−2.051, p = 0.046, as shown in Figure 4. These results indicate that students in the Student-Identified section rated both group and individual projects slightly higher in effectiveness compared to those in the Industry-Provided section.

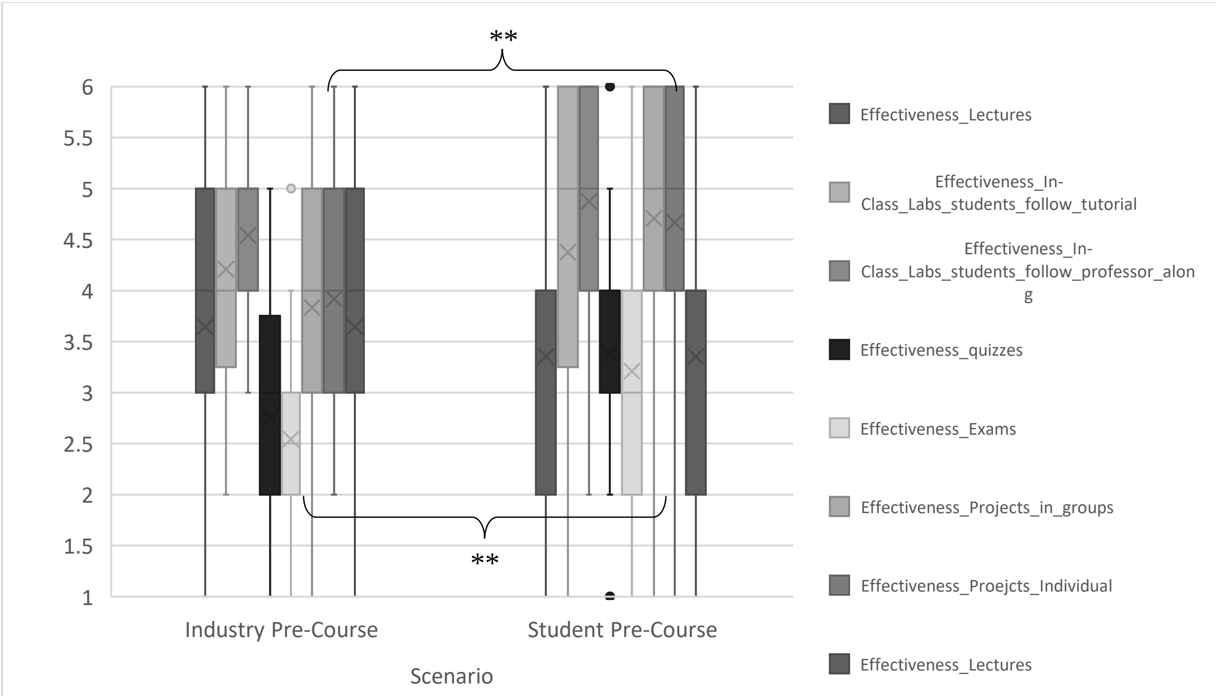

Figure 7. Comparison of students' perceived level of effectiveness of different learning methods across both sections.

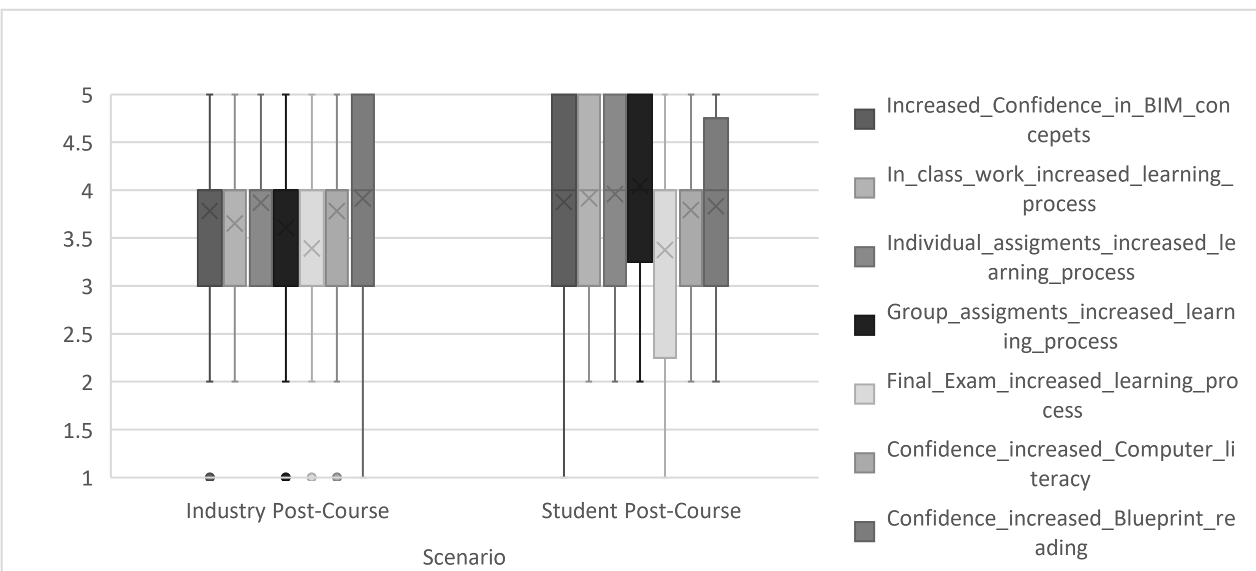

Figure 8. Students' post-course reflection on the learning process. No significance was found when comparing both sections

4.3.2 Effect of Learning Methods on Skills Development and Improved Learning

Students were asked to rate their agreement on how the learning methods influenced their skills development and improved learning, as shown in Figure 8 and Figure 9. Responses from the Industry-

Provided section were moderate, while those from the Student-Identified section were more positive. However, statistical analysis revealed no significant differences between the two sections.

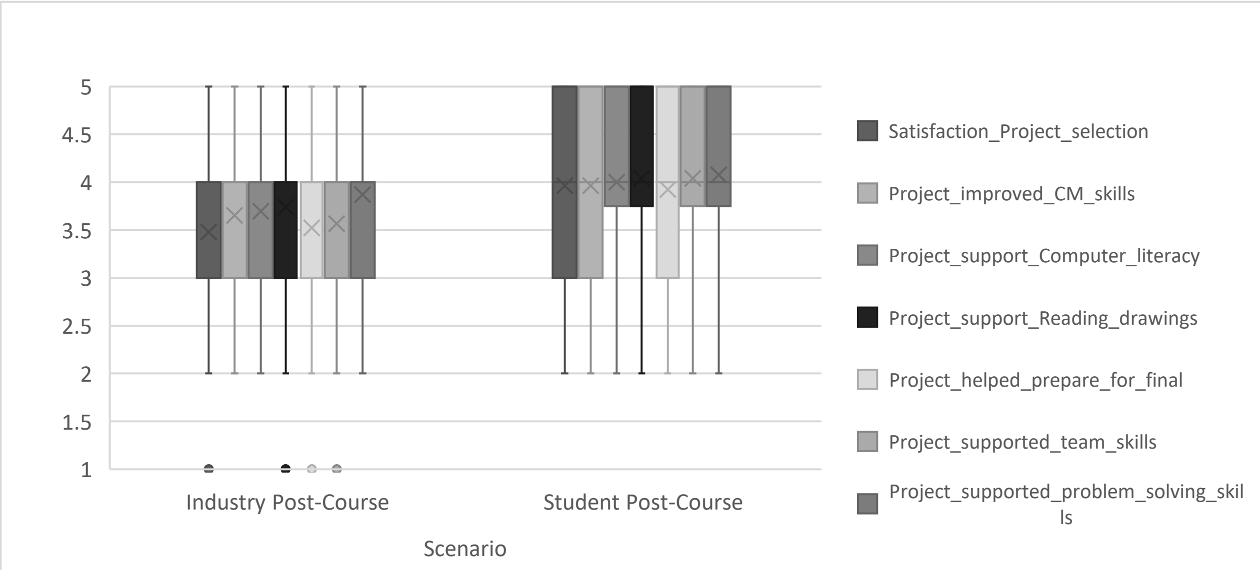

Figure 9. Students' reflection on Project Outcomes. No significance was found when comparing both sections

4.4 Students' Preferred Project Selection

Lastly, students were asked to reflect on the project selection process and rank their preferences among different project options. Figure 10 displays the results for the Industry-Provided section, while Figure 11 shows the rankings for the Student-Identified section.

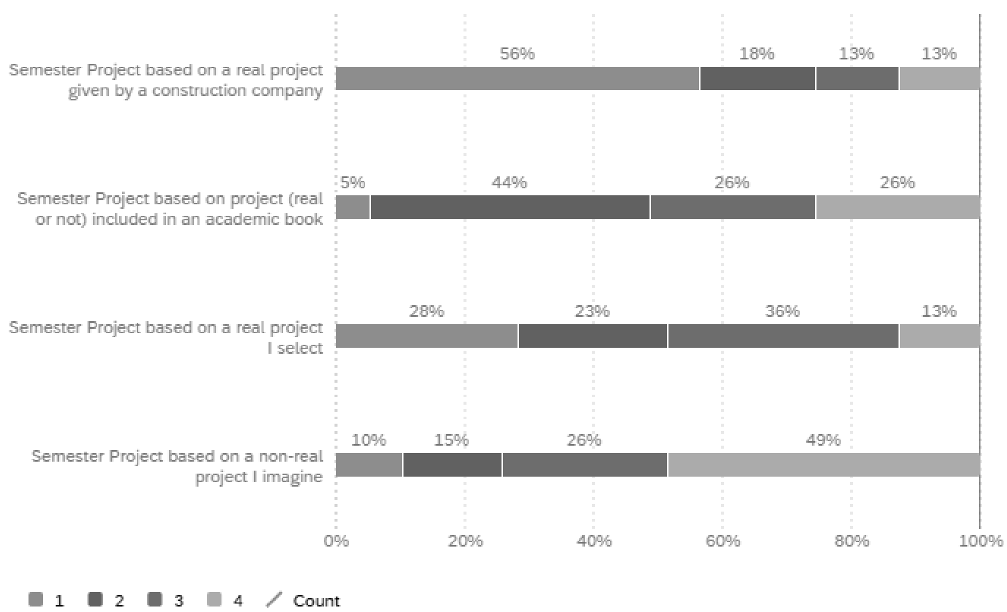

Figure 10. Students' rankings of preferred project selection for the Industry-Provided section

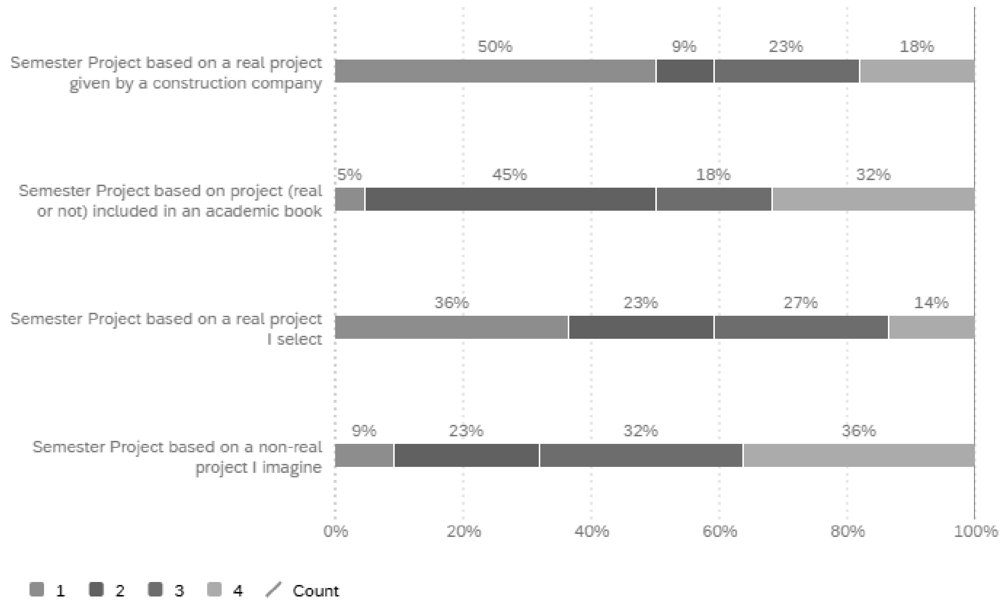

Figure 11. Students' ranking of preferred project selection for the Student-Identified section

A significant difference was found between the two sections regarding the preference for a real project from industry. Students in the Student-Identified section ranked this option as their top choice more frequently than those in the Industry-Provided section, $t(37) = -1.802$, $p = 0.003$, as illustrated in Figure 12.

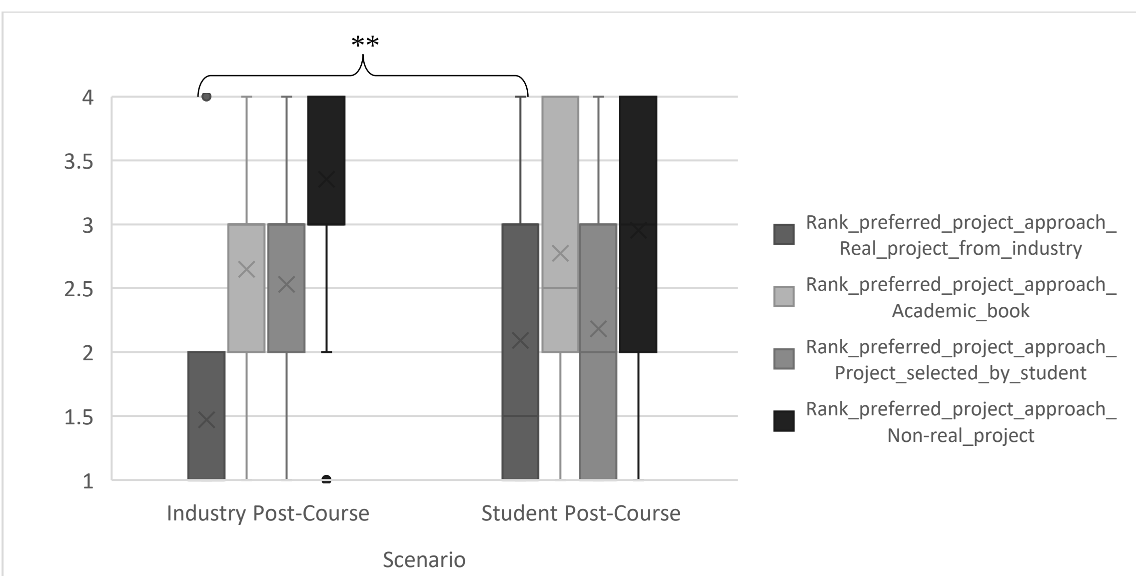

*Figure 12. Comparison of Student's Rankings of Project Selection across Sections. **indicates significance at p>0.05. All others, no significance was found*

5 Discussion

5.1 Hypotheses Evaluation

The study investigated three hypotheses regarding the effectiveness of Student-Identified and Industry-Provided project-based learning approaches in BIM education. The results provide valuable insights into the validity of these hypotheses.

- **Hypothesis 1:** Students who participate in an Industry-Provided PBL approach will demonstrate significantly higher academic performance than students who participate in a Student-Identified PBL approach.
  The analysis of final exam and overall course grades revealed no significant differences between the two sections, indicating that both approaches effectively supported student performance. This outcome highlights the robustness of the standardized curriculum and suggests that PBL impacts engagement and satisfaction more than performance metrics.
- **Hypothesis 2:** Students' familiarity with and interest in BIM and related software will increase over the duration of the course, regardless of whether they participate in a Student-Identified or Industry-Provided PBL approach.
  While both approaches resulted in increased self-reported familiarity with Revit, no significant differences were observed between the sections. However, the decline in interest in Revit, particularly in the Industry-Provided section, was statistically significant. This suggests that while familiarity improved across the board, factors associated with the PBL approach may have influenced students' perceptions of the software's appeal.
- **Hypothesis 3:** Students will report similarly high levels of satisfaction with PBL, regardless of whether the approach is Student-Identified or Industry-Provided.
  Both approaches were well-received by students, as reflected in their positive ratings of engagement, satisfaction, and confidence in applying BIM concepts. However, significant differences in engagement levels suggest that the Student-Identified approach may foster greater project ownership and motivation. Figure 13 presents the statistical differences in student engagement between the two sections in a more focused manner than presented in Figure 4.
  It is also important to highlight that this increased engagement was distinct from overall engagement with the course. This distinction is particularly noteworthy given that the class is project-based. Additionally, the observed engagement was different from "enjoyment," which is defined separately.

5.2 Impact of Student-Identified and Industry-Provided Approaches

The Student-Identified approach allowed students to exercise autonomy and creativity, which likely contributed to higher engagement and satisfaction with the semester project. This approach encouraged students to take ownership of their learning, aligning well with the goals of project-based education. Conversely, the Industry-Provided approach provided valuable exposure to real-world challenges, enhancing students' understanding of practical applications. However, the structured nature of this approach may have limited students' sense of agency, which could explain the slightly lower engagement levels.

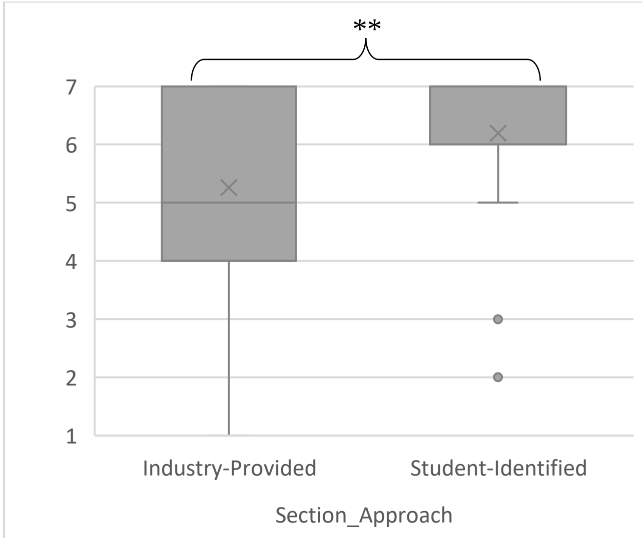

*Figure 13. Student Engagement with Project across course sections.**indicates significance at p<0.05*

5.3 Engagement and Ownership

The data demonstrated that engagement with the project was significantly higher in the Student-Identified section. This finding highlights the importance of autonomy in fostering a deeper connection to the learning process. Students in the Industry-Provided section appreciated the relevance of real-world projects but may have struggled with the constraints imposed by external stakeholders. Balancing autonomy and structure could enhance engagement across both approaches.

5.4 Reflections on Pedagogical Implications

Both approaches demonstrated unique strengths, suggesting that a hybrid model might be the most effective for teaching BIM concepts. Allowing students to choose from a curated list of industry projects could combine the benefits of real-world exposure with the motivation and ownership fostered by autonomy. Additionally, integrating reflective activities throughout the project could help students better connect their experiences with broader learning objectives, enhancing the overall learning process. Providing additional support for Industry-Provided projects, such as clearer guidelines for managing stakeholder expectations, could further mitigate challenges associated with external collaboration and ensure a smoother learning experience.

5.5 Broader Implications for BIM Education

The findings underscore the importance of tailoring pedagogical approaches to the diverse needs of students in construction management and architecture programs. While project-based learning is inherently beneficial, the specific implementation strategy can significantly influence students' engagement, satisfaction, and preparedness for professional practice.

5.6 Limitations and Future Research

This study was limited to two sections of a single BIM course at one university, which constrains the generalizability of its findings. Future research should address this limitation by exploring the longitudinal impacts of these approaches on students' career readiness and their professional application of BIM concepts. Additionally, studies should examine the effectiveness of hybrid models that combine student autonomy with real-world relevance to optimize learning outcomes. Finally, further research is needed to assess variations in outcomes across diverse student demographics and institutional contexts to provide a more comprehensive understanding of these pedagogical approaches.

6 Conclusion

This study compared Student-Identified and Industry-Provided project-based learning approaches in an introductory BIM course to evaluate their impact on student engagement, satisfaction, and learning outcomes. Both approaches proved effective in enhancing students' familiarity with BIM concepts and their ability to apply Revit, with no significant differences in overall academic performance. However, the Student-Identified approach demonstrated advantages in fostering student engagement and ownership, while the Industry-Provided approach provided valuable real-world exposure, preparing students for professional challenges.

The findings highlight the unique strengths of each approach and suggest that a hybrid model, which blends autonomy with real-world relevance, could maximize the benefits of project-based learning in BIM education. By allowing students to select from a curated list of industry projects, integrating reflective practices, and providing clear guidelines for Industry-Provided collaborations, educators can create a more balanced and impactful learning experience.

This study contributes to the growing body of knowledge on effective pedagogical strategies for teaching BIM in construction management and architecture programs. While the results are promising, they are limited to a single course at one institution. Future research should investigate the long-term impacts of these approaches on career readiness, explore hybrid models in greater depth, and examine their effectiveness across diverse educational contexts and student demographics. By doing so, educators can further refine project-based learning methods to better prepare students for the evolving demands of the AEC industries.

References

Abbas, A., Din, Z. U., & Farooqui, R. (2016). Integration of BIM in construction management education: An overview of Pakistani Engineering universities. *Procedia Engineering*, 145, 151–157. https://doi.org/10.1016/j.proeng.2016.04.021

Jin, R., Yang, T., Piroozfar, P., Kang, B. G., Wanatowski, D., Hancock, C. M., & Tang, L. (2018). Project-based pedagogy in interdisciplinary building design adopting BIM. *Engineering, Construction and Architectural Management*, 25(10), 1376–1397. https://doi.org/10.1108/ECAM-08-2017-0147

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, 19(3), 267–277. https://doi.org/10.1177/1365480216659733

Larmer, J., & Mergendoller, J. R. (2010). Seven essentials for project-based learning. *Educational Leadership*, 68(1), 34–37.

Müller, M., Loures, E., Mendes Jr, R., Canciglieri Jr, O., Freitas, M. D. C. D., & Frederico, G. F. (2016). Developing BIM culture in a university–Past and future steps. *Transdisciplinary Engineering: Crossing Boundaries*, 358–367. https://doi.org/10.3233/978-1-61499-703-0-358

Peterson, F., Hartmann, T., Fruchter, R., & Fischer, M. (2011). Teaching construction project management with BIM support: Experience and lessons learned. *Automation in Construction*, 20(2), 115–125. https://doi.org/10.1016/j.autcon.2010.09.009

Stewart, R. A. (2007). Investigating the link between Student-Identified learning readiness and project-based learning outcomes: The case of international master's students in an engineering management course. *European Journal of Engineering Education*, 32(4), 453–465. https://doi.org/10.1080/03043790701337197

Succar, B., Sher, W., & Williams, A. (2013). An integrated approach to BIM competency assessment, acquisition, and application. *Automation in Construction*, 35, 174–189. https://doi.org/10.1016/j.autcon.2013.05.016

Tai, M. H., Chen, K. L., & Chang, Y. L. (2019). Development of a project-based online course for BIM learning. *Sustainability*, 11(20), 5772. https://doi.org/10.3390/su11205772

Wu, W., & Hyatt, B. (2016). Experiential and project-based learning in BIM for sustainable living with tiny solar houses. *Procedia Engineering*, 145, 579–586. https://doi.org/10.1016/j.proeng.2016.04.036

Zhang, J., Xie, H., & Li, H. (2019). Project-based learning with implementation planning for student engagement in BIM classes. *International Journal of Engineering Education*, 35(1), 310–322.