”Exploring the Capstone Journey: Student Perspectives”

Dr. Jaby Mohammed, Illinois State University

Dr. Jaby Mohammed is an Associate Professor in the Department of Technology at Illinois State University and serves as the Engineering Technology Program Coordinator. He holds a Ph.D. in Engineering and an MBA. His teaching and research interests include manufacturing systems, quality engineering, continuous improvement, applied analytics, and the integration of generative AI in engineering technology education. Dr. Mohammed has contributed to curriculum development and ABET-ETAC accreditation efforts and actively collaborates with regional partners, including the City of Bloomington, on applied student projects. He also serves as ASEE Campus Representative for Illinois State University and Councilor-at-Large for the Illinois State Academy of Science.

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Abstract

Capstone courses serve as a pivotal point in the educational journey of engineering technology students. While a significant portion of the undergraduate engineering technology curriculum typically revolves around technical knowledge, capstone courses mirror genuine engineering technology (manufacturing technology related) experiences. These courses often provide students with the chance to tackle practical, open-ended projects and engage with real clients and industry experts. The role of a capstone project in an engineering technology program at Illinois State University is to bridge the gap between theoretical knowledge and practical application. Students will form teams composed of members possessing diverse technical skills to create and execute a lean production process. The course's tasks are designed to facilitate the students' shift from the academic environment to roles of authority within a corporate context.

Most of the research in capstone classes have been focused on areas such as pedagogy, project outcomes, assessment, and the impact of capstone experiences on student learning and professional development. In this paper authors would investigate the to gain the insights into student perspectives on to capstone projects, exploring their experiences, challenges, and perceived benefits. This research could also help improve the capstone course based on student feedback.

Introduction

Capstone courses play a critical role in engineering technology programs by providing students with a culminating educational experience that integrates technical knowledge, professional skills, and real-world application. These courses are designed to simulate authentic industrial environments in which students must apply engineering principles to open-ended problems while working collaboratively in teams. As such, capstone experiences are widely recognized as essential for preparing graduates to transition effectively from academic settings to professional roles in industry.

Within the Engineering Technology program at Illinois State University, the capstone course, TEC 392: Manufacturing Organization and Materials, serves as the program's primary culminating experience. According to the course description, TEC 392 focuses on the study of industrial production systems, including product, manufacturing, and plant engineering, through the management of a production-based project. Students are organized into teams composed of members with diverse technical competencies and are tasked with developing and implementing a lean production process. Course activities are intentionally structured to support students' transition from classroom learning to positions of responsibility within a corporate manufacturing environment.

The course supports multiple program outcomes that reflect the breadth of competencies expected of engineering technology graduates. These outcomes include the ability to analyze and

apply electrical, electronics, and programming logic principles within automated manufacturing environments; monitor and control lean manufacturing or industrial systems individually and as part of a team; select appropriate manufacturing processes for a wide range of production applications; and utilize two-dimensional and three-dimensional computer-aided design tools to develop products, machines, and manufacturing aids. Additional outcomes emphasize the interpretation of manufacturing documentation, as well as the demonstration of project management, planning, and cost analysis skills competencies that are central to professional practice in manufacturing and engineering technology fields.

In Fall 2023, the Engineering Technology program-initiated efforts to pursue accreditation through ABET under the Engineering Technology Accreditation Commission (ETAC). One key requirement of ABET-ETAC accreditation is the inclusion of a culminating design experience that incorporates design principles, problem solving, and decision-making within realistic constraints. Historically, students enrolled in TEC 392 worked on a common manufacturing project in which they completed a manufacturing job and conducted a process study on the resulting product. While this approach emphasized production and process analysis, it provided limited opportunity for students to engage in the full design perspective expected of a culminating design experience under ABET-ETAC criteria.

As the program began aligning TEC 392 with accreditation requirements, an important first step was to better understand how students perceived the existing capstone structure and their experiences within it. Prior research on capstone courses has largely focused on instructional strategies, assessment methods, project outcomes, and the impact of capstone experiences on student learning and professional development. However, fewer studies have emphasized student perspectives on capstone design experiences within engineering technology programs, particularly during periods of curricular transition driven by accreditation requirements. Similar program-level assessment and curriculum alignment efforts have demonstrated the importance of continuous improvement frameworks in supporting accreditation readiness within technology programs [16].

This paper seeks to address this gap by examining student perspectives on the capstone experience in TEC 392. By exploring students' experiences, challenges, and perceived benefits, this study aims to inform improvements to the course structure and ensure alignment with both educational best practices and ABET-ETAC expectations.

To better understand how the capstone course supports student learning and aligns with expectations for a culminating design experience, this study adopts a student-centered evaluation approach. A survey was administered to students enrolled in the capstone course to capture their perspectives on skill development, teamwork, instructional support, resource availability, and overall preparedness for professional practice. The findings from this survey inform the research questions presented in the following section, which guide the analysis of student experiences and identify opportunities for continuous improvement of the capstone course. Previous work within

engineering technology education has emphasized the importance of structured coursework planning and curriculum alignment to support successful capstone outcomes and professional readiness among students [14,15].

Research Questions

As the Engineering Technology program at Illinois State University works to align its capstone course with ABET-ETAC requirements for a culminating design experience, it is essential to understand student perceptions of the current capstone structure and learning outcomes. Student feedback provides valuable insight into how effectively the course supports skill development, teamwork, design integration, and professional preparation. Guided by the results of a student survey carried out in the capstone course, this study is structured around the following research questions:

RQ1. How do students perceive the overall effectiveness of the capstone course in preparing them for professional practice in engineering technology and manufacturing environments and how satisfied were you with the capstone design experience?

RQ2. How do students evaluate teamwork, collaboration, communication, and conflict management within their capstone project teams?

RQ3. How clearly do students perceive the capstone project requirements and expectations, and how effective is the instructional and advisory support provided throughout the course?

RQ4. What challenges do students encounter in balancing capstone project demands with other academic, professional, and personal responsibilities?

RQ5. What gaps in resources, tools, or prerequisite preparation do students identify as affecting their capstone experience?

Literature review and Background

Capstone courses are widely recognized as a critical component of undergraduate engineering and engineering technology curricula, serving as a culminating experience that integrates technical knowledge, professional skills, and real-world problem solving. These courses are intended to prepare students for professional practice by exposing them to open-ended problems, teamwork, design constraints, and industry-relevant processes [1], [2].

A substantial body of literature has examined the pedagogical structure and learning outcomes of capstone courses. Prior studies have shown that capstone projects promote higher-order cognitive skills, including systems thinking, problem solving, and decision making, while reinforcing technical competencies developed throughout the curriculum [3], [4]. In engineering technology

programs specifically, capstone experiences often emphasize applied design, manufacturing processes, and production systems, reflecting the practice-oriented nature of the discipline [5,18].

Another major area of research focuses on assessment and evaluation of capstone experiences. Researchers have explored a variety of assessment methods, including rubrics, peer evaluations, industry feedback, and performance-based measures, to evaluate both individual and team outcomes [6], [7]. These assessment strategies are frequently linked to accreditation requirements, particularly those established by ABET, which emphasize measurable student outcomes and continuous improvement [8].

The role of capstone courses in supporting professional skill development has also been well documented. Studies consistently report gains in communication, teamwork, leadership, and project management skills because of capstone participation [9, 10]. Earlier studies examining team effectiveness within engineering design environments similarly highlight the relationship between collaboration quality and student satisfaction in project-based learning contexts [18,19]. These professional competencies are often cited by industry stakeholders as essential for workforce readiness, reinforcing the importance of capstone courses as a bridge between academia and professional practice [11]. Prior research has also demonstrated that spatial visualization ability plays a significant role in supporting student success and retention within engineering technology programs [17]. The integration of lean manufacturing concepts within engineering technology curricula has also been shown to strengthen applied problem-solving ability and workforce readiness competencies [20].

Despite the breadth of existing research, fewer studies have focused explicitly on student perspectives of capstone experiences, particularly within engineering technology programs. While some research has examined student satisfaction and perceived learning gains [12], there remains a need for more systematic investigations into how students experience capstone design courses, the challenges they encounter, and the aspects they find most beneficial. Understanding student perceptions is especially important during periods of curricular transition, such as when programs modify capstone structures to align with accreditation requirements.

Additionally, limited research has addressed how students perceive the design component of capstone courses in engineering technology programs. As ABET-ETAC places increasing emphasis on a culminating design experience that incorporates realistic constraints, decision making, and professional responsibility [8], programs must evaluate whether existing capstone models adequately support these expectations from the student perspective.

This study contributes to existing literature by examining student perceptions of a capstone course within an engineering technology program undergoing alignment with ABET-ETAC accreditation requirements. By focusing on student experiences, challenges, and perceived benefits, this work provides evidence to inform continuous improvement of capstone course design and delivery.

Methodology

Research Design: This study employed a mixed-methods survey-based research design to examine student perceptions of the capstone experience in an Engineering Technology program. The survey included both quantitative Likert-scale items and open-ended qualitative questions, allowing for triangulation of student perceptions related to skill development, teamwork, instructional support, workload balance, and resource availability. This approach is commonly used in engineering education research to capture both measurable trends and contextual insights from student experiences.

Participants and Context: Participants in this study were students enrolled in the capstone course, TEC 392: Manufacturing Organization and Materials, within the Engineering Technology program. The course serves as the program's culminating experience and requires students to work in teams to develop and implement a lean production process. Survey participation was voluntary and anonymous, and responses were collected near the conclusion of the course to ensure that students had completed most project activities.

Survey Instrument: The survey instrument consisted of multiple sections addressing key aspects of the capstone experience. Likert-scale questions were used to assess perceptions of teamwork, communication, instructional support, clarity of expectations, preparedness for professional work, and overall satisfaction. Open-ended questions prompted students to reflect on skills developed, challenges encountered, rewarding aspects of the project, gaps in resources, and suggested improvements to the Capstone course. Course redesign efforts supporting alignment with program outcomes and accreditation expectations have also been informed through backward design frameworks applied within engineering technology instruction [21].

The survey items were designed to align with program outcomes and areas of interest related to ABET-ETAC requirements for a culminating design experience. A summary of survey questions and response distributions is provided in the Results section.

Data Analysis: Quantitative data from Likert-scale items were analyzed using descriptive statistics, including response counts and percentages, to identify trends in student perceptions. Qualitative responses from open-ended questions were analyzed using thematic analysis. Responses were reviewed and coded to identify recurring themes related to skill development, workload balance, instructional clarity, teamwork dynamics, and resource needs. These themes were then used to contextualize and support the quantitative findings.

Mapping of Survey Items to Research Questions: To ensure alignment between the research questions and the data collected, each research question was mapped to specific survey items, as summarized below.

- RQ1: Student preparedness and overall value
  This research question was addressed using survey items related to overall satisfaction with

the capstone experience and students' perceptions of preparedness for professional work. Relevant items included:
    - Do you feel the capstone project prepared you for professional work?
    - Overall, how satisfied are you with your capstone design experience?
    - Open-ended responses describing the most rewarding aspects of the capstone experience.
- RQ2: Teamwork and collaboration
  Team dynamics were evaluated using multiple Likert-scale items and qualitative feedback:
    - How would you rate the collaboration within your capstone team?
    - Did you feel your contributions were valued by your team?
    - How effective was communication within your team?
    - Did you encounter any conflicts within your team?
      These items provided insight into collaboration quality, communication effectiveness, and conflict presence.
- RQ3: Clarity of expectations and instructional support
  This research question was addressed through survey items related to course structure and faculty engagement:
    - How clear were the project requirements and expectations?
    - How would you rate the level of support provided by your capstone advisor or instructor?
    - How accessible was your capstone advisor or instructor?
      Open-ended responses regarding rubrics, pacing, and ambiguity in project requirements were also analyzed.
- RQ4: Workload balance and constraints
  Student workload and time-management challenges were examined using:
    - Did you face any difficulties balancing the capstone project with other academic or personal responsibilities?
    - Qualitative explanations describing employment commitments, course load, scheduling conflicts, and project scope limitations.
- RQ5: Resource and preparation gaps
  Resource availability and preparation were explored through:
    - Were there any gaps in resources or tools needed for your project?
    - Open-ended suggestions for additional training, prerequisite coursework, and access to software or materials.

Results and Discussion

This section presents the results of the student survey carried out in the capstone course, TEC 392. Findings are organized according to the research questions and include both quantitative results from Likert-scale items and qualitative themes from open-ended responses.

Overall Capstone Experience and Professional Preparation (RQ1)

Students generally reported positive perceptions of the capstone experience and its value in preparing them for professional practice. When asked whether the capstone project prepared them for professional work, the majority of respondents indicated agreement. Specifically, 71.43% of students either agreed or strongly agreed that the capstone project prepared them for professional work, while 14.29% expressed neutrality and 14.29% disagreed.

Overall satisfaction with the capstone experience was similarly positive. Most students reported being satisfied or very satisfied with the course, with only a small number indicating neutral or dissatisfied responses. These results suggest that, overall, students viewed the capstone course as a meaningful and beneficial component of their engineering technology education. Table 1 represents student responses regarding their overall satisfaction with the capstone design experience. The results show that most students (85.7%) reported being satisfied or very satisfied, indicating that the capstone experience is positively supporting student learning and engagement.

Table 1: Overall satisfaction with capstone design experience

Satisfaction Level	Responses	Percentage
Very satisfied	4	28.6%
Satisfied	8	57.1%
Neutral	1	7.1%
Dissatisfied	1	7.1%

Table 2 represents student responses regarding whether the capstone project prepared them for professional work. The results show that 71.43% of students either agreed or strongly agreed that the capstone experience helped prepare them for their professional careers. A smaller portion of students (14.29%) reported neutral responses, while another 14.29% indicated disagreement. Overall, these results suggest that the capstone project is effectively supporting workforce readiness for most students while also identifying an opportunity for continued enhancement of industry-aligned experiences.

Table 2: Preparedness for professional work

Response Category	Number of Students	Percentage
Strongly Agree	3	21.43%
Agree	7	50.00%
Neutral	2	14.29%
Disagree	2	14.29%
Total	14	100%

Teamwork, Collaboration, and Communication (RQ2)

Survey results indicate generally positive team dynamics. When asked to rate collaboration within their capstone team, most students rated collaboration as excellent or good, with fewer students reporting average or poor collaboration. Most respondents also indicated that they felt their contributions were valued by their team. A large portion of students either agreed or strongly agreed with this statement, while only a small number expressed neutrality or disagreement.

Communication within teams was rated positively overall, with most students indicating that communication was effective or very effective. However, a small number of students rated communication as ineffective, indicating some variability in team experiences.

Regarding conflict, most respondents reported that they did not encounter conflicts within their team, while a smaller subset acknowledged experiencing conflicts during the project. These findings suggest that while teamwork was largely effective, some teams faced interpersonal or coordination challenges.

Table 3 represents student feedback on teamwork dynamics during capstone experience. The results show that 71.4% of students reported no team conflicts, indicating generally positive team functioning. Additionally, 64.2% of students rated team communication as effective or very effective, suggesting strong collaboration among most project teams. A smaller portion of students reported neutral or ineffective communication, highlighting an opportunity to further strengthen structured teamwork and communication support within capstone teams.

Table 3: Team Collaboration experience

Collaboration Metric	Response Category	Number of Students	Percentage
Team Conflicts	No conflicts	10	71.4%
	Experienced conflicts	4	28.6%
Communication Effectiveness	Very effective	8	57.1%
	Effective	1	7.1%
	Neutral	4	28.6%
	Ineffective	1	7.1%

Table 4 summarizes student perceptions of how their contributions were valued within their capstone teams and their overall evaluation of team collaboration. The results indicate that 85.7% of students agreed or strongly agreed that their contributions were valued, reflecting a strong sense of inclusion and engagement within project teams. In addition, 71.4% of students rated team collaboration as excellent or good, suggesting that most teams functioned effectively and supported cooperative learning. A smaller portion of students reported average or poor collaboration experiences, highlighting opportunities to further strengthen structured teamwork practices in future capstone offerings.

Table 4: Student Perceptions of Team Contribution Value and Collaboration Quality

Collaboration Metric	Response Category	Number of Students	Percentage
Contributions Valued by Team	Strongly agree	7	50.0%
	Agree	5	35.7%
	Neutral	1	7.1%
	Disagree	1	7.1%
Overall Team Collaboration Rating	Excellent	7	50.0%
	Good	3	21.4%
	Average	2	14.3%
	Poor	2	14.3%

Clarity of Expectations and Instructional Support (RQ3)

Students provided mixed feedback regarding the clarity of project requirements and expectations. While many students rated the project requirements as clear or very clear, a portion of respondents indicated that expectations were only somewhat clear or not clear. This suggests that ambiguity in project scope or deliverables was a concern for some students.

Instructor and advisor support was rated positively overall. Most students rated the level of support as good or excellent, and nearly all respondents indicated that the capstone advisor or instructor was accessible. These findings highlight strong instructional support while also indicating opportunities to improve clarity in project expectations and documentation.

Table 5 represents student responses regarding the clarity of capstone project requirements and expectations. The results show that 92.9% of students indicated that project requirements were at least somewhat clear, with 50% reporting that expectations were clear or very clear. Only one student (7.1%) reported that expectations were not clear. Overall, these results suggest that students generally understood the project expectations, while also indicating an opportunity to further improve communication of requirements at the beginning and throughout the capstone experience.

Table 5: Student Perception of Clarity of Capstone Project Requirements

Response Category	Number of Students	Percentage
Very clear	4	28.6%
Clear	3	21.4%

Somewhat clear	6	42.9%
Not clear	1	7.1%
Total	14	100%

Workload Balance and External Constraints (RQ4)

A majority of students reported facing difficulties balancing the capstone project with other academic or personal responsibilities. Qualitative responses revealed that common challenges included full-time employment, third shift work schedules, concurrent coursework, and overlapping group projects.

Some students noted that unclear or shifting due dates contributed to rushed work, particularly when project milestones coincided with other obligations. Despite these challenges, at least one respondent indicated that the workload did not negatively impact performance, although it required additional effort and time management.

Table 6 represents student responses regarding whether they experienced difficulties balancing the capstone project with other academic or personal responsibilities. The results show that 64.3% of students reported no difficulty managing their responsibilities alongside the capstone project, while 35.7% indicated some challenges with workload balance. Overall, these findings suggest that most students were able to successfully manage the capstone requirements; however, a notable portion experienced time-management challenges, indicating an opportunity to further support workload planning and project scheduling strategies within the capstone course structure.

Table 6: Student Ability to Balance Capstone Project with Other Responsibilities

Response Category	Number of Students	Percentage
No difficulties	9	64.3%
Experienced difficulties	5	35.7%
Total	14	100%

Resource Availability and Preparation Gaps (RQ5)

Most respondents reported having adequate resources to complete their capstone projects; however, a subset of students identified notable gaps. Reported gaps included insufficient training in tools such as Minitab and Microsoft Project, which students were expected to already know. Limited time and material availability were also mentioned as constraints. Despite these

challenges, some students acknowledged that the capstone environment encouraged adaptability and problem-solving in unstructured settings, reflecting real-world engineering practice.

Table 7 represents student feedback regarding the availability of resources and tools needed for their capstone projects. The results indicate that 78.6% of students reported having adequate access to the necessary resources and tools, suggesting that the program is generally providing sufficient support for project completion. However, 21.4% of students identified gaps in resources, highlighting an opportunity to further strengthen access to equipment, software, or technical support to enhance the overall capstone experience.

Table 7: Availability of Resources and Tools for Capstone Projects

Response Category	Number of Students	Percentage
No gaps in resources/tools	11	78.6%
Experienced gaps	3	21.4%
Total	14	100%

Discussion

Overall, survey results indicate that students viewed the capstone course as a valuable and generally positive learning experience that supported skill development and professional preparation. Strengths of the course included teamwork, instructor accessibility, and opportunities for hands-on application. Areas for improvement centered on clarity of expectations, workload balance, prerequisite preparation, and resource support.

Students provided several suggestions for improving the capstone program. Common recommendations included requiring certain prerequisite courses prior to enrollment, allowing more in-class group work time, starting the project earlier in the semester, and offering projects with a stronger emphasis on advanced design rather than extensive business documentation.

Several respondents also expressed interest in working on projects that they could retain after completion, suggesting a desire for more tangible or portfolio-ready outcomes. These findings provide actionable insights for refining the capstone course structure and strengthening its alignment with ABET-ETAC expectations for a culminating design experience.

Limitations

Methodological Limitations: As with many survey-based studies, the findings are based on self-reported data and reflect student perceptions rather than direct measures of learning outcomes. Additionally, results are specific to a single institution and course context. Despite these

limitations, the study provides valuable insight into student experiences and offers actionable feedback to support continuous improvement of the capstone course.

Conclusions and future work

This study examined student perceptions of the capstone course, TEC 392, within the Engineering Technology program at Illinois State University as the program works toward alignment with ABET-ETAC accreditation requirements. Using a mixed-methods survey approach, the study captured student perspectives on skill development, teamwork, instructional support, workload balance, resource availability, and overall preparedness for professional practice.

Overall, survey results indicate that students view the capstone experience as a valuable and meaningful component of their undergraduate education. Students reported developing a broad range of technical and professional skills, including applied design, manufacturing processes, communication, leadership, and problem-solving abilities. Team collaboration and instructor accessibility were identified as strengths of the course, suggesting that the learning environment effectively supports student engagement and mentorship.

At the same time, the findings revealed areas for improvement that are particularly relevant to the implementation of a culminating design experience. Students identified challenges related to workload balance, clarity of project expectations, prerequisite preparation, and access to certain tools and resources. These concerns highlight the importance of clearly defined design requirements, structured project milestones, and alignment between prerequisite coursework and capstone expectations.

The results of this study provide actionable feedback to support continuous improvement of the capstone course. Student insights will be used to inform course revisions aimed at strengthening the design component, enhancing clarity and pacing, and ensuring alignment with ABET-ETAC criteria. More broadly, this work contributes to the engineering technology education literature by emphasizing the importance of student perspectives in evaluating and refining capstone design experiences.

Future work will focus on implementing targeted course modifications and assessing their impact on student learning outcomes, design proficiency, and professional readiness. Continued evaluation of the capstone experience will help ensure that the course effectively serves as a culminating design experience and prepares graduates for success in engineering technology and manufacturing careers.

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