

Article

Multidisciplinary Capstone Senior Design Projects: A Comparative Analysis of Industry-Sponsored and Faculty-Sponsored Projects Using Comprehensive Performance Metrics

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Abstract: Engineering education has continually evolved to embrace Project-Based Learning (PBL), a dynamic classroom approach emphasizing learning through engagement in real-world projects. The study conducts a comparative analysis of multidisciplinary Capstone Senior Design Projects across Electrical Engineering, Mechanical Engineering, and Computer Science at Texas A&M University at Texarkana. The research emphasizes understanding the dynamics of student collaboration within these disciplines and scrutinizes the impact of industry and faculty sponsorship on these projects. The methodology involves a comprehensive comparative analysis, employing diverse performance metrics to evaluate the effectiveness of different sponsorship models. This approach aims to uncover the influence of these models on project outcomes and students' educational experiences. The results reveal notable differences between industry-sponsored and faculty-sponsored projects. Industry sponsorship leads to higher performance in overall project execution and professional skills development. In contrast, faculty-sponsored projects are more effective in nurturing teamwork and communication abilities among students. The findings suggest that each sponsorship type presents unique benefits and challenges. Industry-sponsored projects provide valuable hands-on problem-solving experience, though they may suffer from inconsistencies in mentorship and varying expectations. Faculty-sponsored projects offer a more stable and consistent educational environment but might lag slightly in performance metrics. Integrating elements from both sponsorship models could provide students with a more balanced and enriching learning experience.

Keywords: assessment; self_and_peer review; capstone; senior design; multidisciplinary project-based learning; industry sponsorship; faculty sponsorship



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1. Introduction

This study examines the application of PBL in multidisciplinary Capstone Senior Design Projects (CSDP) at Texas A&M University at Texarkana (TAMUT), where collaborative efforts extend beyond traditional project work to embody the core principles of PBL—interdisciplinary learning, collaboration, and reflection. By comparing industry-sponsored and faculty-sponsored projects, this research identifies how each sponsorship model aligns with and supports PBL outcomes, such as problem-solving, self-directed learning, and integrating theory with practice, crucial for preparing students for the complexities of modern engineering challenges.

Engineering harnesses mathematical and scientific knowledge gained through academic learning, experience, and real-world application. Professionals creatively develop techniques to utilize nature's materials and forces for human benefit in this discipline. They innovate and build effective devices, systems, and infrastructures. The Accreditation Board of Engineering and Technology (ABET) defines engineering design as a systematic

process to create systems, components, or processes that meet specific needs within constraints. It is a repetitive, imaginative process where fundamental sciences and engineering principles are applied to transform resources into practical solutions [1–4]. The capstone design project is a crucial element in design education involving real-world engineering challenges. Successfully conducting capstone courses in electrical engineering (E.E.), mechanical engineering (M.E.), and computer science (C.S.) is vital yet complex. These projects often differ from actual design office scenarios, potentially turning them into analytical rather than design experiences [5–8]. The influence of site-specific conditions and local regulations on E.E., M.E., and C.S. projects highlights the need for faculty with industry experience for more impactful education. To bridge this gap, numerous educational institutions collaborate with industrial clients to sponsor these capstone projects [9,10].

The evolution of multidisciplinary CSDP has significantly enhanced student collaboration across various disciplines and altered the dynamics of industry and faculty sponsorships [11]. Despite this progress, there is a notable deficiency in comprehensive research exploring these aspects in depth. Most existing studies tend to focus on either student collaboration, industry sponsorship, or faculty sponsorship, treating them as isolated variables. Rarely do they examine the interplay and combined impact of these factors on project outcomes and student development. This gap highlights the need for more integrative research to fully understand the synergies and challenges of these elements in engineering education.

In a recent study referenced in [1], the authors investigate the impact of industry involvement on student learning in civil and environmental engineering courses at Florida Gulf Coast University (FGCU). By utilizing surveys from both students and practitioners, the research assesses the benefits of industry participation, focusing on the roles of practitioners as mentors and judges. The paper also examines two capstone projects to illustrate effective industry engagement. In [12], the authors aim to understand the motivation and value of industry sponsors of senior mechanical engineering capstone design projects. The study in [13] discusses the evolution of engineering curricula to meet industry needs, focusing on interdisciplinary teams, team building, and project management.

Further, the research in [14] discusses Seattle University's senior design program in Civil and Environmental Engineering. This year-long, industry-sponsored program meets ABET 2000 requirements, combining technical problem-solving with soft skills development such as leadership and communication. It outlines assessment methods and includes feedback from sponsors, alumni, and faculty. In [15], a capstone course, students developed software for an industry sponsor, comparing test-driven development (TDD) with test-last methods. Surprisingly, the test-last group was more productive and wrote more tests. The study suggests other factors such as ambition and motivation may influence outcomes more than the chosen development approach.

While this research offers valuable insights into the impact of industrial sponsorship on CSDP, it lacks a comparative analysis that would illuminate the perceived values of these projects from both industrial and faculty sponsorship viewpoints. Additionally, involving students from various disciplines in such a comparison study could provide a more comprehensive understanding of how different sponsorship models influence project outcomes and student learning experiences in a multidisciplinary context.

Other research on CSDP tends to focus on specific elements such as student assessments, skill improvement, team formation, and the use of internships, but often lacks a comprehensive comparison of these elements' overall impact on student learning outcomes. For instance, the study in [16] targets enhancing self- and peer-review accuracy by implementing various interventions over four years. Article [17] investigates an engineering capstone project aimed at boosting building information modeling (BIM) skills, employing team-based Learning (TBL) and 360-degree feedback. Study [7] reviews engineering project assessment rubrics to align with international engineering alliance standards, highlighting gaps in complex problem-solving. Research [18] delves into team formation in software engineering, proposing criteria for better cohesion. Lastly, [10] examines the influence of

internships on capstone projects in computer science, noting improvements in student skills and project complexity.

This study emphasizes the role of CSDP in fostering collaboration and practical skills in academic settings, particularly at TAMUT. It delves into a detailed comparison between industry-sponsored and faculty-sponsored projects using a variety of performance metrics. This comparative analysis is crucial as it highlights how different types of sponsorships influence student learning and the overall effectiveness of projects. By providing a comprehensive evaluation of these sponsorship models, the study aims to offer valuable insights into optimizing project-based learning in engineering education, enhancing the practical application of theoretical knowledge, and preparing students for real-world challenges.

2. Structure of CSDP

The CSDP at TAMUT is a multidisciplinary venture involving E.E., M.E., and C.S. students. The course's structure facilitates the formation of multidisciplinary teams, matching them with projects based on their interests. Of the 11 projects undertaken, 7 received industry funding, mainly from local manufacturing firms, with two C.S. projects sponsored by TAMUT's local I.T. department and a sheriff's office. This study demonstrates that incorporating real-world, project-based learning with industry engagement in capstone courses is advantageous for students, faculty, and industry partners. Undergraduate teams in the capstone course worked alongside fellow students, faculty members, and potential clients to adhere to project deadlines. Projects involved developing software, hardware, interfaces, system integration, and testing, requiring teamwork with professionals outside the capstone team. This experience brought forth challenges in teamwork, communication, documentation, scheduling, and various project management aspects, mirroring larger-scale industry projects. The CSDP thus serves as a practical platform for students to engage in teams and solve real-world problems through a two-semester, 6-credit-hour design process, either by developing new products/services or contributing to existing industry projects.

The CSDP is typically sponsored by industry partners and faculty members, with academic and industry mentors guiding students through the entire design process. This includes project initiation, scope definition, planning, various design stages, testing, performance analysis, simulation, and final presentations. The industry-sponsored projects provide students with hands-on experience in real-world scenarios, enabling collaboration with engineers and customers. Such projects have been significantly beneficial for the E.E., ME, and C.S. programs at TAMUT. Led by two faculty members from the E.E. and M.E. departments, the course is structured to create multidisciplinary teams matched with projects that align with their interests. Each project was supervised by academic and industry mentors. A total of 11 projects were undertaken in the course, involving teams of 3–4 students, with 7 projects receiving industry funding. These projects mainly involved collaboration with local manufacturing companies, alongside two C.S. projects sponsored by TAMUT's I.T. department and a sheriff's office. The course enrollment for the spring 2023 semester was 39 students. It was held once a week for 2 h and 45 min, where students formed their teams, a strategy aimed at minimizing potential conflicts during the semester.

In the CSDP, students begin the fall term by submitting and presenting their initial proposals. Once these are approved by their academic mentors, they commence work on their projects. Regular weekly meetings with the course instructor are required, where students provide oral updates in class. At the end of the second term, they are expected to submit a final report, deliverables, and an electronic team notebook and participate in a public poster and project presentation. Industry mentors play a crucial role in this process, judging the students' presentations and offering valuable feedback to both faculty and students, thereby enriching the learning experience in the capstone course. This feedback is instrumental in enhancing student performance on their projects and providing them with skills for their future engineering careers. Student performance is evaluated based on individual effort (28%) and teamwork (72%).

Individual contributions include reviews by industry and faculty mentors and peer reviews, while teamwork encompasses various components: 8% for the proposal report and presentation, 7% for oral updates in class, 7% for the electronic team notebook, 15% for the midterm report and presentations, and 35% for the final written reports and design and poster presentations. Industry mentors use a faculty-provided rubric to assess the final design of poster presentations, evaluating the student teams' verbal presentation skills, including organization, delivery, and professionalism, as well as written presentation skills such as content and poster quality.

3. Materials and Methods

This study's research methodology is crafted to meticulously compare industry-sponsored and faculty-sponsored projects, utilizing a set of strategic metrics that offer an all-encompassing evaluation of each project's effectiveness. The metrics applied include:

- *Overall Performance*: This metric assesses the overall success and outcomes of the projects, focusing on how well the objectives were met and the quality of the final deliverables.
- *Mentors' Evaluation*: The input from mentors who oversaw the projects is crucial. Their insights shed light on the teams' methodologies, problem-solving skills, and compliance with project guidelines.
- *Peer Reviews by Team Members*: This involves the team members assessing each other and highlighting the team dynamics, individual contributions, and the overall cohesion within the group.
- *Self-Review by Team Members*: Important as well, this metric looks at each member's self-review, focusing on their personal development, the challenges they encountered, and their individual input to the project's success.

The assessment of individual contributions and team dynamics in team projects uses specific evaluation criteria for self-review and peer review. These criteria (EC1 to EC6) include:

EC1 Attendance and Punctuality: Regular attendance and timely arrival at team meetings are crucial, reflecting commitment to the team's schedule.

EC2 Responsibility: Team members should responsibly contribute to collaborative tasks and assignments.

EC3 Timeliness: Completing assignments on time, especially for industry projects where deadlines might be strictly defined.

EC4 Quality of Work: High-quality work preparation ensures tasks are completed and performed to a high standard.

EC5 Cooperation and Support: A cooperative and supportive demeanor is essential for maintaining team harmony and effectiveness.

EC6 Listening Skills: Effective listening to fellow team members is crucial, underscoring the importance of communication within the team.

A numerical scoring system is used in the study to enable a clear and measurable comparison. Each project and its components are rated on a scale of 1 to 4, with 4 being the highest. This scale provides an efficient means to assess and compare performance levels across different projects. Moreover, the study calculates the standard deviation for these scores to determine the variability or dispersion in the data. Understanding the consistency of results across various projects and metrics offers a deeper insight into the performance differences between industry-sponsored and faculty-sponsored projects. This methodological approach highlights each sponsorship model's strengths and areas for improvement, providing a comprehensive evaluation of their effectiveness.

4. Results

4.1. Overall Performance

The overall performance assessment encompasses a comprehensive evaluation of all tasks undertaken within the CSDP. This evaluation integrates a variety of components: midterm and final presentations, interim and final reports, assessments from mentors and

peers, and the caliber of the electronic notebooks maintained by the participants. The data is categorized according to the nature of the project sponsorship: industry or faculty. This research analyzed the collective efforts of 11 teams spanning three distinct academic disciplines—electrical engineering, mechanical engineering, and computer science—which are detailed in Tables 1 and 2. Of these teams, four were under faculty sponsorship, and the remaining seven were supported by industry partnerships.

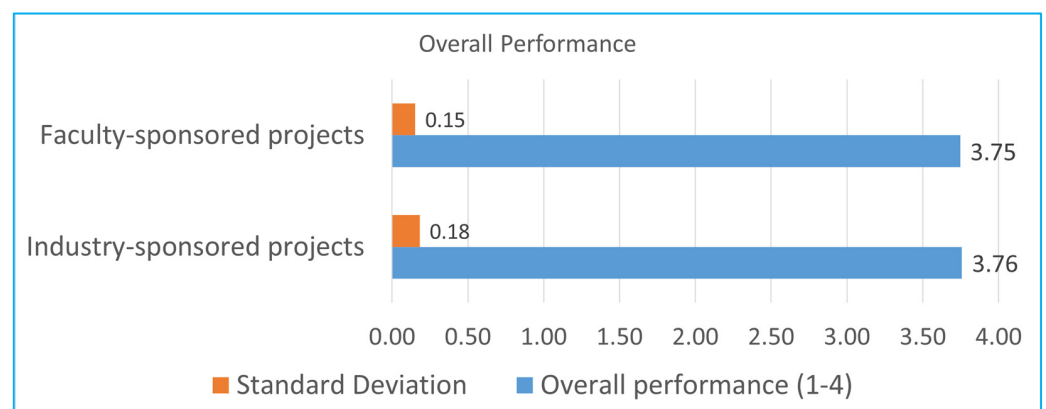
Table 1. Industry-sponsored projects in AY 2022/2023 at TAMUT.

Team No.	Students Majors	Project Title	Objectives
2	M.E. and E.E.	Hydraulic Power Unit Design and Overview	The project goal is to design and build a hydraulic power unit for Ledwell & Sons, Texarkana, TX, which will be used to test feed trailers before they are sold to the customer. The unit is mobile and transported by a forklift.
3	CS	Data Management in an Archival System	The project's goal is to reorganize archived data via software. The software will include a Python implementation of Optical Character Recognition (OCR), a database implementation of Microsoft Access, and an offline HTML program for keyword searching and other preferred features.
4	M.E. and E.E.	Transverse Tetris Table	This project aims to design and construct an effective and efficient transverse plasma table for JCM Industries, Texarkana, TX. The current plasma table is slow, inefficient, and unsafe during operation. By redesigning the plasma table, safety in the workplace and the overall production rate at JCM are significantly increased.
7	C.S.	Engineering a Secure Intranet Network	This project aims to engineer and deploy a secure Intranet network for Texas A&M University–Texarkana. The network was engineered to support a secure website and its client systems.
9	M.E. and E.E.	Automated Channel Stacker	The project's goal is to design and construct an automated channel stacker for New Millennium Building Systems, Hope, AR. The problem concerns the automation of the collection of cut channels from a channel cutter.
10	EE	Small Maintenance Rovers	This project aims to design and construct small maintenance tethered rovers to perform inspections inside the pipelines. This project will provide an opportunity for companies to perform inspections efficiently to result in less downtime and prevent any unexpected failures in the surrounding environments.
11	E.E. and C.S.	Control Cabinet Temperature Monitoring System	The project aims to develop a temperature monitoring system for Cooper Tires Texarkana AR control cabinets. The system will provide real-time monitoring and forecasting of the temperature in the control cabinets. The project improves the functionality and productivity of Cooper Tire's manufacturing processes and reduces the costs associated with damaged control panels and inactive processes.

Table 2. Faculty-sponsored projects in AY 2022/2023 at TAMUT.

Team No.	Students Majors	Project Title	Scope
1	M.E. and E.E.	Design and Manufacturing of an Archimedes Screw	The objective of this project is to design and manufacture a prototype Archimedes screw turbine to generate electricity. The design parameters for the Archimedes screw turbine were determined based on the current literature from various researchers. However, this study also highlights opportunities for improving the design and manufacturing processes.
5	CS	Hunter Sunder	This project is an Interactive Media game for Android devices. Its purpose post_creation is simply an interactive experience for users to enjoy in their off time, offering light entertainment to them as they go about their day-to-day.
6	C.S. and M.E.	Fiber Optic Motor Control	The project's goal is to design and construct a fiber optic cabling system that can control equipment in an industrial environment using a central access point and monitor its status. This design demonstrates how using fiber optics creates a flexible industrial environment due to its inherent properties, allowing easy use in harsh environments.
8	CS	ElectricEdge	This project aims to develop a platform that aims to provide a convenient and cost-effective solution to the growing demand for accessible and affordable charging infrastructure for electric vehicles.

Figure 1 compares students' overall performance between faculty-sponsored and industry-sponsored projects, with performance measured on a scale from 1 to 4. The performance for faculty-sponsored projects stands at 3.75 out of 4, with a standard deviation of 0.15, indicating a relatively uniform performance among the participants. In contrast, industry-sponsored projects have a marginally higher overall performance, scoring 3.76 out of 4, with a standard deviation of 0.18, suggesting a slightly broader range of outcomes. The difference in overall performance between the two types of projects is minimal, at just 0.01 points, or a mere 0.27% higher for industry-sponsored projects. The standard deviation is also quite close, with industry-sponsored projects showing only 0.03 points.

**Figure 1.** Overall performance in CSDP on a scale of 1–4.

4.2. Mentor Evaluation

The groups of students involved were matched with faculty and industry mentors according to the thematic focus of their projects. This strategic pairing was designed to harness the specific expertise of each mentor type, aiming to provide the most relevant and

beneficial guidance possible. A comparative analysis of the evaluations provided by the industry and faculty mentors is presented, reflecting the distinct assessment approaches and expectations derived from their respective professional and academic backgrounds. The juxtaposition of these evaluations yields a nuanced view of the mentorship's effectiveness and the differential impact it may have on the students' project results.

Figure 2 depicts mentor evaluations of student performance in faculty-sponsored and industry-sponsored projects, scored on a scale from 1 to 4. Faculty-sponsored projects received a higher evaluation, with an average score of 3.71, compared to industry-sponsored projects, with an average score of 3.45. This indicates that mentors rated faculty-sponsored projects more favorably by a margin of 0.26 points, translating to a 7.53% higher score compared to industry-sponsored projects. The variability in scores, as indicated by the standard deviation, is higher in industry-sponsored projects, at 0.49, compared to 0.38 for faculty-sponsored projects. In percentage terms, the standard deviation for industry-sponsored projects is 28.95% higher than that for faculty-sponsored projects. This suggests that mentors gave a broader range of evaluations to industry-sponsored projects, pointing to a less consistent performance within this group. Overall, these numbers reflect a trend where faculty-sponsored projects not only scored higher on average but also had more consistent evaluations.

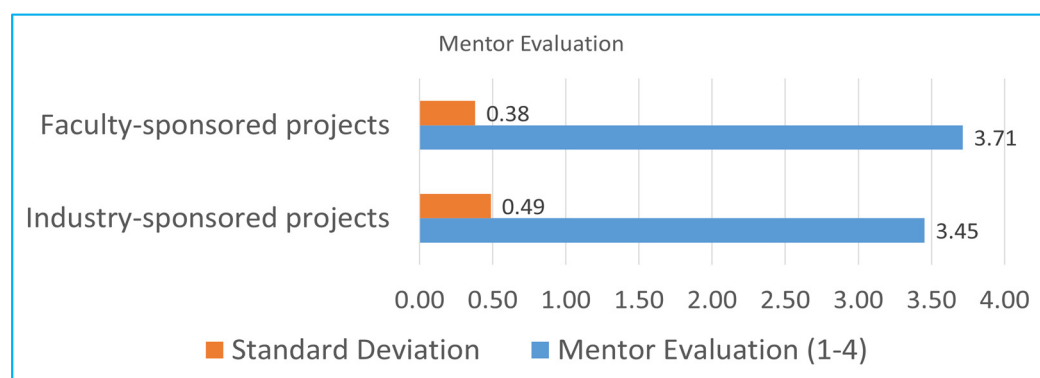


Figure 2. Industry and faculty mentor evaluations on a scale of 1–4.

Figure 3 illustrates a self- and peer-evaluation form, an essential tool for systematically assessing CSDP. It is thoughtfully crafted to evaluate a range of performance indicators. Common criteria include attendance and punctuality, assessing each member's regular participation and timeliness. Another key aspect is responsibility, reflecting on the degree to which team members fulfill their roles and highlighting accountability in teamwork. The form is likely to include an assessment of how promptly tasks are completed, a vital element in project management, especially stressed in areas such as E.E. and M.E. Work quality is another key criterion, with evaluators examining the completeness and accuracy of the deliverables in relation to the project's aims. Additionally, the form assesses the ability to nurture a cooperative and supportive team atmosphere, evaluating this ability as a measure of teamwork and mutual support.

Furthermore, in collaborative environments, effective communication, including listening skills, is crucial and expected to be included in the evaluation. These aspects are usually rated on a scale ranging from 1 to 4, where 1 indicates the least favorable outcome and 4 is the most favorable. This scoring system allows for a detailed and measurable assessment of each participant's input. The form, serving a dual purpose, facilitates both self-review and peer review, guaranteeing that each team member's performance is thoroughly evaluated from various angles, thereby enriching the learning experience of the capstone project.

Peer Evaluation Form for Team Projects				
Project Title :				Team no.
Write the name of each of your team members (including you) in a separate column. For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column.				
	Student #1 (Self-evaluation)	Student #2	Student #3	Student #4
Attends team meetings regularly and arrives on time.				
Take responsibility in team efforts to complete the assigned tasks				
Completes team assignments on time.				
Prepares work in a quality manner.				
Demonstrates a cooperative and supportive attitude.				
Demonstrates effective listening skills to other team members.				
TOTALS				

Figure 3. Self- and peer-review evaluation forms on a 1–4 scale.

Figure 4's peer-review chart evaluates team performance for industry-sponsored and faculty-sponsored projects on a 1-to-4 scale. Industry-sponsored projects excelled with a perfect 4.0 in attendance and punctuality, while faculty-sponsored projects scored a slightly lower 3.5, indicating a 12.5% difference. Both types of projects rated equally well at 3.75 for responsibility and timely completion of assignments. Remarkably, both achieved perfect scores in preparing quality work and in exhibiting cooperative, supportive attitudes, reflecting exemplary standards and teamwork. However, industry-sponsored projects maintained perfect scores for effective listening skills, whereas faculty-sponsored projects lagged slightly at 3.5, a 12.5% lower rating.

The standard deviations for industry-sponsored projects were consistently zero, showing uniformity in peer evaluations, but faculty-sponsored projects showed more variability, with a standard deviation of 0.7 in meeting attendance, assignment completion, and listening skills. This suggests a broader range of peer perceptions of faculty-sponsored projects. Despite this, faculty-sponsored projects still received high marks, illustrating a generally positive assessment from peers across all categories, while industry-sponsored projects consistently garnered perfect peer evaluations.

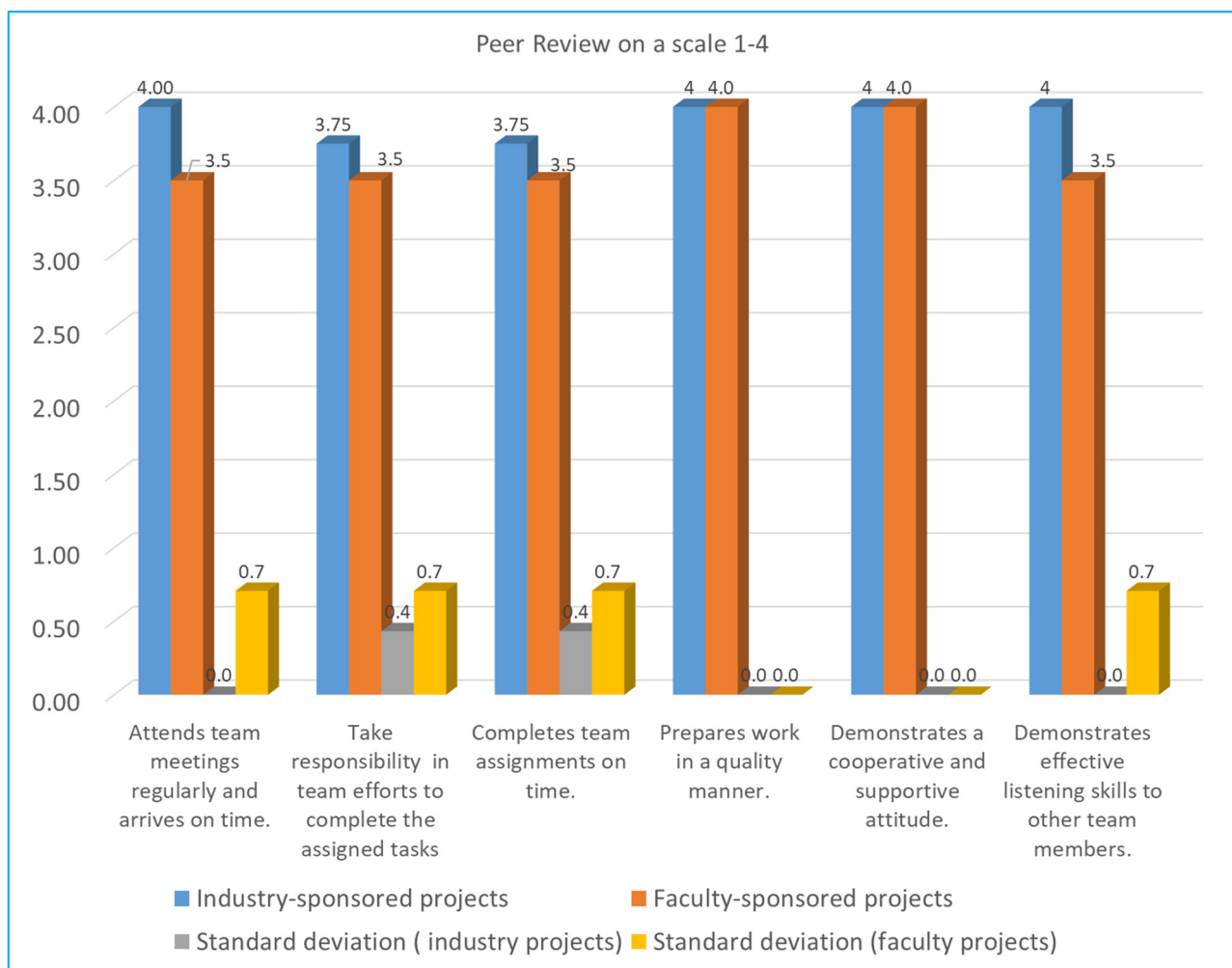


Figure 4. Peer-review results.

Figure 5's analysis of self-evaluation data in CSDP highlights distinct contrasts between industry and faculty-sponsored projects. Industry-sponsored projects scored a perfect 100% in attendance and punctuality, surpassing faculty-sponsored projects, which achieved 95.75%. In contrast, faculty-led projects showcased superior performance in responsibility, attaining 95.75% compared to the industry's 84%, hinting at a greater sense of commitment. Timeliness in completing assignments was nearly equivalent for both, with industry-sponsored projects slightly leading at 97.73%, against faculty's 95.83%. In terms of work quality, both types of projects maintained high standards, with industry scoring 95.45% and faculty at 95.83%.

However, faculty-sponsored projects outshone in fostering cooperative attitudes and demonstrating effective listening skills, scoring an impeccable 100% in both, exceeding the industry's 95.45% and 97.73%. The standard deviation analysis indicated greater variability in industry-sponsored projects, particularly in "Responsibility in Team Efforts", with a standard deviation of about 0.505. This variation suggests a wider range of individual experiences in industry projects, in contrast to faculty projects, where scores were more tightly clustered, especially in categories where they attained perfect scores. Overall, while industry-sponsored projects have a slight edge in areas such as punctuality and timeliness, faculty-sponsored projects are notable for their strengths in teamwork and communication skills.

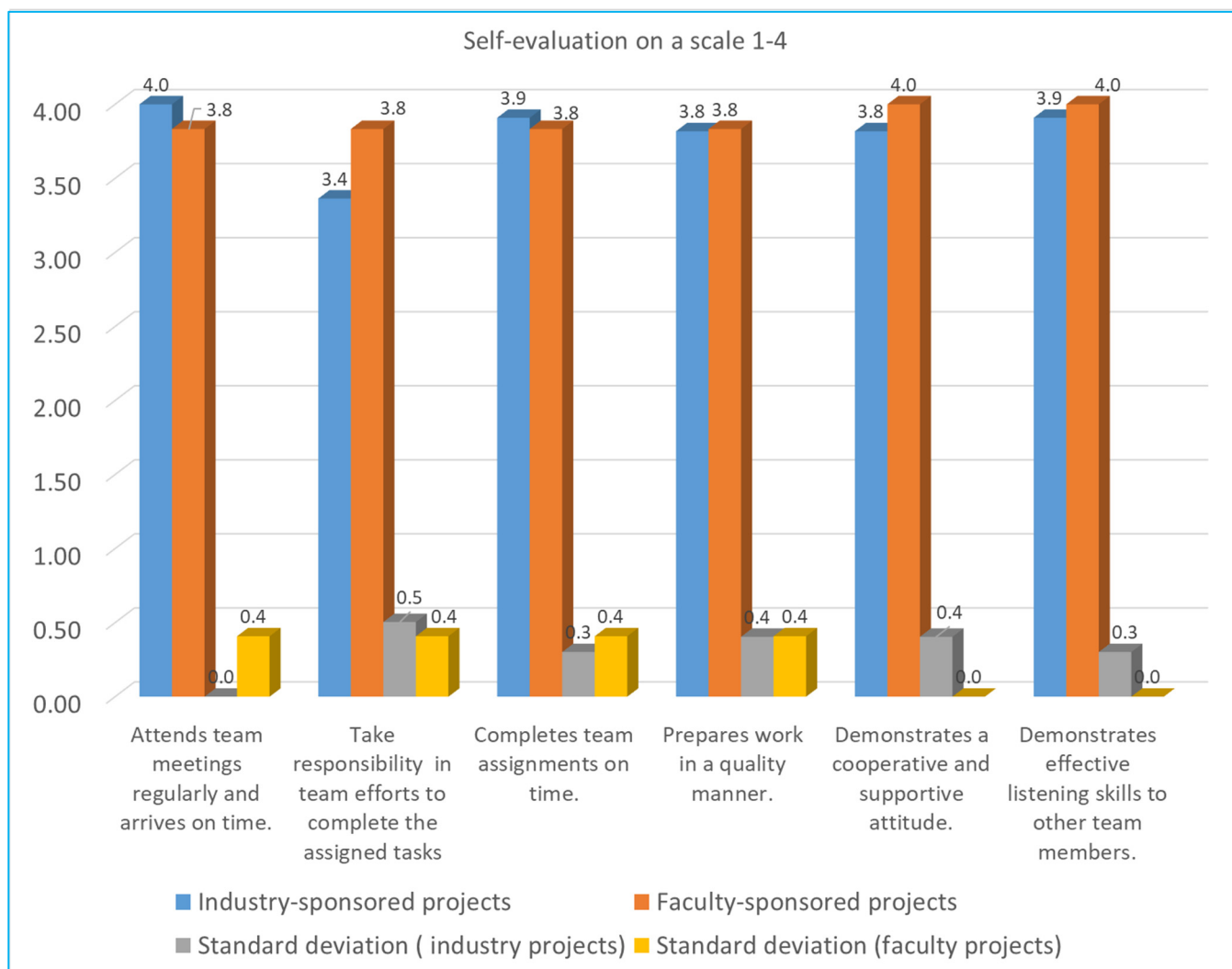


Figure 5. Self-review results.

5. Discussion

The comparative analysis of industry-sponsored and faculty-sponsored projects in CSDP, utilizing numerical data and percentages, reveals key differences between these two models. Industry-sponsored projects slightly outperformed in overall performance, scoring an average of 3.76 out of 4 compared to faculty-sponsored projects' 3.75. This minimal difference, just 0.01 points or 0.27% higher for industry projects, suggests a marginally more effective approach to meeting project objectives. The similar standard deviations (0.18 for industry and 0.15 for faculty) indicate consistent project outcomes across both models. The independent samples *t*-test (Welch's *t*-test) [19], conducted with the actual data points, resulted in a *t*-statistic of approximately 0.151 and a *p*-value of roughly 0.882. Therefore, based on this statistical test, the difference in performance scores between industry-sponsored and faculty-sponsored projects is not statistically significant.

In mentor evaluations, faculty-sponsored projects achieved an average score of 3.71, surpassing industry-sponsored projects' average of 3.45. This difference of 0.26 points, or a 7.53% higher score, suggests faculty mentors may favor projects more aligned with academic standards. Industry-sponsored projects showed a higher standard deviation of 0.49, compared to 0.38 for faculty-sponsored projects, indicating 28.95% greater variability due to diverse industry expectations and standards.

The independent samples *t*-test (Welch's *t*-test) for mentor evaluations resulted in a *t*-statistic of approximately -1.366 and a *p*-value of approximately 0.192. The negative

t -statistic indicates that the average mentor evaluation score for the industry-sponsored projects is lower than for the faculty-sponsored projects. However, the p -value is higher than the conventional alpha level of 0.05, meaning that the difference in mentor evaluation scores between the two groups is not statistically significant at the 5% significance level.

Peer and self-reviews in these projects offer a window into team dynamics and the individual roles played. Industry-sponsored projects excelled with perfect punctuality and listening skills scores, whereas faculty-sponsored projects scored a lower 3.5 in these areas, marking a 12.5% difference. However, in areas such as responsibility and cooperative attitudes, faculty-sponsored projects performed better, scoring 0.26 points or 7.53% higher in mentor evaluations. This points to different skill set priorities: industry-sponsored projects tend to enhance professional conduct and communication skills, while faculty-sponsored ones focus more on teamwork and collaboration.

The standard deviations in peer reviews show a notable contrast. Faculty-sponsored projects exhibited more variability (0.7) in areas such as meeting attendance, assignment completion, and listening skills, unlike industry-sponsored projects, which generally showed little to no variability. This suggests a broader spectrum of experiences within faculty-sponsored teams, allowing for greater individual differences. However, the independent samples t -test (Welch's t -test) was conducted for each of the six peer-review evaluation criteria, comparing scores from industry-sponsored projects with faculty-sponsored projects. For EC1, EC2, EC3, and EC6, despite having positive t -statistics indicating that the average scores for industry-sponsored projects might be higher than those for faculty-sponsored projects, the p -values are high (0.500 and above for EC1 and EC6, and 0.710 for EC2 and EC3). This means that for these criteria, there is no statistically significant difference in peer review scores between the two groups.

For EC4 and EC5, the standard deviation of zero indicates no variation in the scores within at least one group, rendering a t -test inappropriate for these criteria. In such cases where there is no variance, the mean scores are effectively the same across all observations within the groups, and thus a t -test is not needed to infer that there is no difference.

Supporting these observations, self-reviews for faculty-sponsored projects displayed significant consistency, especially in "Cooperative and Supportive Attitude" and "Effective Listening Skills", where they achieved perfect scores of 100%. In contrast, industry projects scored slightly lower at 95.45% and 97.73% in these categories. This consistent scoring in faculty-sponsored projects suggests a more uniform focus on teamwork and communication skills. Yet, all p -values of Welch's t -test are much greater than 0.05, indicating no statistically significant difference between the scores of peer reviews of industry-sponsored and faculty-sponsored projects for any of the six evaluation criteria.

In summary, Welch's t -test, a form of statistical significance testing, indicates no statistically significant difference between the evaluation criteria used for industry-sponsored and faculty-sponsored projects. However, descriptive statistics can still offer valuable insights into the nature of the data and potential areas of interest for future research or practical application.

6. Recommendations

Integrating faculty and industry-sponsored projects represents a forward-looking strategy that leverages the strengths of academic and practical perspectives in educational programs. The next steps could involve:

Developing a Hybrid Model: Creating a framework that combines the structured, theory-based approach of faculty-sponsored projects with the dynamic, real-world challenges of industry-sponsored projects. This model would encourage a balanced curriculum that prepares students for both academic and practical challenges.

Collaboration and Partnership Building: Strengthening partnerships with industries and incorporating their feedback into the curriculum design. This ensures that the projects remain relevant to current industry standards and needs.

Curriculum Integration: Incorporating projects as a core component of the curriculum rather than as extracurricular activities. This integration would ensure that all students gain valuable experience in both types of projects.

Assessment and Continuous Improvement: Establishing robust assessment mechanisms to evaluate the effectiveness of the hybrid model. Feedback from students, faculty, and industry partners should be used to refine project objectives and outcomes continuously.

Scaling and Diversification: Expanding the range of projects to cover more disciplines and industries. This diversification would provide students with a broader exposure to various fields and challenges.

By integrating both faculty and industry-sponsored projects, educational programs can offer a more comprehensive and practical learning experience, better preparing students for the challenges of the modern workforce.

7. Conclusions

The experiences and outcomes of students in industry-sponsored versus faculty-sponsored projects in CSDP differ significantly, each with its own unique advantages and challenges. Students participating in industry-sponsored projects, scoring an average of 3.76 out of 4 in overall performance, gain invaluable exposure to real-world problems and practical applications of their theoretical knowledge. However, they may face challenges adapting to the industry environment, which could be reflected in the slightly higher standard deviation (0.18) in these projects compared to faculty-sponsored ones (0.15). This variability might stem from industry mentors' fluctuating availability and diverse expectations. Despite these challenges, the value of industry-sponsored projects is considerable. Engaging in real-life problem-solving enhances critical thinking and problem-solving skills and potentially increases job placement prospects. The experience of dealing with tangible, industry-relevant challenges provides a significant advantage in the job market, as students are better prepared for the dynamics of a professional setting.

On the other hand, faculty-sponsored projects scored slightly lower in overall performance (3.75 out of 4) but offered a more consistent and structured learning environment, thanks in part to the more regular availability of mentors. Faculty mentors, typically scoring an average of 3.71 in mentor evaluations compared to 3.45 for industry mentors, provide guidance that is closely aligned with the academic objectives of the projects. These projects may not offer the same level of industry engagement, but they excel in developing foundational skills such as teamwork, communication, and academic rigor—skills that are also critical in professional settings.

Regarding peer evaluations, industry-sponsored projects received higher scores in professional skills such as punctuality and listening, with perfect scores of 4.0, indicating their effectiveness in preparing students for professional environments. While scoring slightly lower in these areas (3.5, a 12.5% lower score), faculty-sponsored projects still foster important collaborative skills and a structured approach to problem-solving.

In summary, the comparative analysis of industry and faculty-sponsored CSDPs provides insights with implications extending into the realms of PBL. Despite the lack of statistically significant differences in performance metrics, the nuanced variations offer a deeper understanding of how PBL principles manifest in a real-world setting. The engagement with actual industrial problems and the academic rigor of faculty-guided projects together reflect the multidimensional benefits of PBL—preparing students academically and for the unpredictable nature of engineering professions. This study advocates for an educational paradigm that integrates the PBL elements found in CSDPs, promoting a balanced approach to engineering education that is theoretically sound and practically oriented.

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