Improving the Productivity of Capstone Project Coaching/Mentoring

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Brady Davies joined the Department of Mechanical Engineering at Brigham Young University in 2022, after practicing design engineering for several decades at various companies including a national lab, several startups, and several mid-to-large size technology companies. During his industry career, Dr. Davies worked in a variety of different industries including automotive, semiconductors, communications, and defense. Dr. Davies now leads the college's interdisciplinary capstone program, where he serves as an Associate Teaching Professor and Director of the Engineering Capstone Program. In this role, teaching and mentoring students is the primary stewardship and focus. The current capstone program serves over 400 students with over 60 projects and over 50 coaches, instructors, administrators, and staff.

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Allyson Gibson is the External Relations Manager and Capstone Coordinator in the Department of Electrical and Computer Engineering at Brigham Young University. She earned her Bachelor of Science in Electrical and Computer Engineering and joined BYU in 2016 during the formation of a unified, multidisciplinary Capstone program. Since that time, she has helped expand the program from fewer than forty sponsored projects annually to more than sixty, significantly increasing industry engagement and student impact. Prior to joining the university, she worked in the software industry, bringing industry perspective to her leadership of sponsor development, coach coordination, and program operations. Her work focuses on designing scalable systems that support sustained program growth while preserving rigorous, high quality, industry sponsored design experiences through strategic relationship management and structured oversight of Capstone teams to ensure strong educational and project outcomes.

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Abstract

Large interdisciplinary engineering capstone programs face persistent challenges in maintaining instructional quality while scaling to meet growing enrollment and financial constraints. In the capstone program examined in this study, a historical one team per coach model provided high levels of instructional support but required substantial coaching resources, which contributed to increasing program costs. This study presents results from a pilot implementation in which a subset of teams operated under a two teams per coach model, with outcomes compared to the one team per coach approach. Coaches supporting two teams were expected to devote approximately three hours per team each week, in contrast to the six hours per week allocated by coaches supporting a single team. Data was collected through weekly coach time tracking, twice per semester student mentoring surveys, twice per semester instructor and coach project success forecasts, and post project sponsor evaluations. Results indicate that teams supported under the modified coaching model achieved comparable mentoring effectiveness and project success ratings despite substantially lower coaching time per team. No meaningful correlation was observed between reported levels of average coaching hours per team and perceived mentoring quality or specific project outcomes. These findings suggest that time spent coaching individual project teams can be significantly reduced, and when supported by complementary mentoring from instructors and program staff, improve scalability and cost efficiency in large capstone programs without degrading educational quality.

Program Context and Research Motivation

The university's engineering capstone program is organized around three core components: industry-sponsored projects with active sponsor engagement, small design teams (typically 5 – 7 student) supported by industry-experienced coaches, and small design teams coached by full time engineering faculty. Across all teams, the primary role of capstone coaches is to provide technical, professional, and project mentoring to both teams and individual students. This mentoring-centered model [1] has been effective for decades and has contributed to very positive student outcomes and sponsor satisfaction. However, as the program has expanded from fewer than a dozen projects at its inception to more than 60 projects today, the resources required to sustain this level of coaching have increased nonlinearly. At the same time, recruiting a sufficient number of fully funded industry sponsored projects has become increasingly challenging, motivating the capstone leadership team to explore alternative instructional and mentoring models that maintain educational quality while improving scalability and financial sustainability.

Mentoring plays a central role in the capstone experience and is primarily delivered through dedicated team coaches who provide technical, professional, and project guidance. While this coaching intensive model has supported strong student and project outcomes, it also represents a substantial portion of overall program costs. A benchmarking study conducted across peer institutions indicated that coaching costs in this program, measured in mentoring hours per team per week, were approximately two to three times higher than those reported at other universities. These findings motivated the following research question: how can coach productivity be improved while maintaining or enhancing mentoring effectiveness, project success, and overall educational quality, while simultaneously reducing the cost of coach mentoring?

To address this question, several programmatic changes were implemented during the 2024–25 academic year, including a pilot of a modified coaching role that emphasized proactive program management and increased focus on individual student mentoring, while reducing overall coaching time. Additional constraints and tracking mechanisms were applied to coaching activities to more clearly define and monitor coach time allocation. These changes were intended to enable coaches to more effectively mentor teams and individual students while improving oversight of project organization and execution. To assess the impact of these modifications, several new data collection instruments and survey measures were introduced.

This paper examines productivity gains in coach mentoring observed during a pilot implementation and analyzes their implications for instructional scalability and cost efficiency in large interdisciplinary capstone programs. Prior national surveys of engineering capstone courses have documented broad trends in course organization, faculty involvement, and industry sponsorship across programs, such as the comprehensive survey reported by Howe and Wilbarger [2]. However, while much of the capstone education literature emphasizes student learning outcomes, project quality, and sponsor satisfaction, comparatively less attention has been given to the instructional staffing models required to sustain these outcomes at scale. By directly examining the relationship between coaching time, mentoring effectiveness, and project success, this work contributes empirical evidence on how alternative coaching models can support program sustainability without compromising core educational objectives.

Mentoring Functions

To contextualize mentoring within capstone education, relevant mentoring frameworks identified in the literature were first reviewed. A comprehensive treatment of mentoring in engineering capstone projects is provided by Pembridge and Paretti [3], who developed a set of mentoring categories grounded in empirical study of capstone teams. This work builds on Pembridge's doctoral research and draws from earlier mentoring theory in organizational contexts, particularly the framework proposed by Kram [4]. Although originally developed for business organizations, these mentoring principles are highly applicable to engineering capstone teams.

Analysis of the program's learning objectives and prescribed student outcomes indicated that the capstone experience places primary emphasis on a subset of the mentoring functions

defined by Pembridge and Paretti [3]. Specifically, the program's educational priorities are most directly supported when mentoring is effective in the areas of Coaching, Challenging Assignments, and Acceptance/Confirmation, as summarized in Table 1 below. These functions align closely with the program's stated instructional goals and are consistently reflected in capstone lecture content, program documentation, and published mission statements. Accordingly, the mentoring functions in Table 1 were evaluated through faculty surveys to assess the extent to which coaching activities supported these prioritized outcomes.

Table 1. *Mentoring functions and associated faculty survey items adapted from Pembridge and Paretti [3].*

Functions		Capstone Faculty Survey Items
Career	*Exposure/ Visibility*	• Enable students to network • Enable students to publish • Enable to get involved with professional societies
	Coaching	• Teach design considerations, technical content • Enable students to synthesize & apply prior coursework • Provide guided questions, suggestions, and ideas
	Protection	• Keep up with status and progress of projects • Keep up with functioning of teams
	Challenging Assignments	• Allow students to interpret data and make decisions • Allow students to make mistakes
Psychosocial	***Role Modeling***	• Provide general topic knowledge and technical expertise • Troubleshoot and solve problems
	Acceptance/ Confirmation	• Introduce students to new experiences • Allow students to grow as individuals and professionals
	Counseling	• Provide solutions to students & tell them what to do
	Friendship	• Get to know students personally including knowing work habits and personalities

Because the program relies on industry-sponsored projects to provide authentic engineering challenges and essential project funding, mentoring must also address functions associated with Protection and Role Modeling to ensure that project outcomes meet sponsor expectations. In addition, a key learning objective not explicitly captured in Table 1 is the development of students' ability to work effectively within interdisciplinary teams, reflecting the professional environments graduates are likely to encounter. While the program provides targeted instruction and mentoring related to teamwork, this competency is primarily developed through team-based project work involving complex objectives, constrained budgets, and fixed schedules.

With these mentoring functions more clearly articulated, the program then evaluated methods to identify mentoring effectiveness and potential gaps, and examined opportunities for improved mentor training and role definition to strengthen the breadth and impact of mentoring across all mentoring roles.

Mentoring Roles

Coach: The capstone program includes a dedicated team coach role that is well-suited to supporting a broad range of mentoring functions across all five categories (shown in red or green as Coaching, Protection, Challenging Assignments, Role-Modeling, and Acceptance/Confirmation), described in Table 1, as well as assisting teams with interpersonal or teamwork challenges. Coaches are either full-time faculty or part-time adjunct faculty drawn from local companies and organizations with experience in engineering design, project facilitation, and collaborative technical work. Their primary responsibilities include providing professional development mentoring aligned with the Coaching, Challenging Assignments, and Acceptance/Confirmation functions, as well as supporting project success through Role Modeling as defined in Table 1.

Instructor: Instructors are responsible for delivering in-class lectures, conducting project reviews, and advising students and teams within their assigned pods (defined as groupings of approximately 12-15 project teams). The program typically includes approximately 60 project teams organized into evenly sized pods, each supervised by a lead full-time faculty instructor. Through these activities, instructors contribute to several elements of the Coaching function in Table 1, with a greater emphasis on academic content and assessment.

External Relations Manager: External Relations Managers provide administrative support and serve as the primary liaison between the capstone program and industry sponsors. They are industry-experienced engineers rather than academic faculty, and they support student teams by mentoring them in professional communication, project management practices, and effective sponsor engagement. At each major design stage, External Relations Managers evaluate and grade team project status briefs and provide formative feedback to help teams clearly communicate project progress, technical decisions, and planned next steps to sponsors. This mentoring and assessment role primarily supports the development of student professionalism and aligns most closely with the Acceptance/Confirmation function described in Table 1, which is not consistently addressed by other mentoring roles.

Additional mentoring sources: Students and teams also receive supplemental mentoring through structured project reviews conducted by a second coach within the pod, referred to as a review coach, who provides technical feedback three times per semester. In addition, students participate in two peer review activities each semester that offer feedback on professionalism and teamwork, further reinforcing mentoring related to interpersonal and collaborative skills.

Coaching Pilot

Historically, coach salaries have represented the largest single cost within the capstone program. A benchmarking study conducted with peer institutions offering comparable capstone

experiences indicated that mentoring costs in this program, normalized by weekly coaching hours per team, were approximately two to three times higher than those reported elsewhere. To bring mentoring costs into closer alignment with peer programs and reduce overall program expenditures, a modified coaching role was piloted during the 2024–25 academic year.

Under the pilot model, approximately half of the coaches continued to support a single team with an expected commitment of six hours per week, while the remaining coaches supported two teams with a total time allocation of approximately six hours per week, or three hours per team. Coaches were assigned intentionally based on project characteristics and program staffing needs rather than at random, or based on whether they would be coaching a single team or two teams, and other criteria. As a result, proportionally more projects that were software-focused were assigned to two-team coaches due to the relative scarcity of coaches with strong software development skills. All coaches were asked to place greater emphasis on project management and task scheduling to support successful execution and to more readily identify students experiencing challenges related to attendance, engagement, or workload management. Given the importance of maintaining a high-quality student experience and ensuring successful project outcomes for industry sponsors, the modified role was piloted in academic year 2024-25 prior to broader implementation in academic year 2025-26.

Although the pilot was primarily motivated by financial considerations, it also addressed increasing challenges in recruiting and retaining qualified adjunct faculty across the wide range of disciplinary expertise required by an interdisciplinary capstone program. As the program expanded from approximately 350 students and 50 projects in prior years to more than 400 students and 56 projects during the pilot year, coaching costs approached half of the program's operating budget, and identifying sufficient numbers of coaches with specialized technical backgrounds necessary for certain projects became increasingly difficult relative to availability in other disciplines. Allowing coaches to support two teams enabled the program to more effectively distribute limited disciplinary expertise across projects while mitigating staffing constraints.

To mitigate potential risks associated with reduced coaching time per team, mentoring contributions from other instructional roles were increased and coach responsibilities were rebalanced to prioritize direct team engagement. Instructors were directed to meet weekly with each team in their assigned pods to review progress, address technical issues, and counsel students demonstrating reduced engagement. At the same time, coach grading responsibilities were reduced somewhat. In prior years, coaches were responsible for grading multiple student submissions throughout the semester. During the pilot, coaches were instead asked to provide high-level feedback at each stage of the design review process without assigning grades. This shift was intended to reduce administrative workload and allow coaches to devote a greater proportion of their time to direct mentoring interactions with teams and individual students.

The pilot study was designed to examine differences in project outcomes and student experiences across three dimensions: (1) variation in how coaches allocated their mentoring time, (2) teams supported by one team versus two teams per coach, and (3) teams coached by full time faculty versus adjunct faculty.

Data Collection and Measures

Data were collected using a combination of time tracking and survey instruments administered throughout the academic year. Project and student success were assessed through surveys administered to instructors, coaches, external relations managers, and sponsors, as well as student surveys evaluating the perceived effectiveness and quality of coaching support.

The data collection approach included the following components:

1. **Coach time tracking:** Each coach was directed to complete a weekly timesheet documenting coaching related activities, recorded in fractional hours and submitted on a weekly basis.
2. **Student surveys:** Students completed two surveys per semester evaluating the effectiveness and quality of mentoring provided by their assigned team coach.
3. **Internal project success forecasts:** Instructors, coaches, and external relations managers each completed two surveys per semester providing forecasts of final project success based on current project status and trajectory.
4. **Sponsor evaluation:** Following project completion, industry sponsors completed a survey assessing project success, including the extent to which project outcomes met sponsor expectations and needs.

Results

Student survey results indicated that coaches supporting two teams received slightly lower mentoring effectiveness ratings than coaches supporting a single team, with an average difference of 3.5 percent. This difference was observed despite two team coaches spending substantially fewer hours per team, averaging 2.12 hours per week compared to 4.57 hours per week for one team coaches.

Project success ratings showed minimal differences between teams supported by one team and two teams per coach. Instructor and coach survey data were available for 29 single coached teams and 24 double coached teams, while sponsor survey data were available for 12 single coached teams and 5 double coached teams. In instructor reported project success estimates, teams supported by two team coaches averaged 8.6 out of 10, compared to 8.8 out of 10 for teams supported by one team coaches. Coach-reported success estimates averaged 9.1 out of 10 for two team coached projects and 8.6 out of 10 for one team coached projects. Sponsor reported success ratings averaged 8.8 out of 10 for two team coached projects, compared to 8.1 out of 10 for one team coached projects.

Analysis of student survey data indicated that teams coached by full time faculty received slightly lower mentor effectiveness ratings than those coached by adjunct faculty, with an average difference of 2.7 percent.

Correlation analyses did not reveal a meaningful relationship between average weekly coaching hours and project success in either instructor or coach surveys. Similarly, no

meaningful correlation was observed between average weekly coaching hours and student reported coaching effectiveness, with the highest R^2 value observed across models equal to 0.25.

All reported differences are descriptive in nature and were not found to be statistically significant given the observed sample sizes.

Conclusions

The results of this study indicate that average weekly coaching time per team was not strongly associated with either project success or student perceived mentoring quality. Across all measured outcomes, teams supported by a one team per coach model, with nominal coaching allocations of approximately six hours per week, performed comparably to teams supported by a two teams per coach model, with approximately three hours of coaching per team per week. Similarly, project success ratings and student evaluations of mentoring effectiveness were comparable for teams coached by full-time faculty and those coached by adjunct faculty (professional engineering) coaches.

Additional findings were obtained via a survey administered mid-way through the 2025-2026 academic year that included responses from 44 coaches, three-fourths of which had coached Capstone previously, and about one-fourth who were coaching for the first time. About one-fourth of the respondents were coaching 2 teams, with the rest only coaching a single team. One interesting finding was that on average, current coaches believed their teams could achieve 38% success (with respect to requirements and sponsor expectations) with no coaching. The same set of coaches on average indicated that their teams would likely achieve 85% success with 3 hours of coaching per week per team (the number dropped to 82% when they spent 6 hours per week per team). Interestingly, the same coaches on average predicted 73% success when only spending 2 hours per week per team. When the relationship between coaching time and project success was queried from a different perspective, on average coaches believed investing 3.3 hours per week per team was necessary to ensure projects were HIGHLY successful, and 2.4 hours per week per team to ensure the project was MOSTLY successful. This data tracks well with the survey results of our pilot program in 2024-2025 reported above.

From a coach satisfaction perspective, of the 32 coaches who had previously coached Capstone (on average they had previously coached 5 teams), 31 (97%) said the coaching experience during the 2025-2026 academic year was the same, somewhat better, or much better. Only 1 coach claimed the experience was somewhat worse. Thus, the changes in coaching commitment and compensation implemented during the 2025-2026 academic year seem to have little if any negative impact and mostly neutral or even positive impact on the coach experience.

All findings suggest that mentoring effectiveness and project success are influenced by a broad set of factors beyond average coaching time or compensation, likely more impacted by individual student characteristics, team dynamics, project complexity, and individual coach attributes. Within the context of this program, the data indicates that when coaches allocate on the order of two to three hours per week to each team, teams are effectively mentored and successful project outcomes result. While these results should not be interpreted as universally

prescriptive, they provide evidence that structured coaching roles can support program scalability and cost efficiency while enhancing educational quality.

AI Use Statement

A generative AI tool (ChatGPT), was used in a limited assistive role for language refinement and structural feedback only. All ideas, interpretations, and conclusions are the sole work and responsibility of the authors.

References

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