

Student Perceptions of Project Management and Team Culture Within Capstone Projects

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Most engineering programs teach professional skills early within their curriculum. By the time students undertake capstone projects, however, the emphasis is mostly on technical communication, public speaking, design, and research skills. Project and team management is at best a broad expectation and frequently an afterthought within capstone projects. Faculty members hold project outcomes at a premium over management. In this research, a survey was conducted to capture the prevalence of project and team management strategies within engineering capstone projects, particularly how students interpreted these requirements. Specifically, how student teams reported they organized themselves around the project goals, and which management strategies were frequently deployed. The survey solicited feedback from about 160 project teams with responses consisting of 186 multidisciplinary students within the College of Engineering. The survey results indicate that students feel they use the full spectrum of management strategies at their disposal. Students also claimed they exhibited strong team culture. A post-survey discussion of the responses revealed that teams frequently rely on a low-level and ad-hoc team management approach that rarely meets the expectations. The survey supports the existing notion that students do not naturally apply team management competencies given past exposure and the opportunity. Instead a more deliberate effort must be made for deep integration of project management within existing capstone projects. This way a more realistic simulation of professional practice can be expected from capstone projects.

Introduction

Capstone design projects are ideal training grounds for engineering students [1]. Students work together as a team to apply their engineering skills and gain field experience before embarking on their eventual careers [2]. The open-ended nature of the experience allows numerous learning opportunities for practicing both technical and non-technical skills. While the primary emphasis of capstone design experience is justifiably technical competency, the non-technical aspects are equally important within engineering careers [2]. A structured training within the broad area of professionalism is required to leverage the capstone design experience and better align with the career needs.

Besides the application of technical knowledge, every capstone project relies on multiple professional skills to be successful. While professionalism is a broad topic, it often includes communication, project management, and teamwork, in relation to engineering projects as essential ingredients for project execution. Communication, in particular, is often sufficiently

integrated within first and second-year engineering courses as oral and technical writing components in preparation for the capstone experience [3]. In fact, communication was and still is part of the Accreditation Board for Engineering and Technology (ABET) review criteria. Recently, ABET introduced a new set of criteria that included, “an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives” [4]. This criterion explicitly captures the need for introducing project management and effective teamwork skills to graduating engineers. Considering engineering programs use capstone design projects to address this criterion, it is important to recognize how well our students meet this expectation. While project management and teamwork may be introduced in the first and second-year engineering courses, how well do students apply these concepts during their capstone experience?

Team management is an essential skill if these students are to remain in high-demand and be globally competitive [5,6,7,8]. Project management is important because it improves the chances of achieving the desired result, ensures efficient use of resources, helps the team to stay on schedule, encourages consistent communication amongst students and professors. For most projects, the amount of work is so large that one person alone cannot handle it [9]. That is why a team is required. A team’s success is also strongly dependent on team culture. A strong team culture relies on effective communication, vision, and trust [10]. While educators recognize the importance of project management and team culture, simply relying on the capstone experience for students to naturally develop, practice, and master this skill set may not be prudent. Student teams regularly fail to meet faculty members’ expectations in terms of project management and struggle to develop a productive team culture. This deficit can be addressed in many ways but first, the need for change must be identified. Once identified, a formal introduction to the fundamentals of project management and team culture prior to a capstone experience may be required. A number of programs have embedded a project management course within its engineering curriculum to train students before undertaking a capstone project [5,9,11]. So how well do students embed these skills within their projects? The integration of project and team management can be studied by looking at the direct outcomes of projects and by capturing the student feedback on how well they utilized these skills within their projects.

In this research, we studied student perceptions of their efforts in managing projects and teams. Two quantitative surveys focused on project management strategies and team culture attributes were conducted with engineering students working on capstone projects. The aim was to recognize student awareness of project management strategies and what constitutes a positive team culture. Follow-up discussions were conducted to understand how students perceived these skills. The working hypothesis of this work was students generally do not meet the project and team management expectations. With this work, notable discrepancies between student perceptions and project expectations were documented. Students noted that project and team management rarely factored into the project assessment to provide clear feedback for areas of

improvement. This work is part of an on-going effort to elevate capstone design experience and better match engineering practice for student readiness. The research question guiding this study is: *How are project and team management strategies perceived by students within a capstone design project?*

Background

Within Rowan University's engineering curriculum, students choose to work on multiple capstone projects that cross traditional disciplinary boundaries over their junior and senior years. Rowan University has six engineering departments, Mechanical Engineering (ME), Electrical and Computer Engineering (ECE), Civil & Environmental Engineering (CEE), Biomedical Engineering (BME), Experiential Engineering (ExEEd), and Chemical Engineering (ChE). The number of students in every team depends on the project's size and need. The size can range from a team of two students up to a team of 15 students. The Junior and Senior Engineering Clinics, hereon referred to as 'clinic projects', allow students to work on potentially four distinct projects with both juniors and seniors from any engineering discipline supervised by a faculty member. The student teams focus on tangible objectives and present their outcomes for each term before moving to another team. This program is referred to as the 'Engineering Clinic Model' [3]. However, with an increase in enrollment and the number of projects, the management load also increases. For instance, in Fall 2019, 160 projects were proposed by engineering faculty members across all the disciplines to over 600 students. A range of two to three projects was managed by each faculty member with approximately 4 students per project. Needless to say, the student teams must manage their time and project deliverables independently with limited faculty members oversight. The team management expectations were not explicitly stated in the syllabus and are often left to the faculty members to set, monitor, and assess. Though anecdotally, project management and team culture within clinic projects has been a noted concern among faculty members. At the same time, clinic projects are regularly used to assess student learning outcomes for the purposes of ABET accreditation. Therefore, the clinic projects provided an ideal context for studying the students' grasp and implementation of project and team management strategies and how they deviated from the program expectations.

Study

Participants

All 600 engineering junior and senior students were asked to participate in the survey via email requests. The participation was anonymous and approximately 31% of the clinic students enrolled in the Fall of 2019. Participants in the study were 185 engineering students from ME, ExEEd, ECE, CEE, BME, and ChE departments.

Measures

In the current study, a 16 question online survey was conducted on project management and team culture. Team management strategies are referred to as team culture, to differentiate from project management. The project management questions were developed using Rowan University's business course content as a resource to identify the core strategies of project management. Table 1 presents the six project management questions related to strategies students used and their frequency of use during the term. Each strategy was accompanied by sample activities.

Table 1. *Questions related to project management strategies and on how frequently students utilized them during the project: 1 = Never, 2 = Occasionally, 3 = Regularly, 4 = Weekly.*

Q1 Problem Solving Techniques Includes: Problem definition, understanding constraints, risk assessment, brainstorming, research alternatives, etc.
Q2 Creating Task Lists Includes: goals, objectives, and to-do lists
Q3 Scheduling Includes: timelines, deadlines, and Gantt charts
Q4 Assigning Responsibilities Includes: defining roles and responsibilities
Q5 Reporting Outcomes Includes: documenting progress, logs, meetings
Q6 Monitoring and Evaluating Includes: monitoring and evaluating processes and members

The team culture questions were based on the work by Kuras, et al. [12]. A subset of questions was selected for this survey. Table 2 presents the ten questions related to team culture and how often they agreed to the statements. These questions formed the second part of the online survey administered.

Table 2. *Questions related to team culture. Students were asked to rate how often they agree to the statements below with 1 = Never, 2 = Occasionally, 3 = Mostly True, 4 = Absolutely.*

Q1 Team members openly express their ideas and opinions
Q2 Members of my team are held accountable for their responsibilities

-
- Q3 Our team makes time to evaluate how effective they work as a group
-
- Q4 Team members willingly take on new responsibilities
-
- Q5 Team members express disagreements constructively
-
- Q6 Our team can have productive meetings without the influence of our supervisor
-
- Q7 Our team members trust and respect each other
-
- Q8 Our team is able to make thoughtful decisions that all team members support
-
- Q9 Our team has the right members to be successful
-
- Q10 I want to be on our team

The foregoing questions were presented to each student individually using an online survey tool. Only group information was retained for the participants while their identities were kept anonymous. Once each student completed the online survey, oral questions were asked to gain a better understanding of student responses. The post-survey qualitative questions were: (1) What aspects of the clinic's experience translate to the engineering profession? (2) What tools are you applying to your clinic's management technique based on your previous experiences? The survey was approved by the Internal Review Board (IRB).

Data Collection and Analysis

Each team met with the data collector for a 15 minutes meeting. Each member scanned a QR code to access the online survey. The mentioned process ensured that no personal data was collected. The team members identified their team via a unique team identifier. The survey was completed anonymously and privately by each member. Following the survey, a short discussion was conducted as a team to gain insights on their responses. Each student responded to the data collector questions individually in a group setting. The data collector and the authors were not directly responsible for the students' grades, except for a single team of 2 students. Likert-style questions were used to assess opinions and attitudes. We used it to easily operationalize the students' perceptions. The analysis was conducted using a spreadsheet program. Reliability analysis, conducted with the SPSS program, showed that Cronbach's number was evaluated to be greater than 0.7.

Results

Project Management

Figure 1 presents a summary of the Likert-scale responses. Every student responded to the survey individually. With respect to Q1, 66% of students see that they apply problem-solving on a weekly basis. As well as 25% of students see that they apply problem-solving on a regular basis. Q2, Q4, and Q5 showed that about 85% of the students surveyed created task lists, assigned responsibilities, and reported outcomes either regularly or on a weekly basis. The results show that all the teams regularly used every project management strategy.

Project Management

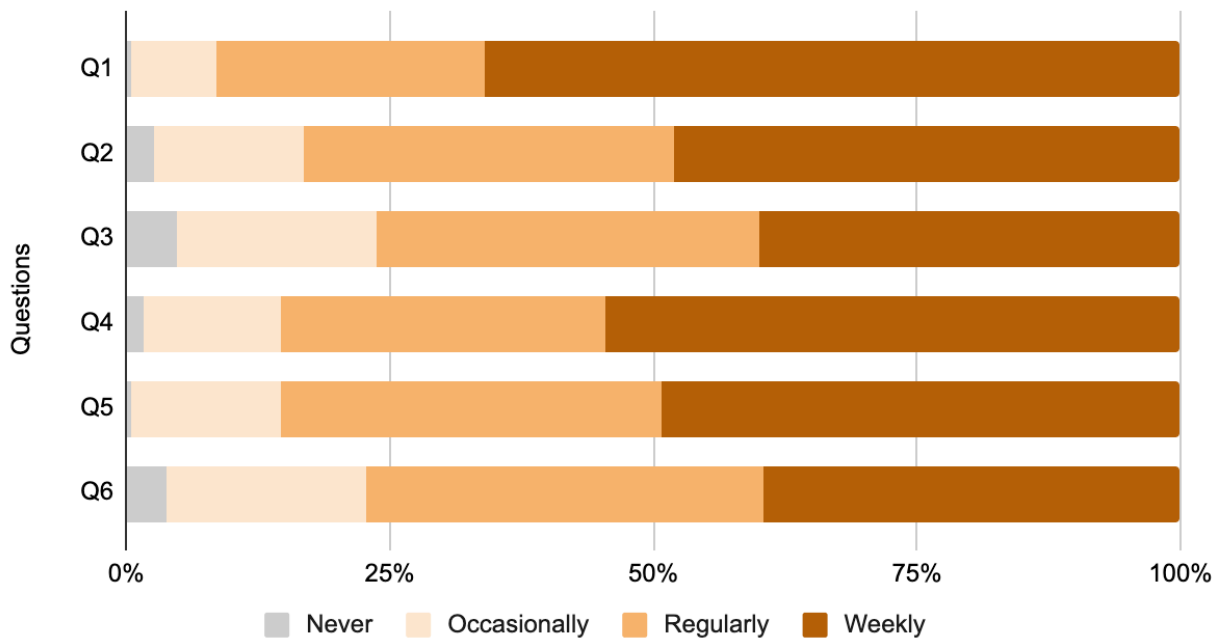


Figure 1. Project Management Summary of ratings per question. Ratings reference: 1 = Never, 2 = Occasionally, 3 = Regularly, 4 = Weekly.

Q3 and Q6 which address scheduling and monitoring and evaluating, on the other hand, received slightly lower ratings from the students. About 76% responded with 'Regularly' or 'Weekly'. Notice that all of the questions received less than 4% of 'Never' rating. Overall, teams regularly employed project management strategies.

Team Culture

Similar to the project management survey, every student responded to the survey individually. Figure 2 presents the summary of the team culture question responses. Team members responded by stating that overall they regularly agreed with the positive team culture statements. In other words, team members regularly engaged in positive team culture activities within their projects.

Q1 and Q8 received the most favorable responses with over 97% responding with 'mostly true' or 'absolutely'. Students felt they openly expressed ideas and opinions and collectively made decisions, respectively. Similarly positive responses were received for Q6, Q7, Q9, and Q10. These questions were related to having productive meetings, trust, the right team members, and the desire to be in the team, respectively.

Q3, however, showed lower ratings. This statement was related to how the team makes time to evaluate how effective they work as a group. Relatively lower rates were also related to members being held accountable and members' willingness to take on new responsibilities. In other words, statements related to reflective strategies and member initiatives received lower rates.

Team Culture

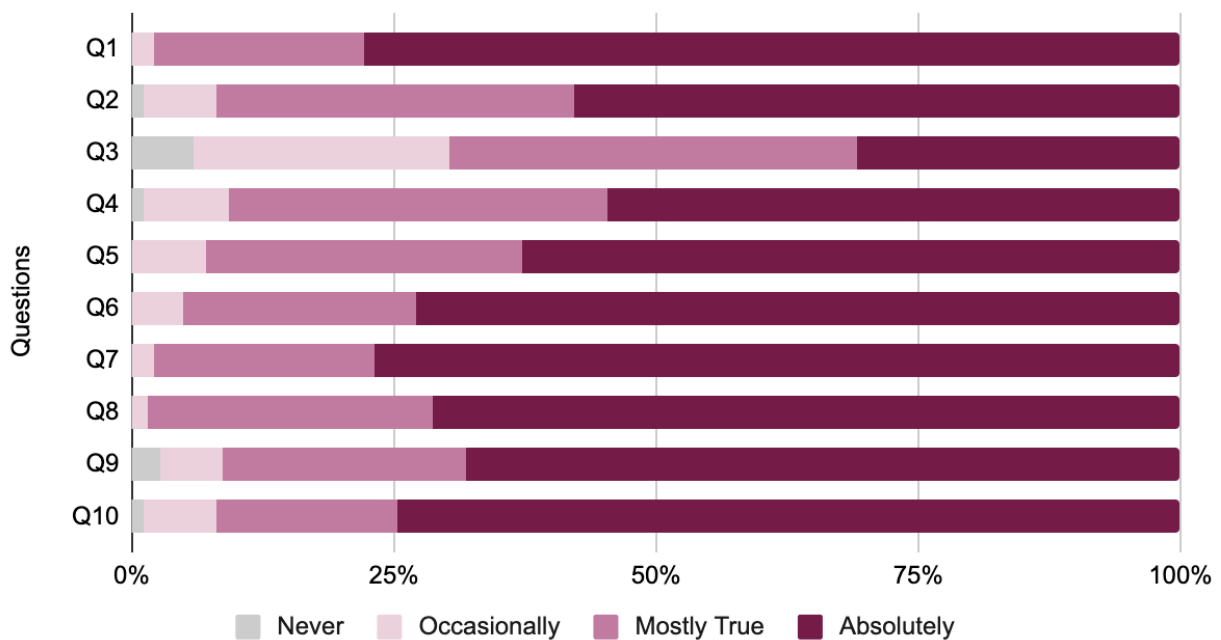


Figure 2. Team Culture Summary of ratings per question. Ratings reference: 1 = Never, 2 = Occasionally, 3 = Mostly True, 4 = Absolutely.

A secondary analysis of the results was conducted. Here the correlation between project management and team culture was studied. A strong correlation can suggest a compounding effect on the project outcome [17, 18, 19]. Here the survey means for every team were compared using the Pearson Correlation between project management and team culture. The analysis yielded a correlation with the ratio of 1:0.620, suggesting teams with poor project management also exhibited poor team culture and vice versa.

Post-survey discussion

The post-survey discussion functioned as a focus group. This portion was conducted as a verbal dialogue between the student teams and the interviewer. There were 58 teams that participated in this 15-20 minute discussion. The results are used to understand the Likert-style question responses and calibrate student perceptions of project and team management strategies. The outcomes of these discussions are used to interpret the survey results next.

Discussion

The study examined student perception of how they used project management and team culture strategies within clinic projects. The results show that students feel they regularly and adequately employed project management strategies and exhibited elements of successful team culture. These results, however, are not corroborated by further evaluation of student responses or even the anecdotal project outcomes. Despite the high frequencies reported by students, overall project outcomes suggest there is a lack of artifacts resulting from project management; and limited evidence of successful team culture. These conclusions are based on past faculty members' reviews of projects. As a result, the post-survey discussions were used to calibrate student perceptions and reconcile with the apparent lack thereof. In general, the skewed student perception of expectation was a result of student interpretation of what constitutes project and team management.

Students regularly oversimplified the basic requirements of project management and team culture. The post-survey discussions revealed that students focused on the low-level management requirements and considered those as adequate. For instance, students often created to-do lists before they began working on the projects. This effort was interpreted as 'creating task lists' and possibly 'scheduling'. A to-do list is only a subset of task list and scheduling activities that constitute project management [13,14]. This idea aligns with the survey results when looking at the relative ratings of the project management strategies. The higher-level management strategies, such as, 'scheduling' (Q3), 'assigning responsibilities' (Q4), and 'monitoring and evaluating' (Q6) received relatively lower ratings, as seen in Figure1. 'Scheduling' in particular received the lowest rating in comparison. This is because teams rarely assigned tasks to a date or time, or prepared Gantt charts to guide their project objectives. Even the highest-rated prompt

(Q1), related to 'Problem Solving Techniques', became difficult to defend after team discussions. Students rarely employed any specific problem-solving methods, considering they struggled to identify any during discussions. Instead teams relied on a more ad-hoc approach. They simply tried to address the problems as they encountered them using the tools at their disposal. For instance, students frequently avoided a thorough literature review to explore existing solutions. Teams relied primarily on their intuition of the potential solution. While this approach can be categorized as 'problem-solving,' it lacks the higher-order thinking or rigor that is expected for a capstone project [13].

A similar bias was present when students were asked about their team culture. They tended to focus on low-level interpretations of the expectations. Students viewed team culture as 'sufficient teamwork'. Students felt working together on a project meant they possessed good team culture to succeed. The conclusion was broadly recognized during the post-survey discussion and confirmed indirectly by the (Q3) prompt, 'Our team makes time to evaluate how effective they work as a group,' which received the lowest rating. Students worked on projects as individuals and rarely as interdependent team members pursuing a common goal. Teams rarely formalized their charter, created action plans after meetings, or held members accountable with follow-ups. Teams never presented conflict resolution strategies or plans. These outcomes may hint at the lack of established purpose for the project which can often motivate team culture [13,15]. Overall, the broad quantitative results seem to suggest that students felt they functioned effectively as teams. However, the evidence from the project outcomes and post-survey discussions identified a discernible gap in expectations between students and faculty members.

There were few exceptions to the foregoing trends, based on post-survey discussions. The small teams, which were composed of 2-5 members, were regularly identified as operating below expectations of project management and team culture. For larger teams, it was observed that team management strategies were more in line with faculty members expectations. Projects with 10-20 students, which were rare and often sponsored externally, effectively utilized project management strategies and exhibited strong team culture, based on the post-survey discussions. It is possible that the circumstances of having a large team working on a complex project and being subject to external review by the sponsors made the team more conducive to better project management and team culture [10,16]. The analysis of the quantitative survey supported this hypothesis. A similar argument can be made for the projects that had faculty members who set clear project management expectations and encouraged a strong team culture. Students often pointed to faculty members' expectations as their primary motivation for improving their strategies. Confirming that setting clear expectations and monitoring the teams can greatly benefit the overall project [14]. Recognizing these high functioning teams helps us identify opportunities to encourage student teams to utilize effective strategies for team management.

An obvious limitation of this work is the lack of connection between student perceptions and the subsequent project outcomes as evaluated by the faculty supervising the projects. Such a study can further discern the impact of inferior strategies on project outcomes. Nevertheless, since the current study was inspired by past faculty observations and the survey indicates the sub-par project and team management strategies employed by students, an improved approach to train students to integrate these skills within capstone projects is needed. These topics are often covered in first-year and second-year engineering courses. Yet, as demonstrated in this work, students fail to connect them to their capstone design projects in the later years.

Conclusions

Capstone projects are used as a culminating technical experience for graduates before embarking on a professional career. However, non-technical experiences are less formally introduced to the students as a practice. To study how student teams manage their project and team culture, a survey was conducted. The survey involved 186 students working across a number of capstone projects. The results showed that students overestimated their ability to manage their projects and teams. The results suggest that students do not naturally build non-technical competencies simply by being involved in a capstone project. The study identified several factors that lead to successful team management, however, the formal integration of management strategies into the curriculum will ensure every student is exposed to the fundamentals. This will directly benefit the project outcomes and prepare graduates who are better suited for their career needs.

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