Evaluating Soft Skill Development in Engineering Education: Aligning Self-Perception with Measured Performance

Dr. Daniel Selvakumar Raja, Greenville College

Daniel Raja is an Assistant Professor and Program Director of Engineering at Greenville University. He specializes in mechanical engineering, with a particular focus on solid mechanics and computational solid mechanics. His academic journey and professional career are marked by a dedication to advancing engineering education and research.

At Greenville University, Professor Raja is known for his engaging teaching style and his commitment to mentoring students. He actively involves his students in research projects, providing them with hands-on experience in the field of engineering. His work not only contributes to the academic community but also aims to solve real-world engineering problems.

Professor Raja's research interests include the development of new materials and the application of computational methods to understand and predict the behavior of solid materials under various conditions. He has published several papers in reputable journals and presented his findings at international conferences.

Outside of his academic responsibilities, Daniel Raja is passionate about community service and often participates in initiatives that promote STEM education among young students. His dedication to both his profession and his community makes him a respected and valued member of Greenville University.

Natalie Schleper, Saint Louis University

Natalie Schleper is an instructor in the Department of Chemistry at Saint Louis University. She holds both a B.S. and an M.S. in Chemistry from Southern Illinois University Edwardsville and researched student misconceptions and their effects on student understanding of chemistry. Natalie is dedicated to fostering a deep understanding of chemistry among her students. At SLU, Natalie is known for managing large class sizes averaging between 600-800 students per semester. She has taught various classes such as Fundamentals of Chemistry lecture, General Chemistry 1 & 2 lecture, recitations, and laboratory, Analytical Chemistry lecture and laboratory, Organic Chemistry laboratory, and Physical Chemistry Laboratory. Natalie's research contributions focus on innovative teaching methods to enhance student engagement and learning outcomes. Research interests include student misconceptions, instructional materials, and integration of technology to STEM courses. Outside of the university, Natalie has a passion for theater and architecture. Before finding her passion for chemistry education, she was a theater major and has an associate's degree in computer aided Drafting and Design.

Evaluating Professional Skill Development in Engineering Education: Aligning Self-Perception with Measured Performance

Introduction and Motivation

This Evidence-Based Practice Full Paper investigates the critical role of professional competencies in the holistic development of engineering undergraduates. Within contemporary engineering practice, professional skills such as leadership, multifaceted communication, and collaborative teamwork are increasingly recognized as vital for career success [1–3]. Professional skills are not only vital in Engineering, they are transferable skills that enable people to communicate effectively, collaborate with others, solve problems, and navigate complex work environments. However, because many engineering programs integrate these competencies implicitly through project-based learning and laboratory deliverables rather than through explicit instruction, students often lack the metacognitive awareness required to identify their own skill acquisition. This lack of recognition creates a significant barrier when students must articulate their professional growth during high-stakes scenarios. Specifically, students frequently struggle in behavioral interviews where the ability to provide concrete evidence of professional skill application is paramount to demonstrating professional readiness.

The primary objective of this study is to analyze professional skill development within an introductory engineering course, exclusively composed of engineering students, at a small, private, rural university. This research evaluates higher-level competencies across four primary domains: (1) *Communication and Documentation*, (2) *Collaborative and Interpersonal Dynamics*, (3) *Design and Technical Proficiency*, and (4) *Professional Standards*. Furthermore, this study addresses the concern that novice students, due to a lack of professional experience, may perceive their skill gains to be significantly higher than their demonstrated performance [4, 5]. To explore this discrepancy, the paper presents a comparison of perceived versus actual gains, with comprehensive course details documented in previous scholarship.

Literature Review and Theoretical Framework

The theoretical foundation of this study is rooted in metacognition defined as the ability of learners to monitor, evaluate, and regulate their own cognitive processes. In the context of engineering education, this involves "calibration," or the degree to which a student's self-assessment aligns with their actual competence. As established in prior studies of this course's Project-Based Learning (PBL) framework, collaborative environments provide essential social cues that trigger metacognitive reflection [6–8]. By engaging in the iterative design processes documented in previous scholarship [9], students are not merely acquiring technical skills; they are placed in a "reflective practicum" where they must constantly assess their contribution to a team. This study builds on that foundation by measuring how these reflective opportunities specifically impact the accuracy of a student's self-perception across professional domains.

This research is grounded in metacognitive theory, specifically the framework established by Flavell [10], which describes how individuals monitor and regulate their own cognitive processes. While the PBL environment of the introductory course was previously shown to enhance student motivation and engagement, the current study focuses on "metacognitive experiences," described as the subjective realizations students have while navigating complex team dynamics. By requiring students to engage in reflective essays and peer reviews, the curriculum encourages a transition from technical execution toward the high-level monitoring of professional skill acquisition. This approach aligns with the dual-assessment model, which compares student self-perceptions to empirical performance to determine the accuracy of their metacognitive calibration.

The tendency for students to miscalibrate their professional growth is best understood through the lens of the Dunning-Kruger effect, which posits that individuals with limited expertise in a domain often lack the metacognitive ability to recognize their own incompetence [11]. Within the context of this first-year engineering course, novice learners may inflate their perceived gains in professional skills because they have not yet reached the level of proficiency required to identify the nuances of high-level communication or complex team dynamics. As a result, students may report an "Expert" or "Advanced" level of competency on subjective surveys while their objective performance, as measured by faculty-led rubrics, reflects a more foundational understanding. By evaluating these parallel data streams, this research assesses the congruence between students' internal perceptions of skill acquisition and their demonstrated proficiency. This analysis highlights the gap between perceived and actual gain, underscoring the importance of pedagogical interventions that help students more accurately bridge the divide between their self-assessment and external performance benchmarks.

In summary, while previous research has extensively documented the efficacy of PBL in bolstering student motivation and technical self-efficacy, there remains a critical need to investigate the metacognitive accuracy of these perceptions. As established by [10], the ability to monitor and regulate one's own learning is a sophisticated cognitive skill that is often still developing in first-year students. This developmental gap, characterized by the Dunning-Kruger effect, suggests that novice engineering students may struggle to accurately calibrate their professional competency gains against empirical benchmarks. By building upon the multidisciplinary course structure detailed in prior scholarship, this study addresses this gap through a dual-assessment model. This approach moves beyond purely subjective student feedback to compare self-perceived growth with objective faculty evaluations across four key professional domains, providing a more rigorous understanding of professional skill acquisition in the introductory engineering experience.

Instructional Design & Assessment

The instructional design and technical scope of the unified introductory engineering course analyzed in this study are grounded in a curriculum previously developed to enhance student engagement through multi-disciplinary projects. As detailed in [9], this course employs a Project-Based Learning (PBL) framework to provide first-year students with a broad overview of various engineering disciplines, including mechanical, electrical, and computer engineering. While the work established the effectiveness of this integrative approach in influencing students' discipline choices and fostering basic technical “hard” skills, the current study extends that research by specifically examining the development and assessment of professional skills within the same pedagogical environment. By building upon the foundational course structure documented in [9], this paper moves beyond general student perceptions to a rigorous comparison of perceived versus actual skill acquisition.

To demonstrate the alignment between the assessment instruments, representative samples of both the student self-reporting survey and the faculty-led program rubrics are provided in Appendix 3. This appendix includes selected items that illustrate the specific performance criteria and scaling logic used to measure student skill development. These excerpts are provided to ensure methodological transparency while maintaining the integrity of the full instruments, which are currently being utilized in an ongoing longitudinal study.

To evaluate the development of professional competencies, a dual-assessment approach was employed, utilizing pre- and post- course surveys to measure students’ perceived growth. The initial survey was administered during Week 8 to establish a mid-semester baseline of students’ self-assessed “comfort and-or awareness” across four primary domains. The follow-up survey was administered on the final day of the course to capture terminal perceptions of growth.

The survey instrument disaggregated professional skills into the following thematic categories:

- **Communication and Documentation**: Assessment items focused on oral communication during group projects, proficiency in technical writing and formatting using the Chicago Manual of Style, presentation skills for diverse audiences, and the capacity to integrate peer feedback.
- **Teamwork and Collaborative Dynamics**: This domain evaluated students’ ability to function effectively within hands-on project teams, management of roles via the Responsibility Assignment Matrix (RAM), conflict resolution strategies, non-verbal collaborative techniques, and familiarity with formal peer evaluation mechanisms.
- **Problem Solving and Design Proficiency**: Students assessed their comfort with brainstorming, design iteration based on empirical testing, adherence to the engineering design process, and the management of open-ended problems using project planning tools such as Gantt charts.
- **Academic Integrity and Professionalism**: This category measured students’ understanding of plagiarism, citation accuracy, and awareness of engineering ethics and professional conduct.

The post-course instrument included the same 5-point Likert-scale items to facilitate a longitudinal comparison of perceived gains. Furthermore, qualitative items were added to the post-test to capture deeper metacognitive reflection. These included self-assessments of personal strengths and weaknesses, career goal articulation relative to multi-disciplinary exposure, and reflective prompts requiring students to identify specific projects (e.g., Tower, Bridge, Logic Gates, or Robotics) and pedagogical experiences that most significantly contributed to their professional skill acquisition.

To complement the student self-assessment data, the instructor utilized rubrics employed by the program to measure the actual gain in professional competencies through structured rubrics aligned with the course's four primary domains. For the Communication and Documentation domain, an Oral Presentation Evaluation Form was used to assess content clarity, the quality of technical findings, organizational logic, and delivery professionality, including the ability to engage an audience and respond to technical questions. Additionally, similar objective rubrics were employed to evaluate the technical writing component, specifically assessing students' proficiency in adhering to the Chicago Manual of Style (CMOS) for citations, report structuring, and the precise formatting of figures and tables.

The Teamwork and Collaborative Dynamics domain was evaluated through a comprehensive Team Member Evaluation rubric. This instrument allowed the instructor to quantify individual contributions across three specific areas: (1) contribution toward the project, such as gathering background information and sharing it with the group; (2) willingness to accept project responsibilities, including punctuality and the performance of assigned duties; and (3) the valuation of others' ideas, measured by how well a student listened to and cooperated with teammates. These faculty evaluations served as the objective benchmarks for comparing students' demonstrated performance against their perceived skill acquisition.

Results & Discussions

Perceived Gain

The longitudinal analysis of the gain in professional skill as perceived by students that were obtained by the pre- and post- test surveys are summarized in Table 1 which can be found in Appendix 1. The data demonstrates a positive shift in perceived competency across all measured categories. To determine the significance of these shifts, a *Wilcoxon Signed-Rank Test* was performed on the pre- and post-course survey responses.

W is the test statistic representing the smaller sum of signed ranks. It quantifies the magnitude and direction of shifts between paired observations by comparing the cumulative strength of positive differences against negative differences. W_{crit} is the threshold of significance derived from the Wilcoxon distribution. It defines the boundary where the observed W is considered too small to have occurred by random chance, given a specific sample size (n) and significance level (p).

Within the Communication and Documentation domain, results indicate that students perceived a statistically significant growth in their professional capabilities over the assessment period. Particularly robust improvements ($p \leq 0.001$) were observed in technical documentation metrics, including written communication ($n = 15, W = 0, W_{crit} = 6$) and the application of the Chicago Manual of Style for both source citations ($n = 18, W = 5, W_{crit} = 14$) and document structure ($n = 15, W = 0, W_{crit} = 6$). Perceptions of oral proficiency also trended upward, with significant gains ($p \leq 0.050$) reported in general oral communication during group projects ($n = 12, W = 11, W_{crit} = 13$) and comfort in delivering formal presentations ($n = 12, W = 11, W_{crit} = 13$).

The analysis of the second primary domain, Collaborative and Interpersonal Dynamics, reveals a more nuanced perception of growth compared to the other competency areas. Statistical significance was observed in only two of the five measured metrics. Students reported a significant perceived improvement in their capacity for conflict resolution ($n = 13, W = 12, W_{crit} = 13, p \leq 0.025$) and increased comfort with the iterative processes of brainstorming and ideation during design activities ($n = 14, W = 19.5, W_{crit} = 21, p \leq 0.050$).

Conversely, three critical interpersonal metrics failed to show statistically significant change over the assessment period: the acceptance and incorporation of peer feedback ($n = 11, W = 19, W_{crit} = 10$), overall effectiveness in teamwork ($n = 12, W = 21, W_{crit} = 13$), and the ability to engage in "silent" or non-verbal collaboration ($n = 12, W = 27.5, W_{crit} = 13$), with all yielding $p > 0.050$. These results suggest that while technical design and individual communication skills were enhanced by the course structure, the deeper complexities of interpersonal group dynamics remained relatively stagnant from the students' perspective.

Results indicate that the category of Design and Technical Proficiency also saw statistically significant perceived growth over the assessment period. Highly significant improvements ($p \leq 0.001$) were observed in two of the related metrics, with both having a W statistic of 0.0. These metrics included students' familiarity with the engineering design process ($n = 17, W_{crit} = 11$) and the use of project planning tools ($n = 21, W_{crit} = 25$).

The other related metrics within this domain including comfort using tools such as the Responsibility Assignment Matrix (RACI), solving open-ended questions, and the ability to iterate designs based on testing and feedback also showed an improvement in perceived skill levels with statistical significance ($p \leq 0.050$). These findings align with the previous documentation of the course's project-based structure, which emphasizes iterative testing and hands-on problem-solving as primary drivers for skill acquisition.

Regarding the forth domain, Professional Standards, the Wilcoxon Signed-Rank Test results indicate that all three measured metrics experienced statistically significant, though varying, levels of perceived growth over the assessment period. The most substantial perceived improvement was observed in students' awareness of engineering ethics and professional conduct ($n = 15, W = 0.0, W_{crit} = 6$), achieving a high level of statistical significance ($p \leq 0.001$). The evaluation of students' familiarity with the evaluation forms used to gauge individual contributions also showed significant growth ($n = 13, W = 12, W_{crit} = 13; p \leq 0.025$). While still statistically significant, the metric regarding the understanding of plagiarism and the implementation of avoidance strategies in technical writing showed a more moderate trend in perceived growth ($n = 12, W = 16.5, W_{crit} = 17; p \leq 0.100$).

Actual Gain

The assessment of actual gain within the Communication and Documentation domain is directly aligned with ABET Student Outcome 3, which requires students to demonstrate an ability to communicate effectively with a range of audiences. To empirically evaluate the acquisition of these skills, the instructor utilized standardized rubrics to assess performance across both formal technical reports and oral presentations, after the initial project to establish a baseline and again after the final project to determine gain. The evaluation focused on four key performance indicators (KPIs) derived from these assessment tools:

- **Organizational Logic**: The student's ability to structure technical materials into a coherent and logical flow.
- **Synthesis and Originality**: The extent to which the student presented complex content in their own words, avoiding over-reliance on jargon or external sources.
- **Evidentiary Support**: The student's proficiency in providing technical data and empirical evidence to substantiate project claims.
- **Linguistic Precision**: The demonstration of professional delivery and the proper usage of the English language within a technical context.

By utilizing these objective KPIs, the instructor generated a performance baseline that transcends student self-perception. In the context of this study's dual-assessment model, these faculty-led evaluations serve as the benchmark for "actual gain," allowing for a direct comparison between a student's perceived comfort with oral and written communication and their demonstrated mastery of professional standards. This comparison is essential for identifying whether the statistically significant perceived gains reported by students reflect a genuine increase in technical communication competence or a metacognitive overestimation common in novice learners.

The assessment of actual gain within the Teamwork and Collaborative Dynamics domain is aligned with ABET Student Outcome 5, which evaluates a student's 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. To empirically measure these competencies, the instructor utilized the "Faculty Use Only" portion of the Team Member Evaluation rubric, after the initial project to establish a baseline and again after the final project to determine gain, to score students across five specific key performance indicators (KPIs):

- **Inclusivity and Environment**: The student's ability to establish a collaborative and inclusive team environment by valuing others' ideas and listening without dominating the conversation.
- **Individual Accountability**: The extent to which the student fulfilled individual responsibilities, including punctuality in completing assignments and performing assigned duties to contribute to the team's overall success.
- **Goal Setting and Deadlines**: The student's proficiency in project management through the definition of clear goals and the adherence to team-imposed deadlines.
- **Task Management and Delegation**: The ability to plan and assign tasks effectively among team members, ensuring a balanced workload and clear roles.
- **Meeting Facilitation**: The student's capacity to organize and facilitate effective team meetings, ensuring consistent communication and project momentum.

By evaluating these KPIs, the instructor generated an objective dataset that measures demonstrated collaborative behavior rather than just student-perceived comfort. In the context of the study's dual-assessment model, these faculty ratings provide the necessary benchmark to determine if the "stagnant" perceived growth reported by students in certain teamwork metrics actually reflects a high level of performance that students have simply failed to recognize, or if it indicates a genuine area for pedagogical improvement. Comparing these objective scores which include team-related duties against the Wilcoxon results allows for a rigorous analysis of how first-year engineering students calibrate their own leadership and interpersonal growth.

The assessment of actual gain within the Design and Technical Proficiency domain is mapped to ABET Student Outcome 2, which requires students to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. To evaluate the acquisition of these technical competencies, the instructor assessed the "Quality of content" and "Originality and complexity" of project deliverables, after the initial project to establish a baseline and again after the final project to determine gain, using seven key performance indicators (KPIs):

- **Specification Adherence**: The degree to which the final design met the established technical and functional project specifications.
- **Technical Definition**: The student's ability to successfully define multi-disciplinary specifications, including mechanical, electrical, material, and manufacturing requirements.
- **Constraint Identification**: The successful identification of accessibility and usability constraints within the design context.
- **Problem Formulation**: The proficiency with which the student identified customer needs and performed a comprehensive analysis of design constraints.
- **Fitness Criteria and Trade-offs**: The ability to establish objective fitness criteria to evaluate potential solutions and navigate technical trade-offs.
- **Ideation of Alternatives**: The effectiveness with which the student developed and explored alternative design solutions.
- **Solution Justification**: The student's capacity to provide a technical and logical justification for the selected solution to solve the complex engineering problem.

By measuring these KPIs, the instructor generated empirical data on students' actual design proficiency, moving beyond their self-reported "comfort" with iteration and open-ended problem solving. This objective baseline is critical for the study's dual-assessment model, as it allows for a direct comparison between the highly significant perceived growth in design familiarity ($p \leq 0.001$) and the students' demonstrated ability to apply the engineering design process to a high technical standard.

To evaluate objective skill acquisition, a longitudinal analysis of actual gains was conducted by scoring student artifacts from early and late in the semester against the program objective's assessment rubrics. These findings, summarized in Table 2 which can be found in Appendix 2, reflect changes in demonstrated competency across the four primary professional domains. The data reveals notable shifts in performance, providing an empirical baseline to compare against student self-perceptions.

The dual-assessment model reveals a striking divergence between student self-perception and empirical performance across technical and interpersonal domains. Within the *Communication and Documentation* category, students reported highly significant perceived growth ($p \leq 0.001$), particularly in technical writing and citation proficiency . However, Table 2 indicates that actual gains in these areas, specifically “Organization” and “References” were not statistically significant ($p > 0.050$). This suggests a metacognitive overestimation consistent with the Dunning-Kruger effect, where novice learners lack the expertise to accurately calibrate their own technical deficiencies.

In contrast, a reverse trend was observed in the *Collaborative and Interpersonal Dynamics* domain. While students perceived their teamwork effectiveness as “stagnant” ($p > 0.050$), faculty evaluations demonstrated highly significant actual improvements in “Timely Task Completion,” “Goal Defining,” and “Individual Task Planning” ($p \leq 0.010$). This indicates that while the PBL environment successfully fosters professional habits, students may not yet possess the reflective awareness to recognize these behavioral gains as formal skill acquisition.

In this comparative analysis of *design and technical* competencies, a high degree of metacognitive alignment was observed between student self-perception and objective faculty evaluation. Students reported a significant perceived gain in managing Open-ended problems ($p \leq 0.050$), which was validated by a corresponding actual gain in their ability to “Formulate the Problem” ($p \leq 0.050$). Similarly, a highly significant perceived increase in “Familiarity with the Design Process” ($p \leq 0.001$) aligned with measured improvements in establishing and applying a “Fitness Criterion” ($p \leq 0.050$). Most notably, student reports of highly significant growth in “Design Iteration” ($p \leq 0.001$) were substantiated by significant objective gains in both the generation of “Alternative Solutions” ($p \leq 0.050$) and the logical “Justification of Solutions” ($p \leq 0.050$). This consistent alignment suggests that when tasks provide tangible technical markers such as the success of a design iteration, first-year students are better equipped to accurately calibrate their professional growth than in more abstract interpersonal or communication-based domains.

Conclusions

This study highlights a complex landscape of metacognitive awareness among first-year engineering students regarding professional skill acquisition. Through a dual-assessment longitudinal model, three distinct patterns of self-calibration emerged. In the *Communication* domain, students exhibited a Dunning-Kruger effect, perceiving significant growth ($p \leq 0.001$) that was not reflected in objective faculty evaluations.

Conversely, in the *Collaborative* domain, students underestimated their progress, failing to recognize statistically significant behavioral improvements ($p \leq 0.010$) in task planning and goal defining.

Most notably, the *Design and Technical Proficiency* domain showed a high degree of alignment; students accurately identified their growth in formulating problems and iterating solutions, matching objective gains ($p \leq 0.050$).

These findings suggest that while project-based learning effectively develops professional competencies, student awareness of that development is uneven. Technical tasks provide tangible markers for self-calibration, whereas abstract interpersonal and communication skills require more explicit pedagogical interventions.

Future Work

Future work will investigate the impact of "calibration based reflection," where students use the same objective rubrics as faculty to self-score their work mid-semester. By making the evaluation criteria transparent and frequent, engineering programs can help students bridge these metacognitive gaps, better preparing them to articulate their professional readiness in future career-entry scenarios.

AI Disclosure

Disclosure of AI-Assisted Technologies: The authors utilized an AI-assisted Large Language Model (LLM) to assist in the structural organization and linguistic refinement. All data analysis and final interpretations were conducted and verified by the authors to ensure scholarly integrity.

References

[1] D. Knight and B. Novoselich, "Curricular and co-curricular influences on undergraduate engineering student leadership: Influences on engineering student leadership," *Journal of Engineering Education*, vol. 106, 01 2017.

[2] H. Passow and C. Passow, "What competencies should undergraduate engineering programs emphasize? a systematic review," *Journal of Engineering Education*, vol. 106, pp. 475–526, 07 2017.

[3] B. Zimmerman, "Becoming a self-regulated learner: An overview," *Theory Into Practice*, vol. 41, pp. 64–70, 06 2002.

[4] S. A. Ambrose, M. W. Bridges, M. DiPietro, M. C. Lovett, and M. K. Norman, *How Learning Works: - Seven Research-BAsed Principles for Smart Teaching*, 1st ed. 989 Market Street, San Francisco, CA 94103-1741: Jossey-Bass, 2010, no. 978-0-470-48410-4 (cloth).

[5] D. Kaufman, R. Felder, and H. Fuller, "Accounting for individual effort in cooperative learning teams," *Journal of Engineering Education*, vol. 89, 04 2000.

[6] B. B. Terranova *et al.*, "Work in progress: Curriculum revision and classroom environment restructuring to support blended project-based learning in first-year general engineering laboratory courses," in *2017 ASEE Annual Conference & Exposition*, no. 10.18260/1-2–29147. Columbus, Ohio: ASEE Conferences, June 2017, https://peer.asee.org/29147.

[7] C. Loes, "The effect of collaborative learning on academic motivation," *Teaching and Learning Inquiry*, vol. 10, 01 2022.

[8] L. Francis *et al.*, "Engaging first-year students with a hands-on course using student-driven projects," in *2019 ASEE Annual Conference & Exposition*, no. 10.18260/1-2–32718. Tampa, Florida: ASEE Conferences, June 2019, https://peer.asee.org/32718.

[9] D. Raja and N. Schleper, “Wip: Evaluating the impact of multi-disciplinary projects on students’ engineering discipline choices,” no. 10.18260/1-2–57406. Montreal, Quebec, Canada: ASEE Annual conference & Exposition, June 2025.

[10] J. H. Flavell, “Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry,” *American Psychologist*, vol. 34, no. 10, pp. 906–911, 1979, https://doi.org/10.1037/0003-066X.34.10.906.

[11] J. Kruger and D. Dunning, “Unskilled and unaware of it: How difficulties in recognizing one’s own incompetence lead to inflated self-assessments,” *Journal of Personality and Social Psychology*, vol. 77, no. 6, pp. 1121–1134, December 1999.

Appendix 1

Table 1: Students’ Perceived Gain of Professional Skill

Group	Metric	n	W	W_{crit}	p
Communication and Documentation					
	Oral Communication	12	11.0	13	≤ 0.050
	Written Communication	15	0.0	6	≤ 0.001
	CMOS Structure & Format	15	0.0	6	≤ 0.001
	Presentation Comfort	12	11.0	13	≤ 0.050
	CMOS Citations	18	5.0	14	≤ 0.001
Collaborative and Interpersonal Dynamics					
	Feedback Acceptance & Incorporation	11	19.0	10	> 0.050
	Effective Teamwork	12	21.0	13	> 0.050
	Conflict Resolution	13	12.0	13	≤ 0.025
	Silent Collaboration	12	27.5	13	> 0.050
	Comfort With Brainstorming	14	19.5	21	≤ 0.050
Design & Technical Proficiency					
	Project Planning Tools	21	0.0	25	≤ 0.001
	Comfort with RACI Matrix	18	20.5	23	≤ 0.005
	Design Iteration	15	7.0	12	≤ 0.005
	Familiarity of Design Process	17	0.0	11	≤ 0.001
	Open-Ended Problems	13	4.5	7	≤ 0.005
Professional Standards					
	Familiarity of Evaluation Form	13	12.0	13	≤ 0.025
	Plagiarism	12	16.5	17	≤ 0.100
	Ethics & Professional Conduct	15	0.0	6	≤ 0.001

Appendix 2

Table 2: Actual Gain of Professional Skill

Group	Metric	n	W	W_{crit}	p
Communication and Documentation					
	Organization	8	18.0	5	> 0.050
	Problem Statement	9	15.0	8	> 0.050
	Inference	11	30.0	13	> 0.050
	Major Sections	7	12.0	3	> 0.050
	References	9	15.0	8	> 0.050
	Nature of Information	10	11.0	10	> 0.050
	Quality of Research Conducted	8	4.5	5	≤ 0.050
	Use of Own Language	8	18.0	5	> 0.050
	Quality of Understanding	11	30.0	13	> 0.050
	Clear Expression of Ideas	10	11.0	10	> 0.050
	Development of Ideas	9	15.0	8	> 0.050
	Artwork/Illustration Supports Core Message	13	21	21	≤ 0.050
	Labels	8	0.0	1	≤ 0.010
	Grammar	12	19.5	21	≤ 0.100
	Punctuation	13	39.0	21	> 0.050
	Spelling	8	13.5	5	> 0.050
	Sentence Structure	10	25.0	10	> 0.050
	Proofreading & Revisions	7	12.0	3	> 0.050
Collaborative and Interpersonal Dynamics					
	Constructive Criticism	9	20.0	8	> 0.050
	Knowledge Sharing	9	15.0	8	> 0.050
	Leadership	9	9.0	10	≤ 0.100
	Timely Task Completion	9	0.0	3	≤ 0.010
	Contribution Towards Team Effort	11	5.5	8	≤ 0.010
	Interaction w/ Team Members	13	12.0	13	≤ 0.010
	Goal Defining	9	5.0	5	≤ 0.020
	Deadline Defining	12	16.5	17	≤ 0.050
	Shared Tasks Planning	10	5.0	5	≤ 0.010
	Individual Tasks Planning	12	6.0	10	≤ 0.010
	Organizing Team Meetings	13	26.0	21	> 0.050
	Facilitating Team Meetings	12	32.5	17	> 0.050
Design & Technical Proficiency					
	Formulate the Problem	15	0.0	20	≤ 0.010
	Fitness Criterion	12	0.0	10	≤ 0.010
	Alternative Solutions	14	0.0	17	≤ 0.010
	Justification of Solutions	12	0.0	10	≤ 0.010

Appendix 3

The following tables provide a representative sample of the rubric criteria used for both student self-assessment and faculty evaluation. To maintain the internal validity of our ongoing longitudinal study and prevent participant priming in future data collection cycles, the full, unabridged instruments have been omitted from this manuscript. The excerpts provided below illustrate the performance dimensions, scaling logic, and level of detail applied across all assessment categories.

Sample representative questions are included in Table 3 that were used to ascertain students perceived gain. Students were asked to choose one of the the five options/comfort levels for each question.

1. : Not at all comfortable or No knowledge
2. : Slightly comfortable or Basic awareness
3. : Moderately comfortable or Some experience
4. : Very comfortable or Confident in application
5. : Extremely comfortable or Can teach others

Table 3: Sample Questions from Student Survey

Communication Skills	How comfortable are you with *written communication* in technical contexts using Chicago Style?
Teamwork and Collaboration	How comfortable are you with *assigning and managing roles* using tools like the Responsibility Assignment Matrix (RAM)?
Problem Solving and Design Thinking	How comfortable are you with *brainstorming and ideation* during engineering design activities?

Sample representative key performance indicators (KPIs) used in the evaluation of a student's oral presentation is shown in Table 4. A Likert-scale of 5 is used.

Table 4: Sample KPIs for Oral Presentation

Content	Clarity of content
Organization	Logical flow of sections/ideas
Delivery	Clear voice with good pace

Sample representative questions used in the team member evaluation survey that is deployed after every group project work to ascertain a student's perception of their team members is shown in Table 5. A Likert-scale of 4 is used.

Table 5: Sample Questions to Ascertain a Student's Team Member Perception

Rate your teammate on the effort they put into researching and gathering background information for the design.	
Rate your teammate on how well they performed their duties relating to their role in the group.	
Rate your teammate on how well they cooperate with others in the group.	

Sample representative key performance indicators (KPIs) used in the evaluation of a student's communication skill is shown in Table 6. A Likert-scale of 5 is used.

Table 6: Sample KPIs for Communication

How well did the student organize the material in the artifact?	
How well did the student present content in their own words to demonstrate comprehension?	
How well did the student demonstrate proper usage of the English language?	

Sample representative key performance indicators (KPIs) used in the evaluation of a student's project management skill is shown in Table 7. A Likert-scale of 5 is used.

Table 7: Sample KPIs for Project Management Skills

How well did the student organize and facilitate effective team meetings (Project management skills)?	
How well did the student establish a collaborative and inclusive environment?	
How well did the student organize and facilitate effective team meetings (Project management skills)?	

Sample representative key performance indicators (KPIs) used in the evaluation of a student's engineering design skill is shown in Table 8. A Likert-scale of 5 is used.

Table 8: Sample KPIs for Engineering Design Skills

How well did the student successfully define specifications?	
How well did the student formulate the problem (i.e., identified customer needs and analysis of constraints)?	
How well did the student develop alternative solutions?	